SUBSISTENCE ECONOMIES AMONG BRONZE AGE STEPPE COMMUNITIES: AN ARCHAEOBOTANICAL APPROACH TO THE STUDY OF MULTI-RESOURCES PASTORALISM IN THE SOUTHEASTERN URAL MOUNTAINS

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Subsistence Economies among Bronze Age Steppe Communities: An Archaeobotanical Approach to the Study of Multi-Resources Pastoralism in the Southeastern Ural Mountains

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The long-standing subsistence model for the Bronze Age communities in the Southeastern Urals region is that of a sedentary agro-pastoral strategy with the dominant use of cattle, horse and sheep/goats. In this dissertation, I describe new evidence suggesting a multi-resource pastoralism without agriculture practice as the dominant subsistence economy among Bronze Age communities in that region. Archaeological evidence in the Southeastern Urals exhibits a long-standing hunting gathering-fishing tradition before the emergence of Bronze Age settlements. In a manner, multi-resource pastoralism continues this tradition by combining different complementary systems of subsistence.

Dissertation data was collected from archaeobotanical samples, local catchment zone analysis, ethnographic studies and archaeological experiments to investigate wild resource exploitation in the Bronze Age. Results showed that wild plant species are related to specific vegetation units in each communities' catchment zones. These communities employed a local-based subsistence economy that intensively exploited specific wild plant resources from their immediate catchment – the meadow zone, in particular. For livestock, grazing was the predominant method for nutrient intake in spring, summer, and autumn; storage fodder was the primary food in winter. The macro-botanical remains found within the enclosed areas exhibited plant resources used for both human diets and fodder collected for livestock. The ashy layer investigated in the non-enclosed areas suggests an outdoor corral; seed assemblages from this area are indicative of fodder storage, indoor corral trash and human living trash, all of which consisted of local wild plant species.

Overall, the continued practice of multi-resource pastoralism was a response to the environmental factors as well as the dynamic human-ecological relationships exhibited in the Bronze Age Southeastern Urals region. Contrary to long-standing beliefs and the tradition of equating social complexity with sedentism and agriculture, these relatively sedentary pastoralist societies show no evidence of agriculture as a mode of subsistence. The multi-resource pastoralism strategy maximized the exploitation of seasonal resources; the intensive use of specific plant resources in the local catchment zone was essential for the development of early pastoralist societies in the Southeastern Urals region.

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1.0 INTRODUCTION

1.1 RESEARCH TOPIC DEVELOPMENT

In world prehistory, pastoralism emerged as a unique and specialized form of subsistence. Many scholars have focused on differentiating this form of the economy from other key patterns of subsistence known throughout early human history (Irons and Dyson-Hudson 1972; Dyson-Hudson and Dyson-Hudson 1980; Galaty and Johnson 1990; Ingold 1980; Irons and Dyson-Hudson 1972; Khazanov 1994; Salzman and Galaty 1990; Salzman 2004:1). In these important studies, pastoralism is defined as a specialized subsistence economy relying on domesticated animals, related secondary products, and spatial mobility organized seasonally.

One of the central questions in studies of pastoralism is how and why this subsistence economy form emerged around the world? Most explanations for the emergence of early mobile pastoralist communities emphasize such orientations emerging from established sedentary, agricultural economies (Flannery 1972; Irons 1975; Lees and Bates 1974; Renfrew 2002:6-7; Sherratt 1983; Wright 1977). Within this realm of discussion, the exploitation of plant resources is an essential component of the subsistence economy.

Paleoethnobotany is the study of the interrelationships between human populations and the plant world through the archaeological record (Pearsall 1989:1). Hence successful incorporation of paleoethnobotanical analysis can always lead to a better understanding of early pastoralist communities. Under this circumstance, I was invited to join the Sintashta Collaborative Archaeology Research Project (SCARP), directed by Dr. Bryan Hanks (University of Pittsburgh) and Dr. Roger Doonan (University of Sheffield), and took on the role of archaeobotanist for the project. My research started with a simple question: Was agriculture practiced by these pastoralist societies and/or did they use agricultural products as part of their subsistence pattern? Hence, my initial research started with a target oriented focus to find domesticated crop evidence through the study of macrobotanical remains recovered through archaeological excavation. Besides looking for evidence of agriculture and/or use of agricultural products, I started to reconsider how and why pastoralism emerged in this particular region.

Traditional models for the emergence of pastoralism in the Eurasian steppes have emphasized the relationship of trade with sedentary agriculturalists in Central Asia or the development of an autonomous local agrarian component to complement livestock herding. For example, Khazanov (1994) developed a typological system that relied on the degree of mobility of pastoralist communities (i.e., nomadic, semi-nomadic, etc.). Cribb (1991:17) later developed a conceptual model with four key dimensions ranging from "nomadic" to "sedentary" (degree of mobility) and "agricultural" and "pastoral" (mode of subsistence). Cribb conducted ethnoarchaeological studies in Turkey and plotted these pastoralist groups in the framework of this model. Cribb's approach provides an important foundation for conceptualizing the variable nature of pastoralist systems along with a continuum of possible subsistence orientations.

The aim of my research with SCARP was to explore the exploitation of plant resources by these pastoralist societies, which included the potential of both domesticated and wild plant species. In the 2008 excavation season, I carried out a systematic flotation process to extract botanical remains from the Middle Bronze Age (2100-1700 BC) enclosed settlement of Stepnoye, which is in the Uy River valley, Chelyabinsk Oblast', in the Southeastern Urals region of Russia (Figure 1).

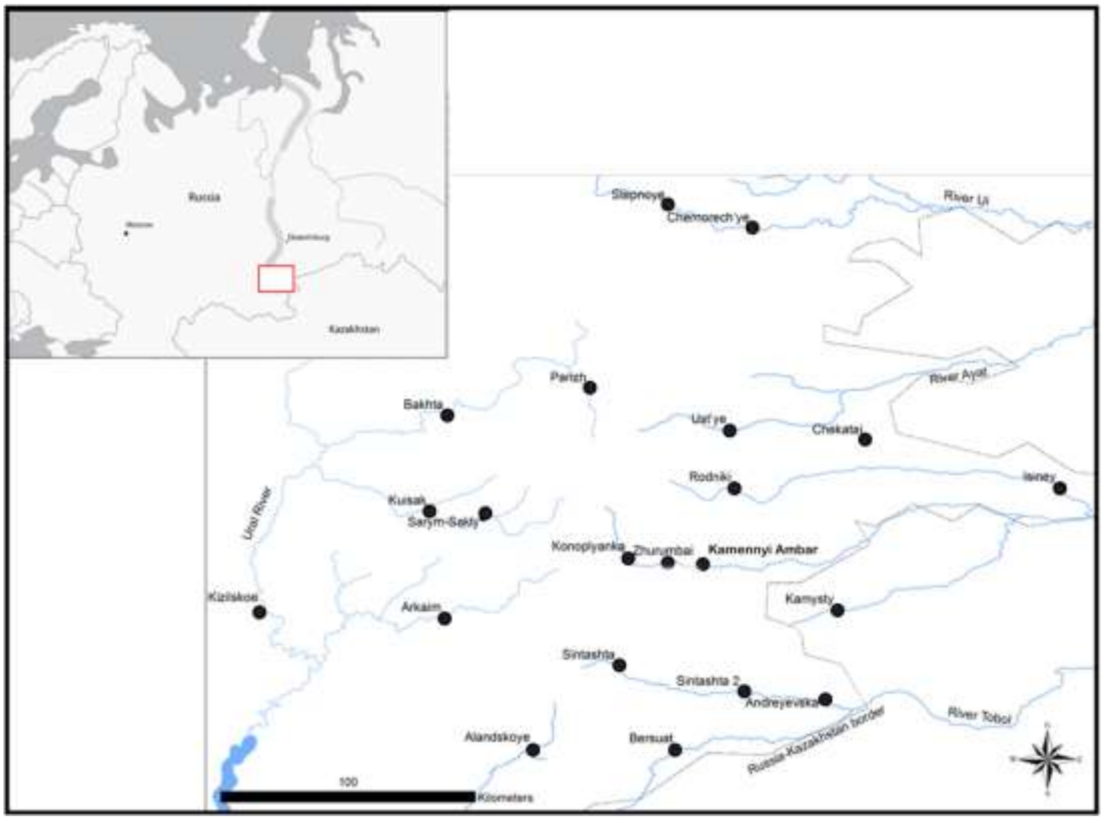


Figure 1 Map of Middle Bronze Age Sintashta-Petrovka settlements in the Southeastern Urals (modified from Doonan et al. 2014: 761)

My collaboration with SCARP has provided an invaluable opportunity to gain experience researching early pastoralist settlements in the Eurasian steppes. The extensive scale of soil flotation that was undertaken at Stepnoye (3,636 L soils, 167 macrobotanical samples) provided the largest to date prehistoric dataset of archaeobotanical remains for the Eurasian steppes. Initially, the archaeobotanical samples from Stepnoye were offered by the SCARP project to me to complete my M.A. dissertation in China. However, due to the difficulty of the transportation of botanical remains across international borders, this plan was held for two years. In 2011, I coordinated with the SCARP project to develop a small archaeobotanical laboratory in the modern-day Stepnoye village and was then able to initiate my planned detailed laboratory studies for my graduate degree.

Since 2011, I began to work closely with Russian scholars from Chelyabinsk State University and the Russian Academy of Science, Institute of Animal and Plant Ecology, in Yekaterinburg. These institutions provided the necessary scientific and institutional support for my laboratory work and ensured access to local seed reference collections and archaeological materials. At the same time, I also started a pilot phytogeographical study in the Uy River valley to investigate the distribution of various plant resources around the MBA Stepnoye settlement. During this period, I recognized a significant differentiation between the subsistence economy in local pastoralist societies and my previous knowledge. After completing my Master's degree program in the Graduate School of Chinese Social Science in Beijing, I looked forward to pursuing doctoral research with Dr. Hanks in the Eurasian steppe. Subsequently, as I began the Ph.D. program in Anthropology at the University of Pittsburgh, I began to collaborate with SCARP at another MBA enclosed settlement known as Ust'ye, which is situated in the Nizhnii Toguzak River valley, Chelyabinsk Oblast', in the Southeastern Urals region. Based on experiences during the Stepnoye settlement excavation, we undertook a similar systematic flotation process of archaeological soils at the Ust'ye settlement. The combination of archaeobotanical remains recovered and identified from the excavations at Ust'ye provided an important comparative set of samples with those recovered and identified previously from the Stepnoye settlement.

In tandem, these results led me to think that the similarity of the subsistence economy in Bronze Age pastoralist communities in the Southeastern Urals region may be closely related to the exploitation and annual usage pattern of local wild plant resources. In many anthropological comparative case studies from around the world, the development of pastoral subsistence economies frequently leads to broader shifts in social and economic complexity. These changes may include demographic shifts, new forms of social organization, and seasonal patterns of spatial mobility (Cribb 1991; Fratkin and Mearns 2003; Homewood 2009; Johnson 1969; Salzman 1980; 2004).

A logical starting point for my investigation of the relationship between the development of pastoral subsistence economies and social complexity is the plant resource usage pattern among Bronze Age pastoralist communities in the Southeastern Urals region. Following this idea, I applied for a National Science Foundation (NSF) doctoral dissertation improvement grant in 2016. The awarded funding (DDRIG #1659946) supported a detailed micro-regional phytogeographical zone study, incorporating previously collected archaeological and archaeobotanical data from SCARP project, and the collection of new ecological information and ethnographic research in the Uy River Valley (Fig. 2)

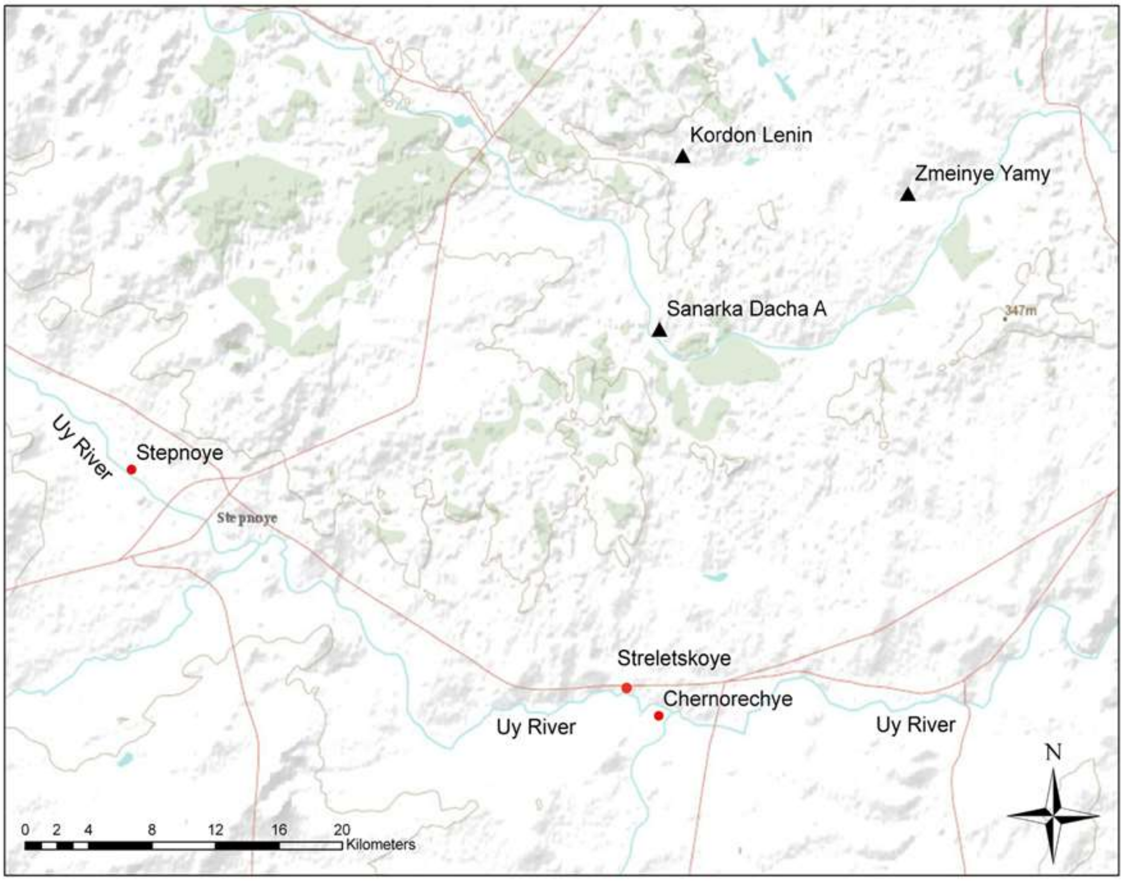


Figure 2 Map of Uy River valley showing key Bronze Age sites (modified from Doonan et al 2013)

This research provided a foundation of archaeological and environmental data in which to develop a more coherent and empirically substantiated model of subsistence practices for these Bronze Age populations.

During one phase of my doctoral dissertation field research (April to August 2017), I joined several other archaeological projects in the region to collect comparative archaeobotanical samples. The results of my work with these projects provided an important comparative context for my dissertation field research activities undertaken in the Uy River valley. The work at the Late Bronze Age (LBA) site of Streletskoye, which is located 17 km east from the MBA Stepnoye settlement, helped to strengthen my interpretations regarding the commonality and continuity of plant resource exploitation strategies utilized by Bronze Age pastoralist communities in the region

These experiences inspired me to reconsider the research of Roger Cribb (1991) in Anatolia, which highlighted the potential of a wider spectrum of subsistence practices among mobile pastoralists in contrast to the rather conventional view that more sedentary pastoralists are dependent on agricultural products (Figure 3).

This in turn stimulated the question in my mind as to what other forms of subsistence trajectories might exist in the Eurasian steppes if agricultural products were not utilized. Following this question, and the research experiences I had working with colleagues in the Southeastern Urals, I focused my interests on utilizing paleoethnobotanical methods to assist with the development and refinement of subsistence models for late prehistoric pastoralist societies. Before moving to the discussion of the results from this region, it is essential to first set out a contextualization of subsistence economies among early pastoralist communities in the broader Northern Eurasia area.

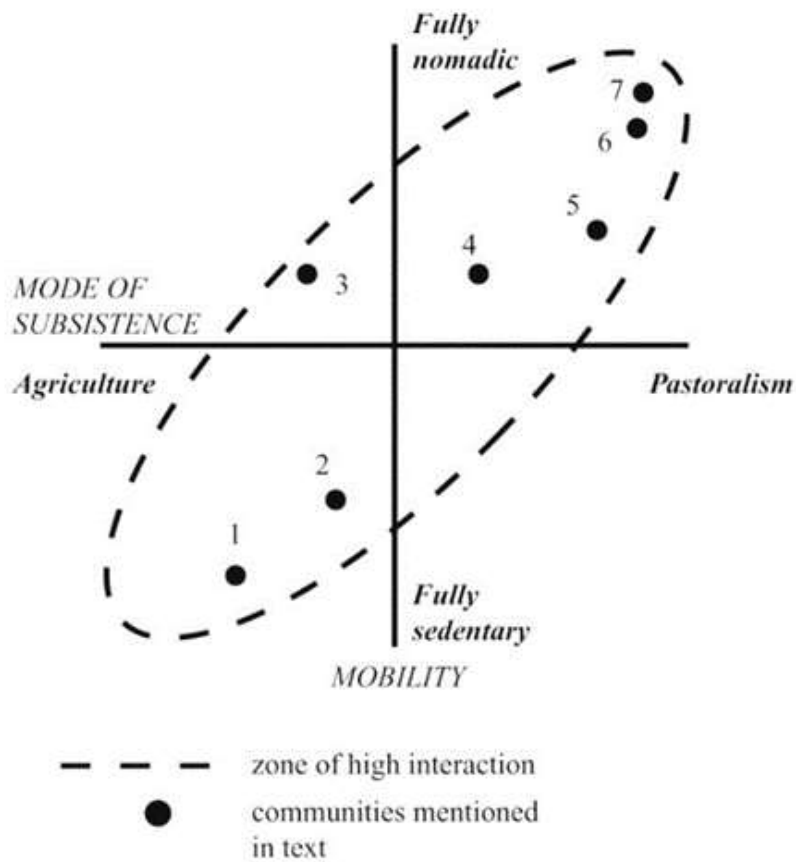


Figure 3 Model showing correlation between mobility and subsistence of a number of contemporary pastoral communities in Anatolia (after Cribb 1991:17)

1.2 CONCEPTUALIZING EARLY PASTORALIST COMMUNITIES IN NORTHERN EURASIA

The dominant geographic feature of Northern Eurasia is the largest unified area of flat land in the world. Besides natural borders such as mountain chains and rivers there are no significant barriers to the movement of humans and animals. The absence of such barriers, and the historical dominance of pastoralist societies, helps explain the size of the cultural, political and military units that appeared historically across Northern Eurasia (Christian 2008). For example, through the Middle Bronze Age (2100-1700 BC), broader regional interactions between peripheral and core regions in the Eurasian Steppe are demonstrated by the overarching similarity of material remains (Anthony 2009; Frachetti 2012; Kohl 2008). Views derived from these interactions have emphasized the importance of an agro-pastoral strategy for achieving increased social complexity among Eurasian steppe societies during the Middle and Late Bronze Age (Kuzmina 2000; Renfrew 2002).

The steppe zone in Northern Eurasia is also a key region for the discussion of the origins, spread and development of early pastoralist subsistence economies. Due to the erratic rainfall of this region, extensive herding economies associated with low population densities and high levels of geographic mobility are dominant in many historical and ethnographic accounts (Allard 2006; Barfield 1989; Di Cosmo; 1994;1999; Khazanov 1984; Kuzmina 2008). The role of pastoralism in human history is an increasing topic of interest and substantial research and publications have focused on northern Eurasia over the past two decades (Anthony 2007; Boyle et al. 2002; Brosseder and Miller 2011; Frachetti 2008; Hanks and Linduff 2009). These studies have provided important information for developing comparative anthropological studies of pastoralism and the various trajectories for its appearance in many regions of the world.

Numerous scholars have emphasized the importance of pastoralism and its relationship to early social, political and economic processes among late prehistoric Northern Eurasian communities (Anthony 2007; Frachetti 2008; 2012; Khazanov 1994; Kohl 2007; Kuzmina 2007; Renfrew 2002). Conventional views of social complexity in pastoralist societies have focused on the importance of transitions towards agro-pastoralism and more structured interactions with sedentary agriculturalist societies (Chang and Koster 1994; Khazanov 1994; Kuzmina 2007; Renfrew 2002; Salzman 1984; 2004). Agricultural production can support sedentism and population growth that influences the nature of social complexity. To manage the organization of agricultural production, storage, the organization of redistribution, and to take advantage of new forms of wealth, new forms of leadership often emerge in such cases (Chapman 1990: 211-219; Earle 1997; Drennan and Peterson 2008; Drennan et al. 2011; Price and Feinman 1995;).

In contrast, recent northern Eurasian studies suggested that the development of pastoralist communities may not relate to agricultural practices and production (Anthony et al. 2005; Clark 2014; Hanks 2012; Houle 2010; Krause and Koryakova 2013; Popova 2006; Privat et al. 2005, Stobbe et al. 2016). As a result, these studies of the development of pastoralist communities in Northern Eurasia suggest different processes allowing for comparison and evaluation of factors contributing to the social, cultural and political development in pastoralist societies that are not contingent on production or access to agricultural imports.

For example, in northwestern Kazakhstan, studies of the Botai culture (ca. 3500 BCE), have illustrated the relationship of early horse domestication to an earlier tradition of hunting and exploitation of wild horse populations (Olsen 2003; Outram et al. 2009). Zooarchaeological and archaeometric analyzes have revealed a very specialized subsistence economy that emerged out of the availability of wild horse populations that may have led to early horse domestication. In another case study, Matyushin (2003) has suggested that hunting-gathering-fishing remained the fundamental means of subsistence even after animal domestication was first introduced to the South Urals region from Central Asia (6000-4000 BC).

In the Samara River valley, archaeological research at the site of Krasnosamarskoe also has shown a complete lack of agricultural goods but reflects a substantial foraging component in the subsistence economy (Anthony et al. 2005; Popova 2006). This work has recovered a "semi-sedentary" subsistence economy based on pastoralism and wild plant use. In Mongolia, Honeychurch and colleagues (Honeychurch 2004; 2009) produced a model for the subsistence economy in the Egiin Gol River valley during the Xiongnu period (ca. 209 BC to A.D. 93) and Orkhon Uighur Empire (A.D. 744-840). The subsistence economy included components of pastoralism, hunting, fishing and gathering of wild plants.

Over the past decade, more intensive studies of subsistence economies and the role of pastoralism have been examined for the Bronze Age and, more specifically, on developments during the first half of the second millennium BC in north-central Eurasia. Recent paleoenvironmental research at the Bronze Age settlement of Kamennyi Ambar in the

Southeastern Urals has shown a distinct lack of evidence for cereal agriculture and highlighted the more intensive use of wild plant resources (Krause and Koryakova 2013:322).

Projects focused on prehistoric dietary patterns also have examined carbon and nitrogen stable isotopes from human, and animal remains. These results have emphasized fish resource use in tandem with pastoralism (Hanks et al. 2018; Ventresca Miller 2014; Privat et al. 2005). At both the Bestamak and Lisakovsk cemetery sites, carbon and nitrogen stable isotope data suggest that primary dietary intake of individuals was terrestrial animal protein, likely in the form of milk and meat. But the slightly elevated $\delta15N$ values in some individuals may reflect supplemental fish consumption.

These recent studies in Northern Eurasia are contributing importantly to more traditional theoretical frameworks that have defined the relationship between agricultural production and the development of pastoralist economies. New data is emphasizing that hunter-gatherer-fisher traditions remained important among early pastoralist communities in Northern Eurasia. These results suggest the need for a new agenda in the study of pastoralism that emphasizes not only the typology and economic orientations of existing pastoralist communities but also one that highlights the significance of multi-resource pastoralism and its role in the development of complex human-environment relationships and resource sustainability. Compared with the exploitation of faunal resources, an empirically substantiated understanding of the use of wild plant resources is the missing component within subsistence economies among early pastoralist communities in many regions of the steppes.

Certainly, in the subsistence economy of pastoralist societies, wild plant resources are a crucial factor for human and livestock consumption and their availability within the environment is of central concern (Binford 1980; 2001; Lee and Daly 1999; Murdock 1967). Hence, this dissertation focuses on wild plant exploitation and annual usage patterns of these resources as a sustainable mechanism in which to examine economic, social and political change during the development of early pastoralist communities in the Eurasian Bronze Age. The rest of this chapter sets out the main idea of this sustainable mechanism and how this connects with the dissertation research that has been completed.

1.3 MULTI-RESOURCE PASTORALISM AND HUMAN-ENVIRONMENT INTERACTION OF EARLY PASTORALIST COMMUNITIES

Anthropological studies from different regions of the world have emphasized that the adoption of pastoralism is essential in the development of communities relying on multiple subsistence systems (Chang and Koster 1986; Flannery 1965; 1969; Homewood 2008; Marshall 2000; Smith 1992; 2000). Early transitions towards herding and the use of domesticated animals were often only one trajectory to emerge out of these broader subsistence strategies (Chang and Koster 1986; Flannery 1965, 1969; Homewood 2009; Marshall 2000; Smith 1992, 2000).

Several archaeological studies in Northern Eurasia have indicated that pastoralism, in conjunction with hunter-gatherer-fisher strategies, persisted for several millennia. Pastoralism, as a form of subsistence economy, converts wild resources that are unsuitable for the human digestive system into products for human consumption and utility (Anthony 2007:137; Barfield 2011:109; Johnson 1969:8; Salzman 2004). Meat and secondary products derived from livestock also substantially increase the carrying capacity of local environments (Khazanov 1994:69; Sherratt 1983). Adaptation towards management and herding of domestic animals, as part of a broad-spectrum pattern of food production, also provided an adequate resource base for demographic growth in human communities. Importantly, foraging patterns and pastoralism share some similar characteristics:

(i)Seasonal mobility

(ii)A deep understanding of animal behavior and plant resources

(iii)Seasonal use schedules within local ecologies

(iv)Relatively low population densities

(v)They are often pushed to more marginal ecological zones when in competition with sedentary agricultural communities

These adaptations have persisted even today in northeastern Asia and parts of southwestern Asia and Africa, where in some cases agriculture was never practiced. The adoption of pastoralism by existing forager populations may also have been a choice due to socio-environmental variables that were historically conditioned. Importantly, Ingold (1980) also has suggested that a significant difference between herding systems and foraging systems is that livestock accumulated as living resources. The accumulation of livestock and associated secondary products can act as a form of wealth accumulation unrealized by foragers. Thus, a detailed investigation of the role that early pastoralist orientations played within traditional hunter-gatherer-fisher subsistence systems contributes importantly to anthropological studies on the origins of multi-resource pastoralism and the part this played in broader social, cultural and political complexity and change.

Multi-resource pastoralism (Salzman 2004), when viewed as an adaptation stemming from foraging subsistence economies, must consider many variables that are essential components of local environments:

(i)Rainfall and temperature

(ii)Topography such as the layout of different geographic units

(iii)Flora, including grazing and browsing to support livestock and edible wild plants for humans

(iv)Fauna, such as predators, and animals used for meat and other resources

A key aim within these subsistence systems is to optimize the location of resources, to maximize the use of these resources for livestock, and to minimize the harmful influence of risk to these resources (Salzman 2004). In comparison with sedentary communities, spatial mobility is often a crucial element within pastoralist subsistence economies regarding seasonal access to resources and the minimization of risk associated with the sustainability of resources (Frachetti 2008:15; Homewood 2008:1; Ingold 1980:27; Salzman 2004:1). Given these considerations, trends that lead to greater levels of sedentarization for pastoralist communities must be understood as maximizing resources and minimizing risk. Salzman (1984) proposed an "adaptation and response model" to understand such processes among pastoralist groups. Sedentarization, as viewed by Salzman, was not the simple result of coercion by external forces but rather reflected dynamic decision-making processes within pastoralist communities and the institutionalized resources that defined options available to them. External social and environmental pressures were important factors in decisions linked to mobility and sedentarization, but other factors also were important in individual community decision-making, regional political, organizational patterns, and ideological systems.

The nature of the local human-environment interaction, therefore, is extremely important to understand decision-making processes and patterns of sedentism and mobility in pastoralist societies. For multi-resource pastoralism, the knowledge of local environments may stem from long-term hunter-forager traditions. Such knowledge helps human communities to adapt and respond to changes in the local environment and, in some cases, develop new forms of subsistence economy. In recent years, greater studies have focused on human-environment interaction in Northern Eurasia, and this has relied on a conceptual "landscape approach." For example, Ingold (2003:152; 2000:42) emphasizes the interconnectivity of nature, culture and human social practice within a single system rather than dichotomous concepts such as "culture and nature." Several studies have applied Ingold's theoretical perspective that focuses on the complex human-environment relationships among late prehistoric Eurasian hunter-gatherer-fishers and pastoralists (Frachetti 2008; Hammer 2014; Jordan 2011). These studies outline the important links that exist between human communities, their activities, material culture, and the surrounding landscape.

Other scholars have emphasized the development of new forms of political organization among Bronze Age pastoralist groups through the corporate construction of monuments that brought together the symbolic importance of landscape, territorial control, and ritual practice (Allard and Erdenebaatar 2005; Anthony 2007; Houle 2010). Popova (2006) has emphasized the significance of political control over specific landscapes in the middle Volga region during the Bronze Age, as political leaders may have maintained economic and political dominance by consistently marking out the best pastures along the river for their herds through the construction of burial mounds for the dead. Frachetti also has employed a "landscape approach" in his work on late prehistoric pastoralism by focusing on habitation ecology, ritual/ideological landscapes, and landscape and identity as the basic components of a conceptual framework (2006:129-132). In this model, key conceptual elements link important theoretical questions to specific analytical methods used by archaeologists in the study of pastoralist groups, environmental resources, and the marking of the landscape with ritual monuments and rock art.

All of the case studies summarized above highlight the importance of habitation ecology in micro-regional settings. In such landscape approaches, the use of empirical data and appropriate units of analysis are crucial in the development and testing of more effective human-environment models (Frachetti 2008:24; Hammer 2014). Recent work by Stobbe et al. (2016) has examined this important issue by using ASTER satellite imagery and pollen analysis to estimate the productivity of local landscape units around MBA settlements in the Southeastern Urals. This data has contributed to the development of a model that suggests a "carrying capacity" estimate for livestock. These important studies provide a foundational framework for this dissertation in that they highlight the importance of moving towards more empirically informed models of human behavioral ecology.

The ideas and research methods outlined above are proposed in order to examine and interpret the longue durée of human-environment interaction in the Eurasia Steppe. As in other regions of the Eurasian Steppe, Bronze Age pastoralist communities in the Southeastern Urals region choose specific ecological niches to their advantage; however, archaeological evidence in this area indicates that there are distinct settlement patterns connected with more sedentary pastoralist communities.

Spengler (2014) has effectively used niche construction theory to explain that pastoralists are not simply passive "niche-dwellers." and therefore do not rely solely on environmentally deterministic models. Therefore, certain environmental factors were a driving factor in the strategic decision making of these early pastoralists. Concomitmant anthropogenic modification processes of the landscape surrounding the settlements also played an important role in the development and long term success of these communities. Human activities, such as harvesting fodder and converting forest into pasturelands, indirectly influenced the character of the surrounding environment and encouraged the growth of nutrient-rich biomasses. Such processes, in turn, also increased the productivity of local catchments for livestock grazing.

Focusing on these important relationships, this dissertation research utilizes a historical ecological approach (Balee 2006; Szebo 2015) to understanding the interactions between humans and their local evnvironments during the Bronze Age in the Southeastern Urals region. Therefore, by initiating a strong contextual approach to the analysis of archaeobotanical remains, this thesis explores important theoretical issues relating to complex human-environment relationships, long-term transitions in subsistence economies and social organization, and the development of early pastoralist societies within Eurasia.

1.4 DISSERTATION FIELDWORK AND RESEARCH

The historical ecology approach in this dissertation research involved a systematic archaeobotanical, phytogeographical and seasonal study of subsistence patterns among early pastoralist communities during the Bronze Age of the Southeastern Urals region. Concerning the selected research methods for this study, this thesis focuses on four main areas of investigation:

1. Flotation and Macrobotanical Analysis

This work provides the direct evidence of plant resources that have been recovered and identified in the Bronze Age settlements in the Uy River valley and the Nizhnii Toguzak River valley (Table 1).

Table 1 Information noting Bronze Age settlements sampled, totals for volume of soil processed, and number of macrobotanical samples recovered

Sites	Liters of soil	Total Samples
Uy River Valley		
Stepnoye	3636	167
Streletskoye 1	91	13
Nizhnii Toguzak River Valley		
Ust'ye	7548	285

2. Phytogeographical Research

This work provides crucial information about local plant species and their spatial distribution patterns and seasonal growth cycles.

3. Ethnographic Studies

These studies collected essential local information from herders and data about local animal husbandry practices.

4. Experimental Archaeology

This work provides an essential empirical context for interpreting archaeobotanical remains recovered from within and outside the MBA settlements where excavations were conducted.

My field research experience in the South Urals region was undertaken between 2008 to 2017. Initially, I was a team member of the Sintashta Collaborative Archaeology Research Project (SCARP), funded by the National Science Foundation and Arts and Humanities Research Council (BCS #0726279; BCS #1024674 AHRC-NSF-MOU) and then co-principal investigator of the subsequent NSF DDRIG grant noted above. During this period, I collected archaeobotanical samples at the Stepnoye, Ust'ye, and Streletskoye Bronze Age settlements. Detailed phytogeographical research was only carried out at the Stepnoye settlement within the Uy River valley and was supported by the NSF DDRIG grant (#1659946). However, general information regarding botanical species distribution and the vegetation zones of both river valleys was recorded during excavation seasons with the SCARP teams (2008-2009; 2011-2013; 2015).

The ethnographic data was collected from different villages in the Southeastern Urals region during the DDRIG sponsored dissertation research, with the major component of this research undertaken at the contemporary village of Stepnoye and adjacent villages in the Uy River valley. Experimental archaeological work, an essential component of the dissertation research was carried out in Uy River valley with the help of local contacts.

In sum, my field experiences from 2008 through 2017 in the South Urals provided me with important information and the collection of new forms of data in which to address the questions that were set out in my NSF DDRIG proposal:

(1) What is the spatial distribution of natural resources in different vegetation units that may be identified for catchment zones associated with Bronze Age settlements?

(2) What was the importance of grazing and foddering in conjunction with the availability of botanical resources in different seasons within these catchment zones?

(3) What is the relationship between the distribution of macro-botanical remains and different zones of anthropogenic activity associated with the enclosed vs. non-enclosed areas of the Bronze Age settlements? How does this variability relate to activities associated with animal husbandry (penning, foddering, manuring, etc.), possible burning of animal dung for fuel, and human plant consumption, as identified through midden deposits external to the enclosed area of the settlement and botanical remains recovered from within the enclosed area?

(4) How does the exploitation of plant resources relate to the development of early pastoralist societies and their economies?

This dissertation builds importantly on collaborations and discussions with Dr. Hanks over many field seasons, as well as with other scholars and their research on the development of pastoral subsistence economies among Bronze Age steppe societies (Gaiduchenko 2002; Hanks and Linduff 2009; Hanks and Doonan 2009; Johnson and Hanks 2012; Johnson 2014; Kohl 2007; Koryakova and Epimakhov 2007; Kosintsev 2013; Rühl et al. 2015; Spengler 2013; Stobbe et al.2016).

Chapter One has set out the framework of the dissertation, especially the development, theoretical orientation and overall aims of the research. Chapter Two focuses more specifically on the history of research in the north central Eurasia region and the South Urals. This chapter also provides a discussion concerning pastoralism, agro-pastoralism and agriculture practices in the South Urals region based on paleoenvironmental and ethnographic data. Chapter Three details the different methodologies used for the dissertation research. Chapters Four through Eight examine the results of field research and data interpretation from different research methods. Chapter Nine provides a detailed discussion concerning human-environment interactions, multi-resource pastoralism, and the development of early pastoralist communities in the South Urals region. The dissertation concludes with Chapter Ten, which provides a final discussion of the results of the dissertation research and thoughts on future directions of research.

2.0 ENVIRONMENT, GEOGRAPHY, AND REGIONAL ARCHAEOLOGY RESEARCH

2.1 INTRODUCTION

The geographical and ecological features in Northern Eurasia create a harsh environment for human life. Low ecological productivity and shortage of easily accessible food energy are common characteristics and lower population densities can be found across the north when compared to other surrounding regions. Nevertheless, the central location of the Eurasian steppes ensured that it had played a prominent role during prehistory and in more recent historical epochs.

Different natural and political gateways influenced the cultural geography in Northern Eurasia through interaction with adjacent territories and populations. Numerous environmental constraints on Northern Eurasia societies stimulated the development of unique ecological adaptations and these shaped the distinctive lifeways and social structures during the prehistoric and historic periods (Christian 2008).

Three main ecological features of Northern Eurasia are interiority, northerliness, and continentality (Christian 2008). The region is largely arid due to the remoteness from seas to the west, south, and east. Adequate moisture is a crucial factor in determining the amount of vegetation and potential food production. Northern altitudes reflect colder temperatures and less sunlight and constrict available resources for regional human and animal populations. The flatness and expanse of the territories structure the continental climate for the region. The large landmass, which is situated far away from coastal marine zones, bring about extreme temperature fluctuations, serve climate, and the overall constraint of the growing season for local natural resources. In combination, these features combine to create a harsh and somewhat limiting environment for human lifeways in Northern Eurasia (Christian 2008).

2.2 AGRICULTURE AND AGRO-PASTORALISM

Since the early twentieth century, starting with Nicholai Ivanovich Vavilov and V. Gordon Childe, many researchers have studied the origins of agriculture and its secondary spread in many parts of the world (Harris 1996). Importantly, pastoralism, and what has been termed "the secondary products revolution," has been linked to these important processes (Sherratt 1981). In the Eurasian steppe, over the past century, most of the chronology of the spread of agriculture has been mapped geographically (Ryabogina & Ivanov2011; Spengler el at. 2013). According to recent archaeobotanical data, one of the most significant gaps in current knowledge on this topic is the Southeastern Urals Region of Northern Eurasia.

Archaeobotanical research is an essential method in the study of the appearance and diffusion of early agriculture in the ancient world. The lack of archaeobotanical studies in Northern Eurasia is primarily related to an overall dearth of archaeological investigations following the collapse of the Soviet Union and centralized support for archaeological studies. In terms of understanding early subsistence systems in the region, Zooarchaeological methods have been better established over the past two decades and been crucial to understanding the emergence of Eurasian animal domestication and early patterns of pastoralism and agro-pastoralism in late prehistoric steppe societies (Anthony & Brown 2003; Bendrey 2011; Olsen 2003).

In the discussion of animal domestication and social development, horse domestication changed the form of transport, interaction and warfare in human history, which has remained a major research topic in Eurasia. In the discussion of the relationship between agriculture and social development in the Bronze Age Southeastern Urals region, the data and information between archaeobotanical and Zooarchaeological research are quite unbalanced.

Recent archaeological studies in the Southeastern Urals region, including the SCARP project and this dissertation research, have suggested that agriculture was not practiced during the Bronze Age (Ruhl et al. 2015; Stobbe et al. 2016; Hanks et al. 2018). In this chapter, I will discuss key factors that may have affected its adoption within the region.

2.3 EARLY EVIDENCE OF AGRICULTURE IN EURSIAN STEPPE

The domestication of plants and emerging agriculture practices began in several centers around the world and stimulated many different processes of diffusion and adoption in adjacent region. There are several environmental factors that mediated these processes, including annual weather patterns, precipitation, soils, and water resources. As a result, the requirements needed for the diffusion and adoption were largely based on the natural environment and the social and technological innovations and adaptations that were made to overcome these restrictions and limiting factors.

Technological improvements, for example, included two key advances; modification of plant features and an alteration of the natural environment. The earliest evidence of domestic wheat (*Triticum aestivum*) in China, for example, dates to around 2500 BC (Long et al. 2018). However, after 2000 years, wheat was used as an important component in the subsistence economy. One of the main reasons for this is the specific characteristics of wheat itself. The natural temperature and water requirements for wheat conflict with the annual weather patterns for most of China. However, through the modification of the growing season and the construction of new irrigation systems provided for wheat cultivation in China (Zhao 2009). Therefore, without detailed archaeobotanical data, the real situation of agriculture practice is difficult to predict when only relying on plant characteristics and natural environment constraints. From the history of wheat domestication in China, we can see the technological improvement takes a long time for new crops in a new environment. Also, in the early history of domestication plants, even technological improvements are insufficient to support the sustainable growth in some difficult natural environments. For example, one would never expect to find evidence of agriculture in the tundra zone of Northern Eurasia because of the environment and technology constraints.

None of the important modern day crops were domesticated in Northern Eurasia. Thus, the diffusion and adoption of domesticated crops into the region is a significant issue for scholar to understand. For example, because of environmental constraints, most of the earliest evidence for the use of domestic crops in Northern Eurasia has been discovered within the border areas. These areas are the primary zones for the spread of agriculture into Northern Eurasia. Using these data, chronological information, environmental data, and the archaeological record from in the surrounding areas, the question concerning the relationship between agricultural practices and related social developments in Northern Eurasia is partly answerable.

Northern Eurasia is a vast territory in the Northern hemisphere. Mountain chains in the southern rim form a natural border and several natural topographical gateways provide passage into the Balkans, The Caucasus, Afghanistan, and Northern China. The tundra area and Arctic Ocean are clear borders for the northern rim of the landmass. From east to west, ecological factors are more critical than the topography itself. West of the Pripyat marshes, there is a vast variety in the natural relief, geology, vegetation, and climate, while east to the Bering Sea there is more uniformity of the landform and of climate. There is no doubt that a vast variety of climates, landscapes, lifeways, and cultures existed in these regions. From prehistory to present, the development of societies was shaped by the variability and similarity of geographic and ecological features at different regional scales.

The dominant geographical feature of Northern Eurasia is that it is the most extensive unified area of flat land in the world. Besides the natural borders, the only significant barriers to the movement of human and animal populations are the large rivers. The general absence of such topographical barriers and the dominance of pastoralist societies helps explain the emergence of large cultural, political, and military formations in Northern Eurasia (Christian 2008). For example, through the Middle Bronze Age, broader regional interactions between peripheral and core regions in the Eurasian steppe zone are demonstrated by the overarching similarity of material culture (Anthony 2009; Frachetti 2012; Kohl 2008). Scholars examining these interactions have generally emphasized the importance of an agro-pastoral economy for supporting trajectories of increasing social complexity among Eurasian steppe societies during the Middle and Late Bronze Age. (Kuzmina 2000; Renfrew 2002).

The Southern Urals region is located within the border zone of the steppe and forest-steppe ecological belts of Northern Eurasia and the importance of these different zones to social, economic and political development has been highlighted by various scholars (Bendrey 2011; Christian 2008; Frachetti 2012). There is enough rainfall to support the growth of grasses but generally not enough for forests within the steppes. Farming is difficult in this region because of erratic rainfall and historically human communities have relied on hunting and herding for subsistence. The topographical nature of the steppes has also allowed for a broader range of mobility for communities dwelling there and the region has been crucial in discussions on the origins, spread, and long term development of nomadic pastoralism. The use of domesticated cereals (agro-pastoralism orientations) has been a significant element in most previous models of socio-economic development in the region (Kuzmina 2000; Renfrew 2002). However, none of these models draw on detailed knowledge of agricultural practices of different archaeological cultures in the Northern Eurasian prehistoric period and much was assumed about the diffusion and adoption of agriculture (Boivin et al. 2012; Jones et al. 2011, Miller et al. 2016; Ryabogina and Ivanov 2011; Spengler et al. 2016;).To understand both the scale and process for the diffusion and adoption of agriculture into Northern Eurasia more detailed evidence for plant use has been of critical importance.

Prior to the dissolution of the Soviet Union in 1991, extensive Soviet archaeological projects in the Eurasian region frequently focused on large agricultural settlements in the oasis region of Central Asia and the exploration of burial mounds (kurgans) in the steppes and forest steppes related to the Bronze and Iron Ages. Little archaeobotanical work was conducted during these projects and Soviet and post-Soviet research on archaeological evidence of agriculture was almost exclusively based on identifying artifacts connected with agriculture such as sickles, hoes and grinding tools (Di Cosmo 1994,Koryakova and Epimakhov 2007).Grain imprints on ceramics were also reported in several instances (Di Cosmo 1994). However, relying solely on artifacts that may have been associated with agriculture is problematic since the function of a specific tool form is assumed. For example, a bronze or iron sickle-shaped knife also can be used for collecting wild plant resources for fodder.

The use of grinding stones as evidence for agriculture is also problematic without accompanying archaeobotanical study. Grinding stones are found across Central Eurasia and date back to the Neolithic in areas where Neolithic sites are found and it must be considered that a grinding stone could be used to process wild plants including wild grains, tubers, and nuts. Grain imprints on ceramics can be an essential clue for evidence of crop usage in societies. However in order to use grain imprints as evidence of local agriculture practices supporting macrobotanical, or microbotanical, evidence recovered from archaeological contexts is required. Although these forms of evidence are problematic on their own for the interpretation of agriculture practices they do provide important supporting evidence when combined with archaeobotanical data.

Prior to the dissolution of the Soviet Union in 1991, few foreign archaeologists could enter the Soviet Union to conduct collaborative archaeological research. In the late 1990s, several new international collaborative research programs began in Eurasia and these focused on the examination of settlements and local patterns of subsistence economies (Anthony et al. 2005, Hanks and Doonan 2009, Krause and Koryakova 2013, Frachetti and Maryashev 2007). These programs of research provided new opportunities for more comprehensive and multidisciplinary studies of late prehistoric subsistence practices in the Northern Eurasian region (Anthony et al. 2005, Hanks and Doonan 2009, Krause and Koryakova 2013). Importantly, the implementation of paleobotany and paleoethnobotany research has significantly improved understandings of the diffusion and use of agriculture within the region (Figure 4).

Figure 4 Regional geography of the Eurasian steppe and the key regional sites with the earliest evidence of agriculture mentioned in this chapter

To understand agriculture practices across the vast territory of Northern Eurasia, a better understanding of the points of origin and diffusion are essential to the development of models that account for the associated social and economic processes that facilitated such movements. The Southeastern Urals region is located far away from any center of early plant domestication and the role diffusion may have played is of paramount importance. Two general forms of such diffusion have frequently been discussed by scholars: (i) demic diffusion processes related to Neolithic farming communities and (ii) the gradual adoption of newly available domesticated plant species by local hunter-gatherer groups (Harris 1996). Because of specific geographical and ecological features the border zones and topographical 'gateways' through more mountainous regions were the first areas to accept agriculture in Northern Eurasia.

Agriculture and the domestication of sheep and goats appear to have dispersed eastwards from Southwestern Asia across the Iranian Plateau into Central Asia(Harris 1996). Agriculture, by the Sixth millennium BC, was based on wheat (*Triticum aestivum*) and barley *(Hordeum vulgare)* and was situated in West Central Asia along the well-watered piedmont zone of the northeastern margin of the Iranian Plateau in southern Turkmenistan. The site of Jeitun, in this region, has been essential for indexing these early transitions in the use of domesticated plants and animals. Impressions of wheat and grain on clay blocks were recovered from this site and the recovery of sheep and goat remains have suggested the importance of an agro-pastoral subsistence economy at the settlement.

At two other archaeological sites in the region, Togolok (5730BC) and Chagall (5050BC), evidence of wheat and barley have been recovered. Some scholars have argued, based on this evidence, that the Jeitun culture represents a process of demic diffusion (Harris 1996). However, it has been difficult to determine with absolute certainty whether the Jeitun culture represented a process of colonization into the region or if there was a more complex process for the adoption of domesticated plants and animals by local indigenous communities. In any case, the Jeitun culture development represents some of the earliest evidence for agro-pastoralism in Central Asia but clear links between this development and the northern steppe and forest steppe zones of Central Asia and North Central Asia have been difficult to ascertain and this has suggested that unstable conditions affected broader diffusion of agro-pastoralism at that time.

In the Western steppes, early pastoralism has been documented for the Tripolye cultures (5000BC). These societies cultivated wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), and millet (*Panicum* sp.). Cattle, sheep, goat, and pigs were used both for meat and secondary products. Contemporaneous hunter-gatherer groups situated east of the Don River were exploiting wild animals, plants, and riverine resources and there is evidence for exchange with the more sedentary Tripolye communities (Frachetti 2012). By comparison, much more archaeobotanical data is available for these developments in the Western steppes because of strong scholarly connections with Europe and decades of related archaeobotanical studies. The vast number of archaeobotanical reports for the region have been used to index the diffusion of domestic plants within the region.

For example, Hunt (2008) has provided a comprehensive collection of all published records of evidence for *Panicum* and *Setaria* prior to 5000 BC in Eurasia. This information has been crucial for documenting the distribution of early evidence of agriculture in Eurasia and has been useful for understanding the spread of agriculture and the specific constraint on such processes regionally.

In the Eastern steppes, Sarazm is an essential agricultural settlement located in the Zarafshan Valley of northern Tajikistan. It was occupied from the fourth to the end of the third millennia BC. This location is in the northeastern edge of a chain of agricultural settlements (Namazga IV) that are distributed across the northern foothill ecozone of the Kopet Dag Mountains (Spengler 2013). These are essential sites in which to understand the diffusion of agriculture into the Eurasian steppes. Archaeological research has suggested these communities were highly dependent on sheep and goat herding. Evidence of stone grinders, pestles, wheat, and barley, suggest a domestic economy engaged in the processing of domesticated cereals (Frachetti 2012).

The site of Begash is another important location for early archaeobotanical evidence of agricultural practices. It is located in the piedmont steppes of the Dzhungar Mountains in Southern-eastern Kazakhstan. Carbonized broomcorn millet(*Panicum miliaceum*) and wheat (*Triticum aestivum*) were recovered through systematic floatation from a cremation burial and associated funerary fire-pit. The direct AMS dates from the millet and wheat seeds is a 2-sigma range of 2460 to 2150 cal BC. This has produced some of the earliest evidence for both broomcorn millet and wheat in the same site within the Eurasian steppes. Moreover, all the charred seeds that were recovered were from a burial context (Frachetti 2010).

The earliest evidence of agriculture in the Far East of Eurasia is found in the Late Neolithic component of the Krounovka 1 site, which is located along the Krounovka River valley of the southern Primorye region and is typical of the Late Zaisanovka culture complex. Flotation of sediments from the the Zaisanovka cultural layer recovered broomcorn millet and foxtail millet (*Setaria italica*). The dating of this site is around 2500 BC (Kuzmin 2013).

In Northcentral Eurasia, the similarity of microlithic technologies has suggested an interaction zone between the southern Caspian Sea and the Southern Ural Mountains during the Mesolithic and Neolithic periods(approximately 6000 to 4000BC) (Matyushin 2003). Based on the analysis of faunal and fish remains recovered from the site of Mullino, it appears that the subsistence economy relied heavily on animal and aquatic resources(Matyushin 2003:381).

Unfortunately, very little work has been undertaken on these sites in recent years and the contact zone proposed by Matyushin has not been examined more fully.

The Southern Urals region has been actively discussed as an important location for the emergence of early agro-pastoralism. The domestication of horses in the broader region of Northcentral Asia has been discussed as connected with the Eneolithic Botai culture in Northwestern Kazakhstan (Outram et al. 2009; Olsen 2003), however, it appears that sheep and goat pastoralism diffused into the region.

Scholars have actively discussed the development of the Sintashta-Petrovka communities during the Middle Bronze Age and most have accepted the sedentary nature of these groups and what has been suggested as an agro-pastoral strategy utilizing horses, cattle, sheep, goats and either domestic or wild pigs (Gadyuchenko 2002). Based on the recovery of sickle-shaped tools at the associated settlements, Zdanovich (2002) has suggested that agricultural subsistence practices were part of the economy as well. Domesticated cereal grains have been reported from excavation of Sintashta-Petrovka sites but these were chance recoveries without the use of flotation methods and only a few examples were reported. Millet (*Panicum* sp.) remains were reported to have been found on a house floor at the Alandskoye settlement and millet and wheat fragments were reported in pottery vessels from both the Arkaim and Alandskoye settlements (Gadyuchenko 2002).

Based on the discoveries of the grain fragments, Gadyuchenko (2002) has argued that agriculture played an essential role in the subsistence economy at the Arkaim site. However, Koryakova and Epimakhov have suggested that because of the severe climatic conditions of the region, combined with the lack of evidence for large storage facilities, agricultural production among these communities remains questionable (2007:89).

The early evidence for agriculture in Northern Eurasia reveals significant differences and gaps both temporally and spatially. It is no surprise, however, that confirmed evidence to date indicates that the border zones and topographical gateways across Central and Northern Eurasia appear to be the first regions to show evidence for the diffusion of agriculture and numerous geographical and ecological variables influenced such trends (Spengler et al. 2016). When viewed geographically, Mongolia is situated quite close spatially to one of the important core regions for the emergence of agriculture (China) and there do not seem to be any clear natural barriers for its diffusion, however, there is a lack of early agricultural evidence here (Spengler et al. 2016). Moreover, when compared with the western and central steppes, both regions were in contact with societies in Central Asia who utilized agriculture but the processes of diffusion and adoption of agriculture in these two regions are significantly different. The earliest sites that show definitive evidence for the adoption and use of agriculture usually relied heavily on other forms of subsistence (pastoralism and hunting-gathering) and agriculture become an additional component within these economies (Spengler et al. 2016, Miller et al. 2016).

One important point is that the diffusion of agriculture is not based on the frequency of interaction with agricultural societies and geographical distances in Northern Eurasia. The demic diffusion of agricultural practices may seldom happen in Northern Eurasia because agriculture was not a significant component in most of the archaeological cultures that are known to date. In Northern Eurasia, early forms of agriculture may not have provided an advantage over other more localized and traditional subsistence strategies (hunting, gathering, fishing and pastoralism). Thus, in the study of the origin and development of complex societies in Northern Eurasia, the adoption or diffusion and use of domesticated cereals may not provide evidence of dramatic shifts in local or regional subsistence economies but rather reflect other aspects of cultural practices such as ritual and trade and exchange. These patterns also suggest that the environmental constraints associated with Northern Eurasia were of fundamental importance to the spread and adoption of agricultural lifeways.

2.4 EARLIEST DOMESTICATED CROPS IN NORTHERN EURASIAN

The earliest evidence of charred domesticated seeds in Northern Eurasia include wheat (*Triticum aestivum*), barley (*Hodeum vulgare*), broomcorn millet (*Panicum miliaceum*), and foxtail millet (*Setaria italica*). Wheat was the most common plant of all Old World crops and the question concerning the original domestication and spread of this crop is still being established. There are three species of wheat recognized in Eurasia, based on cytogenetic criteria. They are diploid wheats (*Triticum monococcum*, commonly known as einkorn wheat), tetraploid wheats (*T. turgidum*, commonly known as emmer wheat) and hexaploid wheats (*T. aestivum*, commongly known as bread wheat).

Einkorn was domesticated in Southwest Asia by the late ninth millennium BC from the wild form *T. monococcum*. Emmer spread across much of Eurasia and has been identified at Jeitun on the borders of Central Asia (Harris 2010). The widest extent of the diffusion of this cereal crop in the archaeological record has not been fully established. However, there is a lack of evidence for it east of the Jeitun culture. It has been suggested that it was replaced by bread wheat in the Eneolithic or Early Bronze Age (Zohary 2012).

Bread wheat is a hybridized species between *T. turgidum* and a wild grass (*Aegilops tauschii*). Bread wheat can be divided into two groups, namely, hulled and free-threshing. Free-threshing bread wheat is easier to process and in many parts of Eurasia it replaced emmer wheat during the Early Bronze Age.

Glume wheat was discovered in the Neolithic at Jeitun (Harris 2010), however, all other remains of wheat found in Central Asia were of the free-threshing wheat variety. Based on a recent study of the diffusion of wheat, it has been shown that all wheat in Northern Eurasia was of the free-threshing bread wheat type (Zohary 2012).

Barley was domesticated as early as 8,000 B.C. in Southwest Asia in the Fertile Crescent from a wild, brittle-raised, two-rowed, hulled form (*H. vulgare ssp. spontaneum*)(Zohary 2012). The domestication process of barley is marked by several key events: (1) around 8,000 BC, non-brittle rachis barley was cultivated in southwest Asia, (2) around 6,500 BC, six-rowed forms are cultivated by mutation, and (3) around 6,000 BC, naked barley (mostly six-rowed) was cultivated in southwest Asia and western India (Zohary 2012). Both hulled and naked forms of barley were recovered from the site of Godin Tepe in Iran. These grains were recovered from the Period V stratigraphic layers dating to around 4,000 BC (Miller 1990). At Anau South, in the Bronze Age stratigraphic layers (Namazga V and VI) dating to 2,500BC , Harris(1996) discovered both hulled and naked barley types. Godin Tepe is the closest site to Jeitun in the region.

Broomcorn millet is usually associated with, or a complement to, foxtail millet at archaeological sites across Eurasia (Hunt 2008). The two grains were domesticated on the Northeastern grasslands of China near the West Liao Rivers (Zhao 2009). Broomcorn millet is present in Eastern Europe by the Late Neolithic and may have spread through Central Asia from different routes (Miller et al. 2016). It has been suggested that foxtail millet originated from wild *Setaria viridis* in northern China (Zhao 2009). The oldest remains of this grain come from the site of Xinglongwa around 5,500 BC in the early Neolithic of Northern China. Differentiating between the wild and domesticated species is difficult because the earliest morphological traits of the domesticated grain is very similar to the wild variety. As Zohary (2012) has suggested, the differentiation between *Setaria italica* and *Panicum miliaceum* can be problematic. It is accepted that foxtail millet spread out of China later than broomcorn millet but it is not so clear when is foxtail millet appeared in Europe (Zhao 2009).

In the Eurasian steppes, the wild species of both millets are available. Moreover, the wild and domesticated species are associated with dry farming agriculture systems. The identification of domesticated millet is problematic because of the morphological similarity and the fact that both types inhabit the same ecotopes. Therefore, early evidence of millet grains in the Eurasian steppes remains an open question requiring further detailed studies.

Compared with other crops, wheat is the most labor demanding, time-consuming, and risky in terms of potential crop failure). In Russia today, winter wheat is planted between August and September and harvested between July and August the following year (Table 2**).** Spring wheat is also grown in Russia today and is typically planted in May, as soon as the soils thaw, and then harvested between August and September of the same year. The growing period of spring wheat is around 100 days (Zhao 2009).

In Southern Eurasia and Southwest Asia almost all of the rainfall occurs during the winter months and wheat is planted in the fall to coincide with the seasonal rains (Zohary 2012). The optimal annual rainfall for wheat is higher than 650 mm and at least 100 to 150 mm occurs in the two months prior to harvest. In general, wheat plants are not productive if there is less than 510 mm of rainfall and 50 – 80 mm of rainfall before the harvest (Peterson 1965). The Water requirements for wheat varies between different landscapes. Nevertheless, the water requirement for wheat is significantly higher than either millet or barley.

Table 2 The annual cycle of wheat and millet agriculture in Russia (FAO org)

	Sowing	**Growing**	**Harvesting**
Winter wheat	August-September	May-June	July-August
Spring wheat	May	June-July	August-September
Barley	April-May	June-July	August-September
Millet	April-May	June-July	August-September

According to FAO org, the water needs for major crops in the Eurasian steppes are listed in Table 3. The water requirements for different plants depend on many factors but adequate soil moisture is especially crucial during the sowing, growing and pre-harvest periods and periods of significant aridity can cause crop failure. As a result, seasonal weather patterns and precipitation are extremely important for the introduction of domestic crops in new regions.

Table 3 The crop water needed for major crops in Northern Eurasia (FAO org; Peterson 1965)

Crop	Planting	Growing	Crop water need(mm/total growing period)
	APRIL- MAY	June-July	
Wheat	Medium	High	>650
Barley	Medium	High	450
Foxtail millet	Low	High	550
Broomcorn millet	Low	High	350

Barley is a less water-demanding crop than wheat. At many sites within the southern region of Central Asia, barley is far more abundant than wheat and this indicates a preference for more drought tolerant crops (Zohary 2012). Barley is often considered a high elevation crop and can grow at elevations well above the limits of wheat cultivation. For example, the early human occupation of the Tibetan Plateau was constrained by the high altitudes there. A recent study has suggested that the cultivation of barley was a primary factor for the emergence of permanent villages in the Tibetan Plateau (Chen 2014).

Broomcorn millet is an essential crop in Northern China. The lower water requirements of broomcorn millet mean that it is more suitable for the dry weather in Northern China. Also, broomcorn millet has typically been associated with nomads in the Eurasian steppes and has been considered as a ‘low investment - fast return’ form of agricultural production (Miller et al. 2016). In a mixed agricultural system where crops are diversified to reduce risk millet can be an important supplementary crop to ensure yields even in drought stricken years (Zhao 2009).

Foxtail millet is usually associated with broomcorn millet in the archaeological record (Zhao 2009). The growing season of foxtail millet is similar to broomcorn millet with higher water requirements and yield rates. Both millets are sown in the late spring and early summer with a growing period of around 80 days. Therefore, millet is always prevalent in mixed agriculture systems because of its short growing season. In comparing the yield rate of these crops – wheat is the highest and barley is generally more productive than the millets. M

According to recent archaeobotanical data, wheat and barley originated in the Near East and both millets originated in China (Spengler et al. 2016; Zhao 2009; Zohary 2012). The geographical distribution of early domesticated crops restricted the diffusion and adoption of plant species by different archaeological cultures. This distribution also led to a different rate of diffusion. For example, the suitable habitation of wheat is always in a location with plentiful water. Foxtail millet is seldom discovered in Northern Eurasia when compared with the evidence for broomcorn millet.

Early agriculture practices in Northern Eurasia relied entirely on the natural characteristics of the domesticated plants. Technological innovation was not necessarily helpful for the diffusion of agriculture during this early period into the region. Because of these issues, it is possible to use recently obtained archaeobotanical evidence to discuss more specifically the use, or lack of use, of domesticated plants by late prehistoric populations in Northern Eurasia.

2.5 THE LACK OF AGRICULTURE IN THE BRONZE AGE SOUTHEASTERN URALS REGION

In Northern Eurasia, because of the constraints of domesticated plant distribution in the early period, wheat, barley, and either millet were the only available choices. Overall, the central steppes region of Northern Eurasia is interesting because archaeological evidence suggests that this was an important interaction zone between east and west in terms of human mobility and the trade and exchange of material resources. Therefore, the potential availability and use, or lack of use, of domesticated plants in this region is a crucial question.

The climate shifts dramatically from warm to cold within the central steppes region as one moves from south to north. The mean July air temperature is 6–8 degrees Celsius in the northern periphery of the zone and is 22 degrees in the southern periphery (Levit 2005). The climate is related to several factors, including the distance from the Atlantic and the closeness to the Arctic, Siberian, and Central Asian high-pressure areas (Koryakova and Epimakhov 2007).

The Southern Ural Mountains region lies perpendicular to the direction of the predominantly westerly winds and the western slopes are more humid than the eastern slopes. The difference in precipitation is approximately 100–150 mm annually. The climate is moderately continental, with long cold and snowy winters, warm summers, and clear transitional periods in the spring and autumn. The precipitation in the peneplain areas reaches 400–500 mm during warm seasons and about 500–600 mm during the entire year (Koryakova and Epimakhov 2007). The whole region is made up of forests, forest-steppes, and dry steppes. In the north part, there are many large developed river networks. These river valleys provided rich biological resources and vegetation in the summer for late prehistoric human and animal populations.

According to broader regional paleoenvironmental studies, there was a significant cooler and more arid climate shift at around 2,500 BC (Anthony 2009). During this period, forests declined, steppe and deserts expanded, and winter became colder and more prolonged. The microregional paleoenvironmental study in the Karagaily-Ayat River valley has suggested a relatively humid climate from 2400-1570 cal BC (Stobbe et al. 2016). The relatively humid weather in the Bronze Age significantly impacted the change in settlement and subsistence patterns and theoretically would have provided a more hospitable climate for the adoption and use of domesticated cereals.

Using this environmental information, combined with plant data, the cultivation of wheat would still have been substantially risky during the Bronze Age in the Southeastern Urals because the annual precipitation was lower than the necessary water requirements for this plant. This problem can be overcome through using irrigation but there is no clear evidence for this in the region at that time. Nowadays, spring wheat is quite common for the region, however, the decision as to what crop to grow shifts substantially because of the weather conditions in April-May. According to the local villagers, if the weather is lower than a certain temperature in late April, the cultivation of wheat is an exceptionally high risk.

The cultivation of barley is conditioned by the same potential problems and risks. For millet cultivation, the biggest problem is high precipitation during the pre-harvest season (July- August), which is a typical weather condition in this region (according to local informants). During the MBA (2100-1700), therefore, there are a number of issues that may have impacted the adoption and use of agricultural cereals by the pastoralist societies occupying the region. And, the adoption of an agro-pastoralist orientation, as some have suggested, may not have been a requirement for the emergence of the more sedentary pattern as reflected by the Sintashta-Petrovka settlements (Claudia 1986; Honeychurch and Makarewicz 2016; FAO). The published evidence of recovered domesticated cereals in the region, as discussed above, may be related to trade or small-scale cultivation but there is little evidence of broader adoption and use of agriculture. Additional discussion of recent stable isotope studies of human and animal bone remains and associated human diets of Bronze Age populations will be discussed further below.

Because of the environmental constraints and insufficient technology, it is likely that agriculture practices were not very suitable in the Bronze Age Southeastern Urals region. Archaeological evidence has suggested that the primary subsistence system in the Bronze Age Southeastern Urals region was pastoralism, or as recently argued, a form of multi-resource pastoralism that utilized wild plant, animal and fish resources in addition to domestic livestock herding (Hanks et al. 2018).

The potential choice of adding agriculture to the subsistence system would have been based on maximization of profit against the minimization of risk for the full subsistence economy. Agriculture would have presented a high-risk subsistence system in the Bronze Age Southeastern Urals region. Also, it would have been a labor-intensive seasonal activity as compare with the other subsistence systems in which there is clear evidence (wild resources and animal husbandry). The annual agriculture cycle would have possibly negated the productivity of the other subsistence systems in terms of cost-labor considerations. For example, if agriculture fields occupied a significant portion of the local catchment zones this would pose important questions about the choices of seasonal labor for harvesting agricultural crops vs. labor requirements for gathering fodder for the winter to sustain the livestock herds. It is likely that agriculture was not an attractive subsistence system for Bronze Age pastoralist communities in the Southeastern Urals region. Instead, the choice of maximizing the collection of wild resource within the catchment zone may have been less risky and less labor intensive. Hence, multi-resource pastoralism may have been a more suitable and sustainable subsistence economy for this region during the Bronze Age.

2.6 BRONZE AGE RESEARCH IN THE SOUTHEASTERN URALS

There is a notion that the specific character of local environments and associated subsistence economies conditioned the specific socio-economic trajectories of late prehistoric

Eurasian steppe societies, including the Sintashta-Petrovka development, to differ from other regions (Frachetti 2008; 2009; Johnson and Hanks 2012; Honeychurch and Amartuvshin 2006; Rogers 2011; Sneath 2007). Russian and foreign scholars alike have highlighted several key developments associated with the emergence of the Sintashta-Petrovka archaeological pattern. These include fortified and enclosed settlements, copper metal production, well-organized household structures, and complex burial rites (Gening 1977; Gening et al. 1992; Zdanvich and Batanina 2007; Zdanovich and Zdanovich 2001). The geographical zone in which these sites are situated in the Southeastern peneplain of the Urals encompasses an area approximately 68,000 sq km in size (Chernykh 1992; Zdanovich 1988; Hanks et al. 2007).

Excavations of Sintashta-Petrovka settlements and cemeteries, carried out since the 1970s, have produced evidence of copper metal production, spoke-wheeled chariot technology, new forms of weaponry, and complex mortuary practices (Gening et al. 1992; Anthony & Vinogradov 1995; Vinogradov 2003; Epimakhov 2005; D. Zdanovich 2002). Scholars have been attracted to the Sintashta-Petrovka pattern because it appears to reflect a distinct transition in social, economic and political organization stimulated by intensive metal production, warfare, and long-distance trade (Anthony 2007; Hanks & Linduff 2009; Kohl 2007; Koryakova & Epimakhov 2007). The conceptualized subsistence model for these communities has been defined as a sedentary agro-pastoral strategy with the dominant use of horse (*Equus caballus*), cattle (*Bos Taurus* and *Bos primigenius*), sheep (*Ovis aries*), and goat (*Capra hircus*) in addition to either domesticated or wild pig (*Sus scrofa*) (Gaiduchenko 2002; Kosintsev 2010).

The Sintashta-Petrovka period, dating to the Middle Bronze Age (2040-1680 cal. BC) (Table 4), represents a perceived abrupt transition from the Early Bronze Age in this region. For example, Sintashta-Petrovka settlements are all located close to water resources on the tributaries of the Tobol and Ural rivers, and range in size from 0.5 to 3.5 hectares (enclosed site area) demonstrating likely occupation phases of approximately 250 years (Epimakhov and Krause 2013). The occupation phases usually consist of two chronological phases. The earlier Sintashta phase is distinguished from the later Petrovka phase by some differences in ceramic styles and metallurgy technologies (Chechushkov 2018; Vinogradov 2013). As noted above, most of the investigated settlements indicate several phases of construction and growth (Zdanvich and Batanina 2002; 2007; Johnson and Hanks 2012). The distance between each settlement ranges between 8km to 70km. Some Russian scholars have suggested the twenty-six nucleated fortified settlements developed as a network of proto-urban steppe 'towns' based on the characteristics of their planning and layout (Chechushkov 2018; Zdanovich and Zdanovich 2002; Zdanovich and Batanina 2007).

Table 4 Comparative Southwestern Urals and Southeastern Urals Chronology (Modified after Judd et al. 2018; Hanks et al. 2007)

SOUTHWESTERN URALS/SAMARA VALLEY CHRONOLOGY		
Cultural Period	Date (cal. BC)	Archaeological Culture
Early Bronze Age	3500-2700	Yamnaya
Middle Bronze Age	2800-1800	Potapovka
Late Bronze Age	1900-1200	Early Srubnaya

SOUTHEASTERN URALS CHRONOLOGY		
Cultural Period	Date (cal. BC)	Archaeological Culture
Early Bronze Age	2140-1940	Seima-Turbino
Middle Bronze Age	2040-1680	Sintahsta-Petrovka
Late Bronze Age	1880-1520	Alakul
Final Bronze Age	1420-970	Final Bronze Age

Excavation of the associated burial mounds (kurgans) was initiated at the very beginning of research of the Sintashta-Petrovka sites. The results from the excavation of graves suggested a hierarchically structured society (Anthony 2007; Epimakhov 2002; Vinogradov 2011). The most outstanding graves in terms of grave furnishing are typically associated with males and include weapons, chariots, and a specific set of sacrificed animals. Excavations of the settlements, occurring as early as 1980, were not published in great detail yet scholars noted evidence of copper metal production and domesticated cereals recovered from house floors at the settlements of Alandskoye and Arkaim (as discussed above).

In the past ten years, two field research monograph publications have been produced from excavations at the Ust'ye settlement in the 1980s (Vinogradov 2013) and recent excavations at the Kamennyi Ambar settlement from 2005-2010 (Krause and Koryakova 2013). While agro-pastoralism has been assumed by many scholars (Zdanovich 2002; Kristiansen and Larsson 2005) there was previously little actual empirical evidence published to support this. As outlined above, millet (*Panicum* sp.) remains were reported to have been recovered from a house floor context at the settlement site of Alandskoye. Millet (*Panicum* sp.) and wheat (*Triticum* sp.) fragments were found in ceramic vessels from both the Arkaim and Alandskoye settlements (Gaiduchenko 2002) (Figure 5). Based on this evidence, Gaiduchenko (2002) further maintained that agriculture played an important role in the subsistence economy of these communities.

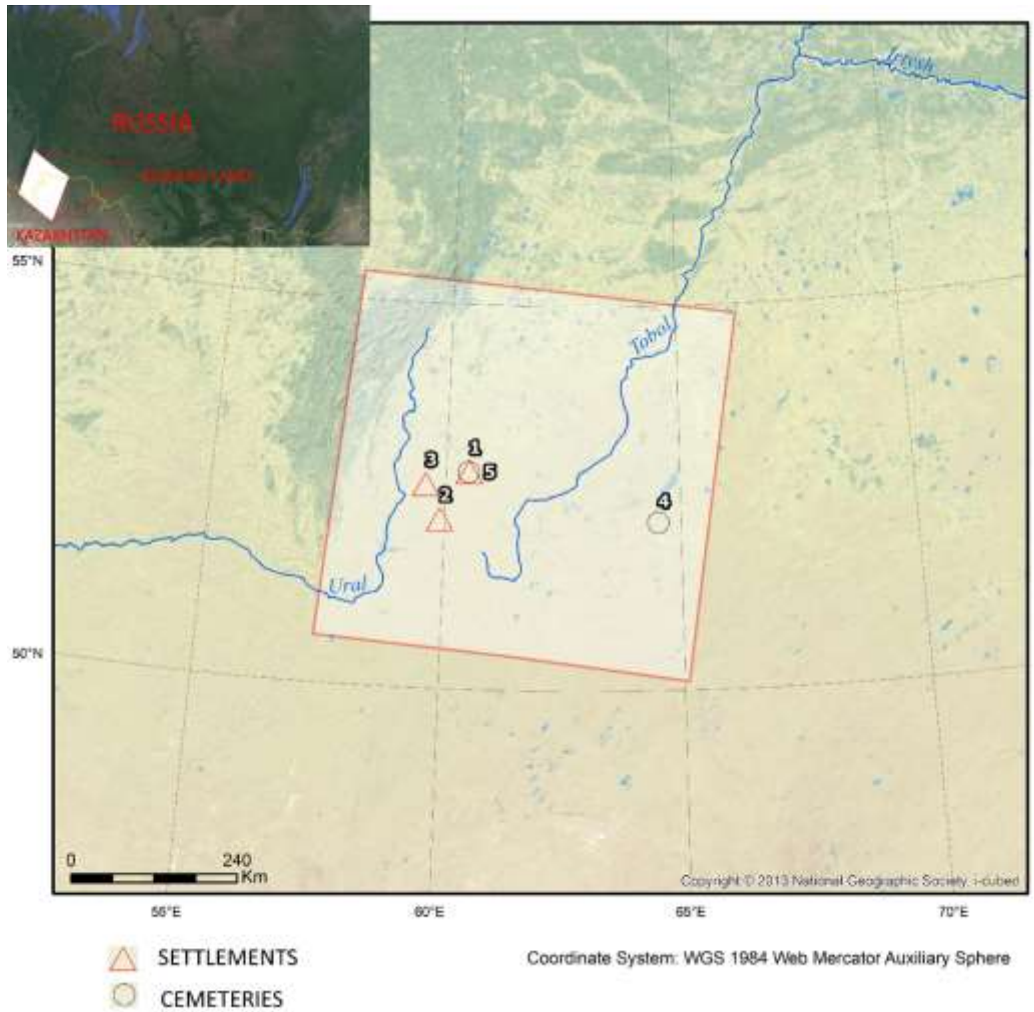


Figure 5 Map of the Sintashta-Petrovka archaeological sites with associated archaeobotanical data (Modified from Chechushkov 2018). Settlements: 1. Kamennyi Ambar (Ruhl et al 2015); 2. Alandskoye (Gaiduchenko 2002); 3. Arkaim (Gaiduchenko 2002). Cemeteries: 4. Bestamak (Ventresca et al. 2014); 5. Kamennyi Ambar 5 (Judd et al. 2018)

Recent detailed stratigraphic excavations and paleoenvironmental research at the Sintashta- Petrovka settlement of Kamennyi Ambar has not produced any evidence of agricultural cereals. Rather, it is argued that local wild plant exploitation, hunting, fishing, and livestock herding contributed to a sedentary pastoralist lifestyle without agriculture or use of domesticated cereals (Stobbe 2013:321-323). As noted above, carbon and nitrogen stable isotope analysis of human remains suggests that consumption of fish has contributed importantly to the diet of many prehistoric steppe communities while evidence for the use of domesticated cereals (particularly millet) is largely absent (Privat et al. 2005; Anthony et al. 2005; Hanks et al. 2018). This includes recent results from studies of the human and animal remains from the cemetery associated with the Kamennyi Ambar settlement (Kamennyi Ambar 5) (Hanks et al. 2018; Ventresca et al. 2018; Judd et al. 2018). These isotopic results are supported by the recovery of a diverse collection of fish remains from Sintashta-Petrovka settlements (Gaiduchenko 2002) and, most recently, from the studies at the Kamennyi Ambar settlement (Stobbe et al. 2013:233-237).

Sedentary pastoralism has been more widely linked to exponential herd growth and related impact on local resources through overgrazing. Such processes may lead to a progressive and permanent loss of productive grazing. It is clear that the relationship between increasing livestock productivity and decreasing risk associated with resource sustainability is a continuous process for pastoralist communities, achieved only through control of land for grazing, regulating the composition and size of herds, and the establishment of seasonal herding strategies including foddering (Cribb1991; Galaty 2013:477; Khanzanov1994; Salzman 1980).

The existing evidence for Sintashta-Petrovka subsistence strongly suggests the need for more detailed studies of multi-resource subsistence resources within local biomes, more substantiated models for local catchment zones, and related settlement patterning. Recent zooarchaeological, archaeobotanical and stable isotope study in Kamennyi Ambar settlement have suggested a multi-resource pastoral subsistence economy during the Bronze Age (Hanks et al. 2018; Judd et al.2018, Ruhl et al.2015; Stobbe et al. 2013; 2016; Ventresca et al. 2018). Multi-resource pastoralism in this region without the use of agriculture practice thus relied on hunting, gathering, and fishing as supplementary component of the subsistence economy. The evidence of fishing has been produced from the recovery of fish bone and high nitrogen values in stable isotope analysis (Judd et al. 2018; Stobbe et al. 2013; Ventresca et al. 2018). Ruhl (2015) and Stobbe (2016) also have use archaeobotanical data to reconstruct the potential use of wild resources within the local catchment zone at the Kamennyi Ambar settlement. Their research suggests a year-round grazing pattern surrounding the settlement. Ventresca et al. (2018) have compared the stable isotope values from modern plants and faunal remains from Bronze Age settlements within Kazakhstan and the results have suggested a consistent pattern of pasture usage during the MBA and LBA. The herding patterns of livestock may comprise extensive grazing in local pastures near the settlements and intensive grazing in non-local pastures. Continued research on the isotopic composition of vegetation surrounding the settlements may help to build a better understanding of seasonal herding strategies. The nature of the pastoral economy, especially wild plant resource exploitation by both humans and livestock during the Bronze Age, is still debatable following these studies and must be complemented through more detailed archaeobotanical studies.

Connecting with the important studies outlined above in this chapter, the primary focus of the dissertation research has been to examine the subsistence economies of ancient pastoralist societies during the Middle to Late Bronze Age period (2100-1500 BCE) in the South Urals region. As outlined in Chapter One, this is based primarily on the macrobotanical analyzes of archaeological soils from Bronze Age settlement sites in this region. The majority of the archaeobotanical samples that were analyzed through this dissertation date to the Sintashta-Petrovka period (approx. 2100-1700BC) as well as the Late Bronze Age (approx. 1700-1500BC). This data was recovered from three different settlements that were occupied during these periods: (i) Stepnoye (2100-1700 BCE) and (ii) Streletskoye 1 (1700-1500BCE), which are in the Uy River valley, and (iii) Ust'ye (2100-1700BCE), which is in the Nizhnii Toguzak River valley. Detailed information about these three settlements, and the associated archaeobotanical samples recovered from them, are presented in next two chapters.

3.0 METHODOLOGY

3.1 FLOTATION AND MACROBOTANICAL ANALYSIS

The field strategy that was pursued to recover direct evidence of Bronze Age macrobotanical remains in the Uy River valley, and the Nizhnii Toguzak River valley, was soil flotation, which is one of the most accepted methods for the recovery, identification, and reconstruction of floral resource use (Hastorf and Virginia 1988; Pearsall 2000; Watson 1976). Prior to the initiation of flotation work by the SCARP project, only a few publications produced by Russian scholars reported on the chance recovery during excavations of botanical remains from the Arkaim and Alandskoye settlements in the South Urals region (Figure 1) (Gaiduchenko 2002).

In the Alandskoye and Arkaim excavations, it was reported that millet (Panicum sp.) remains were recovered from a house floor context and millet (Panicum sp.) and wheat (Triticum sp.) fragments were found in ceramic vessels from both settlements (Gaiduchenko 2002). In comparison, the recovery, identification, and analysis of faunal remains are well established and documented within the region (Gaiduchenko 2000; Koryakova and Epimakhov 2007; Kosintsev 2010; Kosintsev and Olga 2014).

In the discussion of Bronze Age subsistence economy, this is, unfortunately, a very unbalanced situation and is largely related to archaeological methods as practiced in the region whereby soil flotation and soil screening are not commonly employed during excavation. To design my first soil flotation work in the Eurasian steppe, I followed the bucket-flotation experience from Dr. Hanks in 2007 and Popova's work (2002) in the Middle Volga River region. First, soil samples were systematically collected from the excavation units for different archaeobotanical studies. Second, in an area where preservation of macrobotanical remains is generally poor (e.g., the sandy soils encountered at the Stepnoye settlement), larger soil samples were collected. In the field research that this dissertation is based on, I collected (bulk sampled) 7-15 liters of soil as a standard volume for samples from every 10 cm horizon level in every 2m x 2m basic excavation unit. However, bulk sampling was conducted by dividing these units into 1m x 1m areas.

Soils from identified archaeological features (e.g. hearths, pits, depressions, wells, bone concentrations) were usually collected in total. Compared with other archaeological projects in the Eurasian steppe (Popova 2006; Ruhl et al. 2015; Spengler 2013), the sampling size and bulk sampled soils is much higher. In 2008, as part of the SCARP research season, we decided to construct a large-scale systematic flotation method, which was the first system of this type in the Southeastern Ural region but was based on a design that was provided by Dr. David Anthony and that was used as part of the Samara Valley Project.

The stratigraphic excavation was carried at the MBA Stepnoye settlement in the summer of 2008 by SCARP, and I supervised the use of the pump-generated flotation machine specially constructed for this work (Figure 6).

Figure 6 Photo showing flotation tank used in dissertation research

A portable gasoline engine water pump and a 120 liter galvanized metal barrel were the major components of this system. A piece of bent PVC pipe with small holes fixed on the middle inner wall of the barrel produced an internal flow of water and circulated water throughout the inner area of the tank. The water pump was connected to the PVC pipe and provided a constant supply of water and the samples were automatically agitated by an internal flow of the water from the bottom of the tank to the top. A screen size of 0.2 millimeters (mm) was used to catch the light fraction in the water at the top of the tank as it flowed towards a small spout and passed out of the tank.

Flotation was undertaken on the bank of the Uy River during the adjacent excavation research. Samples taken directly from the excavation units were measured with a small plastic bucket with volumetric measurements and were recorded to the nearest 0.5 liter. Hand agitation of the soil in the tank continued until no more charred materials were observed on the surface of the water. The collected light fraction was transferred to a muslin pouch for drying and storage. Then, the muslin pouch was hung on a rope to air dry in the camp and was kept in a shaded location to prevent the cracking of charred remains. The heavy fraction material sank to the bottom of the tank and was collected and sieved through a 5 mm metal screen and then sorted into different categories (ceramics, lithics, metals, slags and faunal remains). Charred plant remains were identified and picked by hand, however, in general, very little charred materials were obtained from the heavy fraction.

These methods also were applied to soil flotation undertaken at the Ust'ye settlement in 2013 and 2015 (7,548 liters, 285 identified samples were achieved).

In the summer of 2017, I utilized a bucket flotation method at the Streletskoye settlement due to the small number of soil samples collected (91 liters, 13 identified samples). A 15-liter plastic bucket was used as the flotation container and all collected samples were air dried in the local laboratory at the campsite (Figure 7).

Figure 7 Photo showing bucket flotation used in dissertation research

Flotation samples from all three settlements (Stepnoye, Ust'ye and Streletskoye) were stored in the local laboratory at the Stepnoye village and analyzed during phases of laboratory analysis of botanical remains in 2015 to 2017. In this laboratory, flotation samples were recorded and then passed through nested geological sieves. All materials, such as charred seeds, charcoal, bronze pieces, animal bones, and lithics were identified and categorized from each sample. Generally, all botanical material larger than 4 mm and 2 mm were sorted as one unit. 4mm sieves were used for samples with a large number of charcoal pieces. The smaller material was broken down into units from the 1mm, 0.5mm and 0.3mm sieves. Material on the 3mm sieves was picked extensively, because most of the charred seeds from these sieves may not relate to human activities. Charcoals larger than 1mm were weighed and recorded. Major categories of charred botanical remains were recovered from the 1-0.5mm sieves; these included seeds, seed fragments, awns, and pods. Plant remains were analyzed under a low power binocular microscope (5x to 70x). For identification of charred plant remains, I collected modern comparative plants from the Uy River Valley and the Nizhnii Toguzak River Valley from the 2009 season onwards. During 2015-2017, I visited the Russian Academy of Science, Institute of Animal and Plant Ecology, in Yekaterinburg. Dr. Korona assisted me there with regional plant identifications for the South Urals. The comparative botanical collections in the archaeobotany laboratory were also important for the identification of charred plant remains. Published identification guides (e.g., Cappers et al. 2006) and publications on local flora (e.g., Czerepanov 2007) also were used during the macrobotanical analysis process.\

3.2 PHYTOGEOGRAPHICAL RESEARCH

Phytogeographical research represents the collecting of information on the geographic distribution of plant species at the macro or micro scales of analysis. Past archaeological projects applied this form of research in the South Urals region (Popova 2006; Ruhl et al. 2015). The result of these reports indicated a significant pattern of local wild resource exploitation.

Following this evidence, in the summer of 2009, I started the pilot survey in the Uy River valley for SCARP that focused on this issue. The results of this initial pilot study partly reflect that archaeologically recovered macrobotanical remains from the Bronze Age Stepnoye settlement could be related to the identifiable contemporary flora within the Stepnoye catchment zone. The study suggested that a comparative study of local plant species found within the settlement catchment zone had the potential to provide detailed information about the local distribution and seasonal availability of plant resources.

In the 2013 excavation season, I started to observe the plant distribution in different landscapes surrounding both the Stepnoye and Ust'ye settlements. After this study, I found that nearly all the plant species recovered from the soils produced through archaeological excavation were also found in the surrounding catchment area among the local and modern-day flora.

Based on evidence to date, the Sintashta-Petrovka MBA subsistence pattern appears to represent a multi-resource form of pastoralism with clear sedentary characteristics. In other comparative anthropological studies, plant resource exploitation patterns may be highly variable but are usually linked to the spatial and temporal distribution of seasonal plant resources within defined zones adjacent to human settlements (Fratkin1994: 69-89; Galaty 2013:479-492;

Homewood 2008:82-85; Salzman 1984). The location of these specific plant patches distributed in different vegetation zones can be related to the plant exploitation pattern within the hinterland zones of the Bronze Age settlement. Due to time management and budget considerations within my NSF DDRIG proposal, and the similarity of geographical settings and archaeobotanical remains at both the Ust'ye and Stepnoye settlements, I ultimately decided to focus on only one settlement (Stepnoye) instead of two. Thus, detailed phytogeographical research was carried out during 2015 and 2016 at Stepnoye and within its catchment zone to understand the plant distribution and seasonal growth patterns of local wild plant species within the Ui River valley.

The doctoral dissertation research strategy partly followed the recent work at the MBA-LBA Kamennyi Ambar settlement, which has productively categorized the local catchment zone around this into different landscape zones: riparian, meadows, ruderal steppe, and steppe woodland (Figure 8).

Figure 8 Vegetation zones in the microregion surrounding the MBA-LBA Kamennyi Ambar settlement (after Wittig et al. 2013: 295)

Preliminary analysis by Rühl et al. (2015) and Stobbe et al. (2016) of plant species recovered from archaeobotanical samples indicates that they were distributed within these landscape zones. These economic catchments were the primary focus of my study within the Uy

River valley and thus provided an important point of overlap and comparative study and analysis between these two projects.

My doctoral research endeavored to explore the relationship between plant resource exploitation in the Bronze Age and the subsistence economy and social organization of the community. Based on my previous experience with SCARP, and Dr. James Johnson's doctoral dissertation survey in the Uy River valley in 2011 (DDRIG, BCS# 1034903), my survey area was closely related to these other projects and the same rivers and other water resources within the defined catchment zone (Figure 9).

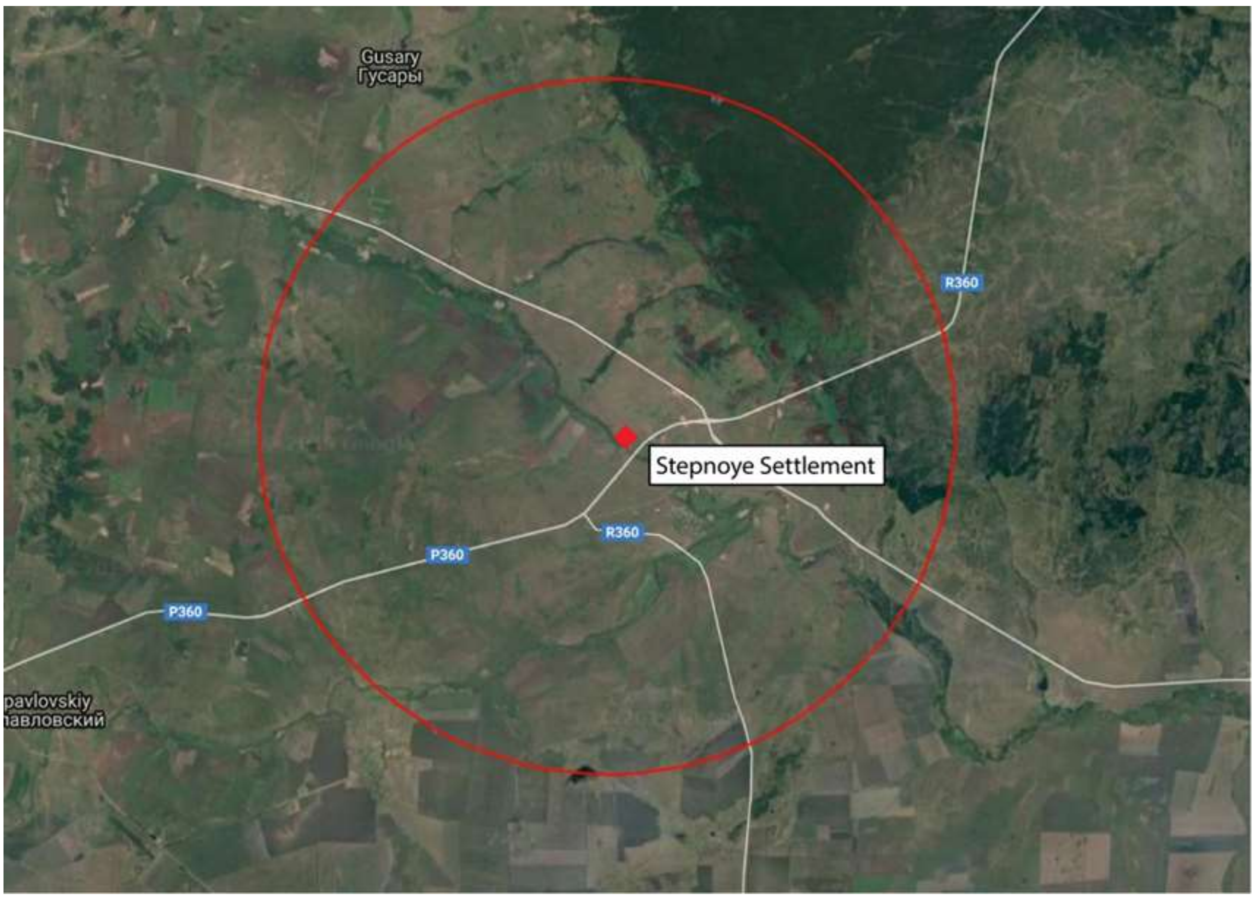


Figure 9 Uy River valley showing location of MBA Stepnoye settlement and catchment zone with 10km radius (Base Image: Google Earth Imagery; modifications by author)

Furthermore, in connection with these two previous projects, I also elected to use a 10 km radius around the Stepnoye settlement. This then included vegetation zones between the main river (Uy) and forest zone to the north as my phytogeographical research area. My survey was mainly conducted in several blocks located along the two major rivers in the region, the Uy River, and associated tributary the Kurasan River.

The total length of my defined survey zone was approximately 20 km long, with the north to south coverage varying somewhat due to alternating distances between the rivers and the forest zones. Both sides of the river banks were covered within this survey. Previous results from the SCARP project and Dr. Johnson's dissertation survey suggested that most prehistoric archaeological sites were located within 1 km of the rivers and the majority within only 500 m. My own observation of local contemporary herding activities indicated that livestock herding was usually done between the main river water resources and the forest zone and this correlated with my targeted survey zone.

The first stage of my survey was the identification of plant resources (genus and/or species) and their association with the four identified landscape zones as noted above. I categorized the distribution of these plant species in the Uy River Valley into different landscape groups. At the same time, I recorded the availability of different botanical parts (seeds, leaves, stems, etc.) from these plants in different seasons. The annual growing pattern was especially important information for my research program as the exact ripening stage of specific plant species can be traced to prehistoric utilization of these same species through analysis of charred seeds from archaeobotanical samples recovered from the settlements. Besides charred seeds, I seldom identified leaves and stems through archaeobotanical analysis, however, both parts are major resources used in foraging economies. Thus, the observation of the *growing* (generally spring-summer) and *withering* (late summer-autumn) seasons (two different stages in the life cycle) can better estimate the amount of usable fodder in a yearly cycle. This work also assisted my study in that it complemented the comparative plant collection of the charred seeds that were analyzed.

The second stage of my survey was based on an understanding of the landscape zones, as I plotted and estimated the range of different vegetation zones within the defined survey area. The formation of the different landscape zones with associated plant species is closely related to water resources between the Uy River and the forest region. In this respect, the edge of the vegetation zones is quite clear according to their distance from identified consistent water resources.

During the 2017 field season, I walked through the survey area over three different seasons (May-June, July-August, and September-October) before the onset of winter, sub-zero temperatures, and the accumulation of snow. The pedestrian survey was designed to survey the hypothesized community catchments (Hanks et al. 2009; Johnson and Hanks 2012; Johnson 2014) to develop a detailed understanding of the plant resources available for local herding activities. I started at the edge of the Bronze Age Stepnoye settlement and then walked along the edge of the meadow zone in specified survey blocks. Most of the survey routes were initiated close to the river and ended at the edge of the forest. During this process, Global Positioning System(GPS) coordinates (using a handheld GPS- Garmin eTrex) could be utilized to sketch the edge of vegetation zones.

Due to the budget and labor limitations, the survey was finished in four months. By the end of the 2017 field season, I surveyed approximately 200 sq. km of landscape that is today utilized for herding within the Uy River valley. Over 100 random GPS points were recorded during the survey period. This work was done to document the edge of different landscape zones using a GPS unit. Other data, such as terrain type, elevation, and distance from water resources, were also recorded.

Recent work by Stobbe et al. (2016) utilized ASTER satellite imagery and pollen studies to estimate the annual productivity of local landscape units around MBA settlements (Figure 10). This work has contributed to the development of two models that suggest a “carrying capacity” estimate for livestock in the annual cycle. *Model A* calculates the grazing capacity within the 4 km radius activity zone throughout the year (Table 5). *Model B* used the number of houses in the settlements and the assumed number of livestock per household from ethnographic data to estimate the grazing capacity in the activity zone (Table 6).

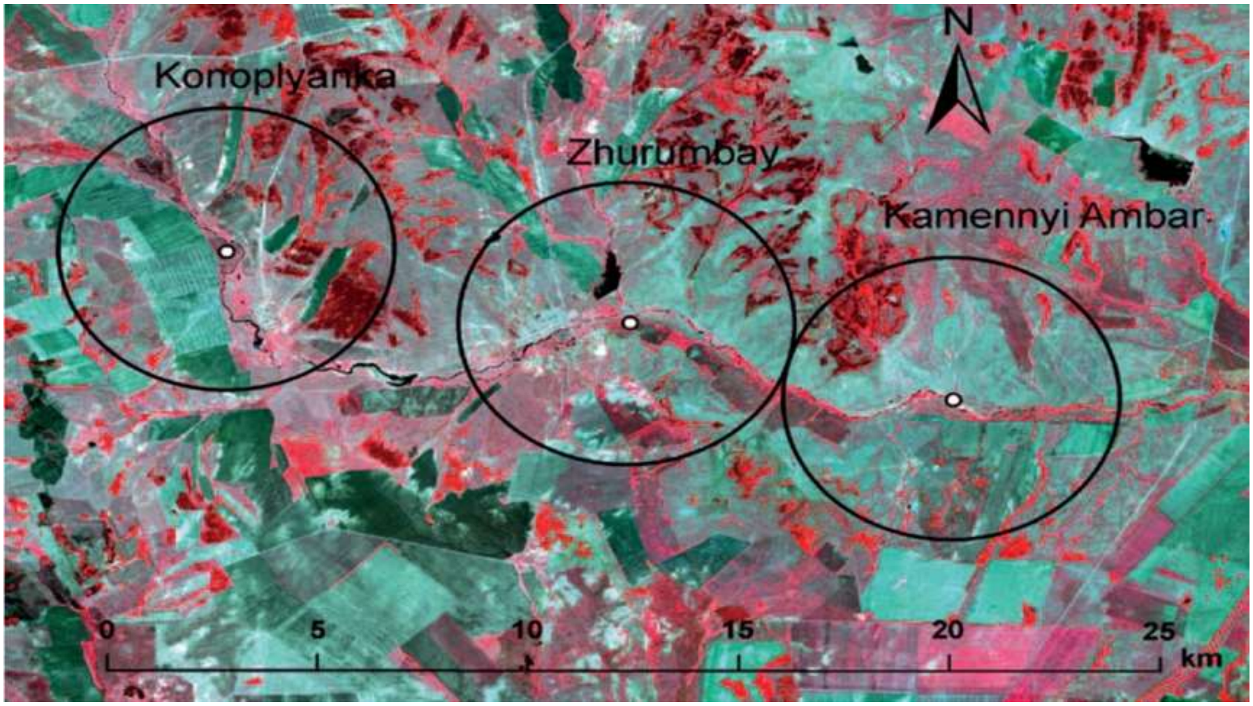


Figure 10 ASTER satellite imagery of the Karagaly-Ayat River valley showing 4km radius activity zones extending from the MBA-LBA settlements of Konoplyanka, Zhurumbay and Kamennyi Ambar (after Stobbe et al. 2016: 12)

Table 5 Estimated data from Model A for the 4km activity zone surrounding the Kamennyi Ambar settlement (Stobbe et al. 2016: 15)

Potential Available Grazing	
Vegetation type	*Total for Activity Zone*
Steppe (tons fresh forage per ha)	18749.5 t
Meadow (tons fresh forage per ha)	4028.4 t
Daily Fodder Needed Per Animal	
Species	*Total # of Livestock Supported*
Dairy cow (0.045 t fresh forage/day)	816
Sheep (0.002 t fresh forage/day)	10274
Horse (0.009 t fresh forage/day)	343

Table 6 Estimated data from Model B for the 4km activity zone surrounding the Kamennyi Ambar settlement (Stobbe et al. 2016: 15)

Estimated population by 41 households	Number of cows	Number of sheep	Number of horses
5 persons/household	246	196.8	29.52
10 persons/household	492	393.6	59.04

These models suggested the 4 km radius catchment zone was sufficient to support a sedentary pastoralist society with year-round grazing pattern and no danger of overgrazing. Compared to Stobbe's work, phytogeographical research can better understand the habitat of plant species from archaeobotanical samples in the catchment zone. The data also was used to construct the geographic distribution of landscape zones within the survey zone. Following this idea, with the data from systematic archaeobotanical work and detailed phytogeographical research, it is possible to focus intently on the issue of the seasonal fodder availability from different landscape zones within the defined catchment zone of the settlement territories.

3.3 ETHNOGRAPHIC STUDIES

Sintashta-Petrovka enclosed settlements are interesting in that they do not reach a size greater than approximately 3.5 hectares even though they appear to grow spatially in 1-3 phases. Such a pattern stimulates several questions. For example, why did these settlements never grow larger than 3.5 hectares? What limited the processes of human demographic growth and centralization at these sites if one considers that the population of these settlements only inhabited the enclosed areas? Did catchment resource sustainability influence this pattern regarding locally available resources? For example, within Sintashta-Petrovka communities there may have been a strong correlation between herd size, human demography, and resource availability within these local catchments. To balance the relationship between human demography and livestock numbers a specific annual resource schedule was required to maximize available resources. Unfortunately, these questions cannot be answered definitively with presently available data from excavations at these sites and it will require much greater attention to better defining and testing catchment zone models for these settlements in the context of understanding associated pastoralist subsistence economies.

Archaeobotanical data that has been recovered, however, has provided direct evidence of plant resource exploitation but to understand the exact organization and potential of this subsistence pattern it is necessary to examine in more detail the importance, and maximum potential, of seasonal plant resources and patterns of exploitation based on local ethnographic data. Scholars from the Soviet Union collected much of the early ethnographic data in the Eurasian steppes. These researchers, such as Larin (1937), Shvan-Guriyskiy (1978), and Sobolev (1960), focused on the edible values of the pasture resources and on estimates of daily nutritional needs for different livestock combinations associated with specific local family units.

There is no doubt that recent ethnographic data can assist with the examination of Bronze Age pastoralist subsistence patterns. However, there are still missing links between the archaeological record and available ethnographic data from the South Urals regions. In discussions on pastoralist subsistence economies, regional differentiation stands out within ethnographic data (Joseph and Sergey 2005). For example, the hay yields can vary from 1000 to 5000 kg/ha from meadow zones due to the different plant species assemblage. And the differentiation can exist in a small area. Environmental constrictions such as elevation boundaries, annual precipitation patterns, and vegetation unit distribution can affect pastoralist communities in different ways.

In terms of regional ethnographic data, Yanguzin (2002) cites the herd structure of an average 18th Bashkir household. The Bashkirs lived on both sides of the Ural mountains and utilized livestock herding and agricultural practices. Yanguizin's work is very important in understanding social structure and herding patterns of local pastoralist communities in the Urals. But the impact of agriculture may influence the comparison with Bronze pastoralist societies in many respects and must be considered carefully when using ethnographic analogies.

Ethnographic studies in this dissertation combined the review of inter-regional data and personal interviews with local communities practicing livestock herding in the Uy River valley. Early subsistence economies usually reflect the dynamic strategies that were used by human communities to cope with local environmental variability, management of demographic growth, and the offset of socio-natural pressures that affected resource sustainability. Archaeobotanical data provides information about plant exploitation patterns from the local environment. Based on this information, ethnographic studies can focus on specific related issues. My research provided important new data on the yield and consumption rate of specific plant species that were identified within the archaeobotanical samples recovered from the Stepnoye settlement

As a reliable regional dataset, ethnographic data was collected from local herders and personal observation during several seasons over a span of several years. It helps to understand the seasonal environmental change, distribution, and variability of essential plant resources. Also, these interviews provided important information on the personal decisions and annual schedules of local herders in the region. At the same time, I personally observed the local herding patterns and recorded the herd sizes and compositions in different seasons. From these observations, I could identify several specific variables that constrained herding practices and by observing the local herders' daily strategies I could identify their solutions to these challenges. During personal communication with my informants, I was told the history of changing practices relating to herding activities in the region. These oral histories are important in that they can be used to examine the relationship between a community and livestock herding and animal husbandry patterns over a long period.

In my experience with local patterns of livestock herding, it was clear that the long winter season is of crucial importance in terms of herding strategies. The solution for this annual challenge *is a well-planned hay/fodder making process* in the local villages. My ethnographic studies recorded important details (location, harvest rate, preparation time, total amount) concerning this process. The location is very important for understanding the relationship between resource distribution and the annual herding pattern. Harvest rates for the cutting and collection of hay/fodder may vary due to vegetation zones, available tools, labor resources, and variation in seasonal growth. A detailed local harvesting rate comparison from different vegetation zone can be useful in evaluating human strategies and choices associated with the haymaking process.

Preparation time and the total amount of hay cut and collected are related to the weather conditions and the number of livestock that require fodder in each year. My personal experience indicated a highly intensive working period during the autumn season.

The collected data from ethnographic studies and different livestock feeding rates could then be used to estimate the basic requirement of fodder for local communities. The amount of required fodder varies by season, however, the data recorded from different months is of great importance to this dissertation research in terms of understanding the carrying capacity of local landscapes about certain species of livestock and estimated herd sizes. In comparison with previous research, ethnographic studies undertaken through my field research were largely based on the questions and analysis results of the archaeobotanical record recovered from the Bronze Age settlements within the local region. Thus, observations of foddering practices and livestock herding patterns in the local area provide an important form of actualistic study in which to better examine and understand essential relationships between local wild flora resources and livestock herding needs.

3.4 EXPERIMENTAL ARCHAEOLOGY

In this dissertation, the interpretation of archaeobotanical samples from different archaeological features is key to reconstructing plant exploitation among Bronze Age pastoralist communities. Several processes might have been active in bringing these seeds into the settlement locale including natural forces, human activities, and animal foraging. Statistical analysis can aid substantially in the interpretation of archaeobotanical remains (Pearsall 2000). One can briefly identify such assemblages by absolute count, density, and ubiquity of plant species in samples. However, it is difficult to identify and separate some processes that may have contributed to similar botanical assemblages, for example, human foraging and animal foraging (Hillman et al. 1997). Also, there are two important questions concerning foraging patterns among Bronze Age pastoralist communities in this region:

(1) Were livestock kept within the confines of the enclosed settlements and/or domestic house units in certain seasons (e.g. winter)?

(2) Was the collection and aggregation of fodder essential for these communities in supporting their livestock herds?

The answers to these two questions can relate to the combination and distribution of archaeobotanical assemblages in quite different ways.

In an important recent study, Spengler et al. (2013) have suggested that the wild seeds recovered from the Begash settlement site in Kazakhstan (Bronze and Iron Age occupation levels) are related to the burning of animal dung for fuel. It suggests a very important process related to the possible distribution of macro-botanical remains within settlement sites as linked to animal husbandry practices. The practice of dung burning is still debatable, but the method of related experimental archeology is well related to the two questions noted above. Because of the harsh seasonal weather conditions in the South Urals region, there is no doubt that the proportion of human subsistence needs is varied among seasons. To understand this process in more detail, I carried out dung-burning experimental studies using contemporary animal dung from the modern villages and natural environment of the Uy River valley over several months within a year.

These experiments provided data on the types of plants consumed within the local region by herded livestock and their ubiquity within associated dung. These results can then be compared with the archaeologically recovered botanical samples from Bronze Age settlements to determine whether patterns of grazing and consumption of certain floral species are similar. Hay-burning experimental studies with similar settings were applied at the same time. The focus of the hay-burning studies was to determine whether the combination of certain plant species from specific vegetation units could be identified in different months. At the same time, the burning process can trace the preservation rate of certain types of plant seeds from the region. In addition to the burning experiments, I pursued fodder harvesting experiments in the Uy River valley. The recovery of prehistoric sickle-shaped tools from both settlements and cemeteries dating to the Bronze Age within the region is especially noteworthy (Koryakova & Epimakhov 2007; Petrova 2004; Zdanovich & Zdanovich 2002).

The major purpose of these “bronze sickle” tools is still debatable but the fact that they served for cutting functions is not in doubt. Based on this evidence, the forage harvesting experiment was divided into two methods that included the use of sickles and hand collection of fodder. The fodder harvest experiment was carried out in 10 places within different vegetation zones to estimate the output of fodder. The same test was carried out in various months to evaluate seasonal differentiation. The amount of harvested fodder in a fixed time frame was calculated. Previous results from SCARP, and the collected data from my fodder experiment methods, formed an important foundation of information for this dissertation.

The results of the experiments, including dung collection and burning, hay collection and burning, and use of “sickle” vs. “hand” collection strategies will be discussed in more detail in the later chapters of the dissertation.

4.0 RESEARCH IN THE UY RIVER VALLEY

The Stepnoye settlement is situated along the Northern bank of the Uy River. This settlement is associated with one of the largest Bronze Age cemetery complexes in the region (Stepnoye I; Stepnoye VII) and includes at least 45 kurgans (barrows) dating from the Middle to Late Bronze Age. Moreover, another Sintashta-Petrovka settlement (Chernorech'ye), and associated cemetery (Krivoe Ozero), are located 20 km down stream and to the south-east of Stepnoye (Figure 11). No open plan large-scale excavation of either settlement had been undertaken prior to SCARP activities in the region.

The Stepnoye settlement is enclosed by a rectanglular ditch and bank complex, and 43 internal linear depressions that range from 6m x 2m to 10m x 15m (Figure 12). These have been interpreted through aerial photo analysis as individual domestic house units (Zdannovich and Batanina 2007:161). In 2007, SCARP field research at Stepnoye was focused on understanding the relationship of settlement placement and catchment zones relating to local resources that included copper and other minerals.

This focus pursued research questions focused on the socioeconomic organization during the Middle Bronze Age. The project pursued a "community" based approach to the study of metal production and subsistence economy (Hanks & Doonan 2009; Doonan et al. 2014) and considered the community as a mid-level unit of analysis that extends beyond traditional perceptions of settlement sites as an aggregation of households and as the primary loci for social organization and activity (Kolb and Snead 1997). The multiscalar research framework pursued through the project focused on the production and subsistence economy and how they intersect with the local landscape and environmental resources.

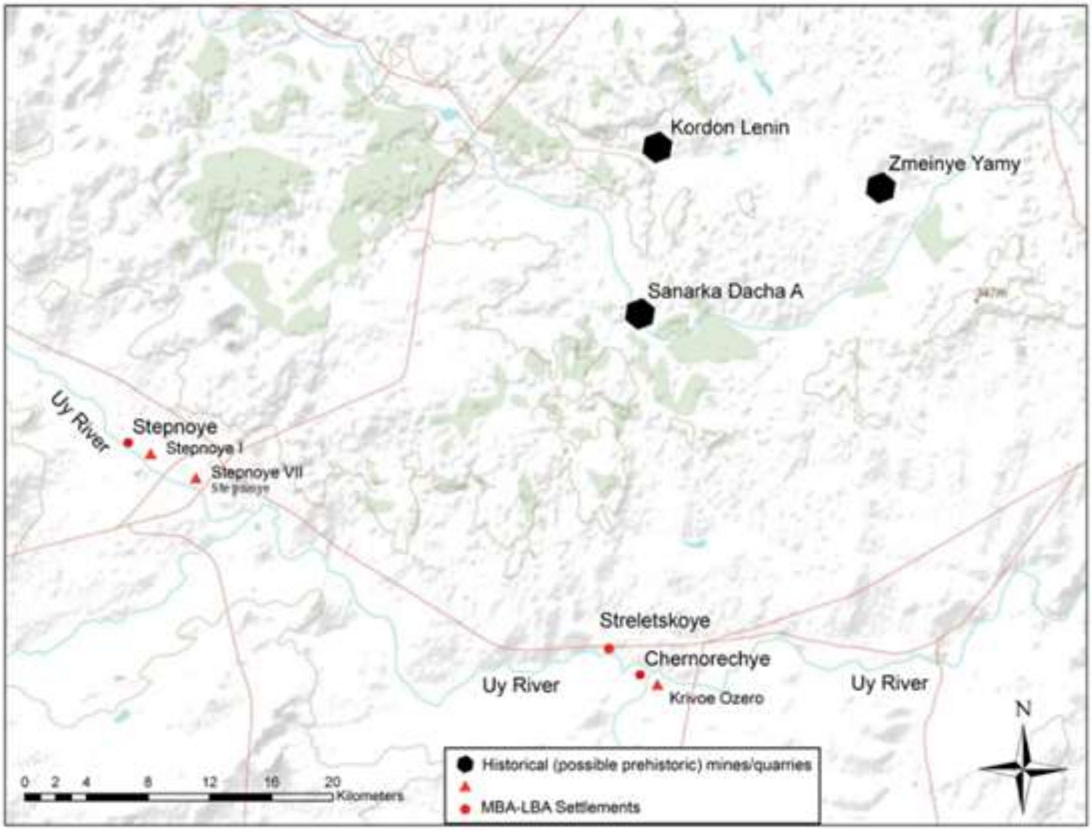


Figure 11 Map of Uy River valley with key Bronze Age sites (modified from Doonan 2013:216)

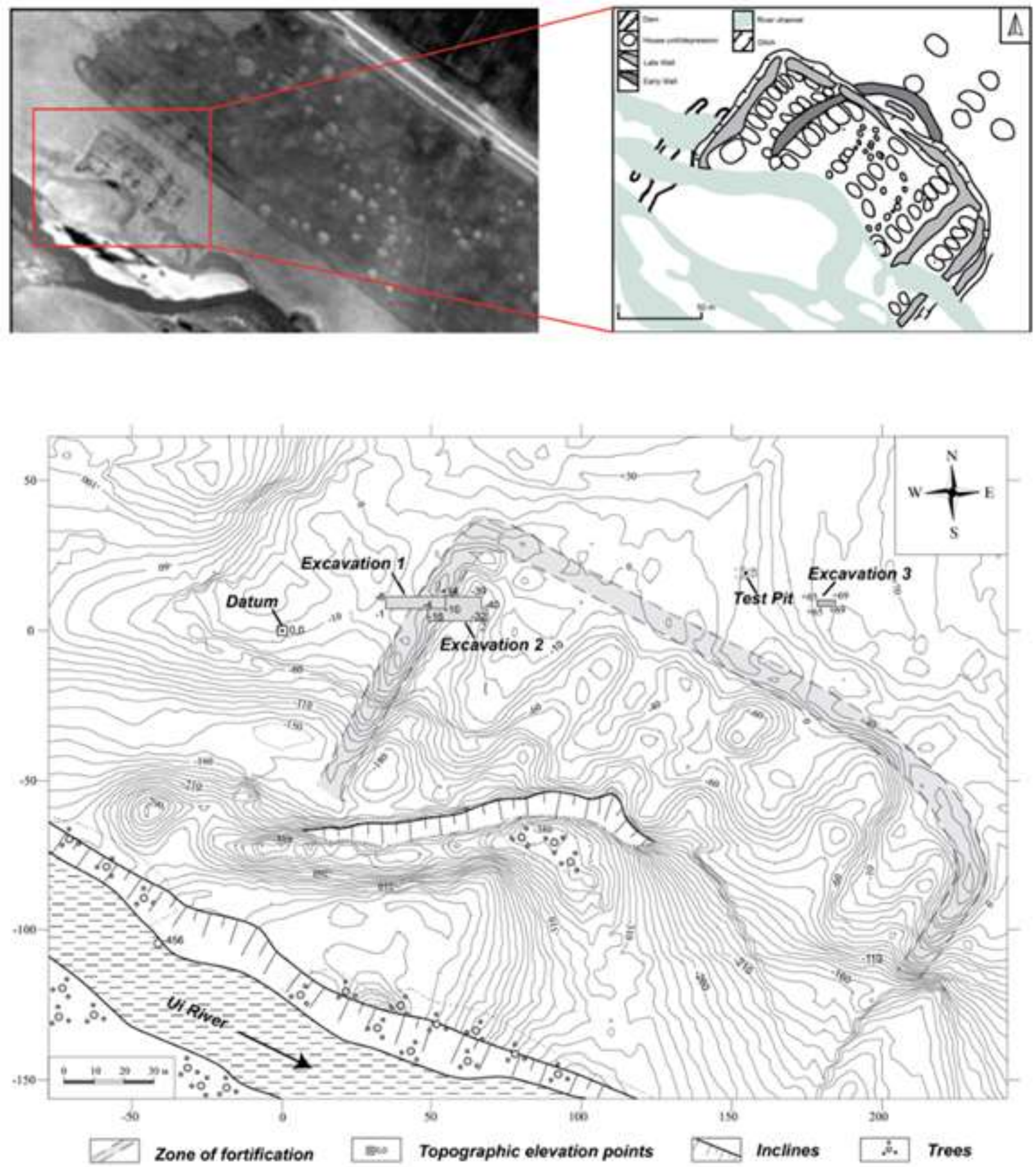


Figure 12 Images of the Stepnoye settlement: upper left – air photo; upper right – air photo interpretation; lower – topographic plan showing excavation units (after Hanks et al. 2010)

4.1 STEPNOYE, 2008 EXCAVATION SEASON

Stratigraphic excavation (4m x 20m trench) was carried out during the 2008 field season within the north-western zone of the Stepnoye settlement (Figure 12) (Hanks et al. 2009). This excavation was carried out for three specific objectives: 1) to expose the nature of the settlement fortification; 2) to verify the relative chronology of the site, and 3) to expose one corner of a domestic 'house' structure to ascertain the depth of the cultural level and to identify the structural characteristics. The excavation area covered the north-western part of the enclosure ditch-bank and one corner of what was interpreted as an internal (within the settlement enclosure) domestic 'house'.

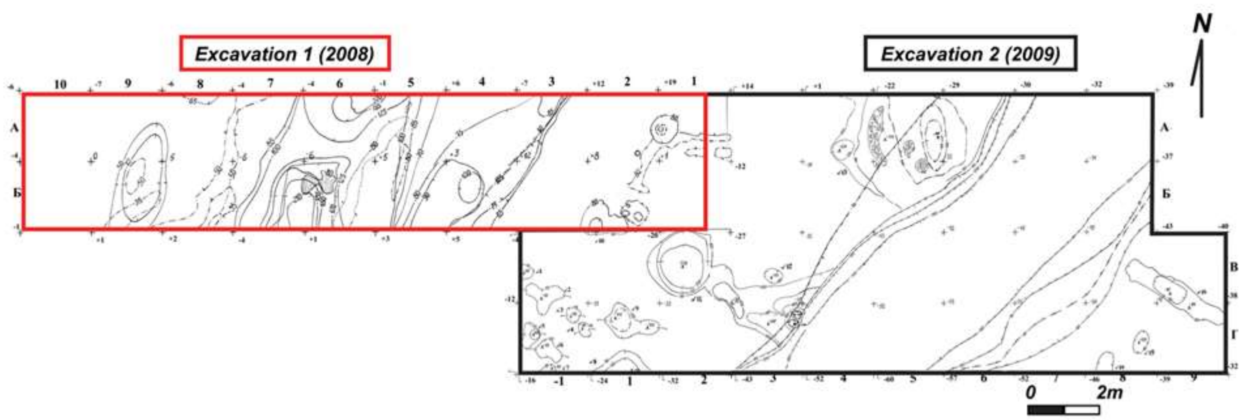


Figure 13 Excavation plan from Stepnoye settlement showing trenches from 2008 and 2009

The excavation was based on a combination of Russian and American methodologies that used 10 cm arbitrary excavation levels and north-south and east-west bulks that were retained for vertical control (2m x 4m spacing). Excavation unit coordinates utilized a combination of Cyrillic letters and numbers. Artifacts were piece potted, and level and context forms were completed as well. All archaeological features were photographed and drawn. All soils removed during excavation were dry screened through 5mm x 5mm metal mesh screen. Bucket flotation of bulk samples was also undertaken from the last three units (2 m x 4 m squares) in the area of the 'house' structure on the eastern end of the trench. Samples were sieved through #10 geological screen, and all fraction material was dried and prepared for botanical analysis(Figure 14).

Based on the excavation and the recovery of diagnostic pottery sherds two occupation layers in the excavation unit were chronologically distinct. The earlier layer represented the Sintashta-Petrovka culture (the Middle Bronze Age), and the later layer represented the Sargary-Alekseevka culture (the Final Bronze Age). Archaeological features recovered during excavation related primarily to MBA Sintashta-Petrovka domestic architecture and activities inside the enclosed area near the fortification wall. Features in this area did not appear to be associated with Final Bronze Age (FBA) occupation.

A 10 sq. meter area of a Sintashta-Petrovka period 'house' structure was uncovered by the close of the 2008 excavation season in the far eastern section of the trench and was identified through post-molds, linear depressions between them, and a compacted 'floor' surface with mottled clay. Soil samples, for bucket flotation, were collected by Bryan Hanks from this area, they were dried and placed in manila envelopes.

Figure 14 Left – photo from 2008 excavation showing soil bulk sampling from 'house' floor for macrobotanical flotation; Right – plan of key features (-80cm below datum) in eastern area of 2008 trench detailing location of artifact finds, post molds and linear depressions associated with 'house' foundations

4.1.1 Sampling Strategy and related features

In the 2008 excavation season, the essential features of the undisturbed cultural layer included a small portion of the house structure, positioned adjacent to the surrounding defensive wall, which was estimated to be about 12 sq. meters in size. In the excavation units 1A, 1B, 2A and 2B, a 10 sq. meter area of the Sintashta-Petrovka period ‘house’ structure was uncovered around the level of -80cm(Figure 15). A total of 12 soils samples (60 liters) were collected separately from the house floor and bone concentration features. All samples were collected in a standard volume of soil (5L). Five of these samples came from the house floor and seven samples from bone concentration feature on the house floor. (Table 7).

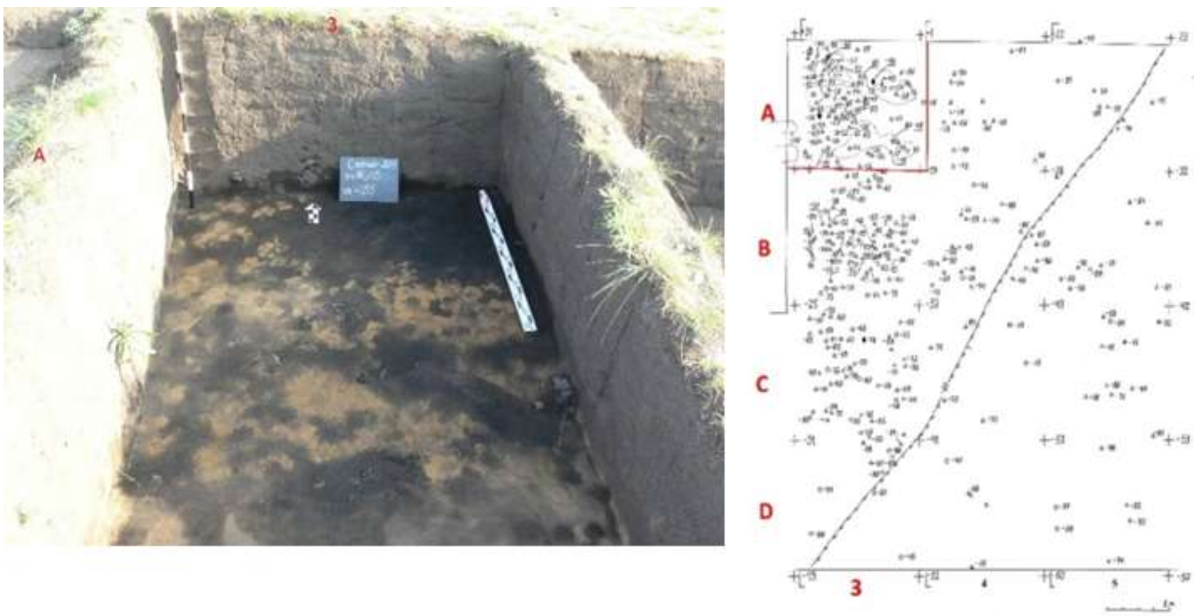


Figure 15 Left – photo from 2009 excavation showing house structure; Right – plan of house structure (-80cm below datum) in eastern section of 2009 excavation detailing location of artifact finds

Table 7 Information noting the number of macrobotanical samples recovered from archaeological features in the Stepnoye excavation from 2008 to 2009

Year	2008	2009		
	Excavation 1	Excavation 2 East	Excavation 2 West	Excavation 3
Bulk Sample		90	7	
Bone Concentration Feature	5	19		
House Floor	7	6		
Pit		14	3	
Midden				16
Total	12	129	10	16

4.2 STEPNOYE, 2009 EXCAVATION SEASON

4.2.1 2009 excavation 2 enclosed settlement

The goal of the 2009 excavation was to further excavate and examine the Sintashta - Petrovka period ‘house ‘structure identified in 2008 and to investigate the internal setting of the settlement (Hanks 2009; 2011; Kupriyanova 2009). A total of 128 sq. meters was excavated in a polygon shape that extended on the 2008 trench excavation within the Stepnoye fortified settlement (Figure 16).

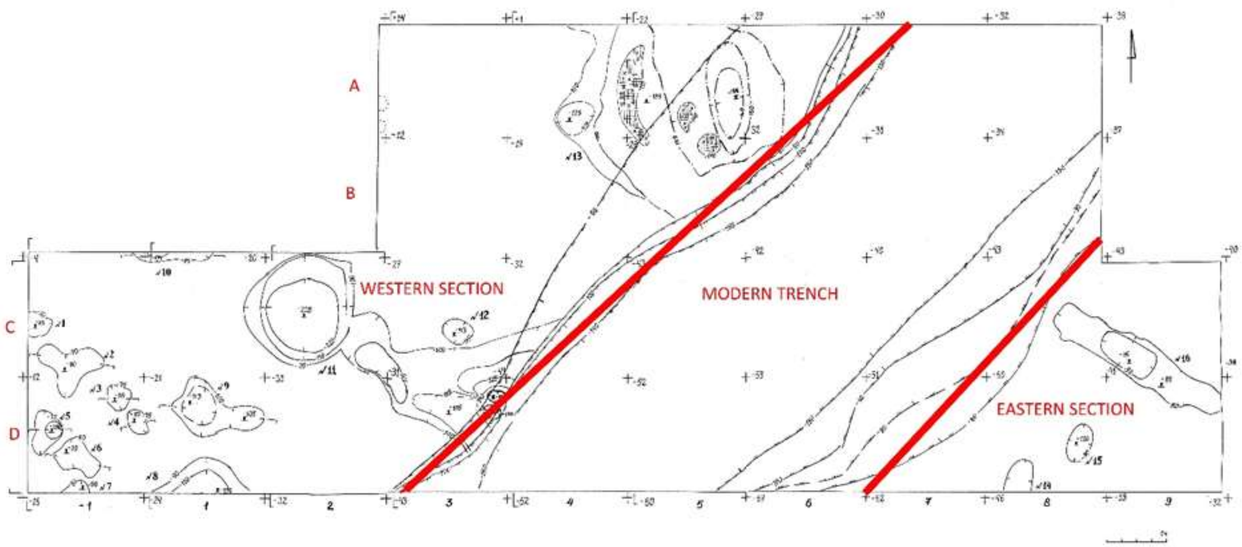


Figure 16 Plan of 2009 excavation 2 enclosed settlement detailing the location of the western section, the eastern section, and the intrusive modern trench that was encountered during excavation

In the 2009 field season, the 128 sq. meter excavation area was substantially effected by the discovery of a modern intrusive trench feature running parallel with the enclosure bank. This modern/historic disturbance was not visible on the surface of the site and it is assumed that this trench was dug and backfilled some time during the Soviet Period. Several rusted metal objects were encountered during the excavation in this area and due to health and safety concerns excavation units in this area were terminated and backfilled. This modern trench thus divided the excavation area into eastern and western sections.

The eastern section of the excavation revealed what was interpreted as an external activity area adjacent to the 'house' unit. The depth of the cultural soils horizon ranged from -20 cm to -120cm. In the eastern section, the upper stratigraphic layer (0-20cm) comprised a turf and plow zone horizon. The cultural layer was represented by a gray humus - sandy loam soil in the eastern section. At level -75 cm, most of the excavation unit reached sterile soil. The essential features of this undisturbed cultural layer included three pits with a clear accumulation of artifacts (Figure 17). The depth of the three identified pits varied from -85 to -120 cm. These pits were infilled with charred wood, fragments of ceramics, fragments of faunal remains, chipped stones and copper metallurgical slags. All identified ceramics were of the Sintashta type. The flotation samples for macrobotanical analysis were collected separately from the three pits.

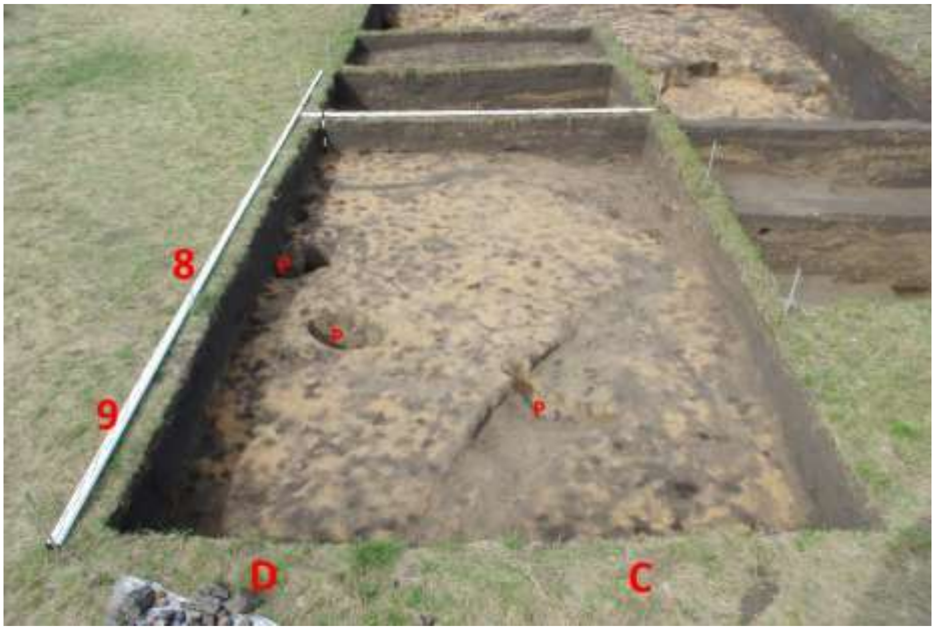


Figure 17 Photo from 2009 excavation 2 identifying the location of the three pit features encountered in the eastern section of the settlement excavation trench

The western section of the excavation included additional exploration of the residential area of the house structure encountered in 2008 (Figure 15). The upper stratigraphic layer (0-20cm) comprised a turf and plow zone horizon, the depth of the cultural soils horizon ranged from -20 cm to -228 cm in the western section. The essential features of the undisturbed cultural layer included ten separate areas with concentrated bones, a house floor, and one pit feature. Flotation samples were separately collected from these features.

The bone concentration areas were revealed in units -1C and 1D from -60 cm to -89 cm (Figure 18). These areas were filled with fragmented bones, ceramics, slags, and chipped stones. Some of the features were probably used for post holes and served as part of the wall structure because of mixed soil and fewer artifact remains. These features formed a linear arrangement and were spaced approximate 120 cm-140 cm.

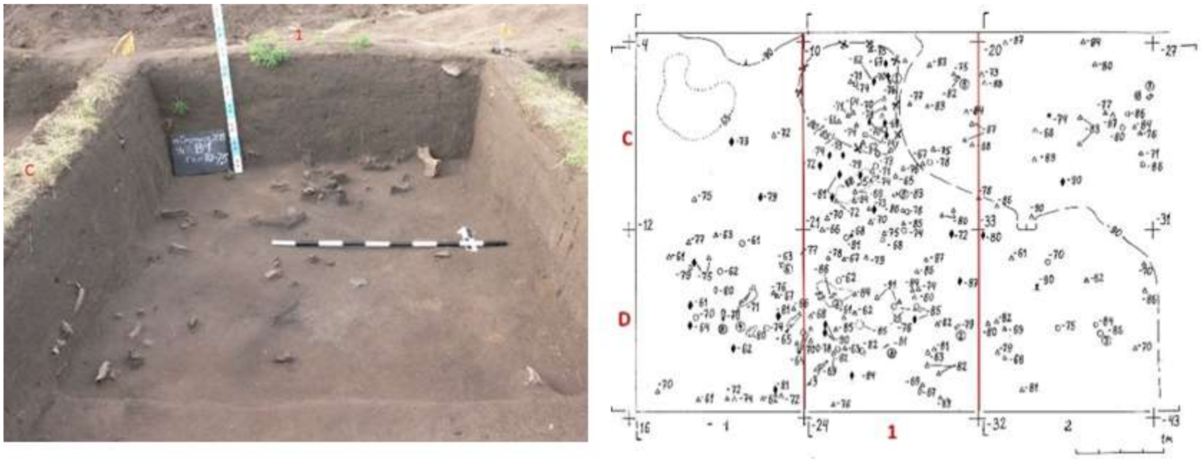


Figure 18 Left – photo from 2009 excavation 2 showing bone concentration area in unit 1C (-75 cm below datum); Right – plan of bone concentration areas (-80cm below datum) in western section detailing location of artifact finds

The house floor was revealed in unit 3A at -85 cm. The thickness of the house floor was around 2cm and was a yellow sandy loam. This was interpreted as the extension of the same house floor encountered during the 2008 excavation season. The house floor was covered with fragmented bones, ceramic sherds, and chipped stones.

The main pit feature was circular in form and was encountered at a level of -95 cm to -100 cm in unit 2C (Figure 19). The diameter of the pit was approximately 180 cm x 180 cm and had an inward sloping wall below this level. As a result, the interior diameter of the pit became reduced to approximately 125 cm at the level of -110 cm. At the level of -180 cm, the horizon was infilled with dark brown loam containing charcoal and a poorly preserved cattle skull. The pit had a flat bottom at a level of -228 cm. The infilling of the pit, at all excavated levels, included mixed fragments of pottery and animal bones, as well as lithics and other small stones. This pit was interpreted as a pyro-technological structure, and similar features have been identified at other Sintashta-Petrovka settlements (Gutka and Rusanov 1995).

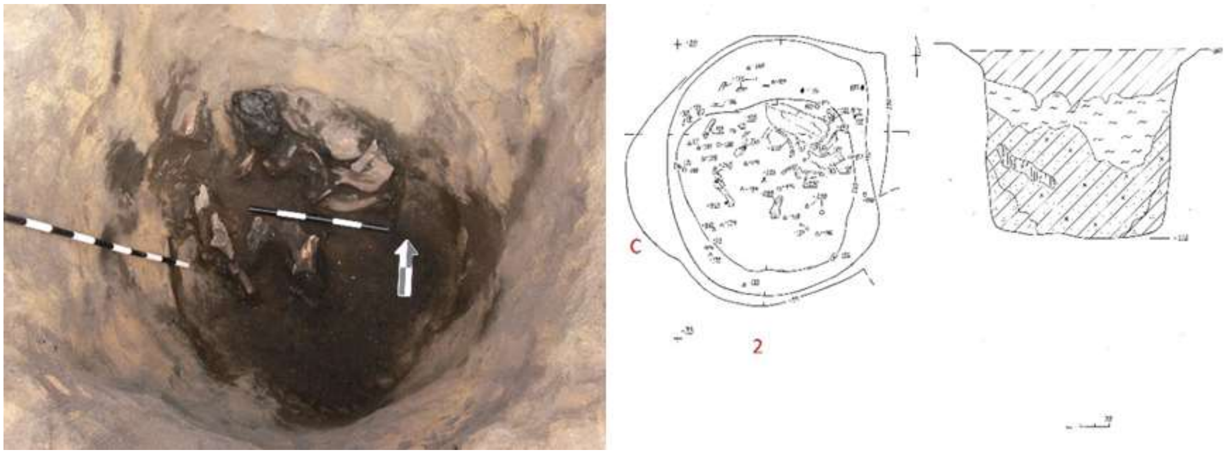


Figure 19 Left – photo from 2009 excavation 2 enclosed settlement showing faunal remains inside pit feature (-120 to -228 cm below datum) in unit 2C; Right – plan and profile of pit features (-120 to -228 cm below datum) in unit 2C detailing the location of artifact finds

4.2.1.1 Stepnoye, Trench 3 Excavation

The investigation of anthropogenic activities outside the enclosed area of the settlement was an important objective during the 2009 excavation season. The identification and excavation of the external “ashy midden” deposit are essential as no such feature had been excavated outside an enclosed Sintashta-Petrovka settlement. The trench 3 excavation was placed approximately 25 to 30 meters north of the enclosed settlement (Figure 12). The excavation trench was rectangular in shape with a size of 2 m x 6 m (Figure 20).

Excavations in this area revealed a thick ashy layer with mixed ceramic sherds, faunal remains, metallurgical slags, and other artifacts. The ash layer was formed about 30 cm below the surface turf, which was approximately 35-40 cm thick (Figure 19). No other feature within the trench excavation was detected. All the recovered ceramic fragments were identified as MBA Sintashta-Petrovka types. No archaeological materials for the FBA were recovered. The Petrovka ceramics were recovered from an ashy level that overlay an earlier deeper cultural level. This suggested the chronology of the ash layer related to a later stage of occupation at the Stepnoye settlement.

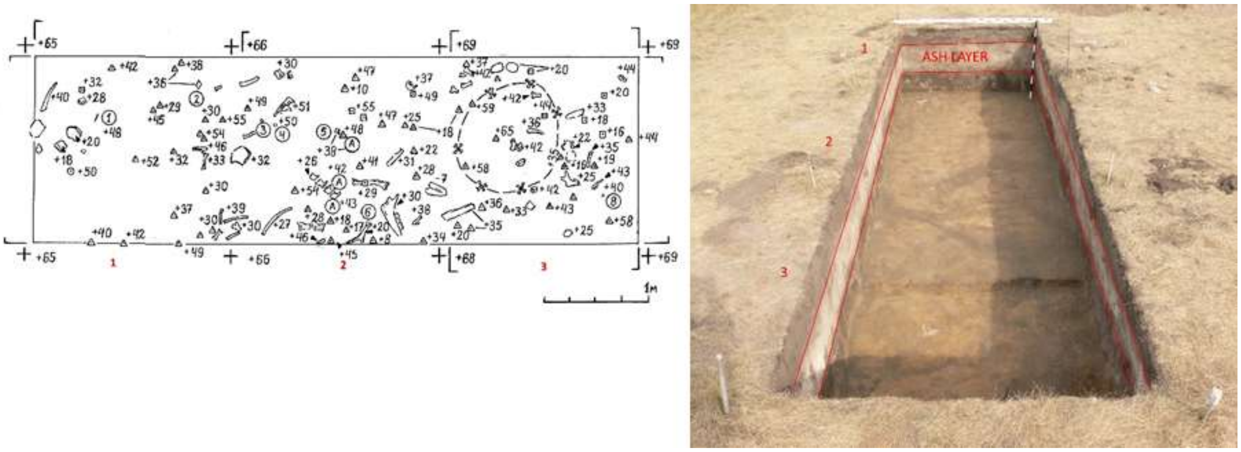


Figure 20 Left – photo from 2009 Trench 3 excavation showing ash layer of midden deposit outside the settlement; Right – plan of the ash layer detailing the location of artifact finds

4.2.2 Sampling strategy and related features

My participation with SCARP began during the 2009 season as the project archaeobotanist. The main aims of my work were to supervise the sampling and flotation of soils removed during stratigraphic excavation, to investigate plant resource exploitation as part of the Bronze Age subsistence economy, and to examine possible seasonal use patterns associated with plant resources and related activities at the Stepnoye settlement. Based on the data from remote sensing, excavation, test pitting and materials analysis, the 2009 excavation area in the Stepnoye settlement was constructed and functioned during the MBA Sintashta-Petrovka period. Features connected with FBA Sargary-Alekseevsky culture were not identified.

The excavations during the 2009 season at the Stepnoye settlement revealed part of a ‘house’ floor, however, detailed structures including furnaces and other copper production related features were not revealed. The trench excavation outside the enclosure area identified a thick ash midden deposit with numerous artifacts but without any clear architectural features. This suggests that MBA, and likely LBA, ‘house’ structures were placed within the enclosed area of the settlement and that the substantial midden deposits created adjacent and external to the boundaries of the settlement complex were linked to human activities associated with the occupation of the settlement. Based on the identified artifacts and associated features, it appears that most of the collected archaeobotanical samples can be linked to the MBA phase of occupation at the settlement.

Soil samples were collected systematically from features and cultural layers during the excavation in 2009. The sampling strategy for soil flotation was adapted to the excavation technique by utilizing the grid coordinate system and 10 cm arbitrary levels. This provided horizontal and vertical contextual control over sampling and allowed for an analysis of macrobotanical ubiquity and spatial distribution inside and outside the settlement. A total of 155 soil samples (3,576 liters) were collected during the 2009 excavation season (Table 8). Collected soil samples were taken from horizontal bulk samples per arbitrary level, 'house' floors, bone concentration features, pit features and midden deposits identified and excavated external to the enclosed settlement area.

Compared with other archaeobotanical projects in the Eurasian Steppe (Popova 2006; Ruhl et al. 2015; Spengler 2016), this sampling and collection strategy produced a vast amount of bulk samples for use as comparative samples in the archaeobotanical analysis (Figure 20). Overall, a total of 97 bulk samples (90 from the western section and 7 from eastern section) were collected from level -30cm to -130cm in 15 excavation units (Table 7; Table 8). The standard volume of bulk samples was 10 L per excavation unit in every stratigraphic level. The soil volume per sample increased in the excavation units where more artifacts and ecofacts were encountered. Also, in some excavation units, more soil samples were collected from specifically identified features.

Table 8 General information of recovered plant remains from macrobotanical samples in the Stepnoye excavation from 2008-2009

	Bulk Sample	Pit	Bone concentration	Midden	House floor	Total
Total(charred seed)	838	518	596	113	175	2240
Grams of charcoal	102.458	70.675	90.678	7.388	8.905	280.104
Liter of soil	2070	532	775	128	131	3636
Total(samples)	97	17	24	16	13	167
Total(sample with seed)	64	17	22	15	13	131
Charcoal density	0.05	0.13	0.12	0.06	0.07	0.08
Seed density	0.40	0.97	0.77	0.88	1.34	0.62
Ubiquity(charred seed)	0.66	1.00	0.92	0.94	1.00	0.78

Archaeological features were defined by distinct characteristics in the soil, such as floor levels, pits, and associated artifacts. In the 2009 excavation season, a total of 42 samples (19 from bone concentration features, 6 from 'house' floors, and 17 from pits) were collected from different features (Table 7). Based on the size of the distinct feature, the collected soil volume varied. In most cases, the entirety of the soil removed from the feature was taken for flotation. Sampling was also increased when greater density of artifacts was encountered during the 10 cm arbitrary level excavation. In Unit 1C, for example, the bone concentration features were further split into 1m x 1m units because of the density of artifacts. Soil samples were then separately collected from each of these sub-units. An additional number noting this was added to the label of the excavation unit (Figure 21).

In the 2009 field season, an additional 16 soil samples were taken from the ash layer in the midden deposit outside the enclosed settlement. This work was the first systematic archaeological excavation in the region that employed flotation outside an enclosed area of a Sintashta-Petrovka settlement. We used the same sampling strategy for soil floatation as that employed in the enclosed area of the settlement. However, the standard soil volume was set at 8 L because of the smaller scale of the excavation. The 2 m x 6 m excavation trench was equally divided into three 2 m x 2 m excavation units (Figure 21). One soil sample was collected per every 10 cm stratigraphic level from the ash layer in every excavation unit.

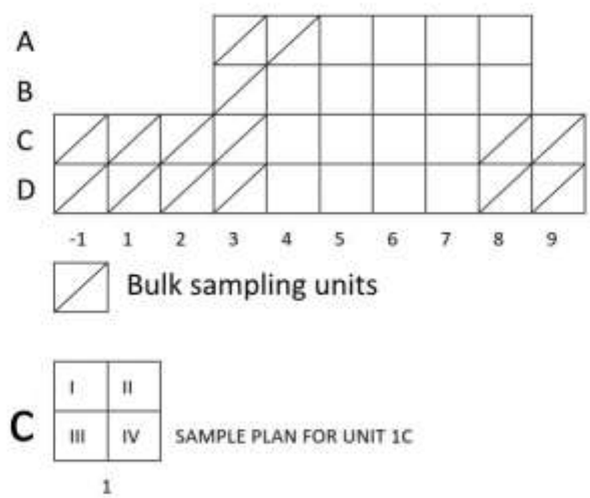


Figure 21 Sampling scheme of the bulk samples and excavation units in the 2009 excavation 2

As one of the first systematic studies of archaeobotanical remains in the Southeastern Urals region, the Stepnoye data provides an important foundation for future projects at the Streletskoye and Ust'ye settlements. The laboratory methods and quantitative analysis for all archaeobotanical samples from the three sites in this dissertation are the same. In this section, I start with the introduction of laboratory methods and quantitative measurements for the dissertation research.

4.2.3 Laboratory methods and quantitative measurements

Due to the high proportion of sand and lack of clay in most soil samples, the charred botanical remains were easily floated and collected in the light fraction. Based on my field experience in the Stepnoye excavation seasons, there was very little botanical remains recovered in the heavy fraction. Thus, the laboratory methods and quantitative analysis in this dissertation are focused on the light fraction.

Once in the lab, the information (sample number, excavation unit, stratigraphic level, feature, liters of soils) on the tag of the archaeobotanical samples was recorded. The tag was kept with the analyzed light fraction as a secondary record. The muslin pouch was removed and the light fraction was passed through nested geological sieves. Mesh sizes larger than 2 mm were used for samples with a vast amount of charred wood material, such as was encountered in the animal bone concentration features. Generally, all botanical remains that were sieved through 2 mm, 1 mm and 0.5 mm mesh were sorted separately but later grouped after the analysis procedure. Other categories of archaeological materials (most identified were faunal material) were also picked out from the samples for other analysis. Materials smaller than 0.5 mm were left on the bottom of the sieve pan and were checked carefully. Identified botanical remains were then picked out and included in the analysis procedure.

In the laboratory procedure, charred and uncarbonized seeds were systematically picked from the light fraction, however, only charred seeds were selected for quantitative analysis. Most uncarbonized seeds were *Chenopodium* spp. *Chenopodium* seeds with a hard husk were well preserved in the local soils and can remain viable for decades (Thompson et al.1997). The preservation of large numbers of uncarbonized *Chenopodium* seeds was reported in other archaeobotanical projects in the Eurasian steppe region (Popova 2006; Ruhl et al. 2015; Spengler 2013). The bulk samples taken from the upper stratigraphic levels during excavation are excellent comparative samples in which to address this issue. Based on the flotation and laboratory experiences I had during the dissertation research, I found a strong correlation between the number of uncarbonized seeds and the related stratigraphic level. Generally, uncarbonized seeds that are encountered in soils from upper stratigraphic levels can range up to ten thousand from one soil sample. This pattern was found in the bulk samples I analyzed from levels -30 cm to -40cm.

The number is significantly decreased in the lower stratigraphic levels (-50 cm to -70 cm) and was absent in features from the lower horizons of the cultural layer (below -80 cm). Based on this evidence, the uncarbonized seeds should be related to the wild growth of modern plants in the excavation area. Therefore, in the laboratory procedure, only carbonized seeds were picked out for identification and quantitative analysis. The uncarbonized seeds were saved for future studies.

Key categories of charred botanical remains include charcoal, seeds and seed fragments, pods and awns. Charcoal pieces larger than 1 cm collected from the flotation samples were collected and weighed to the nearest 0.001 gram. All seeds and seed fragments were divided by family, genus, and species, if possible. Seeds and seed fragments were separated into categories based upon taxonomy, then they were counted and recorded. One piece of seed fragment was also counted as one seed in Total (charred seed). Well preserved whole seeds were measured (length and width of the entire caryopsis). Pods and awns were counted separately in different categories.

The main quantitative measurements in this dissertation include 'total', 'density', and 'ubiquity'. 'Total' is the raw number of each taxon in each sample. A total number of plant remains is the frequency of plant remains in human-plant interactions (Popper 1988). But this number is always affected by preservation, sampling, the function of features and various other factors. 'Density' is the raw number of each taxon divided by the liters of soil in each sample. Density is useful for the comparison of the plant remains from different samples. Ubiquity is the number of samples in which the taxon appears within a group of samples (Popper 1988). Each sample with the present taxon counts as 1 in this measurement. Ubiquity is a standard quantitative measurement that can be used to discuss the frequency of use of a plant resource among ancient societies.

4.2.4 Interpretation of flotation samples

In this section, the archaeobotanical samples from the 2008 and 2009 excavations seasons are discussed. The general results of the collection of archaeobotanical samples is provided in Table 5. A total of 167 flotation samples from the Steponoye excavation have been fully analyzed as part of the dissertation research. The samples vary in volume from 5 to 220 liters of soil, for a total of 3,636 liters of floated and analyzed soil. The ubiquity of charred seeds in the Stepnoye archaeobotanical samples is 0.78. The lowest ubiquity of charred seeds is from the bulk samples (0.66), which represents the frequency of plant usage that is the lowest among the samples. The ubiquity of all features is higher than 0.9. This number suggests a strong correlation between plant resource usage and the function of the features associated with MBA occupation and use of the settlement.

Charcoal was a major component identified in the Stepnoye archaeobotanical samples. A total of 280.104 grams of charcoal were analyzed (Table 8). The charcoal density is 0.08 grams/liters of soils in the Stepnoye archaeobotanical samples. The number varies from 0.05 (bulk samples) to 0.133 (pit features) grams/liter of soil. Charcoal density can be highly related to the function of anthropogenic features, subsistence practices, and the use of local resources. Importantly, compared with other archaeobotanical projects from the Eurasian steppe, the average charcoal density from different collected samples ranged from 1.77 to 0.002 grams per liter of soil. As Spengler has noted (2013), the lowest density generally comes from the samples of the cultural layer without specific features (Spengler 2013).

This is a similar pattern found with the Stepnoye samples, that is, the charcoal density in the bulk samples is lower than all other specific features. However, the charcoal density is quite similar in different features. For example, the density of the pit features (0.133 grams/liter of soil) and bone concentration features (0.117 grams/liter of soil) are similar and a little higher than the average density. Compared with the ‘house’ floor (0.068 grams/liter of soil) the lower density may be related to cleaning practices that took place within the ‘house’ unit when it was occupied. Generally, the accumulation of charcoal inside the ‘house’ unit is associated with the activity area and pit features. This may explain why these features have higher charcoal densities inside the ‘house’ unit.

The charcoal density of the midden deposit (0.058 grams/liter of soil) is the second lowest in the Stepnoye samples. Usually, the formation of ashy soil is related to a long burning process and this process can burn most charcoal to ash. The similar charcoal density between the features inside/outside the settlement suggests the formation of the midden deposit is related to the activities inside the 'house' units within the enclosed area of the settlement.

The charcoals were identified and assigned to two species: *Betula pendula* and *Pinus sylvestris.* Both species are dominant withing the Stepnoye archaeobotanical samples and both are commong species in the forest in the local region today. This finding is the same as the Kammenyi Amber archaeobotanical results which were obtained in the Southeastern Urals region (Ruhl et al. 2015). Besides the tiny pieces of charcoal recovered from the flotation samples, the large charred wood blocks were also recovered during excavation. This suggests that timbers were collected from the steppe woodlands in the local environment for fuel and construction materials for the settlement and associated 'house' units.

4.2.5 Interpretation of charred seeds

There was a total number of 2,240 carbonized seeds and seed fragments recovered from the Stepnoye excavation. The seed density was 0.64 seeds/liter of soil in the Stepnoye archaeobotanical samples (Table 5). The number varied from 0.4 seeds/liter of soil (bulk samples) to 1.34 seeds/liter of soil (house floor) and the ubiquity of the charred seeds was 0.78. This number varied from 0.66 (bulk samples) to 1 (house floor, pits). The seed density (0.77 to 1.34 seeds/liter of soil) and ubiquity (0.92 to 1) of all features was found to be much higher than the bulk samples. This suggests that the preservation of archaeobotanical remains are highly variable across the excavated settlement features.

All of the bulk samples that were collected from levels -30 to -130 cm, comprising the upper stratigraphic levels, were mixed with numerous modern seeds and grassroots. Based on the experiences during flotation of these soils, the number of modern plant parts were significantly decreased in the bulk samples collected from the lower stratigraphic levels (Table 9).

Table 9 The total number of bulk samples from different excavation units and stratigraphic level in 2009 excavation 2 enclosed settlement

	-1C	-1D	1C	1D	2C	2D	3A	3B	3C	3D	4A	8C	8D	9C	9D
30-40							1	1							
40-50	2	3	1	1			1	1							
50-60	3		3	1	1	1	1	1			1				
60-70	2	1	1	2	1	1	1	1	1		1			1	1
70-80	2	1	3	4	1	2	2	2	1		1		1	1	1
80-90	1		2	1	5	3		1	4		2	1	1		
90-100				1	4	1			1		1				
100-110				1	1						2				
110-120						1					1				
120-130										1	1				

[1] Bulk sample units with total numbers of samples from the individual units

Also, most of the bulk samples (34) without charred seeds are collected from level -30 to -75 cm in the upper layers. It proved that these layers might be disturbed by later human activities and the preservation of charred plant remains is poor in the soils samples. Thus the systematic bulk samples in this dissertation research are very good comparative samples to rethink about the frequency of plant resources in Bronze Age pastoralist societies in this region. The comparison between seed density of the bulk samples from different stratigraphic level can trace the effect of later human activity on the preservation of charred plant remains.

Compared with other archaeobotanical projects from the Eurasian steppe, the average seed density ranged from 43.7 to 7.7 seeds/liter of soil, and the ubiquity of charred seeds are 1.(Ruhl 2015; Spengler 2013). The ubiquity of charred seeds from the Stepnoye project is lower than others, and the seed density is much smaller than Kammennyi Ambar archaeobotanical project (7.7 seeds/liter of soil) in the South Urals region. There are big differences in sampling strategy compare with this dissertation project and other works.

First, a systematic bulk sampling strategy is applied to this project. It is because the quantitative data of the bulk samples can provide a reliable background reference for comparison of the plant resources usage pattern in different features from the same site. Second, in this project, all of the soil from most of the features are collected for flotation. For some big features(house floor, pit), we collected separate samples from the different stratigraphic level and excavation units. This sampling strategy is an intensive, systematic study of the plant remains from all features covered in Bronze Age societies. Thus the total number and liters of soil from this dissertation project are much higher than any other projects in Eurasian steppe.

The feature-oriented sampling strategy of another project usually takes one sample from the part of the abundant archaeological materials in the feature. Therefore, the seed density is usually much higher than the average number for the feature. For example, the highest seed density per single sample at Stepnoye was 33.3 charred seeds/liter of soil from a pit feature. This number is around 33 times more than the average pit feature's seed density (0.97 seeds/liter of soil). It can be suggested that the seed density may be highly varied within the same feature and, therefore, an intensive sampling strategy for features might be an important consideration for future projects in the Eurasian steppe region.

Since the article of Kamennyi Ambar settlement excavation grouped the archaeobotanical samples from different features in the same house unit as a whole(Ruhl 2015). The ubiquity of charred seed in most house unit is 1. Using this number, the ubiquity of the charred seeds from identified features at Stepnoye (0.92 to 1) are comparable to those achieved at the Kammennyi Ambar settlement. The ubiquity of charred seeds from the Stepnoye samples indicates that the sampling strategy used in at the Stepnoye settlement is an efficient way to recover charred plant remains from features and is comparable to other project results. At the same time, an intensive sampling strategy for single feature and cross-feature comparisons in the same house units helps to trace the relationship of specific plant resources and human activities in related features. The sampling strategy used in the Stepnoye settlement provided better comparative data about the different features and associated human activities in the house unit. Therefore, I also used a similar sampling strategy during the Ust'ye excavation.

The totals and percentages of charred seeds for all families in Stepnoye excavation are listed in Table 10. The interpretation in this section focus on what presence of these families means from features. Furthermore, it helps us to understand the plant usage pattern and related human activities inside/outside the enclosed settlement. A discussion of the seed morphology and related landscape setting around the site will be presented in chapter 6.

Table 10 The total number and percentage for all families in the botanical samples from Stepnoye excavation 2008 to 2009

			Bulk Sample	Pit	Bone concentration	Midden	House floor	Total
Total		Total	838	518	596	113	175	2240
		Percentage	0.37	0.23	0.27	0.05	0.08	
Meadows	Fabaceae	Total	493	328	435	28	128	1412
		Percentage	0.59	0.63	0.73	0.25	0.73	0.63
	Lamiaceae	Total	32	21	18	1	4	76
		Percentage	0.04	0.04	0.03	0.01	0.02	0.03
Ripirian	Cypereceae	Total	32	18	17	5	6	78
		Percentage	0.04	0.03	0.03	0.04	0.03	0.03
Rubural	Polygonaceae	Total	52	13	19	2	2	88
		Percentage	0.06	0.02	0.03	0.02	0.01	0.04
	Chenopodiaceae	Total	22	45	1	42	2	112
		Percentage	0.03	0.09	0.01	0.37	0.01	0.04
	Astereceae	Total	9	4	8	1	2	24
		Percentage	0.01	0.01	0.01	0.01	0.01	0.01
Steppe	Poaceae	Total		1	2		1	4
		Percentage		0.01	0.01		0.01	0.01
	Rosaceae	Total	7	7	5			19
		Percentage	0.01	0.01	0.01			0.01
	Euphoriaceae	Total			1			1
		Percentage			0.01			0.01
Forest	Pinaceae	Total	2	2			2	6
		Percentage	0.01	0.01			0.01	0.01
	Betulaceae	Total			1			1
		Percentage			0.01			0.01
Other	Unidentified	Total	189	79	89	34	28	419
		Percentage	0.23	0.15	0.15	0.30	0.16	0.19

The total number of charred seeds from Stepnoye excavation is 2240. All of the charred seeds are wild seed. There are 1821 seeds around 82 % of the charred seeds could be identified at least to family level. In total, over 35 different species (at genus and species level) from 11 plant families were present. The number of unidentified seeds is 419. Around 60% of these fragments appear to have some characteristics of the Fabaceae family (*Medicago* and *Vicia* sp.), but the characterized part for identification is missing among these seed fragments. Thus we just group it as unidentified in this dissertation. The rest of the unidentified seeds are round in shape without diagnostic characteristics that would aid in identification.

Among the carbonized seeds recovered from Stepnoye, the most common plant family are Fabaceae (mainly *Medicago* spp., *Vicia* spp., and *Melilotus/Trifolium* spp.), followed by Chenopodiaceae (*Atriplex* sp. and *Chenopodium* spp.), Polygonaceae (*Polygonum* spp. and *Rumex* spp.), Cyperaceae (*Carex* spp.) and Lamiaceae (*Mentha* spp.)(Table 11). 63% of the seeds recovered and identified belonged to the *Fabaceae* family (1412 seeds). The percentage of Chenopodiaceae, Polygonaceae, Cyperaceae and Lamiaceae families are all less than 5% of the total seeds. The rest of the identified families are all less than 1% of the total seeds.

Table 11 The total number of major species in the botanical samples from Stepnoye excavation 2008 to 2009

Families	Species	Bulk samples	Pit	Bone concentration	Midden	House Floor
Fabaceae	Vicia spp.	143	96	119	14	54
	Medicago/Melilotus/Trofolium spp.	306	176	297	10	71
Chenopodiaceae	Chenopodium spp.	6	17		18	
	Atriplex sp.	16	28	1	24	2
Polygonaceae	Polygonum spp.	15	10	9	2	2
	Rumex sp.	38	1	10		
Cyperaceae	Carex spp.	29	16	14	4	6
Lamiaceae	Mentha spp.	7	4	7		1

The seed production rate and preservation of identified families are varied. For example, an individual plant of *Chenopodium album* L. can produce as many as 50,000 to 70,000 seeds per year (Mandal and Pal 1990). Fabaceae, like *Vicia cracca* L., an individual plant only produce around 5,000 seeds per year (Doronina 2008). Chenopodiaceae seeds with their hard seed coat are more resistant to decomposition than Cyperaceae and Fabaceae seeds.

There is an extraordinarily large number of Fabaceae seeds from the Stepnoye settlement. Several species from the Fabaceae family have been identified. Because of the poor preservation condition and morphological similarity, *Medicago*, *Melilotus*, and *Trifolium* genus were grouped in this project. The total number of identified *Medicago/Melilotus/Trifolium* spp. is 874, around 62% of the *Fabaceae*. According to the morphology, these species may be included *Medicago falcata*, *Medicago lupulina*, *Medicago sativa*, *Melilotus wolgicus Poir.*, *Trifolium arvense, Trifolium montanum*, and *Trifolium repens.* The number of *Vicia* spp. is 424 around 31% of the *Fabaceae*. Most of the *Vicia* spp. identified in the Stepnoye settlement samples are probably *Vicia cracca*. *Fabaceae* are valuable fodder plants that are utilized in the region now for livestock. The species mentioned above are typical plants represented the meadow zone environment along the Uy River valley in which the Stepnoye settlement is located. Besides of Fabaceae families, Lamiaceae(*Mentha* spp.) also located in meadow zone. These species are also located in meadow zones and use as fodder now.

The riparian zone today along the Uy river valley comprises several *Carex* spp. (mainly *Carex distans* and *Carex ovalis*). These species are associated with the Cyperaceae family from the archaeobotanical samples. The total number of Cyperaceae is 74. 67 of these seeds are *Carex* spp., and the rest are *Eleocharis* sp.(*Eleocharis palustric*). These plant can easily found in wetland zones along the main river. These plants usually have a very long stem. Thus riparian zone filled with Cyperaceae is a natural shelter for livestock to hide in the summer storm.

The total number of identified Chenopodiaceae family is 112. *Atriplex* sp. and *Chenopodium* spp.(included *Chenopodium album* and *Chenopodium polyspermum*) were identified. In the samples from upper stratigraphic levels near the present day surface, significant amounts of modern *Chenopodium album* are recovered. As a result of herding activities from the modern Stepnoye village, and surrounding villages in the local region, the Chenopodiaceae family is prominently identified around the ancient Stepnoye settlement. Compared with the *Chenopodium* spp., modern *Atriplex* spp. are seldom found in the samples recovered from the settlement excavations. Chenopodiaceae family was identified as a dominant flora in the ruderal zone along the Uy River. The seed of The ruderal zone is the disturbance of natural steppe by human and/or animal activities. The daily activities by human and livestock will continually destroy natural vegetation of the steppe inside the village and surrounding area. Thus Ruderal zone is always found in modern villages and the surrounding area. The enclosed settlement and surrounding area in the Bronze Age should also be disturbed by the daily herding activities. Thus the distribution of Ruderal zone should be similar in the Bronze Age. The presence of carbonized *Chenopodium* seeds was reported in the Samara River Valley and Kamennyi Ambar and suggested as edible grains required a detoxification method(Popova 2006; Ruhl et al. 2015). Since the distribution of Chenopodiaceae plants is closely related to the Stepnoye settlement, and the seed production rate is extremely high, the Chenopodiaceae can be over-represented in the Stepnoye samples. The role of Chenopodiaceae in the Bronze Age Stepnoye human diet may be limited.

The total number of Polygonaceae is 86. The identified species included Polygonum spp.(*Polygonum persicaria, Polygonum aviculare, Polygonum convolvulus*) and *Rumex cripus*. These plants are commonly found within the contemporary ruderal zone. The seeds can collect and dehusk before consumption(Hillman 2000). They can play a role in human nutrition. There are 24 Asteraceae(*Artemisia* sp.) identified in Stepnoye samples. They are also from the ruderal zone can be collected as fodder in the modern village. The usage of these seeds may be the same in the Bronze Age.

Poaceae, Rosaceae, and Euphoriaceae are identified families from the undisturbed natural steppe. In Uy River valley, *Stipa* spp.(*Stipa pennata* and *Stipa capillata*) covered most of the land around the ancient settlement and the modern village. In the recovered archaeobotanical samples, only 2 *Stipa* seeds were identified. 2 *Poa* sp. from the Poaceae family also .recovered from the archaeobotanical samples. All 12 Rosaceae seeds are grouped in *Fragaria/Potentilla* sp. In Uy river valley, *Fragaria viridis* (wild strawberry) are widely distributed and commonly gathered and consumed raw by local villagers. Thus these wild seeds are assumed to have contributed to the human diet. The total number of Euphorbiaceae(*Euphoria* sp.) is just 1. It is a common grass in the natural steppe zone.

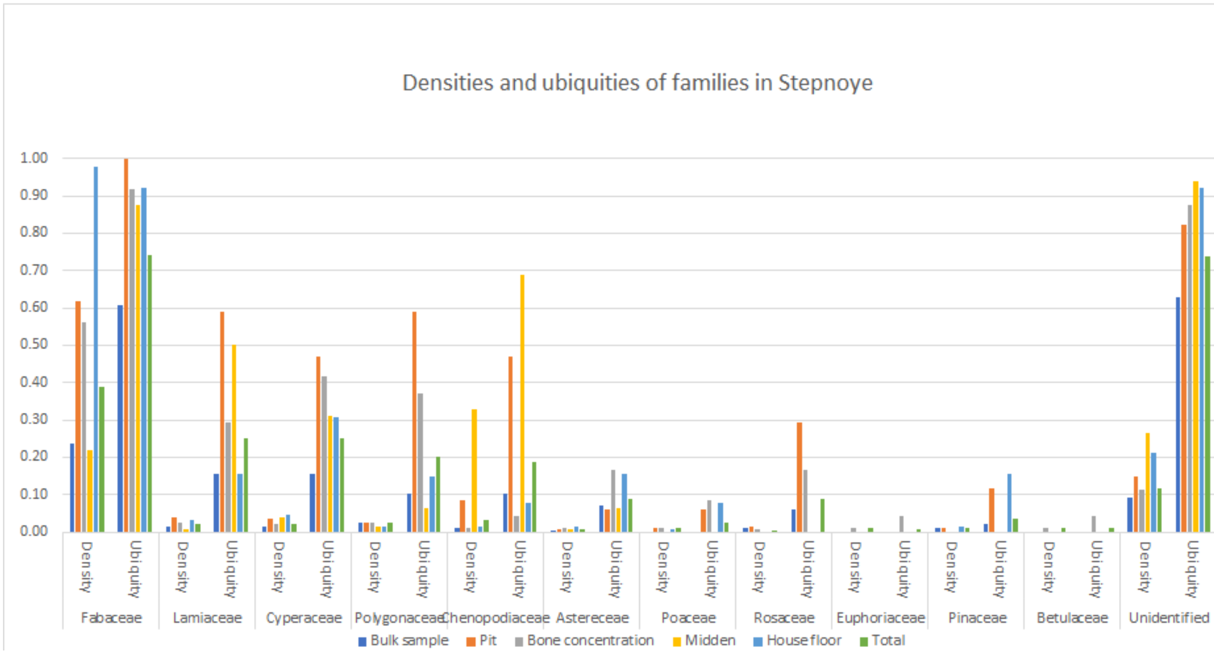
Identified Pinaceae(*Pinus* sp.) and Betulaceae(*Alnus* sp.) are dominant species in the local forest today. *Pinus sylvestris* and *Alnus pentula* are major species found within the local forests today. Charcoal pieces from the identified samples also represent these two species. The total number of identified Pinaceae is 6 and 1 Betulaceae. These seeds are not edible. They may be collected during the gathering of firewood and construction materials. Thus the number of these seeds are relatively low in the archaeobotanical samples.

Overall, the total numbers and percentages of Fabaceae are dominant among seed assemblage in archaeobotanical samples collected from bulk samples, pit features, bone concentration area, and house floor. In midden features, Chenopodiaceae has the highest total number and percentage, and Fabaceae is the second. The comparison of the total number and percentage between different families can be affected by a single event produced a huge amount of charred seeds. The further interpretation of the plant usage pattern will rely on ubiquities and densities (Table 12).

Table 12 The seed densities and ubiquities for all families in the botanical samples from Stepnoye excavation 2008 to 2009

		Bulk Sample	Pit	Bone concentration	Midden	House floor	Total
Soil in liters		2070	532	775	128	131	3636
Total Samples		97	17	24	16	13	167
Fabaceae	Density	0.24	0.62	0.56	0.22	0.98	0.39
	Ubiquity	0.61	1.00	0.92	0.88	0.92	0.74
Lamiaceae	Density	0.02	0.04	0.02	0.01	0.03	0.02
	Ubiquity	0.15	0.59	0.29	0.50	0.15	0.25
Cyperaceae	Density	0.02	0.03	0.02	0.04	0.05	0.02
	Ubiquity	0.15	0.47	0.42	0.31	0.31	0.25
Polygonaceae	Density	0.03	0.03	0.02	0.02	0.02	0.02
	Ubiquity	0.10	0.59	0.37	0.06	0.15	0.20
Chenopodiaceae	Density	0.01	0.08	0.01	0.33	0.02	0.03
	Ubiquity	0.10	0.47	0.04	0.69	0.08	0.19
Astereceae	Density	0.00	0.01	0.01	0.01	0.02	0.01
	Ubiquity	0.07	0.06	0.17	0.06	0.15	0.09
Poaceae	Density		0.01	0.01		0.01	0.01
	Ubiquity		0.06	0.08		0.08	0.02
Rosaceae	Density	0.01	0.01	0.01			0.01
	Ubiquity	0.06	0.29	0.17			0.09
Euphoriaceae	Density			0.01			0.01
	Ubiquity			0.04			0.01
Pinaceae	Density	0.01	0.01			0.02	0.01
	Ubiquity	0.02	0.12			0.15	0.04
Betulaceae	Density			0.01			0.01
	Ubiquity			0.04			0.01
Unidentified	Density	0.09	0.15	0.11	0.27	0.21	0.12
	Ubiquity	0.63	0.82	0.88	0.94	0.92	0.74

(Continuation of the previous table)



The seed density of Fabaceae(0.24 to 0.98 seeds/ liter of soil) is much higher than any other families in bulk samples, pit features, bone concentration area, and house floor. At the same time, the ubiquity of Fabaceae(0.61 to 1) is the highest in all sample categories. This evidence proved the importance of *Fabaceae* in the subsistence economy of Stepnoye settlements. The seed density of *Fabaceae* suggested the highest frequency of the plant usage inside the settlements. And the ubiquity suggested Fabaceae are widely distributed inside/outside the human activity zone. These plant resources are closely related to the daily Bronze Age activities. Fabaceae are well known as high nutrition fodder over the world. It is no surprised that Bronze Age pastoralist societies in Uy river valley intensively use these plant resources for livestock. After fully boiling process, these seeds are edible for the human. The extremely high seed density and ubiquity among seed assemblage may partly be related to the human diet.

The seed density of Lamiaceae(0.01 to 0.04 seeds/liter of soil) is quite low in all samples, but the ubiquity is relatively high in Midden(0.5) and Pit(0.59) features. In Uy River valley, Lamiaceae also plant families found in meadow zone. The leave and steam parts of the identified *Mentha* spp. are edible for human/livestock. The usage of these plants may be similar to *Fabaceae*, but the low seed density suggests they are just by-products from *Fabaceae* usage.

The seed density of Chenopodiaceae(0.33 seeds/liter of soil) is the highest family in the midden samples. And the ubiquity in pit feature(0.47)and midden deposit(0.67) is quite high among seed assemblage. However, in other sample categories, these numbers are low among all families. It suggests the usage of Chenopodiaceae are closely related to the function and formation of specific features. The midden deposit is outside the Stepnoye settlement. The major cultural layer is an ash layer filled with archaeological materials from the enclosed settlement. Ash layer usually formed from long burning process. And the thickness of the layer suggested a long period dumping process in this area. Thus this layer may comprise the plant remains from the settlement and natural plant remains located in the midden deposit. Since midden deposit is a constantly disturbed area, it is a typical ruderal zone in the modern villages. *Chenopodiaceae* always dominates the vegetation in this zone. Some of the Chenopodiaceae seeds in midden samples may not relate to the human activities inside the enclosed settlement but the plant growth in the midden deposit outside the settlement. Thus the contribution of Chenopodiaceae for subsistence economy may be lower than the statistical number reflected in the archaeobotanical samples.

There are 4 pit features recovered in Stepnoye settlement, 3 of them found in the east section, and 1 in the west section. The seed density and ubiquity of Chenopodiaceae are uneven in these features. In 3 pits in the eastern section, the seed density and ubiquity is 0. All of the Chenopodiaceae are related to the deep pit in the western section. The depth of the pit is 228 cm, this depth is about 100cm than average steppe soil level in Stepnoye excavation. Compare with other Sintashta-Petrovka Settlement; probably this pit is a collapsed well. A further detail comparison between the well features from Stepnoye and Ust'ye will present in chapter 5 .

Same as Chenopodiaceae, Polygonaceae also plant found in ruderal zone. The seed density(0.02 to 0.03 seeds/ liter of soil) is low in all samples, but the ubiquity is high in pit (0.59) and bone concentration area(0.37). The pit and bone concentration feature usually comprised the food remains from daily life. *Identified Polygonaceae*(*Polygonum* spp. and *Rumex* sp.) can be roasted and consumed by the ancient human. Thus these seeds may be used as food resources in Bronze Age Stepnoye settlement.

The seed density of Cyperaceae is low(0.02 to 0.05 seeds/liter of soil) in all samples. The ubiquity is higher in feature samples(0.31 to 0.47), but much lower in bulk samples (0.15). Cyperaceae can be widely used for different purpose. The seed of the identified *Carex* spp. can be roasted and consumed by the ancient human. The stems can be used for basket crafting in modern village. The habitat of Cyperaceae is riparian zone along the Uy river valley not close to Stepnoye settlement. Thus charred seed appeared in archaeobotanical samples inside/outside the settlement should be related to human gathering used in daily life.

The ubiquity of Rosaceae is relatively high in the pit (0.29) and bone concentration features(0.17). The modern plant related to the identified *Fragaria/Potentilla* sp. is wild strawberry can be edible as raw. And these seeds just found inside the settlements. Thus we can assume these seeds are food resources for Bronze Age pastoralists.

The seed density and ubiquity of Asteraceae, Poaceae, Euphorbiaceae, Pinaceae*, and* Betulaceae are very low among all samples. All these families can find in the surrounding area of Stpenoye settlement. It can bring in the settlement by human, livestock or natural force(wind or rain). Thus the detailed reason is difficult to discuss by the low numbers here. The recovered of all plant species from the surrounding area of Stpenoye settlement suggested a strong local catchment based subsistence economy for plant resource exploitation.

The total numbers, percentages, densities, and ubiquities of families show a clean pattern that Fabaceae is the only dominant plant resources in the subsistence economy. The recovery of charred seed from other families in different features are related to the function of these plants and the formation of the feature. For further discussion, a comparison of plant resources usage and features between Stepnoye and Ustye will present in chapter 5.

4.3 STRELETSKOYE 1

4.3.1 Streletskoye 1 excavation

The settlement of Streletsk 1 is an unfortified site located on the left bank of the Ui River, approximately 3 km to the southwest of the Chernorech'ye modern village and 13 km to the southeast of Stepnoye. Streletskoye 1 is one of the largest Bronze Age settlements in the Uy River

Valley(Kupriyanova et al. 2013). The settlement includes eight house-depressions and a significant midden deposit layer located on the periphery of the house-depressions running parallel with the edge of the Uy River (Figure 22). In 2012, excavation units covered 400 sq. meters and were placed over the visible midden deposit that is exposed along the river bank. The objective of the research was to recover archaeological finds associated with the erosion of the river bank.

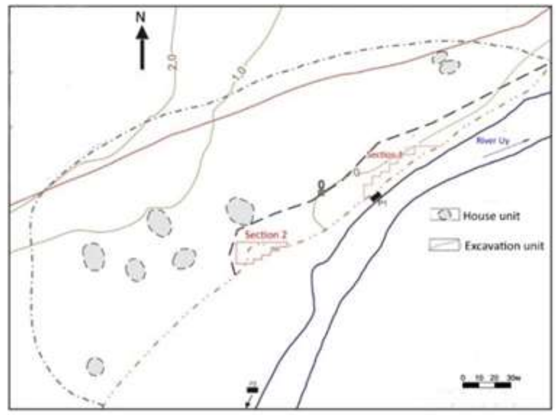


Figure 22 Left –Aerial transect during the period of 2012 Streletskoye 1 excavation showing the excavation area(Modified from Hanks 2012; Right – Streletskoye 1 house depressions and excavation area(Modified from Bikmulina et al. 2017)

The 2012 excavation season was the first conducted at the Streletskoye 1 settlement. The excavation did not cover the area associated with the house depressions and rather focused specifically on the midden area. The exposed midden layer that was excavated during the 2012 excavation at Streletsk 1 was filled with ashy soil mixed with archaeological artifacts. These findings are an important indicator of repeated burning processes through human activity at the site. The ash layer of the midden deposit produced numerous archaeological finds.

The ceramic artifacts of the excavation represented several Bronze Age cultures in this region and included: Sintashta-Petrovka, Alakul, and Sargary culture (Kupriyanova et al. 2013).

Most of the ceramics could be relatively dated to the Late Bronze Age Alakul culture (1700-1500 BCE). The Sargary ceramic all come from the upper part(-20 to -40 cm) of the ash layer. Most of the ceramic from the ash layer are Alakul culture. Only several pieces of Sintashta-Petrovka ceramic are found in the bottom of excavation section 1. Based on the analysis of artifacts from the 2012 excavation at Streletsk 1, most of the midden deposit is related to the Alakul culture represented by the Late Bronze Age (1700-1500 BCE) in this region (Kupriyanova et al. 2013;

Bikmulina et al. 2017). Thus, the formation of the ash layer is mainly related to the Late Bronze Age.

More than 4,000 artifacts were recovered during the excavation and represented Ceramic sherds, animal bones, lithic debitage and cores, stone tools and objects, bronze sickles, chisels, bone ornamentation, ritual objects (ornaments, amulets, astragals for play or fortune-telling), miniatures-Ceramic and ceramic vial. The excavation was separated into two sections (Figure 22). The nature of the artifacts in each section differs in terms of overall number recovered and their type.

In Excavation section 1, most artifacts represented household waste (e.g. fragments of ceramic vessels, processed faunal remains and broken stone and bone tools). In Excavation section 2, many of the finds are represented by waste products of technical production (blanks of stone and bone tools, chips, etc.) and different tools. Evidence of metallurgical production (e.g. slags, droplets, etc.) was not recovered, although several pieces of bronze objects were recovered in the excavation (e.g. sickles, chisels, needles and a knife blade fragment) (Kupriyanova et al. 2013).

As noted above, in 2016 I was awarded an NSF doctoral dissertation improvement grant to research the subsistence economy among Bronze Age communities in the South Urals region. Previous research had been undertaken in the region with support from SCARP and focused on the collection of macrobotanical samples from Middle Bronze Age settlements. Thus, as part of my sponsored NSF doctoral dissertation research, I decided to return to the Ui River valley in the summer of 2017 to collect additional samples related to the Late Bronze Age and, more specifically, the settlement of Streletskoye 1. With the assistance of Russian colleague Natal'ya Batanina (Chelyabinsk State University), I collected 13 soil samples for macrobotanical flotation at Streletskoye 1 during the 2017 field season.

4.3.2 Streletskoye 1 flotation samples

The aim of the archaeobotanical work in Streletskoye 1 is collecting comparative samples from LBA settlement in Uy river valley. The midden deposit previously identified and excavated in 2012 at this settlement provided an important opportunity to examine possible macrobotanical subsistence evidence at this site that was representative of the Late Bronze Age. The finds from previous excavations suggested that the midden deposit at Streletsk 1 was closely related to the human occupation at the site. Experience gained during field research at the Stepnoye and Ust'ye excavations, and their associated midden deposits, provided essential archaeological data about these communities. Midden deposit located outside the settlement usually comprised the archaeological remains from the human activities inside/outside the housing unit. The exposed ash layer profiles of the midden deposit are perfect for profile samples. Because the major ash layer is easy to identify on the profile. The exposed profile also save the field cost expenditure and time for excavation. Thus midden deposit is a good location for profile sample collecting to study the subsistence economy.

4.3.3 Sampling strategy and field method

The aim of the archaeobotanical work in Streletskoye 1 is collecting comparative samples from LBA settlement in Uy river valley. The midden deposit previously identified and excavated in 2012 at this settlement provided an important opportunity to examine possible macrobotanical subsistence evidence at this site that was representative of the Late Bronze Age. The finds from previous excavations suggested that the midden deposit at Streletsk 1 was closely related to the human occupation at the site. Experience gained during field research at the Stepnoye and Ust'ye excavations, and their associated midden deposits, provided essential archaeological data about these communities. Midden deposit located outside the settlement usually comprised the archaeological remains from the human activities inside/outside the housing unit. The exposed ash layer profiles of the midden deposit are perfect for profile samples. Because the major ash layer is easy to identify on the profile. The exposed profile also save the field cost expenditure and time for excavation. Thus midden deposit is a good location for profile sample collecting to study the subsistence economy.

In the summer of 2017, I collected samples from remaining accessible profiles of the 2012 excavation (areas not backfilled following the 2012 excavation). The midden deposit cultural layer was composed of ash. Recovered artifacts included: animal bones, pottery fragments and lithics from the house units. No clear architectural features were identified within the excavation area during the 2012 season. Based on the typology of the diagnostic ceramics(little MBA ceramics found in the bottom of the cultural layer, and FBA ceramics only found in the upper part of the ash layer), it can be suggested that the Streletskoye 1 midden deposit was mainly formed during the LBA.

A total of thirteen flotation samples were collected and fully analyzed during the summer of 2017. All of the samples were collected from the identified cultural level as revealed in the exposed excavation profile(Figure 23). All analyzed samples were given a laboratory number that was matched to the flotation sample number on the tags. The laboratory number was assigned to the flotation sample before analysis. The sample context number was associated with the excavation section where the samples were collected. The general information of the flotation samples is displayed in Table 13.

Table 13 General information of recovered plant remains in macrobotanical samples from Streleskoye 1

	Section1	Section2	Total
Total(charred seed)	33	9	42
Grams of charcoal	0.058	0.123	0.181
Liter of soil	63	28	91
Total(samples)	9	4	13
Total(sample with seed)	9	4	13
Charcoal density	0.001	0.004	0.002
Seed density	0.53	0.32	0.46
Ubiquity(charred seed)	1	1	1

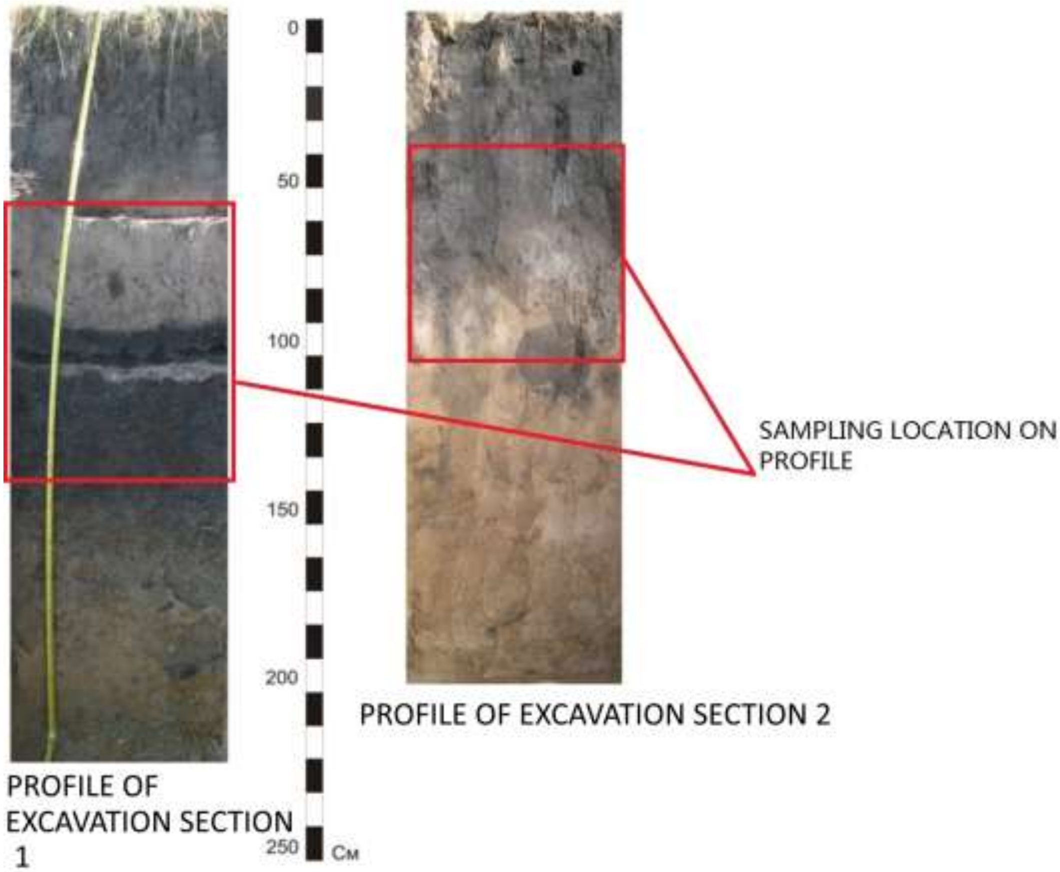


Figure 23 The Sampling location on the Streletskoye 1 midden deposit profile

Bucket flotation is the major process to separate charred plant remains from soil deposits collected from the midden deposit layer. Soil samples were separately collected from the profile of the 2012 excavation Units 1 and 2(Figure 23). The standard volume for every sample was 7 liters. Nine samples were collected from Unit 1 and four samples collected from Unit 2. Those samples were randomly collected from the stratigraphic layer that contained Alakul' ceramic sherds. The collected samples were floated on site. Samples were measured with a bucket with volume measurements that were recorded to the nearest 0.5 liter. Mesh screen of 0.2 mm was used to collect the light fraction from the surface of the bucket. Agitation of the soil in the water was continued until no additional charred material was observed floating on the water surface. The light fraction was transferred to a muslin pouch for air drying. The flotation samples (light fraction) were air-dried and bagged in a local laboratory. The light fraction was kept in a shaded location to prevent possible cracking of the recovered macrobotanical specimens. All recovered elements, such as seeds, charcoal, bronze pieces, animal bones, and lithics were extracted from each sample. In total, 91 liters of soil were floated and all samples contained charred plant remains.

4.3.4 Interpretation of flotation samples

Charcoal specimens larger than 1 cm in size recovered from the flotation sample were collected and weighed. A total of 0.181 grams of charcoal were analyzed (Table 13). *Betula pendula* and *Pinus sylvestris* were the dominant species recovered and identified from the Streletskoye 1 settlement. Both species can be considered as major species within surrounding forests today within the region. This evidence suggests that timbers may have been collected from the steppe woodlands in the local environment. The charcoal density of 0.002 grams per liter of soil recovered from the flotation samples. This number is much lower compared with macrobotanical data from Stepnoye excavation in the Uy river valley where the charcoal density in different features ranged from 0.05 to 0.13 grams per liter of soil (Table 13).

The charcoal density is highly related to the function of features, subsistence model, and local resources. Higher charcoal density usually relates to the frequency of human activity. The reason for the low charcoal density of the Streletskoye-1 samples may relate to the formation of the midden deposits. The ashy mixed material from this stratigraphic layer represents materials that may have been removed from hearths/ovens and dumped in this location adjacent to the pit-house features in the site. During the sample collecting process, we can’t see any sample that comprises a significant amount of charcoals. The formation of the ash layer is related to a long-time burning process(Bikmulina et al. 2017), and this process usually destroys most charcoal in the feature. For example, The charcoal density of Stepnoye midden deposit(0.06 grams per liter of soil) also relatively lower than other features. Thus, the low charcoal density of Streletskoye 1 midden deposit just partly reflect the frequency of human activity in the settlement.

The Seed density of Streletskoye 1 midden deposit is 0.46 seeds/liter of soil. In comparison, this number is lower than Stepnoye archaeobotanical samples(0.62 seeds/liter of soil), but higher than the seed density just in Stepnoye bulk samples(0.4 seeds/liter of soil). Since my dissertation research at Streletskoye 1 focused on collecting samples only from an ashy midden layer outside the house structure, it may be expected that soils associated with burning and burned features could produce the lower seed density. At the same time, the ubiquity of charred seed in Streletskoye 1 flotation samples is 1. This number is very similar to the ubiquities of charred seed in Stepnoye midden deposit (0.94). Thus, we can assume the recovery rate of charred seed is similar in Stepnoye and Streletskoye midden deposit. And the frequency of plant resources usage and associated features in both site may be similar too.

Compare with two excavation sections, the Seed density is higher in excavation section 1, but the charcoal density is a little higher in section 2(Table 14). According to the archaeological materials, section 1 is filled with the household trash, and section 2 is mainly related to waste products of technical production(Kupriyanova et al. 2013). This pattern suggested charred seeds may be more close related to daily human activities inside the house unit, and charcoal is widely used in technical production. To better understand this differentiation, a further study inside the Streletskoye 1 house units is required to provide comparison data in the future.

Flotation analyses produced a total of 42 carbonized seeds and seed fragments (Table 14). There are 32 seeds around 75% of the charred seeds could be identified at least to family level. In total, over 10 different species (at genus and species level) from 7 plant families were present. The number of unidentified seeds is 10. All of these fragments appear to have some characteristics of the Fabaceae family (*Medicago* spp. and *Vicia* sp.), but the characterized part for identification is missing among these seed fragments. Thus we just group it as unidentified in this dissertation.

Table 14 The total number and percentage for all families in the botanical samples from Streletskoye 1

		Section1	Section2	Total
Total	Total	33	9	42
	Percentage	0.79	0.21	
Fabaceae	Total	10	4	14
	Percentage	0.31	0.45	0.34
Cyperaceae	Total		1	1
	Percentage		0.11	0.02
Salicaceae	Total	2		2
	Percentage	0.06		0.05
Chenopodiaceae	Total	3	1	4
	Percentage	0.09	0.11	0.1
Rosaceae	Total	8		8
	Percentage	0.24		0.2
Rubiaceae	Total	1		1
	Percentage	0.03		0.02
Caryphllyllaceae	Total	2		2
	Percentage	0.06		0.05
Unknown	Total	7	3	10
	Percentage	0.21	0.3	0.24

Among the carbonized seeds, the most common plant family represented is Fabaceae (*Medicago* spp. and *Vicia* spp.), followed by Rosaceae (*Potentilla/Fragaria* sp.)(Table 11). 34% of the seeds identified are represented by the Fabaceae family (N=14 seeds) and the Rosaceae family(N=8 seeds) is represented by 20 % of the total seeds recovered. Moreover, the number of seeds from other identified families are much lower than Fabaceae. This pattern is very similar to the pattern of archaeobotanical samples recovered from the Stepnoye settlements in Uy river valley. All of the identified seeds in these samples are representative of plants that grow around the site today. Moreover, none of these species have been cultivated plant in this region. These results help us to understand the usage of the landscape and the herding pattern associated with this particular settlement. The identified macrobotanical remains originated from different vegetation within the site catchment zone. However, most of these grow in specific vegetation units according to their specific habitat requirements. The major requirement for these plants in this region is water supply and the best pastures still can be found along the river today. According to the environmental constraints around the ancient settlement(Figure 24), and the observed comparative modern vegetation, the recovered and identified carbonized seeds will be briefly summarized below.

Figure 24 The surrounding environment of Streletskoye 1 settlement

4.3.5 Interpretation of charred seeds

There are two genus from the Fabaceae family that have been identified at the Streletskoye 1 site; *Medicago* spp. and *Vicia* spp. *Medicago* spp. and *Vicia* spp. are valuable plants for foddering livestock in this region today. Most of these species can be identified within the meadow zone along the floodplain of the river. The size and nature of the meadow zone can vary due to rainfall and overall water levels but the best pastures for contemporary herding are located in this zone today. According to the morphology, size and local availability, the Vicia sp. from Streletskoye 1 are likely *Vicia cracca*. The *Medicago* spp. are likely *Medicago lupulina* and *Medicago sativa*.

The identified Rosaceae seeds are *Fragaria* sp. During the field work period, these plants can easily found on the surface of house depressions. In Uy river valley, *Fragaria* spp. fruit can easily be collected in summer. Nowadays, *Fragaria viridis* L. is commonly gathered by local people and eat raw. The total number(8)and percentage(24%) of Rosaceae is quite high among other plants in the archaeobotanical samples. And all these seeds come from excavation section 1, they may eat by ancient people as today.

The riparian zone in Streletskoye 1 comprises several *Carex* species (*Carex distan*s and *Carex ovalis*),. They are part of the Cyperacea*e* family and can be found in wetlands along the river. The leaves and stems can be used as basketing materials now.

The Chenopodiaceae family is dominant in the ruderal zone. The ruderal zone represents the disturbance of natural steppe by human and/or animal activities. In the Streletskoye 1 samples, *Chenopodium* spp. (*Chenopodium album* , *Chenopodium polyspermum* and *Chenopodium hybridum*) were recovered. In the upper part of the ash midden layer at the site, significant amounts of modern Chenopodium album L. were recovered. Because of substantial herding activities associated with the surrounding villages in this region, the Chenopodiaceae family is widely spread around the settlement area.

The identified Saliaceae is *Salix* sp. that may be related to fuel usage. In Streletskoye 1, these trees are growing along the river bank. Compare with *Pinus* sp. and *Alnus* sp. from forest zone, *Salix* sp. is small shrub or tree close to the settlement and easier to get. In the identified charcoal pieces, we cannot find *salix* sp. The reason may be related to the size of *salix*, it is easier to burnout compare with pine and betula. Thus in the midden deposit with long time process, salix usually burns to ash without charcoal remains. These *salix* seeds only found in section 1 suggested the *salix* may rarely use in technical production. People in Streletskoye 1 probably use it in daily cooking because of the easy accessible location.

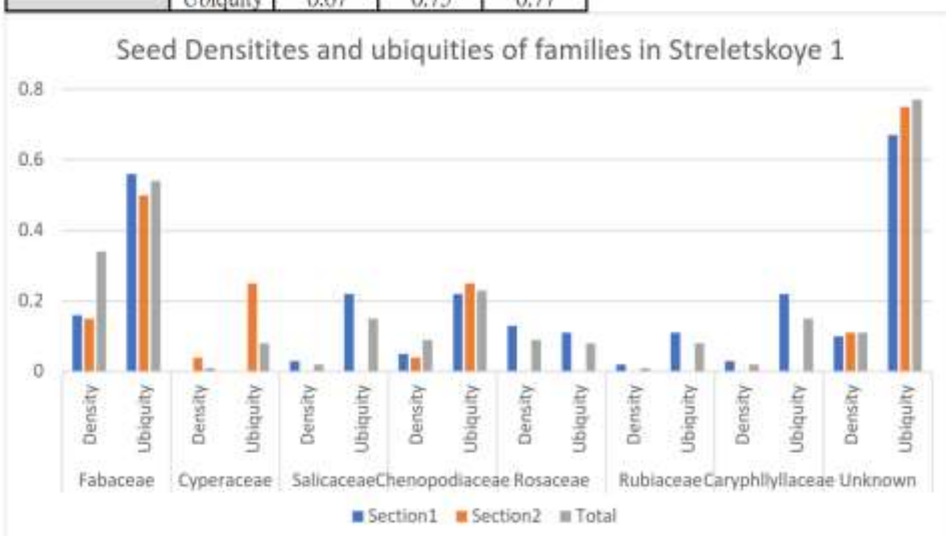
There are no seeds recovered from flotation samples associated with a forest zone. The identified charcoal mainly *Pinus* sp. and *Alnus* sp. Both plants are major species found in local forests today. Charcoal pieces from the macrobotanical samples represented these species and appear to indicate either the collection of wood being used for fires or burned wooden construction materials associated with the settlement.

The total number and percentage of Rubiaceae and Carphllyllaceae are very low in archaeobotanical samples. The identified Seeds are *Galium* sp., and *Silene* sp. In Uy River valley, these plants are very common wild grass in the Steppe zone. it can bring in the midden deposit by livestock and natural force(wind or rain).

Besides of Total number and percentage of families, the seed densities and ubiquities listed in Table 15.

Table 15 Seed densities and ubiquities of all families in the botanical samples from Streletskoye 1

		Section1	Section2	Total
Soil in liters		63	28	91
Total Samples		9	4	13
Fabaceae	Density	0.16	0.15	0.34
	Ubiquity	0.56	0.5	0.54
Cyperaceae	Density		0.04	0.01
	Ubiquity		0.25	0.08
Salicaceae	Density	0.03		0.02
	Ubiquity	0.22		0.15
Chenopodiaceae	Density	0.05	0.04	0.09
	Ubiquity	0.22	0.25	0.23
Rosaceae	Density	0.13		0.09
	Ubiquity	0.11		0.08
Rubiaceae	Density	0.02		0.01
	Ubiquity	0.11		0.08
Caryphllyllaceae	Density	0.03		0.02
	Ubiquity	0.22		0.15
Unknown	Density	0.1	0.11	0.11
	Ubiquity	0.67	0.75	0.77



The seed density(0.34 seeds/ liter of soil) and ubiquity(0.54)of *Fabaceae* are highest in both excavation sections. It suggested the importance of *Fabaceae* are high in the subsistence economy of Streletskoye 1. Fabaceae is the main plant resources widely used by ancient human in Streletskoye 1. The seed density(0.13 seeds/ liter of soil) of Rosaceae are also high in section 1, but the ubiquity(0.11) is low among all plants. The identified Rosaceae seeds probably wild strawberry gathered by ancient people. The fruit can eat raw as a whole, and make jam in the local villages now. It is a seasonal plant resource just available for a short period in summer. The low ubiquity can be partly related to the seasonal availability of this plant.

Chenopodiaceae has a relatively low seed density(0.09 seeds/liter of soil) and high ubiquity(0.23). Chenopodiaceae can be overrepresented in archaeobotanical samples because of the reproduction rate. And the area around the house depressions after disturbed by human/livestock always filled with Chenopodiaceae plants. It also increases the chance that these seeds to get in the settlement.

Overall, the plant remains from Streletskoye 1 and Stepnoye in Uy River Valley share some similar traits. First, we can see the intensive use of Fabaceae in two sites. Second, all of the plant species can found in the local catchment zone surrounding the settlement. Third, most of the recovered families are the same in Streletskoye 1 and Stepnoye archaeobotanical samples. The reason for these similarities can be a similar microenvironment setting(weather, vegetation, and rainfall)because the distance of two settlements is less than 20 km, and located in the same river valley. The primary component of the subsistence economy in two sites is pastoralism also make the plant usage pattern are similar.

Besides the similarities of the two settlements, the interesting thing is the differencing between two sites. The main occupation phase of Stpenoye is MBA, while Streletskoye is LBA. Stpenoye is a big enclosed settlement with approximately 50 house units(Johnson 2014:67), and Streletskoye 1 is an unfortified settlement with 8 house units(Bikmulina et al. 2017). The archaeobotanical result from two sites suggested the subsistence economy of MBA and LBA are similar and probably no differences in plant usage pattern. The size and population of the settlements may not cause the change of subsistence economy during MBA to LBA. The location of Bronze Age settlements is related to the distribution of specific plant resources, for example, Fabaceae. Thus, most of the plant resources are local catchment based and used by the bronze age pastoralist in two settlements. The result of the phytogeographical survey, ethnographic study and experimental work in Uy river valley in the following chapter will present a detail discussion about these traits.

5.0 RESEARCH IN THE NIZHNII TOGUZAK RIVER VALLEY

In the 2013 field season, SCARP began excavation at the Ust'ye settlement. This season of research followed on from previous campaigns in 2011 and 2012 that focused on geophysics and geochemistry of the settlement, associated cemetery (Solntse II), and other identified Bronze Age settlements and cemeteries within the Nizhnii Toguzak River valley. These research activities were funded through a new AHRC-NSF-MOU grant that was obtained in 2011 (#1024674). This program of research sought to extend the work completed in the Uy River valley and Stepnoye settlement through a more comparative framework of research in another valley. A similar set of research questions focused on examining local catchment zones in the Nizhnii Toguzak River valley related to settlement patterning, mining and metal production, and subsistence economies. The experience I gained through my collaborative research with SCARP at Stepnoye was applied at the Ust'ye settlement, which focused on sample recovery and botanical analysis both from contexts within the enclosed area of the settlement and in areas adjacent to the settlement.

Ust'ye is a Bronze Age settlement located on the Nizhnii Toguzak River valley. It consisted of four hypothesized settlement phases (Zdanovich & Batanina 2002) in which Ustye I was interpreted as a fortified Middle Bronze Age settlement. The other four phases were interpreted as unfortified Late Bronze Age occupations (Vinogradov 2014). The size of the settlement is about 28,000 sq. m (23,000 sq. m within the enclosed area of the settlement). Geophysics surveys were completed in 2011 by the SCARP team and these indicated that the overall size of the enclosed site was larger than previously thought and that additional phases of enclosure (bank and ditch features) were present (Hanks 2012; Hanks et al. 2013; Vinogradov 2013).

An earlier project that focused on AMS dating of the Bronze Age in the Southeastern Urals determined that there were three chronological occupation phases at Ust'ye corresponding to: Phase I (Sintashata) 2030-1770 cal. BC, Phase II (Petrovka) 1880-1740 cal BC, and phase III (Alakul-Srubnaya) 1670-1500 cal. BC (Hanks et al. 2007). The 2011 geophysics results also indicated that the exact boundaries of the Ust'ye I area comprised four possible phases, and at least 25 identified house structures (Figure 25; Figure 26) (Vinogradov 2013; Hanks et al. 2014; Hanks and Doonan 2009). Thus, the research undertaken at the Ust'ye settlement has the potential to contribute to a better understanding of the long-term subsistence economy history of Bronze Age pastoralist communities in the region.

Research at the Ust'ye settlement was first conducted by Professor Nikolai Vinogradov (Chelyabinsk State Pedagogical University, Russia) from 1984 to 1992 (Vinogradov 2013). Two occupation phases were identified in these early excavations. The oldest and deepest stratigraphic occupation levels correspond with Sintashta-Petrovka artifacts and the later upper stratigraphic levels with Petrovka artifacts.

Figure 25 upper - Google Earth view of Ust'ye settlement area and Solntse II Cemetery; lower – Soviet era air photo interpretation of Ust'ye settlement features (modified from Hanks 2012)

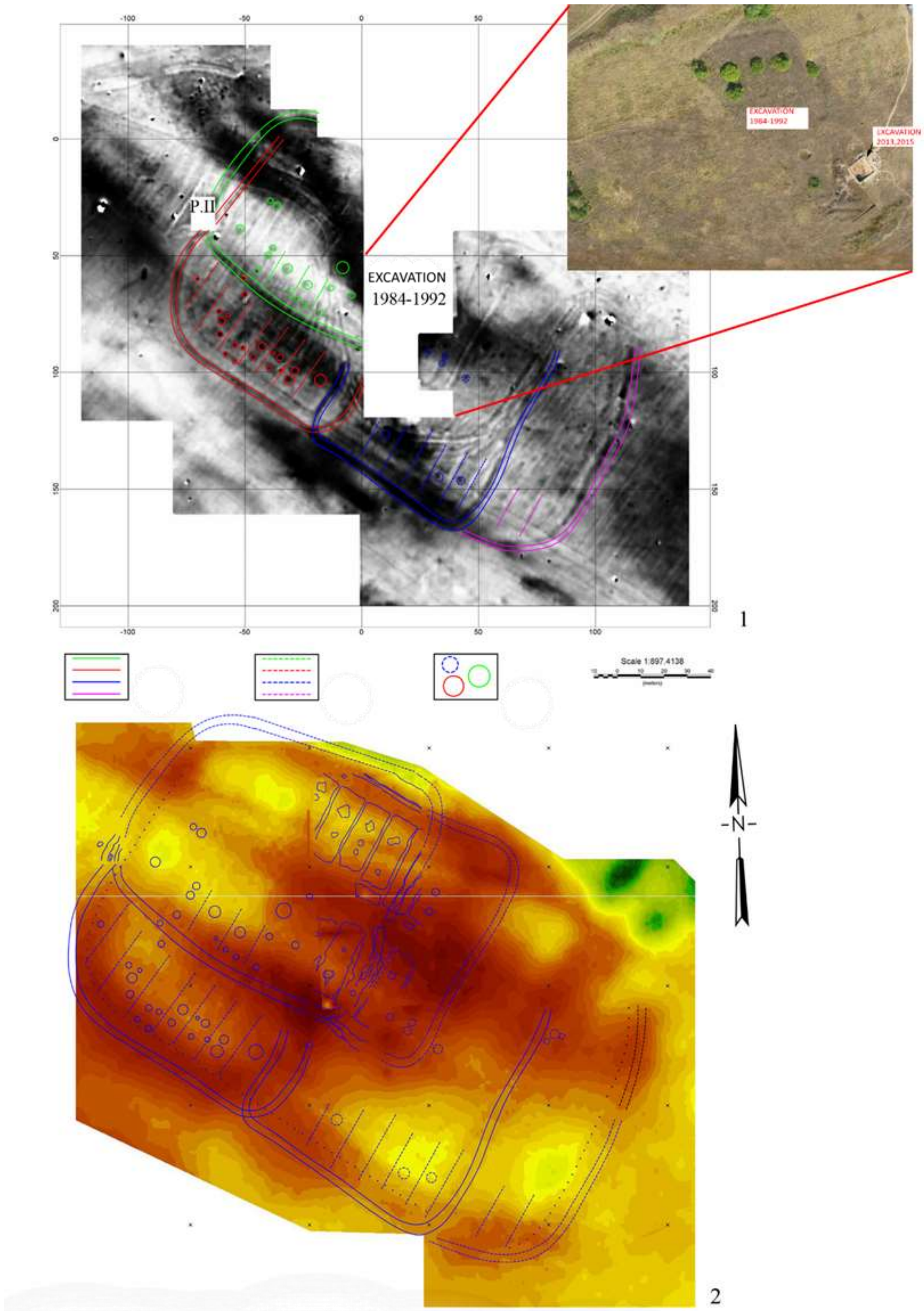


Figure 26 upper – Greyscale plot of 2011 geophysics survey and air photo showing the excavation units (Modified from Hanks 2012); lower – Topographical interpretation of the Ust'ye settlement features (Modified from Hanks 2012)

5.1 UST'YE, 2013-2015 EXCAVATION SEASON

The excavation conducted by SCARP in 2013 and 2015 was situated adjacent to the south-eastern side of Vinogradov's earlier excavations (Figure 26). The combined area of excavation in 2013 and 2015 was 64 sq. m. The excavation methodology followed conventional Russian methods of excavating in 10cm arbitrary levels (in more complex areas 5cm levels were used) and north-south vertical balks were left in place every 4 meters. The excavation grid units were labeled using a combination of the English alphabet and numbers (Figure 27). All excavated soils, except the surface soil layer and approximately 10 cm of root enriched soil below, were dry sieved through 1/4 inch screen. Artifacts were piece potted, and level and context forms were completed as well. All archaeological features were photographed and drawn. The excavation in 2013 was interrupted due to extreme weather conditions and was completed during the summer of 2015.

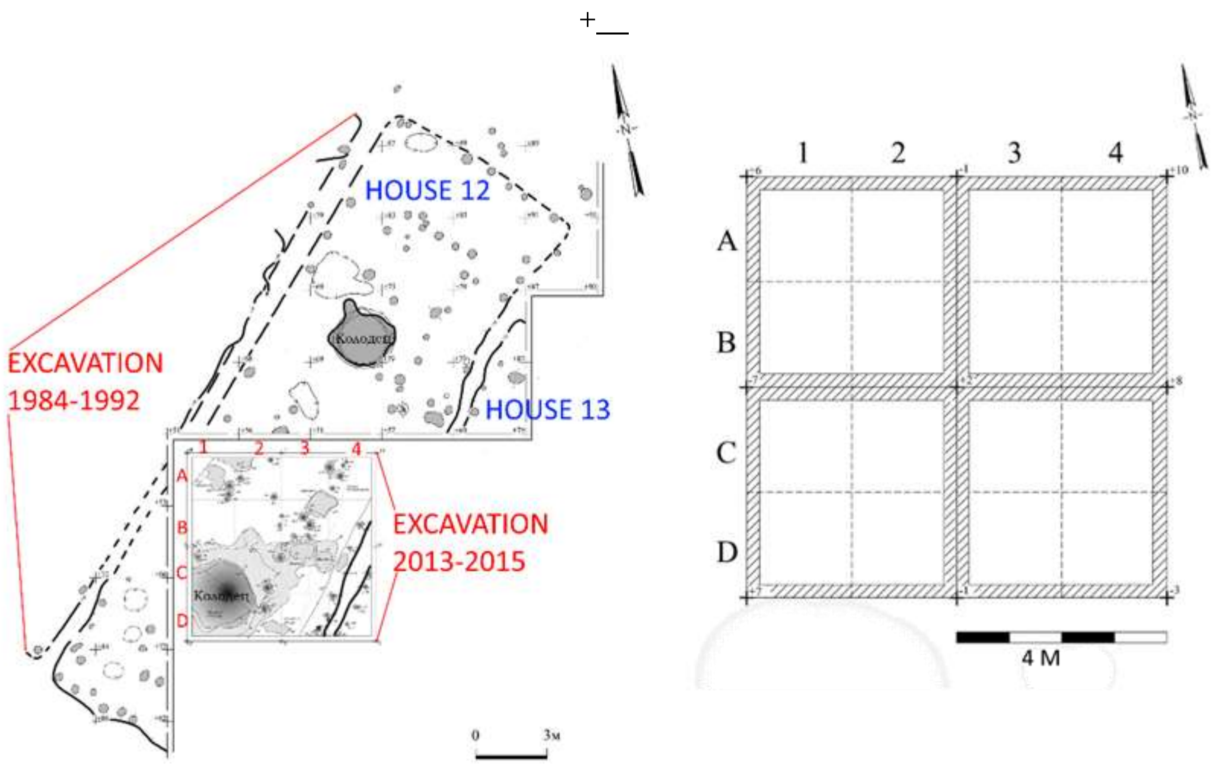


Figure 27 Left – Location and Plan of Ust'ye Excavation 2013 – 2015 excavation seasons (modified from Alaeva 2015); Right – Excavation coordinate scheme used for Ust'ye in 2013-2015 (modified from Alaeva 2015)

In the summer of 2013, 16 excavation units were placed in the southern part of house structure 12 at Ust'ye (Figure 27). The upper stratigraphic layer (level 0 to -20 cm) below the datum (cmbd) comprised a gray humus sandy loam soil and represented a mixed context of plow zone soil (Figure 28).

Figure 28 Photo of all excavation units at -10cm below the datum (modified from Alaeva 2015)

Figure 29 Left - Photo of all excavation units at -40 cmbd (modified from Alaeva 2015); Right - The profile of the well feature in unit CD1 (modified from Alaeva 2015)

Level -20 to -30 cmbd represented a stratigraphic layer immediately below the plow zone. The depth of the cultural layer ranged from - 40 cmbd near the edges of the excavation up to -420 cmbd at the bottom of the water well feature (Figure 29).

The western and southwestern zones (units ABCD 1-2, units ABC 3) of the cultural layers are represented by a dark gray sandy loam (Figure 29). The eastern edge of the excavation area exposed a surface of redeposited continental clay (units CD 4) that is situated near the boundary of the house structure (Figure 29). The northern part of this stratigraphic level contained numerous animal bones and small ceramic sherds. The levels encountered lower than -40 cmbd represented undisturbed cultural layers with finds of ceramics, animal bones, bronze artifacts, and metallurgical slags. The essential features of the undisturbed cultural layer included one water well feature (Object 5), a stone hearth (Object 1), 29 postholes (P1-29), and several artifact concentration depressions (Objects 2-4,6-8). The general information of identified features and postholes are listed in Tables 16 and 17.

Table 16 General information of postholes in the Ust'ye Excavation (Alaeva 2015)

Pit	Unit	Level of surface(cm)	Dimensions(cm)	Depth(cm)
1a	A-1	-49	28 x 20	30
1b	A-1	-50	38 x 32	26
1c	A-1	-52	40 x 40	24
2	A-2	-38	18 x 18	18
3	A-2	-44	35 x 30	34
4	B-2	-47	20 x 20	10
5	B-3	-44	16 x 16	10
6	A-4	-56	30 x 30	20
7	A-4	-50	14 x 14	14
8	A-4	-52	22 x 16	16
9	A-4	-55	20 x 18	10
10	B-3	-56	42 x 36	30
11	A-4	-52	56 x 44	40
12	B-3	-55	20 x 20	10
13	B-3	-54	22 x 24	22
14	B-4	-38	30 x 26	22
15	C-4	-40	20 x 14	8
16	C-4	-40	18 x 18	40
17	D-4	-44	34 x 30	24
18	D-3	-40	24 x 24	54
19	D-3	-38	48 x 24	20
20	D-4	-40	28 x 18	26
21	D-4	-40	20 x 17	28
22	C-2	-71	56 x 46	46
23	D-2	-60	34 x 30	46
24	A-2	-55	34 x 30	34
25	C-4	-32	16 x 16	24
26	B-3	-50	28 x 50	12
27	D-3	-40	20 x 20	20
28	D-4	-40	20 x 20	20
29	C-1	-48	26 x 30	30

Table 17 General information of identified features in the Ust'ye excavation (Alaeva 2015)

Feature	Function	Unit	Level of the surface (cm)	Depth(cm)
Object 1	Stone hearth	D 2-3	-49	16
Object 2	Artifact concentration depression	C 2-3	-53	20
Object 3	Artifact concentration depression	C 3	-53	5
Object 4	Artifact concentration depression		-43	22
Object 5	Well	CD 1-2	-90	330
Object 6	Artifact concentration depression	AB 3	-52	9
Object 7	Artifact concentration depression	A 1-2	-54	20
Object 8	Artifact concentration depression	A 1		

A total of 29 post holes (Level -32 to -71 cmbd) were situated in at least four parallel rows (Figure 30). The first row of postholes was situated in the south-east corner of the excavation unit and was likely associated with House Structure 13. The other three rows of post holes were associated with the east, west and central part of House Structure 12. The clear distinction of the rows of post holes aided the interpretation of the wall structure of the house unit.

Postholes in Ust'ye excavation

Postholes in unit CD 3-4

Figure 30 Upper - photo from Ust'ye excavation showing location of postholes (Alaeva 2015); Lower -photo from Ust'ye excavation showing row of postholes in unit CD 3-4 (Alaeva 2015)

The stone hearth (Object 1) was found adjacent to the water well (Object 5) in the house structure, located within unit D2-3 on the south side of the excavation unit (Figure 31). The location of the hearth is similar to other house units within the Ust'ye settlement. All the stones recovered from the hearth had traces of thermal exposure, indicated by fire-cracking and traces of the burning process (Alaeva 2015: 33-34). As part of house structure 12, the date of the hearth can be connected to the Petrovka period.

Stone hearth

Stone hearth(bottom)

Figure 31 Left - photo of Ust'ye excavation showing the stone hearth (Alaeva 2015); Right - photo from Ust'ye excavation showing lower level of stone hearth (bottom) (Alaeva 2015)

The water well (Object 5) was located in units CD 1-2. The construction of the well can be relatively dated to the MBA Sintashta-Petrovka phase, based on the identification of a Sintashta-Petrovka type vessel at the bottom of the well (Alaeva 2015:42). The function of this feature can be well established as a water well because the depth of the bottom (-420 cmbd) was below the level of groundwater. The collapse of the well walls and the formation of the upper levels of soil infilling most likely occurred during the later Petrovka occupation of the site (Alaeva 2015:42). The recovery of Sintashta-Petrovka type ceramics at the bottom of the well also helps in dating the construction of the well. The infill layers revealed mixed Sintashta-Petrovka and Petrovka type ceramics and suggest that the well was used in both periods.

Animal bones distributed at different levels suggest that the majority of the infill layers were related to household remains (Figure 32). The location of the well is clearly associated with the stone hearth (Figure 32). The major finds from the different levels of the well features are listed in Table 18.

Table 18 Major finds from different levels of the well feature

Depth(cm)	Dimension(cm)	Sintashta ceramics	Petrovka ceramics	Animal bones	Lithic
-90-110	260 x 240	4	2	156	
-110-130	210 x 200	1		20	
-130-150	180 x 180		1	45	
-150-200	160 x 160	1	7		
-200-250	100 x 100	2	4	15	4
-250-300	100 x 100	3	3	1	1
-300-350	90 x 90		2	102	1
-350-420	85 x 85	6		1	1

Figure 32 Left - photo from Ust'ye excavation showing location of well and associated stone hearth (Alaeva 2015); Right - photo from the Ust'ye excavation showing the faunal remains and ceramics on the profile of the well feature (at -250 cmbd) (Alaeva 2015)

Objects 2 and 3 were connected and formed an oval-shaped area with mixed Sintashta and Petrovka type ceramic sherds and fragmented animal bones. This may have been a ditch feature or passage to separate House Structures 12 and 13 (Figure 33). Object 4 was situated deeply under the post-holes located in units C4 (Figure 33). The location and layer of Object 4 suggests this is one of the earliest features associated with the house-structure that was constructed during the Sintashta-Petrovka period. Object 6 was located within units A3 to B3 from -52 to -59 cmbd (Figure 34). It was determined to be a portion of columnar pits, likely dated to the time of construction throughout both the Sintashta-Petrovka and Petrovka phases (Alaeva 2015). Three ceramic vessel fragments were found within this context. Objects 7 and 8 were small depressions located on the west side of the excavation. Both of them extend throughout the Sintashta-Petrovka and Petrovka phase constructions (Figure 35).

The recovered features and artifacts suggest that House Structure 12 is a typical house type dating to the Ustye I settlement phase. Most of the excavation units contained mixed Sintashta-Petrovka and Petrovka phase archaeological materials and only one feature Object 4 is confirmed to be related to the Sintashta period.

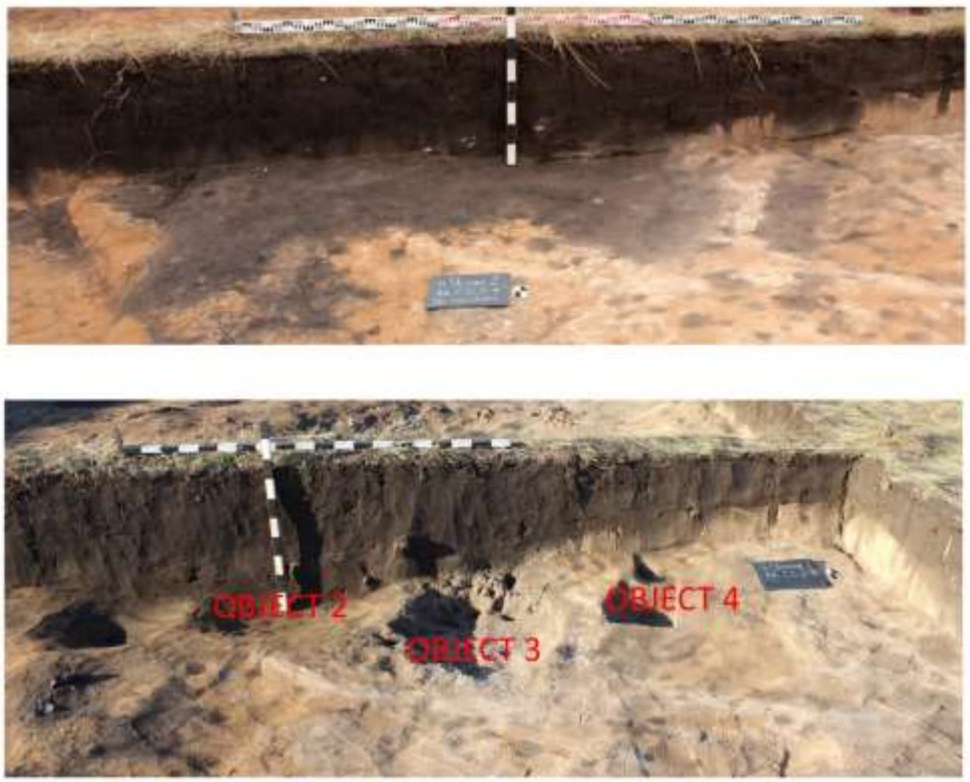


Figure 33 Upper - photo from Ust'ye excavation showing the location of Objects 2, 3 and 4 (Alaeva 2015); Lower - photo from Ust'ye excavation showing the structure of Objects 2,3 and 4 (modified from Alaeva 2015)

Figure 34 Photo from Ust’ye excavation showing the surface of Object 6 (Alaeva 2015)

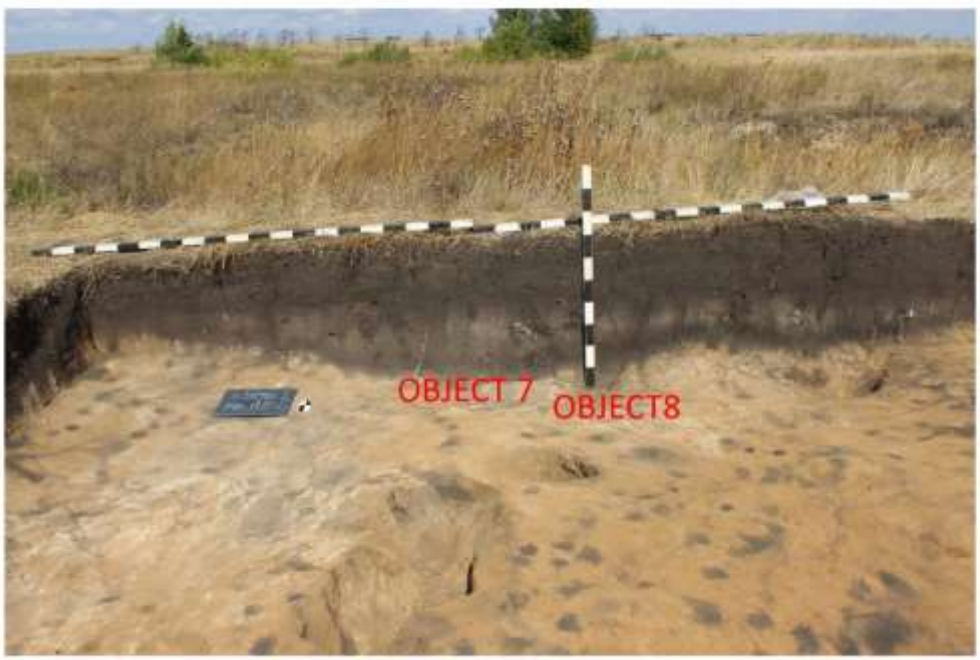


Figure 35 Photo from Ust’ye excavation showing the location and structure of Objects 7 and 8 (modified from Alaeva 2015)

The geophysical and geochemical surveys undertaken in 2011 identified a discrete midden deposit outside the Ust’ye settlement. In the 2012 season, a 1 m x 2 m test pit (Test Pit #1) was undertaken to investigate the structure of the midden deposit. This investigation identified large quantities of broken bone, slag and ceramic sherds. To further characterize the variability of finds and to acquire datable material, a 1 m x1 m test pit (Test Pit #2) was dug in 2015 just west of Datum 1 (Figure 36). Based on the experience of the Stepnoye excavations, the aim of the test pits was to provide ground truthing for the HHpXRF geochemistry and to produce essential archaeological materials from the midden deposit to compare with materials obtained within the enclosure of the settlement. The midden deposit was filled with fine ashy silts, the depth of the test pit to natural soil was approximately around -70 cmbd. No archaeological feature within the test pit was identifable. Similar to the midden deposit identified at the Stepnoye settlement, the Ust'ye midden deposit was formed by an ashy layer mixed with small bronze artifacts, ceramic sherds, animal bones, copper slags, and other archaeological materials. This suggests that the formation of the midden deposit was related to the daily deposition processes associated with the occupation of the Ust'ye settlement. All of the recovered ceramic fragments represent Sintashta-Petrovka and Petrovka types and suggest a relative MBA date range.

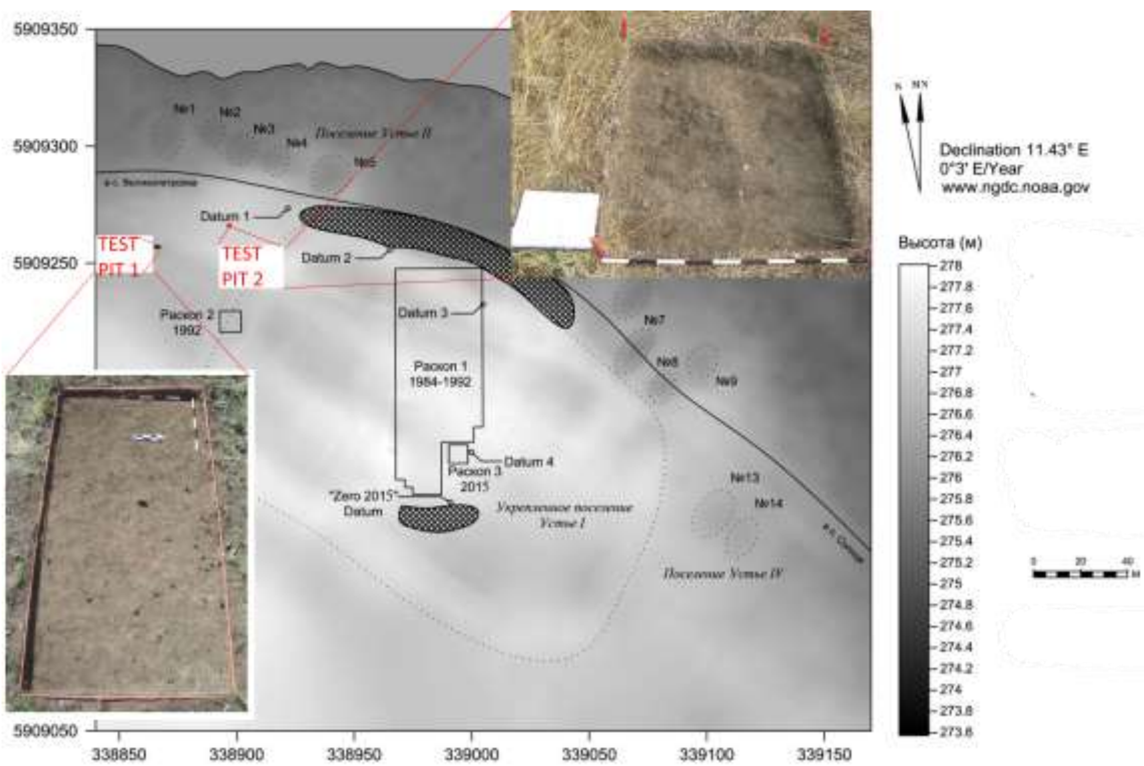


Figure 36 Excavation plan of the Ust'ye excavation showing the locations of test pit 1 and 2 (modified from Alaeva 2015)

Based on the data from remote sensing, excavation, test pitting, and materials analysis, we can assume the Ust'ye I settlement was constructed and functioned during the MBA Sintashta-

Petrovka phase with secondary occupation during the Petrovka phase. The two seasons of excavation (2013 and 2015) revealed additional areas in the southern zone of House Structure 12, but detailed features relating to copper smelting furnaces were not revealed. The excavation of Test Pit 2 outside the enclosure area revealed a thick ash midden deposit without any associated archaeological features. This test pit, and related geophysical survey, did not provide any evidence of MBA house structures being built external to the enclosure walls. However, these studies did provide important information relating to human activities and the deposit of archaeological materials that were closely related to the occupation of the enclosed area of the settlement.

Based on the recovered artifacts and the associated archaeological features, all collected archaeobotanical samples date to the MBA Sintastha-Petrovka culture. The collected soil samples for macrobotanical analysis were recovered from the identified MBA cultural layers and associated house floors, post holes, ditch and well features internally and the midden deposits external to the settlement enclosures features.

5.1.1 Sampling strategy

Soil samples were collected systematically from features and cultural layers from every level. The bulk samples (-20 to -90 cmbd) were collected as a comparative sample to determine the frequency of plant resources used in the settlement. Based on my experience during the excavation of the Stepnoye settlement, 15L samples were used as a standard volume for macrobotanical analysis. The actual volume may have been reduced due to individual archaeological feature sizes (pits, trenches, etc.). Soil samples were collected from every excavation unit (2 m x2 m). The sampling strategy was adapted to the excavation technique, by defined conventional horizons of 5-10 cm each, which allowed for sampling to be conducted within a vertical grid system. This design aimed to generate a sequence of archaeobotanical samples of Bronze Age houses and associated structures. It was envisioned that his data could then be combined with HHpXRF data collected at the same scale in order identify and characterize different activity zones related to the Bronze Age house structures.

Most of the excavation units (2m x 2m) were further split into four sections and soil samples were collected separately from each section. In this case, an additional number was added to the label of the excavation unit. A more detailed arrangement of this is noted in Figure 34. Additional soil samples were collected in locations were concentrated artifacts were encountered. All soils recovered from pit, trench, post mold, and midden features were taken for flotation. The excavation in 2013 was interrupted due to extreme weather conditions and was completed during the summer of 2015.

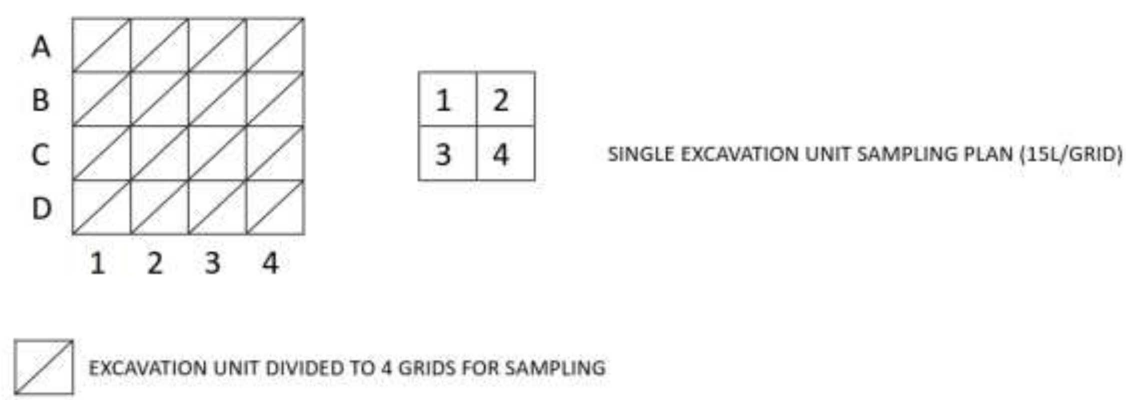


Figure 37 Sampling scheme of the bulk samples and excavation units in the 2013 and 2015 Ust'ye excavations

Additional soil samples for macrobotanical analysis were collected in 2015 from a midden deposit that was identified in 2011 to the north west of the settlement area. This midden deposit, which is located external to the enclosure features of the Ust'ye settlement, is situated approximately 30m from the stratigraphic excavation carried out in 2013 and 2015. This location was test trenched in the 2012 field season. It can be suggested that the midden deposit was continually used by the Ust'ye community during the MBA. The further characterization and test pitting of this midden deposit was carried out during the final 2015 season. I utilized the same sampling strategy for macrobotanical analysis of this feature as that employed in the enclosed area of the settlement. A total of 5 soil samples were collected from every 10 cm stratigraphic layer within the 1 m x 1 m test pit (Table 15 – "midden" column).

Table 19 General information of recovered plant remains from macrobotanical samples in the Ust'ye excavations in 2013 and 2015

	Bulk Sample	Midden	Well	Post Hole	Features	Stone Hearth	Total
Total(charred seed)	1749	83	1922	413	458	240	4865
Grams of charcoal	231.444	4.947	91.626	12.037	39.554	3.584	383.192
Liter of soil	6157	100	342	324	520	105	7548
Total(samples)	218	5	23	21	10	8	285
Total(sample with seed)	189	4	23	21	10	8	255
Charcoal density	0.038	0.049	0.268	0.037	0.08	0.034	0.051
Seed density	0.284	0.830	5.62	1.275	0.88	2.286	0.645
Ubiquity(charred seed)	0.867	0.8	1	1	1	1	0.895

Overall, a total of 285 samples were recovered (10 from features, 5 from the midden deposit, 218 from bulk samples, 23 from the water well, 21 from postholes, and 8 from stone hearth) from 7,548 liters of soil that were floated, processed, and dried during the 2013 and 2015 excavation seasons (Table 19). Based on the size of the individual features the collected soil volume varied. In most cases, the entirety of the soil removed from the features was taken for flotation. During the excavation of the upper stratigraphic levels samples also separately collected from every 10 cm level.

5.1.2 Interpretation of flotation samples

A total of 209 samples were taken during the 2013 excavation season and were primarily recovered from the cultural house floor layer and related features (pits, post molds, hearths, etc.). A total of 76 samples were taken in 2015, comprising 6 samples recovered from the ash layer of the external midden deposit. All analyzed samples were given a laboratory number matched with the flotation sample number on the tags. A total of 67 samples relate to discrete features. A total of 218 bulk samples were taken from identified cultural layers. In this case, samples varied in volume from 2 to 160 liters of soil, for a total of 7,548 liters of analyzed soil for both excavation seasons. Flotation samples and their associated contexts are displayed in Table 19 and as noted charcoal and charred plant seeds were the major components identified in the archaeobotanical samples recovered from Ust'ye.

Charcoal fragments larger than 1 cm that were identified in the flotation samples were collected and weighed. Charcoal was a major component identified in the Ust'ye archaeobotanical samples. A total of 383.192 grams of charcoal were analyzed (Table 19). The charcoal density was 0.051 grams/per liter of soil in the Ust'ye archaeobotanical samples. The number varied from 0.268 (well) to 0.034 (stone hearth) grams/per liter of soil. Charcoal density can be highly related to the function of anthropogenic features, subsistence practices, and the use of local resources. Importantly, compared with the Stepnoye excavation and archaebotanical analysis in the Uy River valley, the average charcoal density at Stepnoye from different features ranged from 0.05 to 0.133 grams/ per liter of soil. The lowest density also came from the bulk samples of the cultural layer without specific features in the Stepnoye samples.

This is a similar pattern found in the Ust'ye samples. The charcoal densities in the bulk samples (0.038 grams/liter of soil), postholes (0.037 grams/liter of soil) and stone hearth (0.034 grams/liter of soil) were lower than the charcoal density of all archaeobotanical samples. The lower charcoal density in the bulk samples is related to the upper stratigraphic levels that were mixed with natural deposition. The charcoal density associated with the postholes features was usually lower because the decay of the supporting pillar can be a slow process. Thus, the chance for charcoal to become part of the posthole infill can be lower compared with other features.

The stone hearth was filled with fire cracked stones but had very limited evidence of actual burning (i.e. limited evidence of charcoal or reddened soil). This feature was probably used as a thermal feature, possibly for steaming. However, there were higher numbers of charred seeds found in the stone hearth area. Presently, it is unknown how the stone hearth feature was used but there was evidence of burning near this feature and so related erosional features connected with site abandonment and disuse may have introduced material into the stone hearth and it collected there.

In Ust'ye, the stone hearth is associated with the well feature. In the upper layer of the well, we can see burned rocks from the hearth (Figure 35). This suggests that soils filled in part of the well from the adjacent hearth and other areas. Thus, the charcoal density (0.268 grams/per liter of soil) and seed density (5.62 seeds/per liter of soil) in the well are the highest among the archaeobotanical samples.

Figure 38 Left - photo from the Ust'ye excavation showing the well and associated hearth (Alaeva 2015); Right - photo from the Ust'ye excavation showing the fire cracked rocks near the well (Alaeva 2015)

Most of the identified features were artifact concentration depressions on the house floor. The charcoal density of these features was 0.08 grams/liter of soil. This number is the second highest among the archaeobotanical samples. It is similar to the charcoal densities of the house floor (0.07 grams/liter of soil) features in the Stepnoye settlement. These artifact concentration depressions may comprise the remains from the house floor of the house unit. Charcoal density can partly reflect the frequency of human activity in the sampling area, and wood/charcoal was widely used in Ust'ye for construction materials (Figure 39). For example, we found several large pieces of burned wood during excavation that may have been related to the house structure in units AB 3-4. The collapse of the house unit may have left burned charcoal within the artifact concentration features on the house floor.
The winter in the Southeastern Urals region is long and cold and this increases the frequency of fuel use inside the house units for heating purposes. This may explain why these features have higher charcoal density within the house unit. The comparison between the artifact finds in the midden deposit and features inside the house unit suggests that the formation of the external midden deposit was related to the daily life activities within the enclosed settlement. However, the charcoal density within the midden deposit (0.049 grams/liter of soil) was relatively lower than the features inside the house unit. The ash layer in the midden deposit suggested a long-duration burning process in this area. Most of the charcoal will be burned during this process.

Thus, we can expect a lower charcoal density in the midden deposit outside the settlement.

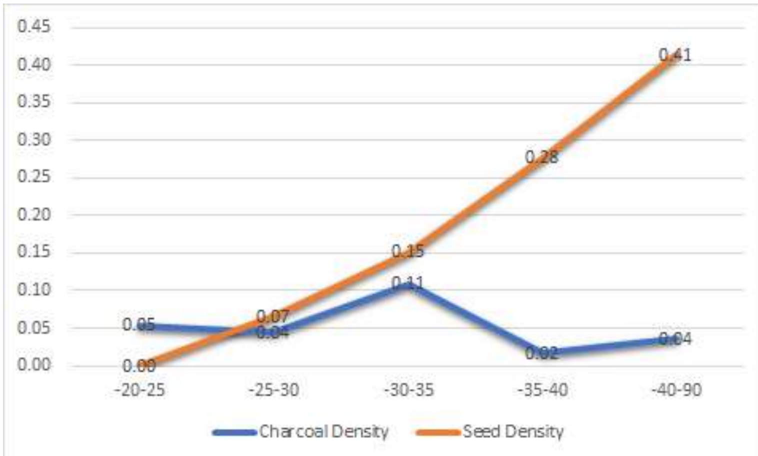
Figure 39 Photo from Ust'ye excavation showing burned wood fragments in units AB 3-4 (at -40 cmbd) (Alaeva 2015)

The charcoal density in the bulk samples was 0.038 this number is lower than the overall charcoal density of the Ust'ye samples. As was discovered during the excavations at Stepnoye, bulk sampling for macrobotanical analysis was an important strategy. At Ust'ye, we took samples from the upper stratigraphic levels (-20 to -40 cmbd) as comparative samples to check the overall disturbance of modern plowing activities on the preservation of plant remains (Table 20). The bulk samples were also removed from the cultural layers (-40 to -90 cmbd) and identified features. Such a sampling strategy provide an important comparative context with which to examine plant usage at the settlement.

The charcoal density from the upper stratigraphic levels also varied in different levels. This may be related to the disturbance of modern plowing. Also, human activities after the abandonment of the settlement can introduce charcoal into the upper stratigraphic layers. The charcoal density of the bulk samples at levels -40 to -90 cmbd was 0.04 and this number can better represent the frequency of charcoal remains within the settlement that were associated with cultural activity.

Table 20 The charcoal densities and seed densities of bulk samples at different stratigraphic level (-20 to -90 cmbd)

Level		Charcoal(g)	Total samples	Total(seeds)	Soil(L)	Charcoal Density	Seed Density
Upper	-20-25	33.85	17		624	0.05	0.00
	-25-30	30	16	44	671	0.04	0.07
	-30-35	65.34	30	91	599	0.11	0.15
	-35-40	21.434	37	342	1235	0.02	0.28
Cultural	-40-90	110.815	118	1271	3072	0.04	0.41



The charcoal remains were identified and assigned to two species: *Betula pendula* (Birch) and *Pinus sylvestris* (Pine). Both species are dominant in the Ust'ye archaeobotanical samples. These trees can easily be found in the surrounding forest today. This result is the same as the Kammenyi Amber archaeobotanical results as well as those from the Stepnoye project in the Southeastern Urals region (Ruhl et al. 2015). Besides the tiny pieces of charcoal that were recovered from the flotation samples, large charred wood blocks were also revealed in the excavation and were identified as these two species. It suggests that timbers were collected from the steppe woodlands in the local environment for both fuel and construction material.

5.1.3 Interpretation of charred seeds

Flotation of archaeological soil samples produced a total of 4,865 carbonized seeds and seed fragments. The seed density was 0.645 seeds/liter of soil in the Ust'ye archaeobotanical samples (Table 15). The number varied from 0.284 seeds/liter of soil (bulk samples) to 5.62 seeds/liter of soil (well samples) and the ubiquity of charred seeds was 0.895. This number varied from the midden deposit (0.8 to 1) for the well, postholes, features and stone hearth. The seed density (0.83 to 5.62 seeds/liter of soil) of all the features is much higher than the bulk samples. It suggests that the preservation of archaeobotanical remains was highly variable across the features. In Table 16, one can see a clear pattern of increasing seed densities from the upper stratigraphic levels to the lower undisturbed cultural layers (based on bulk sampling). This suggests that the preservation of charred seeds are related to later human activities at the site perhaps in a post-abandonment phase of occupation at Ust'ye 1.

The seed density (0.645 seeds/liter of soil) in the Ust'ye archaeobotanical samples is nearly the same as that encountered at Stepnoye (0.6 seeds/ liter of soil). Both projects utilized an intensive systematic sampling strategy. These results suggest that the frequency of plant usage in the two settlements may have been quite similar. When compared with the seed density encountered at the Kammennyi Ambar settlement (7.7 seeds per liter of soil), seed density is much lower at Ust'ye and Stepnoye. The reason is partly related to the sampling strategy.

The intensive, systematic sampling strategy that was employed at these two settlements through my dissertation research comprised significantly more bulk samples when compared with the feature focused sampling strategy employed at Kamennyi Ambar. This results in a significantly lower average seed density calculation because of the total soil volumes processed. Nevertheless, seed density estimates provide essential information concerning general plant usage patterns. Furthermore, bulk sampling also provides an important form of 'control' in which to compare the potential impact of seed remains from a single event associated with the use of specific archaeological features. For example, If we compare the well feature in Ust'ye and the possible well feature (deep pit in unit 2C) in the Stepnoye excavation, these wells always have an extremely high seed density among all samples processed at those sites (Table 21). The archaeobotanical research at Kammennyi Ambar focused on five well features and this focus may account for the high seed density in the archaeobotanical samples at that site.

Table 21 Comparison of seed density (seeds/liter of soil) in water well features in the Stepnoye and Ust'ye excavation

	charcoal	seed	soil	sample	seed density	charcoal density
stepnoye	63.655	463	496	14	0.93	0.13
ust'ye	91.626	1922	324	23	5.93	0.28

Major Families	Seed Density		Ubiquity	
	Stepnoye	Ust'ye	Stepnoye	Ust'ye
Fabaceae	0.5	0.84	1	1
Chenopodaceae	0.09	2.07	0.42	0.87
Cyperaceae	0.03	0.14	0.5	0.74
Polygonaceae	0.02	0.11	0.65	0.48
Poaceae	0.01	0.33	0.07	0.83
Rosaceae	0.02	0.06	0.29	0.39
Lamiceae	0.04	0.03	0.5	0.22

The seed density in the stone hearth (2.286 seeds/liter of soil) is the second highest among the archaeobotanical samples recovered at Ust'ye. This reason may be related to the function of this feature. The stone hearth may have been used for thermal feature, which increases the chance of charred seeds being introduced into the feature context. The stone hearth, and associated well feature, were suggested as a possible metallurgical production feature in the Russian field report (Alaeva 2015), However, this interpretation is not accepted by the project PIs Bryan Hanks and Roger Doonan. According to them, there was little supporting evidence for this feature being associated with metallurgy and the stones represented fire cracked rock that may have been produced through cold water being introduced to heated stones.

The seed density associated with this feature may provide important information about the function of this feature. The low charcoal density and high seed density suggests a relatively long burning process and high frequency of plant usage. In the Bronze Age, this stone hearth may have been used primarily for warming the house unit with a long burning time in winter and at night. Also, it may have been used for the cooking process and this would account for the high seed density. Therefore, the function of the stone hearth was likely related to daily activities and was not used for metallurgical production, as discussed above.

The range of seed densities from other features inside/outside the enclosed settlement feature was (0.83 to 1.275/liter of soil) and this is similar to the densities encountered at the

Stepnoye settlement (0.77 to 1.34/liter of soil). This suggests a similar frequency of plant usage at the two settlements. The total number and percentage of the identified plant families are listed in Table 22.

Table 22 The total number and percentage for all plant families in the botanical samples recovered from the Ust'ye excavations in 2013 and 2015

		Bulk Sample	Posthole	Well	Feature	Stone Hearth	Midden	Total
Total	Total	1749	413	1922	458	240	83	4865
	Percentage	0.36	0.08	0.40	0.09	0.05	0.02	
Fabaceae	Total	668	142	286	159	64	7	1326
	Percentage	0.39	0.35	0.15	0.35	0.27	0.09	0.28
Caryophyllaceae	Total	2						2
	Percentage	0.01						0.01
Lamiceae	Total	43		11		4		60
	Percentage	0.02		0.01		0.02		0.01
Amaranthaceae	Total	4	2	1	2	4	2	13
	Percentage	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Salicaceae	Total	4		4				8
	Percentage	0.01		0.01				0.01
Montiaceae	Total	1						1
	Percentage	0.01						0.01
Cyperaceae	Total	96	18	48	17	16	2	197
	Percentage	0.05	0.04	0.03	0.04	0.07	0.02	0.04
Polygonoceae	Total	42	6	38	12			98
	Percentage	0.02	0.01	0.02	0.03			0.02
Asteraceae	Total	46	7	36	3	3		94
	Percentage	0.03	0.01	0.02	0.01	0.01		0.02
Chenopodiaceae	Total	92	52	708	18	10	55	935
	Percentage	0.05	0.13	0.37	0.04	0.04	0.67	0.19
Urticaceae	Total	9				1		10
	Percentage	0.01				0.01		0.01
Poaceae	Total	117	5	114	15	5		266
	Percentage	0.07	0.01	0.06	0.03	0.02		0.05
Rosaceae	Total	161	5	22	13	3		204
	Percentage	0.09	0.01	0.01	0.03	0.02		0.04
Euphorbiaceae	Total	14			2			16
	Percentage	0.01			0.01			0.01
Rubiaceae	Total	4						4
	Percentage	0.01						0.01
Betulaceae	Total	1				1		2
	Percentage	0.01				0.01		0.01
Pinaceae	Total	13		6		1		20
	Percentage	0.01		0.01		0.01		0.01
Brassicaceae	Total	4						4
	Percentage	0.01						0.01
Apiaceae	Total	14	1					15
	Percentage	0.01	0.01					0.01
Caprifoliaceae	Total		1					1
	Percentage		0.01					0.01
Solanaceae	Total	3			2			5
	Percentage	0.01			0.01			0.01
Unidentified	Total	374	174	643	216	128	17	1552
	Percentage	0.21	0.4	0.33	0.47	0.5	0.2	0.3

The total number of charred seeds recovered from the Ust'ye excavation is 4,865. All of the identified charred seeds relate to wild plant resources. There were 3,282 charred seeds (70 % of the total sample) that were identified at least to the family level. In total, over 40 different species (at genus and species level) from 21 plant families were present. The number of unidentified seeds was 1,552. Most of these fragments appear to have some characteristics of the Fabaceae family (*Medicago* spp. and *Vicia* spp.), but the parts required for accurate identification were missing among the fragments. Therefore, these have been grouped as unidentified for the purposes of this dissertation. The remainder of the unidentified seeds were round in shape and lacked the diagnostic characteristics needed for identification.

Among the carbonized seeds recovered from Ust'ye, the most common plant family is Fabaceae (mainly *Medicago* spp., *Vicia* spp., and *Melilotus/Trifolium* spp.), followed by Chenopodiaceae (*Atriplex* sp. and *Chenopodium* spp.), Poaceae (mainly *Poa* spp. and *Stipa* spp.), Cyperaceae (mainly *Carex* spp.), Polygonaceae (*Polygonum* spp. and *Rumex* spp.), Rosaceae (*Fragaria/Potentilla* sp) and Asteraceae (Table 8). A total of 63% of the seeds recovered and identified belonged to the Fabaceae family (1,412 seeds) (Table 19). The percentages of Fabaceae (28%) and Chenopodiaceae (19%) seeds are the highest among the archaeobotanical samples with Polygonaceae, Cyperaceae, Poaceae, Polygonaceae, and Asteraceae families representing approximately 5% of the total seeds. The rest of the identified families represent less than 1% of the total seeds recovered.

Table 23 The total number of charred seeds from major plant species in the botanical samples recovered from the Ust'ye excavations in 2013 and 2015

Families	Species	Bulk samples	Well	Feature	Midden	Stone Hearth	Posthole
Fabaceae	Vicia spp.	161	76	67	2	36	42
	Medicago/Melilotus/Trofolium spp.	430	185	76	5	23	84
Chenopodiaceae	Chenopodium spp.	30	708	7	48	10	35
	Atriplex sp.	62		11	7		17
Polygonaceae	Polygonum spp.	27	11	5			1
	Rumex sp.	7	13	1			2
Cyperaceae	Carex spp.	83	44	15	2	12	17
Poaceae	Stipa spp.	72	93	15		5	5
	Poa spp.	42	20				
Rosaceae	Fragaria/Potentilla sp.	149	22	3		13	5
Asteraceae		30	35	3		2	6

There were a large number of Fabaceae seeds (N=1,326) recovered from the Ust'ye settlement. Several species from the Fabaceae family have been identified. Because of the poor preservation conditions and morphological similarity, *Medicago, Melilotus*, and *Trifolium* genus were grouped together in this project. The total number of identified *Medicago/Melilotus/Trifolium* spp. was 803 and these represent 61% of the Fabaceae recovered. According to the morphology, these *Medicago/Melilotus/Trifolium* spp. may be included: *Medicago falcata, Medicago lupulina, Medicago sativa, Melilotus wolgicus Poir., Trifolium arvense, Trifolium montanum,* and *Trifolium repens.* The number of *Vicia* spp. is 384 representing 29% of the *Fabaceae* recovered. Most of the *Vicia* spp. identified in the Ust'ye settlement samples are probably *Vicia cracca.* This proportion is similar to that encountered at the Stepnoye settlement and suggests that the Fabaceae species were intensively used in the two settlements. Fabaceae are valuable fodder plants that are utilized in the region now for livestock. The species mentioned above are typical plants represented within the meadow zone environment along the Nizhnii Toguzak River valley in which the Ust'ye settlement is located.

Besides the Fabaceae families, Lamiaceae (*Mentha* spp. and *Lypocus* sp.), Caryophyllaceae (*Gypsophila perfoliate*), and Amaranthaceae (*Amaranthus* sp.) are also located in the meadow zones and are used as fodder today for livestock.

The total number of these plants is much lower than *Fabaceae* in the meadow zone. These data suggest that the gathering of *Medicago/Melilotus/Trifolium* spp. and *Vicia* spp. was intentional by the Bronze Age occupants of the Ust'ye settlement. In a pastoralist subsistence economy, *Fabaceae* has the highest nutrient value among other families in which to sustain livestock on fodder. At the same time, the seeds, leaves, and stems of *Fabaceae* are consumable by humans after prepartion. Thus, the high number of these plants can reflect the high value and usage pattern in the subsistence economy for livestock and also possibly for human consumption.

The riparian zone next to the Ust'ye settlement is dominated by Cyperaceae plants. During the excavation, it was possible to view a seasonal herding camp across the river from the Ust'ye settlement. The area in which the camp was located was extensively covered by Cyperaceae plants. The total number of Cyperaceae charred seeds recovered in the archaeobotanical samples was 197. A total of 173 of these seeds were *Carex* spp. (including *Carex distans* and *Carex ovalis*) and the rest were *Eleocharis* sp. (*Eleocharis palustric*). The morphology of *Carex* spp. are very similar but vary in overall size. Since the habitat is the same for these species they have been grouped for the purposes of the dissertation research. Typically, the growth of these plants require a consistent supply of water and therefore are found along the main wetland zones of the rivers and their tributaries. These plants usually have a very long stem and can form a type of natural shelter along the riparian zone for livestock during summer storms. In the local village, these plants also are used as material for making basketry. It is very difficult to identify the remnants of the stem and leaf of these plants during archaeological excavations. However, Cyperaceae are widely distributed in the zones adjacent to the Ust'ye settlement and likely represented an important plant resources in the Bronze Age.

Besides the Cyperaceae families, Salicaceae (*Salix* sp.) and Montiaceae (*Montia fontana*) also were located in the riparian zone. *Salix* sp. is a typical tree that grows along the Nizhnii Toguzak River. These trees are not tall and rely heavily on a consistent water supply. *Salix* sp. was not found in the charcoal remains in the archaeobotanical samples and the quality of the *Salix* trunk is not as productive as pine and birch (forest zone) for burning. Thus, *Salix* sp. may have rarely been used at the Ust'ye settlement for fuel. Montiaceae is a wild grass that grows in the riparian zone. The number of recovered seeds representing this plant was just and it may have been introduced into the settlement through human/livestock agency or natural forces (rain or wind).

The total number of identified charred seeds representing the Chenopodiaceae family was 935. *Atriplex* sp. and *Chenopodium* spp. (including *Chenopodium album*, *Chenopodium polyspermum*, *Chenopodium rubrum* and *Chenopodium hybrium*). In the soil samples taken from the upper stratigraphic levels near the present day surface, significant amounts of modern *Chenopodium album* were recovered. As a result of the disturbance of the land through modern herding and agricultural activities in the area, the modern Chenopodiaceae family is prominently identified in the upper stratigraphic levels at Ust'ye. Compared with the *Chenopodium* spp., modern *Atriplex* spp. are seldom found in the samples recovered from the settlement excavations.

The Chenopodiaceae family was identified as a dominant flora in the ruderal zone along the Nizhnii Toguzak River valley. The seeds of the ruderal zone generally represent disturbance of the natural steppe environment by human and/or animal activities. The daily activities of humans and livestock will consistently effect the natural vegetation associated with the steppe environment both inside the village and in the surrounding areas. As a result, ruderal zones are always found in modern villages and the surrounding area even today. Such processes would have been a part of the natural functioning of the Ust'ye settlement in the Bronze Age and this would have stimulated the growth of the ruderal zones.

The presence of carbonized *Chenopodium* seeds was reported in the archaeological research projects in the Samara River valley and at Kamennyi Ambar and it was also suggested that these may have been plants consumed by humans following a required preparation method for detoxification (Popova 2006; Ruhl et al. 2015). Because the seed size of these plants is very small (1-2 mm), the number of Chenopodiaceae seeds to be used in a single meal would be large. This may be partly interpreted through the extremely high number of Chenopodiaceae that were recovered from the water well features in the Bronze Age settlements.

During excavation, a layer of infilling with decayed bones was typically encountered in the wells. In this particular context, the total seed numbers densities of the potential plant resources related to human subsistence was also highest among all samples (Figure 40; Table 24). For example, the total number of recovered Chenopodiaceae seeds in the Ust'ye well context (specific level with decayed animal bones) was 570 seeds from 87 liters of soil. The seed density is 6.5 times the average seed density from the samples at the level of -130 to -150 within the well**.** In comparison, the total number and density of most plant species in the decayed bone layer within the well feature was also higher than the total number and density of seeds from all samples from the Ustye site. But the increased rate of other plant species in the decayed bone layer within the well feature is much lower than the Chenopodiaceae in the decayed bone layer within the well feature.

The high number of Chenopodiaceae in the decayed bones level may be related to a single event or specific activities. It can be suggested that this level has a high frequency of plant usage but that the total number of Chenopodiaceae may be overrepresented in the well feature. The reason for this is related to the high seed reproduction rate of the plant and the better preservation of the macrobotanical remains due to the hard coat of the seed. The associated animal bones and Chenopodiaceae plant resources likely reflect human subsistence activities and therefore may be related to kitchen processing waste.

Figure 40 Photo from the Ust'ye excavation showing the profile and macrobotanical sampling locations within the water well feature (Alaeva 2015)

Table 24 Total number and density of major families from two layers in the well feature

Level	-130-150		Filled with decayed bones	
Families	Total number	Seed density	Total number	Seed density
Chenopodaceae	93	1.03	570	6.55
Rosaceae	10	0.11	5	0.06
Fabaceae	73	0.81	167	1.92
Lamiaceae	2	0.02	8	0.09
Polygonaceae	7	0.08	27	0.31
Poaceae	13	0.14	25	0.29
Cyperaceae	13	0.14	26	0.30

The total number of Polygonaceae seeds recovered was 98. The identified species included *Polygonum* spp. (*Polygonum persicaria, Polygonum aviculare, Polygonum convolvulus*) and *Rumex cripus*. These plants are commonly found within the contemporary ruderal zone. The seeds can be collected and dehusked before consumption and can play a role in human nutrition (Hillman 2000). There were 24 Asteraceae seeds (*Artemisia* sp.) and 10 Urticaceae seeds (*Urtica dioica*) identified in the Ustye archaeobotanical samples. These plants also grow within the ruderal zone and can be collected as fodder and are used by modern day herders in the region today. It is likely that these plants were utilized by the Bronze Age occupants of the Ust'ye village.

Poaceae, Rosaceae, Euphoriaceae, and Rubiaceae are identified plant families from the undisturbed natural steppe landscape. In the Ust'ye excavations, *Stipa* spp. (*Stipa pennata* and *Stipa capillata*) covered most of the land around the ancient settlement and the steppe zone between the river and the forest zone. In the recovered archaeobotanical samples, 179 *Stipa* seeds, 8 *Stipa* awn, and 65 *Poa* seeds were identified. This number is much higher than at the Stepnoye settlement and indicates an important difference between the two settlements.

Both settlements are surrounded by the natural steppe zone that is covered by *Stipa* spp. and *Poa* spp. The use of this plant is highly related to the overall proportion of vegetation zones within the local catchments. Therefore, the number of Poaceae seeds recovered should be similar at both settlements. However, the low number of Poaceae (N=4) recovered at the Stepnoye settlement suggests that the ancient occupants of the Stepnoye settlement did not collect Poaceae purposefully.

In the Ust'ye settlement, a greater representation of Poaceae seeds (N=266) may indicate a greater focus on the collection of these plant resources. In the Kamennyi Ambar project, a rare number of *Stipa* seeds were identified (N=12) but there was a high number of *Stipa* awns recovered (N=190) (Ruhl et al. 2015). This is a good example of how multi-resource pastoralism may have functioned among these Bronze Age communities. For example, the mature seeds and awns of the *Stipa* spp., which are available in July and August, are not used typically for livestock consumption. Thus, the charred *Stipa* seeds recovered at Ust'ye and Kamennyi Ambar are most likely related to human subsistence.

Multi-resource pastoralism, as a broader subsistence economy, generally focuses on maximizing the available local resources for livestock maintenance but also draws on other resources within a defined catchment area (Salzman 1980, Spengler 2014). The gathering of *Stipa* spp. from within the catchment zone appears to have been a particular strategy by the occupants of the Ust'ye I settlement phase but many not have been as suitable for occupants of the Stepnoye village. The reason for this variation may be related to the distribution of the highest value plant resources (e.g., Fabaceae) within the individual catchment zones associated with the settlements. Therefore, the choice of specific plant resources may have varied between settlements. A more detailed discussion of these strategies, and associated catchment zone studies, will be provided in the later chapters of the dissertation that present data from the phytogeographical and ethnographic studies in the Uy River valley.

All 204 Rosaceae seeds that were recovered from the Ust'ye I settlement are grouped with *Fragaria/Potentilla* sp. In the Nizhnii Toguzak River valley, *Fragaria viridis* (wild strawberry) are widely distributed and commonly gathered and consumed by local villagers. It can therefore be assumed that these resources also potentially contributed to the diet of the Bronze Age occupants of the settlement. The total number of Euphorbiaceae (*Euphoria* sp.) was 16, and Rubiaceae (*Galium* sp.) was 4. These are common grasss associated with the natural steppe zone and were likely used as fodder for the livestock during the Bronze Age.

The identified Pinaceae (*Pinus* sp.) and Betulaceae (*Alnus* sp.) are dominant species in the local forests today. *Pinus sylvestris* and *Alnus pentula also* are major species found within the local forests. Charcoal pieces from the identified samples also represent these two species. The total number of identified Pinaceae was 20 and 2 for Betulaceae. The number of these seeds are relatively low in the archaeobotanical samples and it should be noted that these seeds are not edible for humans. They may be collected as part of the gathering of wood for fuel and construction materials. Thus, these seeds were found associated with the stone hearth and associated well feature but not in the other features inside the house unit.

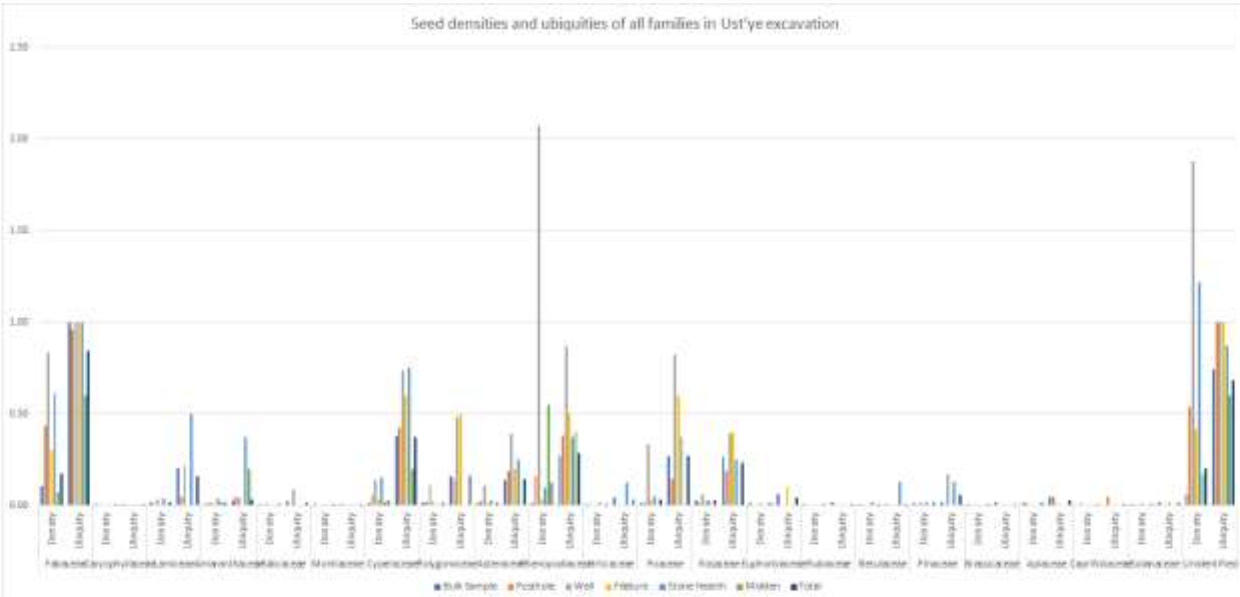
Brassicaceae (N=4), Apiaceae (N=15), Caprifoliaceae (N=1), (Cephalaria sp.), and Solanaceae (N=4) (*Solanum* sp.) remains were recovered in the archaeobotanical samples at Ust'ye settlement. These botanical families grow across different vegetation zones today within the local catchment of the settlement. The function of these plant species may be related to the use of fodder for livestock. The total number of these families is relatively low as represented within the archaeobotanical samples. It is possible that the gathering of fodder by the Bronze Age occupants did not focus specifically on these plants but they were collected as a byproduct of targeting other plant resources in the same vegetation zone.

Overall, the total numbers and percentages of Fabaceae and Chenopodiaceae are dominant among the seed assemblages identified from the archaeobotanical samples. The total number of Fabaceae collected from the bulk samples, features, postholes, and stone hearth are the highest, while Chenopodiaceae are the highest in the well and midden deposits. The uneven distribution of Chenopodiaceae seeds in the samples from the well was discussed above. In the midden feature, this number may be affected by the fact that Chenopodiaceae plants may have grown in abundance within the disturbed area of the midden deposit outside the enclosed area of the Ust'ye settlement. The repetitive dumping process with associated burning activities may have contributed to the formation of the midden ash layer. These activities likely contributed to the increased colonization and growth of this area by Chenopodiaceae plants. This interpretation can be supported based on the total number and percentage can be affected by the plant remains from a single event left in the features**.** For example, a single processing event can produce thousands of seeds in the location where archaeobotanical samples were collected. Therefore, the total number and percentage of plant species represented by the charred seeds may be an overrepresentation of actual plant use patterns. Thus, the further interpretation of the plant usage patterns will rely on ubiquities and densities listed in Table 25.

Table 25 Seed densities and ubiquities for all plant families recovered and identified in the archaeobotanical samples from the Ust'ye excavations in 2013 and 2015

		Bulk Sample	Post Hole	Well	Feature	Stone Hearth	Midden	Total
Soil in liters		6157	324	342	520	105	100	7548
Total Samples		218	21	23	10	8	5	285
Fabaceae	Density	0.11	0.44	0.84	0.31	0.61	0.07	0.18
	Ubiquity	1.00	0.96	1.00	1.00	1.00	0.60	0.85
Caryophyllaceae	Density	0.01						0.01
	Ubiquity	0.01						0.01
Lamiceae	Density	0.02		0.03		0.04		0.02
	Ubiquity	0.20		0.22		0.50		0.16
Amaranthaceae	Density	0.01	0.02	0.01		0.04	0.02	0.01
	Ubiquity	0.02	0.05	0.04		0.38	0.20	0.04
Salicaceae	Density	0.01		0.01				0.01
	Ubiquity	0.02		0.09				0.02
Montiaceae	Density	0.01						0.01
	Ubiquity	0.01						0.01
Cyperaceae	Density	0.02	0.06	0.14	0.03	0.15	0.02	0.03
	Ubiquity	0.38	0.43	0.74	0.60	0.75	0.20	0.38
Polygonoceae	Density	0.02	0.02	0.11	0.02			0.01
	Ubiquity	0.16	0.14	0.48	0.50			0.16
Asteraceae	Density	0.02	0.02	0.11	0.02	0.03		0.01
	Ubiquity	0.14	0.19	0.39	0.20	0.25		0.15
Chenopodiaceae	Density	0.01	0.16	2.07	0.03	0.10	0.55	0.12
	Ubiquity	0.27	0.38	0.87	0.50	0.38	0.40	0.29
Urticaceae	Density	0.01				0.02		0.01
	Ubiquity	0.05				0.13		0.03
Poaceae	Density	0.02	0.02	0.33	0.03	0.05		0.04
	Ubiquity	0.27	0.14	0.83	0.60	0.38		0.27
Rosaceae	Density	0.03	0.02	0.06	0.03	0.03		0.03
	Ubiquity	0.27	0.19	0.39	0.40	0.25		0.23
Euphorbiaceae	Density	0.01			0.01			0.01
	Ubiquity	0.06			0.10			0.04
Rubiaceae	Density	0.01						0.01
	Ubiquity	0.02						0.01
Betulaceae	Density	0.01				0.02		0.01
	Ubiquity	0.01				0.13		0.01
Pinaceae	Density	0.01		0.02		0.02		0.01
	Ubiquity	0.02		0.17		0.13		0.06
Brassicaceae	Density	0.01						0.01
	Ubiquity	0.02						0.01
Apiaceae	Density	0.01	0.01					0.01
	Ubiquity	0.05	0.05					0.03
Caprifoliaceae	Density		0.01					0.01
	Ubiquity		0.05					0.01
Solanaceae	Density	0.01			0.01			0.01
	Ubiquity	0.02			0.02			0.02
Unidentified	Density	0.06	0.54	1.88	0.42	1.22	0.17	0.21
	Ubiquity	0.74	1.00	1.00	1.00	0.88	0.60	0.68

(Continuation of the previous table)



The seed density of Fabaceae (0.07 to 0.84 seeds/liter of soil) was found to be much higher than any other families in the bulk samples, features (artifact concentration depressions), postholes, and stone hearth. At the same time, the ubiquity of Fabaceae (0.6 to 1 seeds/liter of soil) is the highest in all sample categories. This evidence has indicated the overall importance of Fabaceae in the subsistence economy associated with the occupation of the Ust'ye 1 settlement. The seed density of Fabaceae suggests the highest frequency of plant usage inside the settlement and the ubiquity suggests that Fabaceae was widely distributed inside/outside the human activity zones associated with the settlement.

These plant resources are closely related to the daily activities associated with the Bronze Age. Fabaceae are well known as a high nutrition fodder in many regions of the world. After fully boiling these plants the seeds can be eaten by humans as well. It is no surprise that Bronze Age pastoralist societies in the Nizhnii Toguzak River valley intensively used these plant resources for their livestock. The extremely high seed density and ubiquity of Fabaceae among the seed assemblages also may be partly related to human subsistence practices. This pattern is the same as that encountered at the Stepnoye and Streletskoye 1 settlements in the Uy River valley. This suggests that the highest value of Fabaceae among available plant resources in the local catchment zones was a common knowledge shared by different MBA and LBA Bronze Age pastoralist communities in the Southeastern Urals region.

The seed densities of Lamiaceae (0.02 to 0.04 seeds/liter of soil) and Amaranthaceae (0.01 to 0.04 seeds/liter of soil) are quite low in all samples but the ubiquity is relatively high in the stone hearth. In the Nizhnii Toguzak River valley, Lamiaceae and Amaranthaceae are also plant families found within the meadow zone. The leaf and steam parts of the identified Lamiaceae (*Mentha* spp. and *Lypocus* sp.) are edible by humans and livestock. The usage of these plants may be similar to Fabaceae, however, the low seed density suggests that they may be just by-products from Fabaceae collection and use. The morphology of Amaranthaceae seeds is very similar to *Chenopodiaceae.* The use of these plant resources may also be related to human subsistence practices in the region.

The seed density of Chenopodiaceae was found to be the highest in the midden deposit (0.55 seeds/liter of soil) and the well within the house structure (2.07 seeds/liter of soil). The ubiquity in the pit feature (0.4) and midden deposit (0.87) is quite high among the recovered seed assemblages and this suggests the usage of Chenopodiaceae is closely related to the function and formation of specific features.

In the midden deposit that was identified outside the Stepnoye settlement, the major cultural layer encountered was an ashy layer mixed with archaeological materials from the enclosed settlement. As discussed above, these ashy layers usually formed as a result of a long duration burning process. The thickness of the ashy layer in the midden suggests a long period of deposit of refuse in this location. Therefore, it may be suggested that this layer is comprised of processed plant remains from the internal zone of the settlement complex and natural plant remains that may have colonized and grown within the midden deposit area during and after its use.

Since the midden deposit area was continuously disturbed during use it was likely a ruderal zone such as those found in the modern villages in the region today. Chenopodiaceae always dominates the vegetation that grows within these zones. Some of the Chenopodiaceae seeds in the midden samples may not relate to the human activities inside the enclosed settlement but the plant growth in the midden deposit outside the settlement.

The reason for the extremely high seed density of Chenopodiaceae was discussed above. And the result and the comparison with seed density and ubiquity of Chenopodiaceae in other samples suggested the overrepresentation of Chenopodiaceae in the archaeobotanical samples from the well. Therefore, the contribution of Chenopodiaceae to the Bronze Age subsistence economy may have been lower than the statistical number reflected in the Ust'ye archaeobotanical samples.

Just like Chenopodiaceae, Polygonaceae and Asteraceae are also plants found in the ruderal zone. The seed density of Polygonaceae (0.02 to 0.11 seeds/liter of soil) is low in all samples but the ubiquity was high in the well (0.48) and artifact concentration depressions (0.5). The artifact concentration depressions may have comprised the food processing remains from daily activities during the occupation of the settlement. The identified Polygonaceae (*Polygonum* spp. and *Rumex* sp.) can be roasted and consumed by humans. Thus, these seeds may have been used as food resources by occupants of the Ust'ye settlement.

Most of the identified Asteraceae seeds represent the Crepis *sp*. (N=12). The seed density of *Asteraceae* (0.02 to 0.11 seeds/liter of soil) is low in all samples taken from within the house unit, and the ubiquity was 0.14 to 0.39 . The highest ubiquity of this plant was also found to be in well. The distribution of Asteraceae in the samples taken from inside the house unit was quite even. These wild grasses can be used as fodder during the summer and seed propagation can take place through wind agency. Therefore, these seeds can easily enter the settlement zone through natural processes associated with the wind and the movement of livestock.

The seed density of Cyperaceae was low (0.02 to 0.15 seeds/liter of soil) in all samples. The ubiquity is relatively higher in samples from the features, well, stone hearth and post molds (0.43 to 0.75). Cyperaceae can be widely used for different purposes. The seeds of the identified *Carex* spp. can be roasted and consumed by human. The stems can be used for basket crafting and local inhabitants of the modern villages use them in this way. These charred seeds appeared in the archaeobotanical samples taken inside and outside the settlement are likely related to the gathering of plant resources in the local catchment by the occupants of the Ust'ye settlement. The habitat of Cyperaceae is the riparian zone along the Nizhnii Toguzak River adjacent to the Ust'ye settlement. The distribution of these plants relies heavily on the water supply of the river. As a result, the relative location between the Ust'ye settlement, Nizhnii Toguzak River, and the riparian zone may have been quite similar during the Bronze Age. Today, this zone offers an excellent location for a summer livestock herding camp because of the consistent source of water and the relatively lush growth of vegetation in the immediate area.

The ubiquity of Rosaceae was found to be low in all samples inside the house unit (0.02 to 0.06). The modern plant related to the identified *Fragaria/Potentilla* sp. is wild strawberry. All recovered seeds were found within the settlement zone and it may be suggested that these represented gathered resources by the Bronze Age occupants.

The seed densities of Poaceae were found to be 0.02 to 0.33 seeds/liter of soil. The seed density of Poaceae was very high in the well. The ubiquity of Poaceae ranged from 0.14 to 0.83 . The highest ubiquity was found in the samples from the well (0.83) and artifact concentration depression (0.6). These seeds are not generally used for livestock fodder. These can be collected for human consumption or they can easily attach to the livestock when they are grazing and be brought into the settlement.

The seed density and ubiquity of Caryophyllaceae, Salicaceae, Montiaceae, Urticaceae, Euphorbiaceae, Pinaceae, Rubiaceae, Betulaceae, Brassicaceae, Apiaceae, *Caprifoliaceae,* and *Solanaceae* were very low among all samples. All these families can be found in the surrounding area of the Ust'ye settlement. They may have entered the settlement through human and animal activities or by natural forces such as wind and rain. As a result, the specific reason for their presence within the settlement is difficulty to define due to the low density and ubiquity. Similar to the Stepnoye settlement archaeobotanical results, the recovery of these plant species from the surrounding area of the Ust'ye settlement suggests a strong local catchment based subsistence economy for plant resource exploitation.

The function of plant remains is based on my observations of modern villagers and the existent comparative archaeological data. The Ust'ye archaeobotanical samples provide a good resource in which to investigate the possible function of plant remains. Different human activities inside the house units always leave evidence of plant usage in different features. In Ust'ye, these features are the well, artifact concentration depressions on the house floor, the stone hearth, and post molds. The post molds do not necessarily relate to immediate occupation of the house units but rather became cavities in which plant remains became trapped after settlement disuse and abandonment. The stone hearth feature and the decayed layer of bone and other infilled materials within the well may be associated with the primary plant resources that were used for subsistence by the Bronze Age occupants of the settlement. The artifact concentration depressions on the house floor also may comprise the refuse generated by daily activities and associated subsistence practices within the house units.

The seed densities of Fabaceae, Chenopodiaceae, Lamiaceae, Amaranthaceae, Polygonaceae, Poaceae, and Cyperaceae were found to be significantly increased in the decayed bone layer within the well. The seeds from these plants my be utilized by humans for subsistence and so the presence of these resources may relate to their collection by the occupants of the village and the seeds can be charred and preserved during the cooking process.

The seed density of *Rosaceae* (identified wild strawberry) is decreased in the decayed bone layer in the well. However, wild strawberries may be eaten without any cooking preparation and so the distribution of Rosaceae was found to be more random among the samples taken from within the house unit. Cyperaceae is also different compared with the other plant families.

Cyperaceae is a multi-function plant resource. The stems can be used for handcrafting baskets and other items, the seeds are edible by haunts, and in the growing season the fresh leaves and stems may be used for livestock fodder. Thus, the ubiquity (0.38) of Cyperaceae is the second highest within all archaeobotanical samples and charred Cyperaceae seeds were found in all samples inside and outside the settlement.

Fabaceae is the dominant plant family recovered from the Ust'ye settlement. The reason for this is that it represents the highest value among all the available wild plant resources. Besides the charred seeds, the leaves and stems are the best fodder for livestock and may also be eaten by humans. A more detailed discussion of these plant resources will be presented in the next chapter.

When comparing the archaeobotanical results from the research at the Ust'ye and Stepnoye settlements, two main patterns can be observed: (1) The total numbers, percentages, densities, and ubiquities of plant families show a clear pattern in which Fabaceae is the dominant plant resource associated with the subsistence economies at the two settlements; (2) In addition to Fabaceae, there are clear similarities and differences in the utilization of plant resources in the two settlements.

These patterns are related to the mechanism of plant resource exploitation through multi-resource pastoralism and the specific availability of plant resources within local catchment zones. The link between the interpretation of the archaeobotanical data and the observed patterns of the local catchment zones, therefore, is very important. In the following chapters, these issues will be examined in more detail through a discussion of a site catchment phytogeographical study, ethnobotanical research, and dung burning experiments. These studies provide a broader context of local plant resource within the Uy River valley and contribute to a more comprehensive model of plant resource use within a microregional context.

6.0 CATCHMENT ZONE ANALYSIS

Analysis of the charred plant macro-remains from the three excavation projects discussed above has identified over 40 different plants classified to genus and species level that represent 21 plant families. These botanical data can help us to interpret the landscape zones that existed around the ancient Bronze Age settlements. Each of the identified plant species represents different habitat requirements and specific ecological zones within the broader steppe environment of the Southeastern Urals region. These characteristics can help to trace the dietary needs and grazing patterns of ancient livestock herds.

The charred seeds in the samples that were recovered from the three settlements originate from multiple landscape zones within the river valleys and the samples share some similar characteristics. For example, Fabaceae is dominant at all three settlements but the location in which these plants grow are situated in different microenvironmental zones. Modern Chenopodiaceae is commonly found in the uppermost stratigraphic layers of the archaeological sites but the overall recovered numbers of plant remains are relatively lower in the archaeobotanical samples.

After comparing my botanical data with the published archaeobotanical results from the Kamennyi Ambar settlement project in the same region, it may be suggested that there is a high similarity of plant species recovered from these sites (Ruhl et al. 2015). The seeds in the assemblages from the three sites also prove that the same species of plants can be commonly found within the catchment zones of the sites today. Thus, the catchment zone analysis in this dissertation follows a comparative ecological zone approach to the botanical studies that have been carried out at the Kamennyi Ambar settlement.

The charred plant seeds recovered from this settlement were separated into five ecological zones (Riparian, Meadow, Ruderal, Steppe, and Forest) (Ruhl et al. 2015:416). These categories can be roughly defined by plant assemblages and overall distance from water resources. A discussion of these archaeological plant remains, and their related ecological zones, will be presented in the following section. The morphology and size of identified plant seeds are listed in Table 26. Also, below, I provide a comparison of different plant species from the same ecological zones among the three settlements studied through the dissertation research. This analysis provides an important characterization of the local catchment settings of the three Bronze Age settlement.

Table 26 Morphology and size of major identified seeds from three settlements

Family,Genus,Species	Surface	Shape	Transversal section	Apex	Length(mm)	Width(mm)
Cyperaceae						
Carex spp.	smooth	ovate,elliptic	discoidal	short beak	1.6-2.8	1-1.8
Eleocharis palustris	smooth	obovoid,spherical	compressed	large beak	1.8-2.1	0.8-1.1
Eleocharis sp.1	smooth	obovoid, spherical	compressed	large beak	0.8-1.2	0.4-0.5
Salicaceae						
Salix sp.	furrowed longitudinal	cylindrical		rounded	1.2-1.5	0.4-0.8
Polygonaceae						
Polygonum convolvulus	smooth	triangular	concave side	cuminate	2.8-3.0	1.9-2.3
Fabaceae						
Vicia cracca	smooth	broad ellipsoid	hilum 1/3 of seed		2.0-3.0	2.0-3.0
Vicia sp. 1	smooth	broad ellipsoid	hilum 1/5 of seed		3-4.5	2-3.5
Medicago/Melilotus/Trifolium sp.1	smooth	prolong elliptic	flattish, radicle 1/2 of cotyledons		2-2.5	1-1.3
Medicago/Melilotus/Trifolium sp.2	smooth	elliptic, ovoid	radicle 3/4 of cotyledons		1.3-2	1-1.2
Medicago/Melilotus/Trifolium sp.3	smooth	irregular-elliptic	radicle 2/3 of cotyledons		1.8-2	1.1-1.3
Medicago/Melilotus/Trifolium sp.4	smooth	asymmetric reniform	flattish, radicle 1/2 of cotyledons		1-1.5	0.7-1
Cyperaceae						
Carex distans	smooth	triangular shape		short beak	1.6-2	1.1-1.3
Carex ovalis	smooth	ovate		long beak	1.5-1.7	0.8-1
Lamiaceae						
Lypocus sp.	smooth	obovate trapeziform	dorsal side slightly convex		1.2-1.4	0.8-1
Mentha sp.1	smooth	ovate	dorsal side slightly convex		0.9-1.2	0.7-0.8
Mentha sp.2	rough	prolong elliptical	dorsal side slightly convex		0.7-0.9	0.5-0.6
Malvaceae						
Malva sp.	smooth	reniform	flattish		1.9-2.1	1.9-2
Asteraceae						
Artemisia sp.	longitudinal furrowed	prolonged obovoid		round	1.3-1.5	0.7-0.8
Crepis sp.	longitudinal furrowed	cylindrically	narrow bottom		3.2-4	0.7-0.8
Chenopodiaceae						
Chenopodium album	smooth	circular	flattish		1.4-1.5	1.2-1.4
Chenopodium hybrium	rounded cavities	circular	flattish		1.4-1.7	
Chenopodium polyspermun	smooth	circular	flattish		1-1.2	0.9-1
Chenopodium rubrum	smooth	circular	flattish		0.5-0.7	
Atriplex spp.	smooth	circular	flattish, prominent radicle		1.4-1.7	
Polygonaceae						
Polygonum aviculare	rough	triangular		pointed	2.8-3.2	1.8-2
Polygonum persicaria	lustrous smooth	triangular		pointed	2.5-3.5	1.8-2.2
Polygonum sp.	smooth	flattish triangular		pointed	1.4-2	1-1.5
Rumex crispus	smooth	ovate to triangualr		short pointed	1.9-2.5	1.1-1.8
Rumex sp.	smooth	ovate to triangualr		short pointed	2.2-2.4	1.2-1.4
Urticaceae						
Urtica dioica	smooth	flattish ellipsoid	dorsal side slightly convex		1-1.2	0.6-0.9
Euphorbiaceae						
Euphorbia sp.1	smooth	ellipsoid to oviod		obtuse	1.3-1.5	1.2-1.3
Euphorbia sp.2	smooth	oblong-ellipsoid			1.7-1.9	0.9-1
Poaceae						
Stipa spp.		long, narrow			7-8	
Echinochloa sp.	smooth	broad ellipsoid	v-shaped hilum		1.8-1.9	1.1-1.2
Poa sp.	longitudia striate	elliptic	pointed hilum		1.5-1.8	0.7-0.9
Rosceae						
Fragaria/Potentilla sp.	smooth			round	1.5-1.8	1-1.3
Alchemilla sp.	smooth	ovoid		acute	1.1-1.3	0.8-1
Rubiaceae						
Galium sp.	wrinkly	round	concave hilum		1.7-1.9	
Pinaceae						
Pinus sp.	rough	prolonged ovate			3-5	2-3.5
Betulaceae						
Alnus sp.	rough	obovoid			2.5-3	2-3.5

6.1 RIPARIAN ZONE

A riparian zone is the interface between a river or stream and the adjacent land. In my survey area, riparian zones have typically formed along bends in the river and on river banks with an overall lower elevation (Figure 41). In the rainy season (mid-May to late August), small seasonal riparian zones form along the small streams from the high elevation region. Because of the environmental constraints (they only grow in the location with high and constant water supply and low elevation spots along the river bank) for the growth of riparian plant species, riparian zones are patchy throughout the catchment area surrounding the settlements. Riparian vegetation usually exhibits plants of the Cyperaceae family and riparian shrubs (mainly *Salicaceae*). Analysis of the archaeobotanical samples identified 5 different plants (genus and species level) from 3 plant families from the riparian zone.

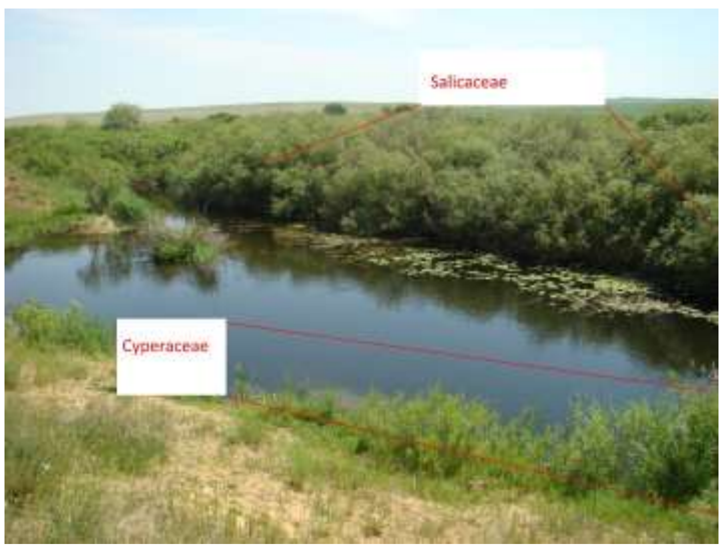


Figure 41 Photo of Riparian zone in Uy River Valley

Cyperaceae was the most common plant family represented in the identified charred seeds in Stepnoye (N=100%), Ust'ye (N=96%) and Stretletskoye 1 (N=33%) settlement. (mainly represented by *Carex* spp.)(Table 27). Salicaceae was found in Ust'ye(N=3%) and Streletskoyeoye 1 (N=77%)settlement. And Montiaceae(1%) only found in Ust'ye settlement. These differences in seed representation of particular species may be caused by differences in soil, elevation, water availability, and human disturbance of the microenvironment. Nevertheless, it is possible to identify similar characteristics of the riparian zones around the Bronze Age settlements.

Table 27 The total number and percentage of identified plants from the riparian zone in three settlements

Settlements	Stepnoye		Ust'ye		Streletskoye 1	
Families/Genus/Species	Total(Seed)	Percentage	Total(Seed)	Percentage	Total(Seed)	Percentage
Cyperaceae						
Carex **spp.**	67	91%	173	85%	1	33%
Eleocharis palustric	7	9%	24	11%		
Salicaceae			8	3%	2	77%
Montiaceae			1	1%		

A similar situation is apparent in the discussion below of the other ecological zones within the settlement catchments. Thus, the interpretation of the catchment zone analysis is based directly on the results of the archaeobotanical research and modern vegetation patterns found in the present day at these locations.

Cyperaceae is a plant family always associated with wetland environments. The charred seeds identified below the subfamily level are *Carex* species and *Eleocharis* (*E. palustric*) (Figure 42). Most species of *Carex* in the survey area are perennial and grow to 10-50 cm in height in the Uy river valley. Almost all the identified seeds were preserved intact. However, identification is difficult because of similar morphologies. *Carex distans* and *Carex ovalis* are identified species from the archaeobotanical samples. *Carex distans* is a perennial plant that can grow up to 50 cm high. *Carex ovalis* is a perennial plant that can grow up to 60 cm high. The growing season of these Cyperaceae species in the Southeastern Urals region are May to July and the withering season begins in August. The number of these plants are very low in the archaeobotanical samples. In the catchment area, these plants grow at the edge of meadow and riparian zones. Like other Cypereae plants, the best habitat is linked to a good supply of water.

The representation of Cypereae seeds in the archaeobotanical samples from the Streletskoyeoye 1 settlement is low (N=1). But this number may be influenced by the total volume of soil (91 liters) that was floated and processed for the Streletskoyeoye 1 site, which was much lower than at the other two settlement. The total number of Cypereae seeds recovered at the Ust'ye settlement (N=173) is highest of the three settlements investigated. I interpret this variation in seed representation as partly associated with the variation in the microenvironments associated with the three settlements. For examples, at Ust'ye, the Cyperaceae family covered most of the riparian zone but at Streletskoyeoye 1 riparian shrubs were much more abundant along that stretch of the river. This growth pattern is related to the nature of the water resource and the difference in the elevation of the river banks at Ust'ye and Streletskoyeoye 1.

There are two springs in the Nizhbii Toguzak River adjacent to the Ust'ye settlement and it was found that Cyperaceae were clustered around the springs because of the constant water supply. As a result, the Riparian zone adjacent to the Ust'ye settlement is quite large and Cyperaceae is abundant there. In contrast, the level of the river bank next to the Streletskoyeoye 1 settlement is not close to the water level of the Uy river and the riparian zone next to the Streletskoye 1 settlement is small and scattered.

Figure 42 Left - Photo of Carex spp. in the Southeastern Urals region; Right – Photo of Eleocharis species in the Southeastern Urals region

My catchment zone survey found that the *Eleocharis* species are perennial plants and are usually clustered together with *Carex* in the catchment zones. Their height is generally higher than *Carex* and can range up to 70 cm. *Eleocharis palustris* was identified in the archaeobotanical samples. The growing season of *Eleocharis* species is from May to July and the withering season begins in August in the Southeastern Urals region. Their leaves and stems can be used as fodder in the growing season, and the seeds are edible for human consumption during the withering season. The total numbers of these seeds are lower than *Carex* spp. in the samples from all three settlements. It may be suggested that the purpose of *Eleocharis* by Bronze Age populations inhabiting the settlements was similar to use of the *Carex* species.

Salix is the only identified riparian shrubs in the archaeobotanical samples (Figure 43). Salix is a perennial plant and can be used as a fuel source. In the survey catchments the height of *Salix* was typically observed at approximately 3-4 meters but some were identified at 10 meters. The growing season is late May to July and the withering season begins in August. The total number of these seeds was very low in the Ust’ye archaeobotanical samples (N=8) and also in the Streletskoye 1 samples (N=2).

Figure 43 Photo of Salix sp. in the Southeastern Urals region

According to Ruhl (2015), the same plant species were also present within the Kamennyi Amber settlement archaeobotanical samples and this is the only record of these wild plants found in this region. My catchment zone analysis led to the collection of some of these plant species from contemporary botanical growth and these provide an important comparative sample for the archaeobotanical remains. The identification of these species with associated information about plant resource use is provided in Table 28.

Table 28 The growing pattern and useable parts of the major identified plants from the Stepnoye settlement catchment zone

	Growing season	Seeding season	usage parts for human
***Carex* spp.**	May-July	August-September	seed
***Eleocharis* spp.**	May-July	August-September	seed
***Salix* sp.**	June-July	August-September	trunk
Polygonum convolvulus	May-July	August-September	seed
Chenopodiaceae	July- August	Late August-September	seed
Polygonaceae	May-July	August-September	seed
***Urtica* sp.**	May-July	August-September	
***Crepis* sp.**	May-July	August-September	
***Euphorbia* spp.**	May-July	August-September	
***Vicia* spp.**	May-June	July-August	leaf, stem, seed
***Medicago/mel/Tri* spp.**	May-June	July-August	leaf, stem, seed
***Carex* spp.**	May-August	August-September	seed
***Lypocus* sp.**	May-July	August-September	
***Mentha* sp.**	May-July	August-September	leaf, stem
***Malva* sp.**	May-July	August-September	
***Artemisia* sp.**	May-July	August-September	
***Amaranthus* spp.**	May-July	August-September	seed
***Stipa* spp.**	May-July	August-September	seed
***Fragaria* spp.**	May-June	July-August	fruit

Since the total number of charred seeds representing the riparian zone is not high this does not suggest the intensive use of these wild plant resources during the Bronze Age. My observation of local herders in the region today also supported this view. Livestock does graze in the riparian zone but in most of my observations of herding practices cattle moved through this zone and into the meadow zones. During the growing season, the leaf and stem of these plants are edible for livestock. In the withering season, the seeds of some riparian plants are edible for human consumption (Hillman 2000). Also, Because of the stable water resources, the riparian zone was also mixed with the meadow zone in the catchment area. Some of the riparian species also grow within the meadow zone. Thus, the charred seeds found in the settlement may relate to herding activities and human gathering in these areas.

The total number of Cyperaceae seeds is significantly high in the riparian zone plants. The reason for this can be the real proportion of plants in this zone, however, the multiple functions of the stem may also affect the result. My ethnographic observations indicated that the stem of

Cyperaceae plants in the survey region can be used for basketry and bedding material for livestock pens or stalls in the modern villages today. So far, no direct archaeological evidence of stem remains of Cyperaceae have been found within the archaeological sites.

However, the ubiquity of Cyperaceae in the samples recovered from archaeological features (such as pits, artifact concentration depressions, house floors, etc.) is much higher than in the bulk samples. This suggests that these plant resources were being utilized and deposited by Bronze Age populations inhabiting the settlements.

Salix can be used as fuel for fires, but the analysis of the recovered charcoal species within the macrobotanical samples does not support this. The trunk of *Salix* is very small. The quality of *Salix* as a fuel is not good and this resource is typically not used as a fuel source in the modern villages along the Uy River. This suggests that *Salix* was not an important resources for the occupants of the Bronze Age villages.

Overall, the riparian zone can be characterized as providing some useful plant resources within the local catchment, however, the archaeological record and recovered macrobotanical samples suggest a relatively lower usage rate of this particular zone by the Bronze Age inhabitants of the settlements

6.2 MEADOW ZONE

In the site catchment survey, the meadow zone was usually located within the river floodplain and seasonal flooding depressions (Figure 44). Depending on the available water supply in different locations the size of the meadow zone can be quite varied. For example, the meadow zone along the main river is usually more developed than along the smaller tributary streams. Due to the consistent supply of water, a broad variety of plant species grow within this zone. In the studied settlement catchments, the vegetation mainly includes species associated with Fabaceae, Poaceae, Lamiaceae, Cyperaceae, Rosaceae, and Asteraceae. Analysis of the archaeobotanical samples produced 11 identified plants (genus and species level) relating to 4 plant families (Table 29).

Table 29 The total number and percentage of identified plants from the riparian zone in three ancient settlements that were investigated

Settlements	Stepnoye		Ust'ye		Streletskoye 1	
Families/Genus/Species	Total(Seed)	Percentage	Total(Seed)	Percentage	Total(Seed)	Percentage
Fabaceae						
Vicia spp.	424	32%	384	30%	1	7%
Medi/Meli/Tri spp.	874	67%	803	64%	13	93%
Lamiaceae						
Mentha spp.	18	1%	56	4%		
Lypocus sp.			3	1%		
Amaranthaceae			13	1%		
Malvaceae	3	1%	11	1%		
Caryophyllaceae			2	1%		

Medi/Meli/Tri spp.= Medicago/Melilotus/Trifolium spp.

Figure 44 Photo of the meadow zone along a tributary flowing into the Uy

Fabaceae was the most common plant family among the charred seeds recovered (mainly represented by *Vicia*, *Medicago*, *Melilotus*, *Trifolium* spp.) in Stepnoye (N=99%), Ust'ye (N=94%) and the Stretletskoye 1 (N=100%) settlement. Lamiaceae (*Lypocus* sp. and *Mentha* spp.), represents 4% at Ust'ye and 1% at Stepnoye. The rest are Malvaceae (*Malva* sp.), Amaranthaceae (*Amaranthus* sp.) and Caryophyllaceae (*Gypsophila perfoliata*), all of which represent less than 1% of the total charred seeds recovered from the meadow zone.

Fabaceae plants are widely distributed in the Eurasian steppe. Many species are considered a natural resource for livestock grazing. The charred seeds identified below the subfamily level are *Vicia*, *Medicago*, *Melilotus* and *Trifolium* species (Figure 45;46). *Vicia Cracca* is the only identified plant to species level. It is a perennial plant and the stems can grow up to 50 cm. Most of the recovered seeds were fragmentary but the remaining parts could be easily identified by the long hilum. The growing season is late May to July and the withering season usually begins in August. According to the morphology and distribution of the plants, The other identified seeds are probably *Vicia tenuifolia.* Since the habitat and growing season of *Vicia* are similar in this region, interpretations have been grouped for these. The total number and ubiquity of *Vicia* spp. were high at all three settlement sites.

Figure 45 Left - Photo of Vicia Cracca in the Southeastern Urals region; Right – Photo of Medicago sp. in the Southeastern Urals region

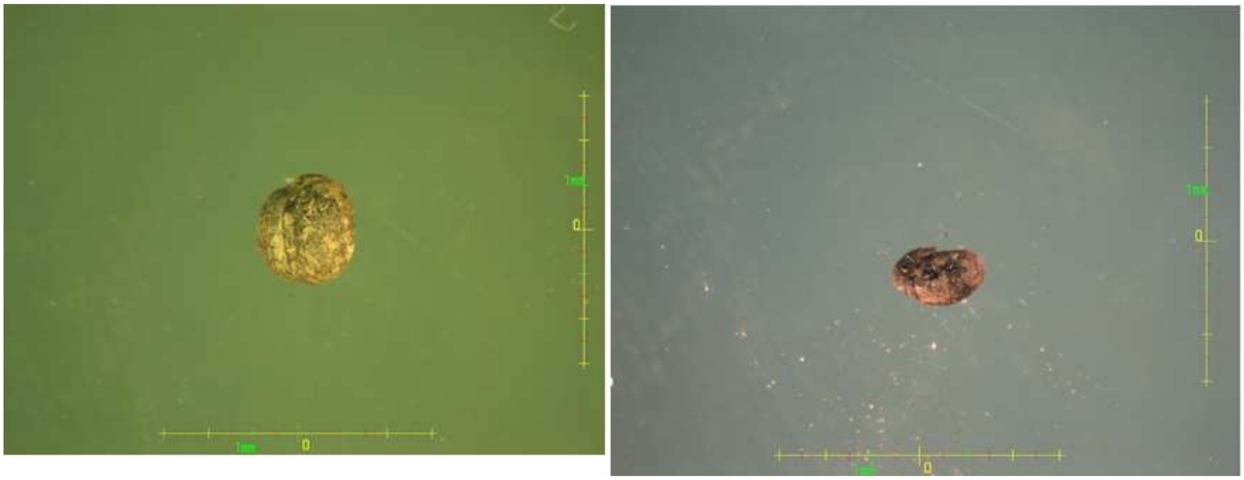


Figure 46 Left - Photo of identified Vicia Cracca in archaeobotanical samples; Right – Photo of Medicago sp. in archaeobotanical samples

Medicago, Melilotus, and *Trifolium* usually grow together in the meadow zone. Their seeds have a similar morphology but vary in overall size. During the laboratory processing of these seeds, because of their similarity, I also grouped them into the same category. There were four major types identified. The total number and ubiquity of these species are the highest at all three settlement sites. In some samples, the total number is over 100. The growing season of these Fabaceae species are May to July in this region and the withering season begins in July. I also identified many Fabaceae fragments in the archaeobotanical samples. These fragments cannot be identified to genus, but the location of the hilum is quite diagnostic and can be related to the Fabaceae families.

Fabaceae seeds are generally spread evenly across the archaeobotanical samples and they are the most abundant and ubiquitous seeds at all three sites. The archaeobotanical results strongly suggest that Fabaceae are among the most important wild plant resources being utilized by the Bronze Age populations inhabiting the settlements. The identified Fabaceae seeds represent plants that are among the most valuable for contemporary animal grazing in the region. Zooarchaeological studies of faunal remains recovered from the Bronze Age settlements suggest a substantial component of livestock herding (Anthony 2007; Hanks et al. 2007; Koryakova and Epimakhov 2007; Zdanovich and Zdanovich 2002). The high number and ubiquity of Fabaceae seeds, therefore, seem very reasonable in the context of livestock husbandry and the grazing of sheep, goats, cattle, and horses. Local herders still focus on these particular plant species in this region and indicate a continuity of the importance of these wild plant resources for patterns of livestock herding and grazing both in ancient times up to the present.

Other recovered charred seeds are Lamiaceae (*Lypocus sp.* and *Mentha spp.*), Malvaceae (*Malva* sp), Amaranthaceae (*Amaranthus* sp.) and Caryophyllaceae (*Gypsophila perfoliata*) (Figure 47). They are common annual flowering plants in the meadow zones. The growing season of these species is around May to July in this region and the withering season begins in late August. The total numbers of these seeds at the three settlement sites are very low. Therefore, it may be suggested that none of these particular species represented special resources for the populations that inhabited these settlements.

Figure 47 Left - Photo of Mentha spp.in the Southeastern Urals region; Right – Photo of Amaranthus sp. in the Southeastern Urals region

Comparing the archaeobotanical results from the Kamennyi Ambar settlement (Ruhl et al. 2014) with the three Bronze Age settlement sites that I examined in my dissertation research – I found that the archaeobotanical samples recovered from the meadow zones have similar seed assemblages. It can be suggested that the high total number and ubiquity of Fabaceae seeds are a common phenomenon in this region among Bronze Age societies. From the catchment zone analysis, I collected some plant species from modern vegetation as a comparative sample. These species and associated information about their use as botanical resources is listed in Table 29.

Several archaeobotanical projects have underscored the importance of the meadow zones for Bronze Age livestock herding societies in the Eurasian steppes (Popova 2005; Ruhl 2015;

Spengler 2013). Because of the weather conditions in the South Urals region, the open range herding period is very short and is primarily associated with the summer months.

Local herders typically focus on the best available pasture areas during this period. Usually, the herding camps are located at the edge of the meadow zones. This location saves time for moving the livestock between different patches of meadow zones and the livestock can get the highest nutrient enrichment in this period. At the same time during the summer months, local people must prepare winter fodder for their livestock. During this time green meadow grass is cut with scythes and stacked along the river in large piles (Figure 48) This meadow hay will be collected in the autumn, transported back to the villages, then used for foddering livestock that are contained in corrals near houses during the winter months.

Figure 48 Photo of winter Hay from last year in Uy River Valley

Therefore, it may be concluded that the herding cycle in this region is closely related to the meadow zones within the catchments along the main river valleys. When comparing archaeobotanical samples and modern vegetation from the meadow zones, there are two different characteristics. First, the vegetation in the meadow zones has the highest variety of plant species because of the consistent supply of natural water resources. Fabaceae is a major plant in this zone, but the abundance is relatively even compared with other species in the modern vegetation. Yet, in the archaeobotanical samples from different settlements the total number and ubiquity of Fabaceae seeds are dominant among other plants. These numbers cannot reflect the real proportion of plant resources in the meadow zones.

Second, most of the Fabaceae plants came from this zone, and they are the most popular fodder resource today in this region. However, in the archaeobotanical samples, one can see the variety is narrowed down to specific genus or species. This result also partly constrasts the real distribution of Fabaceae plants in the meadow zones. These characteristics suggest that the Bronze Age communities focused on specific Fabaceae plants from the meadow zones.

The number of other plant species identified in the archaeobotanical samples is relatively low. These plants can be used as fodder in the modern vegetation. Livestock will eat these plants during free range herding and herders will randomly gather these plants as byproducts of target plant species. Thus, these seeds can be brought into the settlement as collected fodder and animal dung. The charred seeds identified in the samples may be related to these process.

Overall, the catchment zone analysis and archaeobotanical results strongly suggest that the meadow zone provided the most important plant resources within the local catchments. The herding patterns associated with the Bronze Age populations occupying the settlement relied on these important resources.

6.3 RUDERAL ZONE

Ruderal zones represent a process of degradation or disturbance of the landscape through human and/or animal activity (Figure 49). The original steppe vegetation is often removed, or damaged, and new plant species colonize the habitat. These areas usually surround the contemporary villages and some areas of the pasture land that is heavily used. The size of the ruderal zone depends on the frequency of human activity and herding practices. Thus, this zone usually exists along the edge of the settlement. In my survey area, most of the original steppe vegetation near the modern villages was significantly disturbed because of the scale of herding and agricultural activity. The degree of the disturbance usually related to the distance from the village that activities were taking place. The typical ruderal vegetation next to the modern village comprised Chenopodiaceae, Polygonaceae, Asteraceae, Fabaceae, Urticaceae, and Euphorbiaceae. From archaeobotanical samples, I identified 15 different plants (genus and species level) of 4 plant families that represent the ruderal zone (Table 30).

Figure 49 Photo of the ruderal zone in the edge of modern Stepnoye village

Table 30 The total number and percentage of identified plants from the ruderal zone in three settlements

Settlements	Stepnoye		Ust'ye		Streletskoye 1	
Families/Genus/Species	Total(Seed)	Percentage	Total(Seed)	Percentage	Total(Seed)	Percentage
Chenopodiaceae						
Chenopodium **spp.**	41	18%	839	73%	4	100%
Atriplex **spp.**	71	32%	97	8%		
Polygonaceae						
Polygonum **spp.**	38	17%	75	7%		
Rumex **spp.**	48	22%	23	2%		
Asteraceae	24	11%	95	8%		
Urticaceae			10	2%		

Chenopodiaceae (*Chenopodium* spp. and *Atriplex* spp.) was the most common plant family among the charred seeds recovered at the ancient settlements of Stepnoye (N=50%), Ust'ye (N=81%) and Streletskoye 1(100%). Polygonaceae (*Polygonum* spp. and *Rumex* spp.) represents 39% at Stepnoye and 9 % at the Ust'ye settlement. Asteraceae represents 11% at Stepnoye and 8 % at the Ust'ye settlement. There was very little Urticaceae (*Urtica dioica*.). identified and this was in the archaeobotanical samples recovered from the Ust'ye settlement (N=2%).

Chenopodiaceae seeds (N=935) are among the most abundant in the archaeobotanical assemblages recovered at Ust'ye. In the other two sites, the total number and ubiquity also were among the highest of the ruderal plants. The identified seeds below the subfamily level were *Chenopodium album*, *Chenopodium hybrium*, *Chenopodium polyspermum*, *Chenopodium rubrum*, and *Atriplex* spp (Figure 50; 51). Generally, all *Chenopodium* seeds have a circular shape with a characteristic embryo beak or radicle. But the size and structural characteristics are divergent for the identified species**.**

To prevent the disturbance of modern Chenopodiaceae seeds, I also collected comparative samples from every stratigraphic layer. The results indicated a slight decrease of these uncharred seeds from the upper disturbed levels to the lower cultural layers. All *Chenopodium* identified in the archaeobotanical samples represent annual plants. They can grow up to around 1m. *Chenopodium album* L. has the biggest total number among these species from the archaeobotanical samples. *Atriplex* sp. has a similar morphology when compared with the *Chenopodium* species. However, the radicle is more prominent. The growing season of these species is around July to August, and the withering season begins in early September.

Figure 50 Left - Photo of Chenopodium album in the Southeastern Urals region; Right – Photo of Atriplex sp. in the Southeastern Urals region

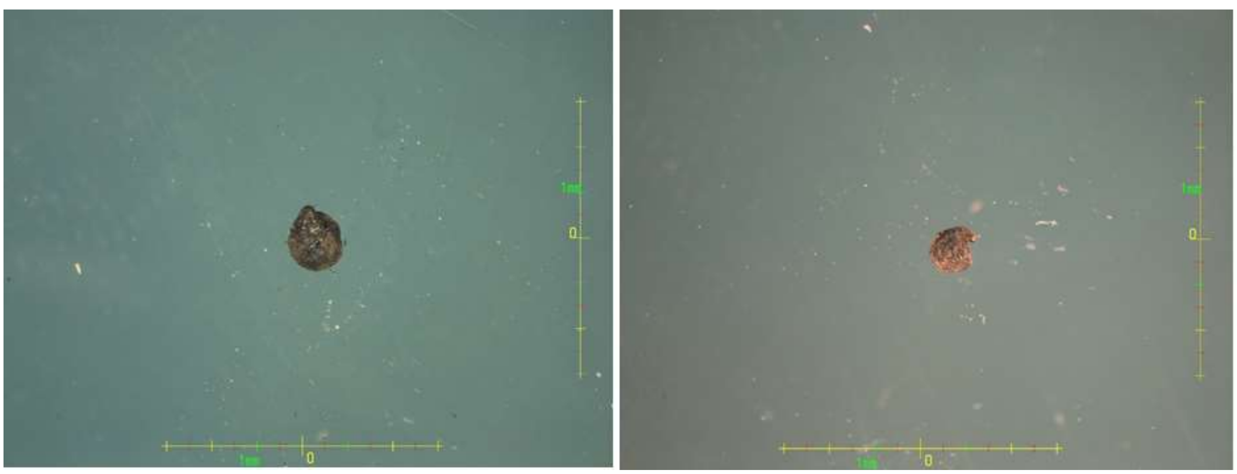


Figure 51 Left - Photo of Chenopodium album from the archaeobotanical samples; Right – Photo of Atriplex sp. from the archaeobotanical samples

In the Ustye samples, Chenopodiaceae seeds were nearly 19% of the total seeds recovered and identified, however, the ubiquity was only around 20%. Therefore, Chenopodiaceae may relate to some specific gathering activities associated with the settlements but were perhaps not used as a daily resource.

Of course, it is important to stress that the results of the archaeobotanical research is related to the conditions of preservation of remains at the sites. Chenopodiaceae seeds have a hard coat and are thus generally better preserved in the soil. During the excavations, we identified a significant amount of Chenopodiaceae seeds in the top excavated layers. However, the seeds of other plant species of modern vegetation were rarely found. The reproduction rate of different plants also contributes potentially to the presence of botanical remains at the archaeological sites. For example, *Chenopodium album* can produce as many as 100,000 to 600,000 seeds (Larina 2008, Mandal 1990). At the same time, Fabaceae, like Vicia Cracca, only produce around 5,000 seeds (Doronina 2008). These two factors may affect the representation of Chenopodiaceae seeds in the recovered archaeobotanical samples.

In the samples recovered from the Stepnoye settlement, the proportion and ubiquity of Chenopodiaceae seeds were much lower. And the distribution of these samples was uneven. The number from the samples inside the settlement was usually found to be quite low but their representation increased slightly in the midden samples that were taken outside the enclosed area of the settlement. This uneven distribution also happened at Stepnoye and at the Kamennyi Amber project. In some house units, the charred seed density of other species was typical but no Chenopodiaceae were recovered (Ruhl et al. 2015).

During the survey, I observed the distribution of Chenopodiaceae within the local catchment at Stepnoye. I could easily identify these plants in the modern village and in the surrounding area. In the village, they always grow along the road, in abandoned areas, and zones where trash and other refuse (manure, etc.) are deposited. Outside the village, they are the first plant species to colonize areas of disturbed land.

Chenopodiaceae, when compared with other plant species, has a low requirement for habitat. This character, combined with a high reproduction rate, makes Chenopodiaceae one of the dominant plants within the local catchment. For Bronze Age societies, the expansion of their occupation zones and relatedherding activities increased the frequency of disturbance of the native steppe vegetation. Without any controlling method, the distribution of Chenopodiaceae plants was likely increased significantly in the area associated with the enclosed settlement and the immediate adjacent areas. Thus, the high number of Chenopodiaceae seeds in the archaeobotanical samples was also likely related to the initial foundation, subsequent growth, and normal human and animal activities associated with the settlement.

The use of Chenopodiaceae plant resources has been discussed in other archaeological projects. Popova (2006) has suggested that the gathering of wild plant foods, especially Chenopodiaceae, played an important role in the diet of the Southwestern Urals region**.** In Krasnosamarskoe, *Chenopodium* also seems to have played a role in human nutrition (Anthony and Brown 2007). Ruhl (2015) also suggested that *Chenopodium* seeds were used to supplement human nutrition at the Kamennyi Ambar settlement. These ideas can be partly supported with the archaeobotanical samples recovered from the Ust'ye settlement excavations, however, data obtained from the Stepnoye settlement are less supportive. If Chenopodiaceae seeds were used as an essential wild food resource, the total number and ubiquity of Chenopodiaceae recovered from the Stepnoye samples appears insufficient to support this theory.

The charred Polygonaceae seeds identified below the subfamily level are *Polygonum aviculare*, *Polygonum persicaria*, *Polygonum convolvulus*, and *Rumex crispus* (Figures 52; 53). All identified polygonum spp. are annual plants and *Rumex crispus* is a perennial plant. The growing season of these species is around May to July, and the withering season begins in August.

Figure 52 Left - Photo of Polygonum sp. in the Southeastern Urals region; Right – Photo of Rumex sp. in the Southeastern Urals region

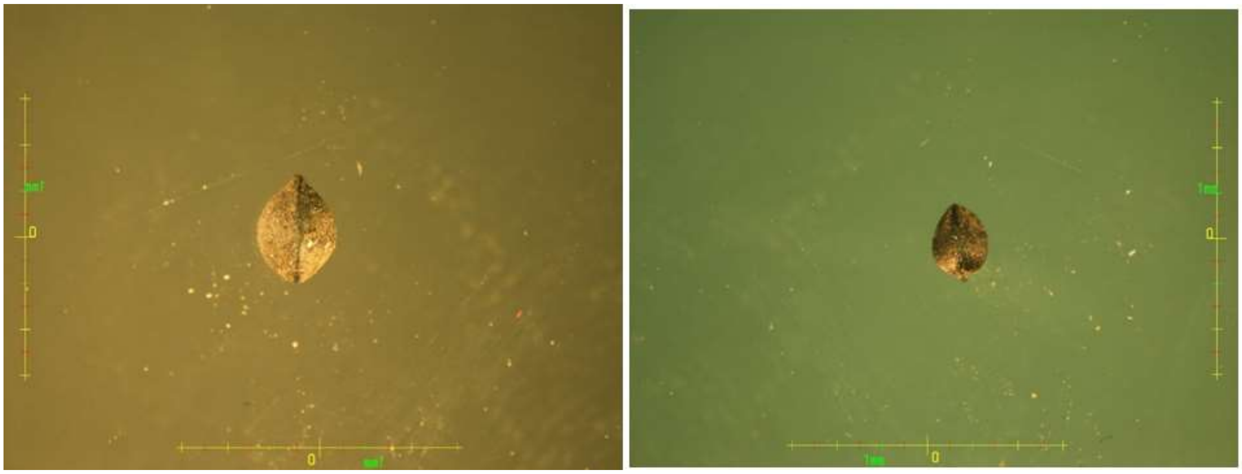


Figure 53 Left - Photo of Polygonum sp. from the archaeobotanical samples; Right – Photo of Polygonum sp. from the archaeobotanical samples

These seeds just found in the samples from the Ust'ye and Stepnoye excavations. The total number and ubiquity of these seeds are lower than Chenopodiaceae from the same ecology zone. In one of the Stepnoye samples, the total number of Polygonaceae was 28. This number is very high compared with other plant species in the same sample. Since this sample is related to a animal bone concentration area related to a house unit, these seeds may have been utilized as a food resource. *Polygonum* seeds were found in the Volga region at the Bronze Age site of Krasnosamarskoe and Peschanyi Dol 1, 2 and 3 (Popova 2006). Popova suggested that they were used as food resources in these societies. This interpretation may partly explain the use of Polygonaceae seeds at the Ust'ye and Stepnoye settlements, but the proportion in the human diet would therefore appear to be quite low at both sites.

Other discovered charred seeds were Asteraceae and Urticaceae (*Urtica dioica*) (Figure 54). They are common annual plants found within the ruderal zones. The growing season of these species is around June to July in this region and the withering season begins in August. The seed propagation of many local *Asteraceae* plants (e.g.*crepis* spp.) takes place through wind currents and this may have been a point of introduction during the withering season. Also, the seeds can become easily stuck on livestock and transported in this manner. Thus, Asteraceae can easily grow and spread within the local villages today. Most of the Asteraceae in the catchment zones are small flowering plants that are difficult to gather and the weight of the seeds is generally very low. This suggests that these seeds were not ideal as a food resource for either livestock or humans during the Bronze Age. Thus the charred Asteraceae seeds that entered the Stepnoye and Ust'ye settlemenst are most likely related to natural forces (wind or livestock). The young leaf of *Urtica dioica* is edible for livestock. However, mature plants, if touching the stem, can produce a rash and so local people usually avoid these plants. The presence of *Urtica dioica* was found only in the samples from the Ust'ye settlement and the total number and ubiquity of the recovered seeds was very low. These do not appear to have been an important plant resource in the Bronze Age (Figure 55).

Figure 54 Left - Photo of Asteraceae from the Southeastern Urals region; Right – Photo of Asteraceae from the archaeobotanical samples

Figure 55 Photo of Urtica dioica from the Southeastern Urals region

Compared to the results of the archaeobotanical studies at Kamennyi Ambar (Ruhl, Herbig & Stobbe 2014) and the three settlements I examined through my dissertation research, archaeobotanical samples identified from the ruderal zone have quite similar seed assemblages. The high total number and ubiquity of Chenopodiaceae and Polygonaceae seeds appears to be a common pattern in the Southeastern Urals region among Bronze Age societies. From the catchment zone analysis, I collected plant species from modern vegetation growth as a comparative sample. After identification, these species and brief information about them as a potential plant resource is listed in Table 28.

As noted above, other scholars have published archaeobotanical research on the use of Chenopodiaceae and Polygonaceae seeds by Bronze Age populations in the central steppes region (Popova 2006; Ruhl 2015). According to these studies, the total number of these plant seeds is higher than other plant species identified through their research. Thus, they have suggested that these edible seeds may have contributed importantly to human diet. Additionally, the seeds of Chenopodiaceae and Polygonaceae plants can be easily obtained from the ruderal zone. Based on my own phytogeographical survey in the Uy River valley, I observed that ruderal zones are always closely associated with modern villages. The high reproduction rate of *Chenopodium* may have ensured a high yield rate for Bronze Age communities. Therefore, it is logical that plant resources associated with the ruderal zones may have been a fairly consistent potential food resource for occupants of the settlements.

Nevertheless, at the Stepnoye settlement, I did not identify a large number of ruderal plant seeds in the archaeobotanical samples. The total number and ubiquity of these seeds are low in the samples taken from within the enclosed settlement area. At the same time, I did identify more ruderal seeds in the samples taken from the midden deposit outside the settlement but the number was still lower than those associated with plant species from the meadow zone.

It is an interesting point to consider that the Bronze Age occupants of the Stepnoye settlement were not focused on the plant resources that may have been closest to the settlement locality. The archaeobotanical results have indicated the priority of meadow zone over the ruderal zone at both the Stepnoye and Ust'ye settlements. During my survey of the valley, it was possible to observe the daily and seasonal choices being made by local herders in the region today. Every morning, the livestock are brought to the herding camps that are situated within the meadow zones. Before nightfall, they bring the livestock in from the meadows and generally place them in pens adjacent to the houses within the villages. These pens are located within areas with highly disturbed land and the livestock, and their dung, introduce the plant seeds from the other ecological zones.

This process may be related to the formation of the Bronze Age midden deposits that have been encountered at Stepnoye and Ust'ye. In the modern Stepnoye village, midden deposits cover most of the ruderal zone at the edge of the village. The plant assemblages from the midden test pit appear to be related to the process of dumping refuse from human activities withing the settlement as well as wild species that may have colonized the midden deposit naturally because of the disturbance. As a result, seeds of the ruderal plants are usually well represented in both total number an dubiquity in the midden deposit archaeobotanical samples.

At Ust'ye, around 80% of the Chenopodiceae seeds were identified from the samples extracted from the well. In the infill layers of the well context, a significant amount of charcoal and decayed animal bones were recovered and over 600 Chenopodiaceae seeds were extracted from 87 liters soil taken from this context. The seed density of these samples is extremely high compared with any of the other samples. Thus, the significant recovery of Chenopodiaceae from these infill layers is an especially interesting and important point for discussion.

Anthony and Brown (2007) have suggested that *Chenopodium* played an important role in the diet of the Bronze Age occupants of the Krasnosamarskoe settlement in the Samara Valley. Ruhl (Ruhl 2015) also found that *Stipa* and *Chenopodium* are always found together. Therefore, it is logical that both plants may have been processed in the same location. These findings may help to partially interpret the archaeobotanical assemblage from the well at Ust'ye. However, the combination of these plants from the same assemblage was not found in other samples taken through our research at the three Bronze Age settlements in the Southeastern Urals region. And, if one excludes the results from the well at Ust'ye, the total number and ubiquity of Chenopodiaceae is quite low at the Ust'ye settlement.

It is likely that Chenopodiaceae, as identified in the samples in the well from Ust'ye, may have been associated with the use of these plants for human subsistence. But, it is important to consider the high reproduction rate (seeds) of a single *Chenopodium* plant per annum and the fact that this could also contribute to an overrepresentation in the archaeobotanical samples. In any case, however, it must be considered that *Chenopodium* was a potentially important plant resource for human diet during the Bronze Age in the Southeastern Urals region. Polygonaceae seeds also can be used as food in human diets. However, the total number and ubiquity identified within the archaeobotanical samples collected through my research suggest that Polygonaceae was likely used only as a supplement in the human diet.

Overall, the catchment zone analysis that I undertook strongly indicated that the ruderal zones are always closely related to areas of intense human activity. Chenopodiaceae and Polygonaceae were found to be major plants from such zones. The archaeobotanical evidence suggests that Bronze Age societies collected these plants as food resources and other plant resources may have been introduced to the settlements through natural processes as well as human and animal activity.

6.4 STEPPE ZONE

The steppe is a natural undisturbed ecological zone (Figure 56) and in general the availability of water is much less when compared to the meadow zones. As a result, the overall variety of plant species is quite low in this zone. In my survey area, steppe botanical resources were usually located between the meadow and forest zones and the higher elevation slopes of small hills adjacent to the Uy River and its tributaries. Based on average summer precipitation and available water supply, the overall size of the steppe zone varies each year. Usually, this zone formed like a belt zone along the forest.

In the steppe zone, Poaceae is a major plant and other plant resources identified during my phytogeographical survey included Asteraceae, Polygonaceae, and Rosaceae. Plant resources associated with the steppe zone that were found in the archaeobotanical samples included 8 different plants (genus and species level) and 4 plant families (Table 31) .

Figure 56 Photo of the steppe zone in the Uy River valley

Table 31 The total number and percentage of identified plants from the steppe zone in the three Bronze Age settlements

Settlements	Stepnoye		Ust'ye		Streletskoye 1	
Families/Genus/Species	Total(Seed)	Percentage	Total(Seed)	Percentage	Total(Seed)	Percentage
Poaceae						
Stipa spp.	2	8%	187	38%		
Poa spp.	2	8%	65	13%		
Echinochloa sp.			4	1%		
Rosaceae						
Fragaria/Potentilla sp.	19	80%	192	41%	8	89%
Alchemilla sp.			12	3%		
Euphorbiaceae	1	4%	16	3%		
Rubiaceae			4	1%	1	11%

Rosaceae (*Fragaria/Potentilla* sp. and *alchemilla* sp.) was the most common plant family among the charred seeds recovered in the archaeobotanical samples at the Stepnoye (N=80%), Ust'ye (N=44%) and Streletskoye 1 (89%) settlements. Poaceae (*Stipa* spp., *Echinochloa* sp. and *Poa* spp.) represents 16% at Stepnoye and 52% at the Ust'ye settlement. Few Euphorbiaceae (*Euphorbia* spp.) were found (N= 17) at Stepnoye and Ust'ye while Rubiaceae (*Galium* sp.) (N=2) was only identified at Ust'ye and Streletskoye 1.

The identified Rosaceae seeds below the subfamily level are *Fragaria/Potentilla* spp. and *Alchemilla* sp (Figure57; 58). *Alchemilla* spp. are small flowering plants that were identified within the site catchment survey area. Since the size of the seeds are also very small, these seeds may be accidentally brought into the settlement. *Fragaria* and *Potentilla* sp. are very similar in morphology and both plants can be identified in the survey area. Therefore, I have grouped these into the same category.

The growing season for these plant resources is June to July and the withering season begins in August. *Fragaria*/*Potentilla* seeds were identified in the archaeobotanical sampled from all three Bronze Age settlements. The total number and ubiquity are high among the common steppe zone plants. In the survey area, *Fragaria viridis* is a wild strawberry and as discussed above may be consumed without any cooking preparation. It is commonly gathered in the summer by local villagers in the region today and either consumed by the household or gathered in larger amounts and sold along the roadsides. During my phytogeographical survey, I easily found patches of these plants on the edge of the steppe zone. In the withering season the harvest rate is quite high and it is possible to gather and fill a small bucket in one hour. Wild strawberries are sweet and juicy and thus offer an attractive plant resource within the steppe zone. The charred seeds found within the archaeobotanical samples are most likely related to human consumption of these plants in the Bronze Age.

Figure 57 Left - Photo of Fragaria viridis from the Southeastern Urals region; Right – Photo of Fragaria/Potentilla sp. from the archaeobotanical samples

Figure 58 Photo of alchemilla sp. in the Southeastern Urals region

Poaceae is a major plant resource in the modern vegetation of the steppe zone. The identified charred seeds below the subfamily level were *Stipa* spp., *Echinochloa* sp. and *Poa* spp (Figure 59). *Stipa* and *Poa* seeds were found in the archaeobotanical samples from both the Ustye and Stepnoye settlements, however, the *Echinochloa* sp. Was only found in the samples recovered from Stepnoye. All of the *Stipa* seeds were found to be fragmentary with length estimations around 7-8 mm. The growing season of these plants is late May through July and the withering season begins in August.

Figure 59 Left - Photo of Stipa sp. in the Southeastern Urals region; Right – Photo of Echinochloa sp. in the Southeastern Urals region

No Poaceae seeds were identified in the Streletskoye 1 archaeobotanical samples and only 4 Poaceae seeds were found in the Stepnoye samples. This number is very low when compared with the other identified plant species. During my phytogeographical survey, I found that when I walked through the steppe zone the mature *Stipa* easily attached to my clothing. Thus, these Poaceae seeds could have been easily transported by humans and animals into the Bronze Age settlements.

At the Ust’ye settlement, however, a total of 179 *Stipa* seeds were identified and they represented 70% of the Poaceae seeds recovered at that site. Around 75% of the *Stipa* seeds were recovered in the samples collected from the well feature and the ubiquity was above 80%. The overall ubiquity of *Stipa* in Ust’ye, however, was found to be 20%. This finding is similar to that for the Chenopodiaceae seeds. A total of 8 *Stipa* awns also were identified in the samples. Usually, the awn of these plants can be understood as clear evidence of food processing as the number of the waste byproduct through processing is generally higher than the seed counts.

The identification of *Stipa* in the archaeobotanical assemblages recovered from the Kamennyi Ambar settlement found that there were more awns and less seeds (Ruhl et al. 2015). The results of my archaeobotanical sampling at Ust’ye produced the opposite result. There are many factors that may account for this including the fact that the typical processing residues many not have existed within the plant assemblages at Ust'ye. The total number of *Poa* sp. is lower than that for the *Stipa* sp. Similar to the identified *Stipa remains*, over 70% of the *Poa* seeds were recovered from the well feature at Ust'ye. *Poa* seeds also can be used as a food resource for human consumption. It is possible that the Bronze Age occupants of the Ust'ye settlement collected both resources at the same time. The number of *Echinochloa* sp. were found to be much lower than the other two species within the Ust'ye samples. In comparison, it may not have been an essential resource during the Bronze Age.

Galium sp. is the only identified genus in the Rubiaceae family, and *Euphorbia* spp. is the only identified genus for the Euphorbiaceae family. The overall recovered number of the two plants was quite low in the archaeobotanical samples and it is important to note that the seeds are not edible by humans. Some *Euphorbia* seeds that were encountered in the archaeobotanical survey were identified as poisonous. As a result, these plant seeds were not likely potential resources from the steppe zone for human consumption.

Compared to the archaeobotanical results from Kamennyi Ambar (Ruhl et al. 2014), and the results from my research at the three Bronze Age settlements, the archaeobotanical samples from the steppe zone had similar seed assemblages (*Fragaria/Potentilla* sp., *Stipa* spp., and *Poa* spp.). But the total number and ubiquity of Poaceae seeds were found to be entirely different among these sites. From the catchment zone analysis, I collected some plant species from modern vegetation as a comparative sample. After identification of these, the species and brief information about these plant resources is provided in Table 23.

During my survey, I seldom observed herders and livestock remaining within the steppe zone. At Stepnoye, I observed that *Stipa* species were very abundant in the steppe zone. Local herders do not collect this species for fodder and livestock consumption. From my interviews with local herders, I was informed that the hard awn of these species can create irritation in the mouths of the livestock and in general livestock prefer not to graze on these plants (Figure 60). As a result, herders generally push the livestock through the steppe area and into the meadow zones. During my survey, I also observed that local herders collect hay for fodder that does include the *Stipa* sp. The seeds of Stipa plants can easily be spread by wind currents and one can find these plants even on the surfaces of the haystack that are construced in the meadow zones. The haymaking locations in the meadows, in fact, are often close to the steppe zone and the processing of cutting the fodder resources includes the accidental gathering of some *Stipa* plants. Although *Stipa* plants are not specifically used for livestock grazing and foddering they do still appear within the livestock grazing areas. As noted above, *Stipa* can easily attach to clothes and the livestock when they pass through the steppe zone and so are easily transported from one ecological zone to another and this may account for the presence of the seed assemblages within the Stepnoye settlement samples.

Poaceae are major plant resources found in the steppe zone. This zone is easy to access and widely spread adjacent to the settlements. But, according to the very low number of seeds recovered from plants within this zone, one can posit that the Bronze Age occupants of the Stepnoye settlement did not heavily utilize these plant resources. It is interesting that Streletskoye 1 also lacks evidence of Poaceae usage.

These two Bronze Age settlements are situated along the same river and are 18.4 km apart. The choice of plant resources was certainly related to the local environmental factors but we must also consider that even though the subsistence strategies were similar there may have been different choices made in resource selection. For example, the archaeobotanical data indicate the meadow zones were a favored source for exploitation but not every settlement community appeared utilize resources located in the steppe zone. Besides Poaceae, other wild plants in the steppe zone, such as *Fragaria viridis*, could have contributed to the human diet. However, it is important to stress overall that the steppe zone has a relatively low variety of available plant species and is primarily dominated by Poaceae. The other plant resources in the zone were seldom found within the archaeobotanical samples from the Bronze Age settlements.

Figure 60 Photo showing the long awn of Stipa sp. in the Southeastern Urals region

Overall, the catchment zone analysis, including phytogeographical study, and the archaeobotanical results from the ancient settlements, have suggested that the utilization of botanical resources from the steppe zone varied between settlements. *Fragaria/Potentilla* sp. were likely popular plant resources in this zone used by the Bronze Age communities. Poaceae is major plant within the steppe zone and they may have been collected for food resources. However, Poaceae does not appear to have been associated with all Bronze Age populations occupying the different settlements. The other plant species identified in the archaeobotanical samples may have been introduced to the settlements through natural agents such as wind currents or through being attached to humans and animals and brought into the settlement through daily activities.

6.5 FOREST ZONE, VARIA AND UNIDENTIFIED SPECIES

The forest zone is usually formed along the upland elevation zones associated with the small hills within the survey zone (Figure 61). Usually, the forest zone is not situated near the main river. *Betula* and *Pinus* are the major species identified in the forest zone. The analysis of the archaeobotanical samples from the Bronze Age settlements also identified these resources(Table 32).

Figure 61 Photo of the forest zone in the Southeastern Urals region

Table 32 The total number and percentage of identified plants from the forest zone in the Three Bronze Age settlements

Settlements	Stepnoye		Ust'ye		Streletskoye 1	
Families/Genus/Species	Total(Seed)	Percentage	Total(Seed)	Percentage	Total(Seed)	Percentage
Pinaceae						
Pinus sp.	5	83%	20	91%		
Betulaceae						
Alnus sp.	1	17%	2	1%		

Pinaceae (*Pinus* sp.) and Betulaceae(*Alnus* sp.) were the identified families among the charred seeds (Figure 62). Besides charred seeds, identified charcoals from the excavation soil samples were only represented by these two families. The seeds are not edible for human consumption and it is most likely that these resources were brought into the settlement through wood gathering activities. Also, the remnants of a large charred wooden log wood was identified in the Ust'ye excavation and some of these may have been used for structural timbers in the houses.

Importantly, Spengler (2013) has discussed the use of animal dung as a fuel resource within the Bronze Age pastoral economies in present day Kazakhstan. According to my archaeobotanical results from the three Bronze Age settlements in the Southeastern Urals region, most of the archaeobotanical plant remains do not appear to have been related to dung burning. Rather, the plant resources from the forest zone were the major source of fuel used in the settlements.

Figure 62 Left - Photo of Pinaceae in the Southeastern Urals region; Right – Photo of Betulaceae in the Southeastern Urals region

My catchment zone analysis and archaeobotanical results suggest that the forest zones were important for the Bronze Age settlements. Pinaceae and Betulaceae were important plant resources associated with all the populations occupying these settlements. The tree resources could be used for fuel and building materials.

Besides the botanical resources from the specific ecological zones discussed above, there were some identified seeds that were difficult to group. Because of the preservation condition, most of these species are just classified to the family level. These include Brassicaceae(N=4 in Ust'ye), Apiaceae(N=15 in Ust'ye), Caprifoliaceae(N=1 in Ust'ye), and Solanaceae(N=5 in Ust'ye). The size of these seeds is quite small and most of them are round shaped. The identification of these seeds was based on the size and remnant characteristics. After comparing the preserved archaeobotanical finds with seeds from modern vegetation it is possible to group these into specific families. Because of the variety of habitat for these plant families it is not possible to discuss them as being related to a specific ecological zone. However, the overall number of the recovered seeds is very low in all samples, and thus will not significantly affect the interpretation of the use of ecological zones within the defined catchments of the settlements.

The unidentified seeds that were recovered included many fragmented plant parts. Based on the general character and morphology of the fragments it is likely that many of them relate to Fabaceae. Since most pieces were too small for clear identification, and the hilum was absent, I have placed them into the unidentified group for the purposes of this dissertation.

6.6 ESTIMATING PASTURE FORAGE

Generally, the area of study is located in the north temperate zone between approximately 50° and 55° north latitude. The landscape of the Trans-Urals peneplain region is represented by rolling grassland steppe with higher elevation areas to the west and an almost flat plain to the east. The topographical elevation gradually declines from 400–350 m above sea level in the west to 200–190 m in the east. The Ural Mountains themselves condition the climate by blocking the flow of air from the west and thus provide a conduit for cold and dry arctic air from the north and northeast. In the summer season, continental tropical air flows up from Asia, bringing hotter amd drier weather. The climate is characterized as continental with mean temperatures below 0°C in winter and above 10°C during summer. The absolute winter minimum recorded has been as low as -50°C. Precipitation declines from 500 mm annually in the north to 300 mm in the south, with the largest amount during the warm months (75%–78% of annual precipitation).

The research area of the dissertation is situated in the steppe zone in the Southeast Urals region. The annual average for snowfall is 24-30 cm, and it usually snows for 153–155 days per year (Levit 2005). The Ural and the Tobol are the two major rivers in the southern Trans-Urals that form the watershed and landscapes. The interfluve is shaped by the beds of smaller tributaries that flow either west towards the Ural or east towards the Tobol. The largest source of water is annual precipitation, which provides 80%–90% of the rivers' volume (Levit 2005).

The climate pattern in the region largely conditioned the type of pastoralist herding patterns that developed here. In summer, the size of the meadow zone is maximized because of the sufficient water supply. Thus, outdoor herding activities and haymaking processes are usually scheduled in the Summer season from May to August. Since the water sources of the rivers depends largely on annual precipitation, the size of the different vegetation zones (especially meadow zone) varies substantially from year to year.

The analysis of the archaeobotanical samples, combined with the catchment zone analysis, provides important empirical evidence for understanding patterns of usage for all the local ecological zones within the catchment. This evidence also allows one to identify some specific differences in the patterns of use between the three Bronze Age villages. The meadow zone provided crucial resources for the ancient pastoralist communities just as it does today for local livestock herding, grazing, and foddering. This zone provides the most valuable area of pasture within the catchment and is also very useful in terms of plant resources that may have been utilized by human populations.

The forest zone was an important resource for the collection of fuel and building materials. Both the forest and meadow zones were essential for other plant resource exploitation as well. Besides these two essential zones, the Bronze Age communities selectively used some plant resources found in other ecological zones. The choices and usage rate of these resources probably relied heavily on the local microenvironmental settings. As I have identified, these varied among the different settlements (Figure 63) and the exploitation of local catchment resources probably represented optimal, and optional, choices that were made by the associated Bronze Age communities.

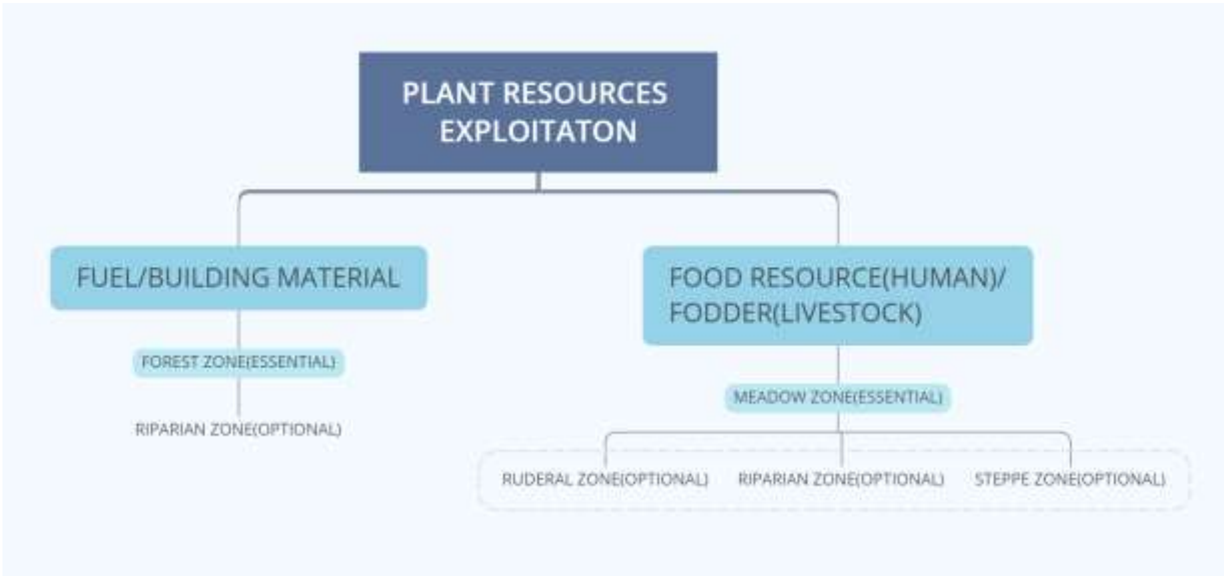


Figure 63 Plant resources exploitation pattern of the Bronze Age settlements and associated ecological zones in the Southeastern Urals region

Catchment zone analysis also stimulated two important questions: (1) How vital was the meadow zone in the Bronze Age subsistence economy? (2) Was the utilization of other ecological zones the result of overall inadequate resources or does this reflect a simple matter of choice and preference to supplement the subsistence pattern?

Stobbe (2016) has suggested two models that may help to address these questions. Model A calculates the biomass production and grazing capacity of the catchment zone and determines the number of animals that can be supported throughout the year. Model B is based on the number of house units in the settlement and an estimation of the number of livestock associated with these households and by extension the size of the potential herd of the Bronze Age communities occupying these settlements (Tables 5 and 6).

In Model A, the catchment size is fixed to a 4km radius. Stobbe utilized GIS software to identify the size of the different ecological zones within the catchment. Finally, she used the average estimated productivity of the steppe zone and meadow steppe to calculate the grazing potential. In Model B, the result suggested that the estimation of total population per house units(up to 10) with total around 1000 livestock from 41 house units in Kamennyi Ambar settlements. There was no danger of overgrazing within the catchment zone. In general, Stobbe suggests that a year-round grazing pattern was possible in the local catchment during the Bronze Age. However, fresh or dried fodder may have been prepared for weak animals or during the harshest winter months.

Sharapov (2017) has recently calculated the size of the catchment zone for the MBA population associated with the Zingeyka valley at 7.5 km in radius. His method combined Stobbe's Model A and Model B. He suggested that the herding pattern of the Bronze Age was similar to the Eurasian extensive pastoralist tradition that relied on very little to no use of prepared fodder. In this model, the vast majority of livestock were kept outside year around (Masanove 2011; Yanguzin 2002) and that corrals were often associated with households for the livestock.

Other scholars have underscored the importance of the seasonal fluctuation of grazing capacity and that pasture productivity from spring to winter can vary from 750-263 kg/ha (Levit & Mironocheva-Tokareva 2005; Sobolev 1960) The winter season in the South Urals region is very long and snow fall can last from five to six months. During the winter in the modern villages of the region only horses are herded outside the village and cattle and sheep are kept close to houses within corrals and covered structures. This minimization of risk method is still essential for local herder today.

Many families within the modern villages have two cows and with the assistance of mechanized machinery it is possible to collect enough winter fodder during a single month of the summer**.** The archaeobotanical samples collected from the ancient Stepnoye settlement also suggests the intensive exploitation of plant resources in the meadow zone instead of other ecological zones. Therefore, my pasture estimations focus on the meadow zone within the Uy River valley. This research began with a pedestrian survey along the edge of the meadow zone and the collection of GPS points. After that, I digitized the general distribution of the meadow zones and estimated the potential grazing capacity within these areas as defined by a catchment zone of 10km.

My pedestrian survey was conducted during the summer of 2017. The summer season provides the highest grazing capacity within the catchment zone. It was also possible, during my survey, to observe local herding patterns at that time of year. In total, I collected 120 GPS points during the pedestrian survey. The discussion of the meadow zone distribution within the catchment zone is therefore based on the results of my survey. After analysis of the GPS points, it was possible to more accurately sketch the extent of the meadow zone within the Uy River valley. Stobbe (2016) used the satellite image and Landsat image for the estimation of pasture. This method will be less precise because of the particular season of the vegetation associated with the time of the satellite image. Also, based on the field experience, vegetation zones in the Southeastern Urals region are difficult to distinguish from Satellite image.

Based on my pedestrian survey, which was undertaken within a 10 km radius around the Bronze Age Stepnoye settlement, four main types of meadow zones were identified (Figure 64):

(1) Year-long Meadow zones along the Uy and Kurasan rivers.

(2) Year-long Meadow zones along the seasonal streams

(3) Year-long Meadow zones along the edge of the forest.

(4) Seasonal Meadow zones formed in the depression areas during the rainy season.

As discussed above, the meadow zone is typically a continuous belt zone adjacent to the main river, especially in lower elevation areas. In the survey area, most meadow zones are continuous large patches along the Uy River. The width of this zone varies from 300-550 meters and is largely dependent on the water supply from the river (e.g. flooding, subsurface water and proximity to the water table, collection of rainwater during heavy precipitation, etc.). One way of estimating the localized available supply of water is by examining the river's width. The most significant meadow patches usually form in locations where the river is widest and the overall landscape elevation is lower.

Besides the meadow zones along the river, there are also small meadow zones that form along the small streams that are tributaries to the main Uy River. These small streams are usually formed from springs with consistent flows seasonally. In Figure 64, it is possible to note that these streams usually flow from the forests (higher elevation upland zones) to the main Uy River. These bisect the steppe and meadow zones that run broadly parallel to the main river course.

The width of the meadow zone along the streams flowing into the Uy River varies from 100-200 meters. In the rainy season, meadows also form in some low elevation depressions within the steppe zone. These depressions hold moisture following rainy periods. The area surrounding these depressions will slowly change to steppe vegetation when the water in the depressions evaporate.

The size of the vegetation also increases in the center of the depressions until the moisture has evaporated. Therefore, the size of the meadow vegetation around these depression is unstable and because of this fluctuation local herders do not consider them to be a significant grazing resource. However, livestock do linger in these locations as they pass through them towards the richer meadow zones.

During my survey, I also found meadow zone areas at the edge of the forests. Usually, the forest is located at some distance from the main river. For example, the Bronze Age Stepnoye settlement is today located approximately 5 km away from a forest zone. The reason for growth of the meadow vegetation adjacent to the forest is also related to water supply (soil moisture) and local soils. The location of the forests is generally associated with higher elevation areas, which receive more snow fall during the winter and early spring, and have sources of underground water (springs). The soil nutrients are usually higher in the forest zone as well because of the humus formation.

It is difficult for the meadow vegetation to grow in the forest zone because of competition with the abundant woody plant species. However, on the edge of the forest and the steppe zone, a narrow belt of meadow vegetation is typically formed. Usually, the width of this meadow belt can expand up to 30 meters. Local herders usually gather and dry fodder from these locations. The drier and less productive steppe zone separates this belt from the summer herding zone along the main river and its tributaries. As a result, livestock do not disturb the vegetation in these areas and the size of the vegetation is quite stable even in years with low precipitation.

Figure 64 Satellite image and photos denoting phytogeographical survey zone, associated meadow zones, and location of the Stepnoye Bronze Age settlement

Meadow vegetation also forms in some locations on the slopes of the upper elevations hills away from the main river course. However, through my observations, I found that local herders never utilize these resources for two main reasons: (1) these places are usually too far away from the herding camps and settlements, and (2) the landscape between these locations is typically covered by steppe grazes and contain no water resources for the livestock. As a result, the cost-efficiency of herding in these locations is very low when compared with the meadow zones next to the consistent sources of water along the main river, its tributaries, and the small seasons streams that flow into it.

There are many environmental factors that separate the meadow zones and rivers, streams, and other ecological zones contribute to these factors. Based on the survey results, elevation is a critical factor in determining the formation of meadow zones along the main river. Most of the GPS points taken during the survey indicated elevations between 255-270m above sea level. However, the elevation difference in the same meadow zone was usually less than 10m. It is, therefore, possible to see a clear elevation separation between the meadow and steppe zones. Sometimes the distance away from the river is not the only factor that influences vegetation growth as some areas of the river bank are much higher than the water surface. As a result, one can only find steppe vegetation growth in these locations.

During the survey, I noted that many meadow zones were distributed throughout the catchment zone. But some of these meadow zones were seasonal and only existed during the rainy season. Thus, there are two basic ways in which to exploit the meadow zones for pastoralism: (1) those locations representing year-long meadow zone growth within the catchment, and (2) locations with lower elevations that promote the formation of only temporary meadow zones within the catchment.

One of the present-day herding camps is situated approximately 1 km from the Bronze Age Stepnoye settlement. This camp is located next to an artificial pond that has been created on a small stream that flows from the upland forest zone 5km to the north. The distance to the main Uy River is around 1 km. This herding area offers year-long meadow vegetation associated with the pond, river, and stream. Also, there are many depression areas surrounding the herding camp that also offer seasonal meadow resources. Overall, the size of the combined meadow zones is relatively stable in this specific area. There is no doubt that the Bronze Age vegetation is somewhat different when compared with the modern vegetation because of the nature of human activities during the modern era. However, the survey results still provide essential information about the formation and distribution of meadow zones in the catchment zone. The overall logic of how to maximize the exploitation of these naturally occurring meadow zone within the local landscape may have been similar during the Bronze Age.

As discussed above, the survey area covered a 10km radius around the ancient Stepnoye settlement. From observing local herders, the actual herding distance utilized is much less than 10km. The limiting factors in selecting grazing areas is also related to proximity of good water resources and the time it takes to move a herd during a single day (Asanov et al., 1992; Coppolillo 2000; Dahl and Hjort 1976). Therefore, based on my observations of local herding within the catchment of the Stepnoye village today, the total radius was reduced to around 5km. The catchment zone of the Stepnoye Bronze Age settlement is quite flat. Thus, the variance between distances shown on the maps that have been produced and the actual walking distance and time of travel is small.

If we consider the landscape and ecological zones that would be contained within a 5km radius around the ancient Stepnoye settlement, rather than a 10km radius, this area would include the key meadow zones along the Uy River and the Kurasan River tributary, small streams flowing into the Uy River (as discussed above), and the edge of the forest zone to the north of the settlement (Figure 64). The small seasonal meadow zones related to the depressions in the landscape were recorded during the pedestrian survey and so my estimations of the resource value of the small catchment is based on detailed data from the phytogeographic survey and related GPS points.

The estimated size of the meadow zones along the river and streams is based on the width (minimum/maximum) of the meadow zone measured during the survey. The size of the potential depression is the area covered by associated elevations (255 to 275m) minus the area of year-round meadow zone. Because these meadow zones formed in depressions with only seasonal meadow type growth during the rainy season, the estimation of the area size was calculated for 1 month only. The results of these estimations are listed in Figures 65 and 66 and Table 33.

Table 33 The estimation of the Meadow zones in a 5 km radius survey area around the Bronze Age Stepnoye settlement

	Location	Size(in ha)	Pasture(t)
	along the river	935-1557	7480-12456
Meadow	along the stream	260-527	2080-4216
	forest edge	78	624
	Potential depression	41-189	328-1512
Total		1314-2351	10512-18808

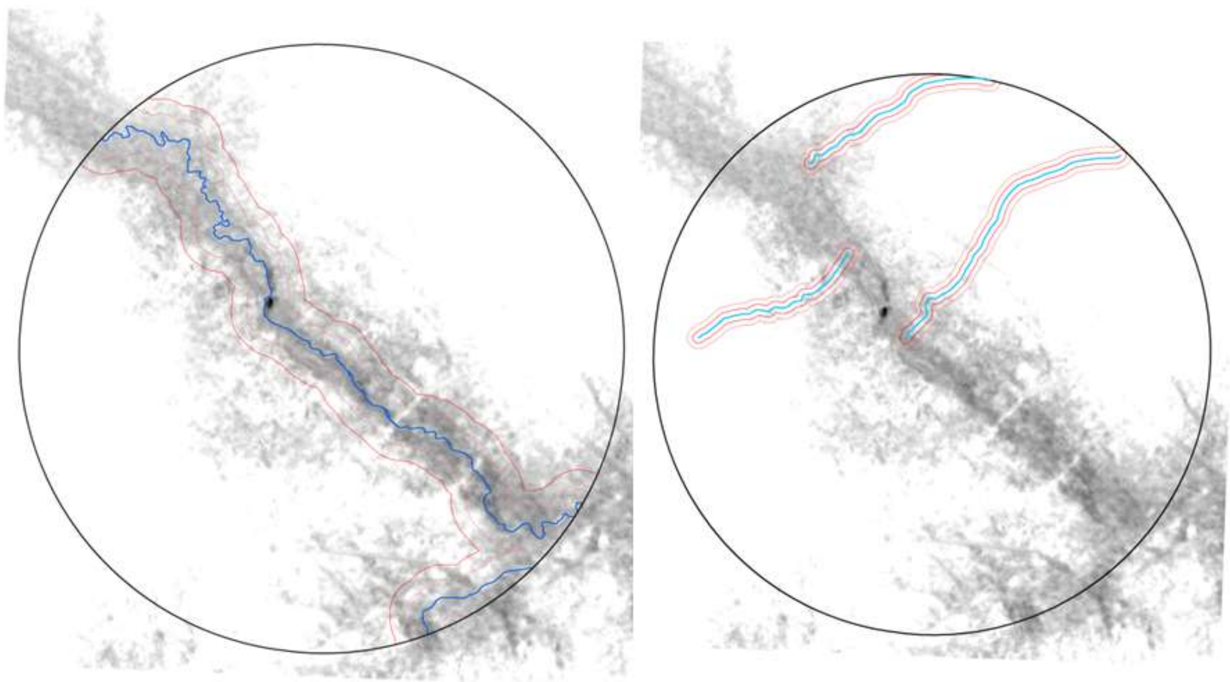


Figure 65 Left-Image indicates the extended meadow zones along the main rivers in the 5km radius survey area; Right-Image indicates the extended meadow zones along the streams in the 5km radius survey area

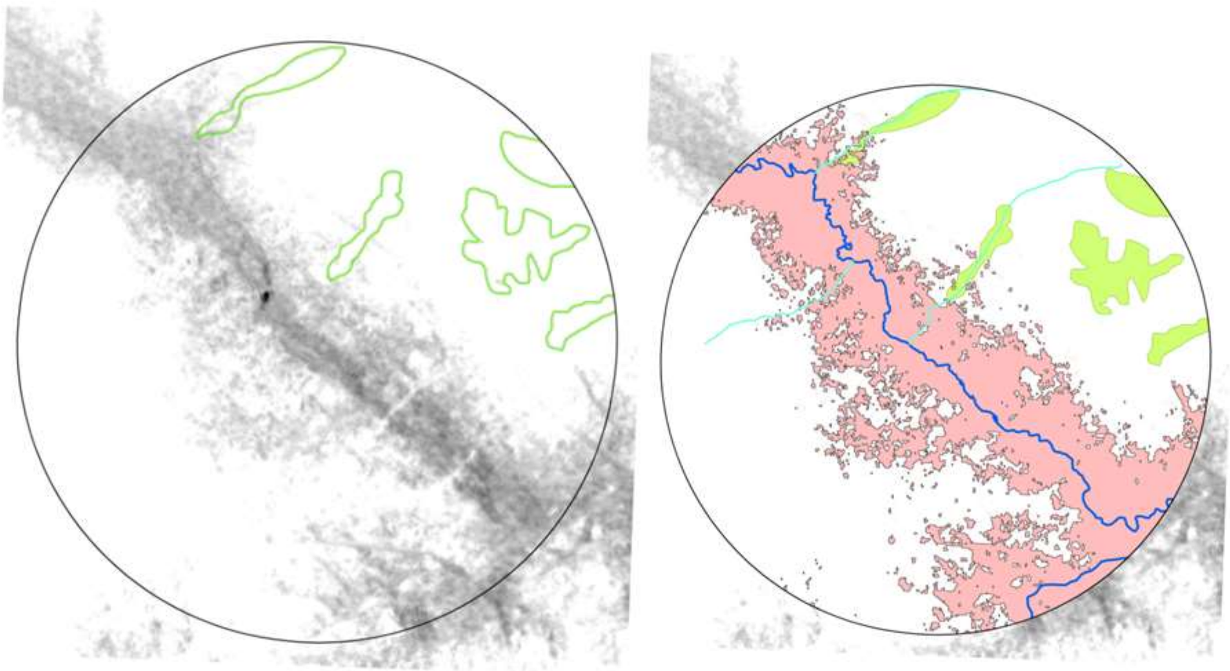


Figure 66 Left-Image showing the extended meadow zones along the forest in the 5km radius survey area; Right-Image showing the location of rivers, streams, forests and the potential depression (seasonal) meadow zones within the 5km radius survey area

The estimated area of the year-long meadow zones in the catchment zone ranges from 1,314 (with a the minimum buffer zone of rivers and streams) to 2,351 ha (with a maximum buffer zone of rivers and streams). This number is quite high when compared with the estimation of other settlements in the Southeastern Urals region (Stobbe 2016). The size of the meadows can have a high inter-annual fluctuation because of the variability and timing of precipitation. This estimation is also combined with Models A and B, as discussed above (Stobbe 2016), and additional comparative data(Frachetti 2008:96, Yanguzin 2002). The estimation of grazing capacity, therefore, is based on the unit productivity of meadow zones (8tons(1000kg)/ha fresh pasture) mentioned discussed by Stobbe (2016). Assuming this is a year-round grazing pattern, the whole fresh pasture is estimated to be between 10,512 to 18,808t.

This estimated number can then be divided by the daily nutrient values for different livestock herds and a maximum estimate for livestock herd species can be produced for the catchment zone resources (Table 34). The meadow zone in the 5km radius survey area around the Stepnoye settlement, therefore, would have the estimated potential to support 7,362 cows, 7,157 horses or 42,941sheep. This number is much higher than the actual livestock herd sizes in the modern Stepnoye village today. Thus, by estimation of the pasture resources in this way, the carrying capacity of this catchment zone would have been more than sufficient for Bronze Age communities occupying the region.

Table 34 The ethnographic data and archaeological data used for pasture resource estimations and livestock nutrient needs

	nutrient needed per day(kg)
cow	7
horse	7.2
sheep	1.2
Frachetti (2008: 96)	
Herd structure for Bashkir household(10 people)	nutrient needed per year(t)
40 cows	102.2
20 horses	52.6
40 sheep	17.5
Total	**172.3**
Yanguzin(2002)	
Herd structure for Bronze Age pastoral (per person)	nutrient needed per year(t)
1.2 cows	3.066
0.14 horse	0.368
1 sheep	0.526
Total	**3.96**
Stobbe(2016)	

We also can estimate the nutrient requirements for the livestock in the Stepnoye Bronze Age settlement. According to the settlement plan, following air photo interpretations, the number of dwellings at this site was approximately 50 (Zdannovich and Batanina 2007). If we use the herd structure for an average 18th century Bashkir household (10 people/per household) as an analogy, the meadow zone in the 5km radius survey area would support 60 to 109 households.

It is also important to utilize the person per household estimates that have been suggested for the Middle Bronze Age, which are from 3 to 10, and for the Late Bronze Age it is 5 (Epimakhov 2002; Johnson 2014; Kosarev 1991; Knoll 2014; Krause 2013). Using the maximum number of estimates for the households in the Stepnoye settlement, and the estimated herd animals per person for the Bronze Age (Stobbe 2016), the result suggests that it would be possible to feed 470 households (up to 10 people per household) in the catchment zone. This estimation is much greater than what was likely for the population at the Stepnoye settlement (interpreted to be 50 house units). However, the results do indicate that the meadow zones in the survey area (5km radius) were more than sufficient to support sedentary multi-resource pastoralism.

From these estimations, we can assume that overgrazing was an unlikely event during the Bronze Age and these results support the interpretation of the archaeobotanical samples obtained from the excavations of the Stepnoye settlement. The meadow zones were essential and sufficient to support the multi-resource pastoral subsistence economy of the community occupying the Stepnoye settlement. This result of these estimations also generates some new questions about plant resource exploitation: (1) If the Bronze Age Stepnoye settlement relied primarily on the meadow zone, what was the annual herding pattern for this society? (2) Does the high numbers of specific charred plant seeds in the archaeobotanical samples represent the original plant usage pattern in the Bronze Age societies?

These results are also related to the constraints on the preservation and representation of the archaeobotanical remains. Plant foods were important components in the diet of livestock and human populations, however, the macrobtoanical studies have relied principally on the presence and identification of charred seed remains. Other plant parts were only rarely found within the samples. According to recent archaeological data, the subsistence economy among most Bronze Age settlements in the region was likely related to a multi-resource form of pastoralism that did not include the use of agriculture. Thus, the proportion of plant seeds in the human diet was likely not very high. It is essential to better understand the exploitation of other plant parts by the Bronze Age communities and to also better understand the annual herding and grazing use of other plants parts. In order to address these important issues in a more detailed way, the next chapter presents ethnographic data that was collected from the region and considers this in the context of a Bronze Age multi-resource pastoralism model.

7.0 ETHNOGRAPHIC STUDIES AND PASTORALISM

The archaeobotanical sampling associated with the excavations of the three ancient settlements, and additional catchment zone analysis and phytogeography survey discussed in the last chapter, have helped to identify key patterns of plant resource exploitation associated with the meadow zones. However, there are still questions regarding herding patterns and plant usage within the microregional catchments. For example, the archaeobotanical samples suggest an intensive use of the meadow zone but some plant species, such as the significant number of *Chenopodium* from the ruderal zone, are primarily associated with the middens and well features at the settlements. To further understand the use of the different ecological zones, I also conducted ethnographic study as part of my dissertation research. Through these studies, I could observe livestock patterns as well as to collect information about the use of wild plant resources from families living in the local villages. This information is used to address several of the research questions that structured the dissertation study and will be discussed in more detail in this chapter.

7.1 HUMAN DIET

Nowadays, the main diet in the local villages still relies to a large extent on dairy products and meat. Grain foods (millet, rice, buckwheat, peas, wheat, and barley) and tubers (potato) are consumed in daily life. None of these species are found in the archaeobotanical samples from the ancient settlements. Moreover, the byproduct of these species is also seldom found in the samples. For example, millet is a major crop in the local farming economy and the villagers often cook this for breakfast. During the harvest of millet, the farmer also harvests wild seeds within the fields and these are brought back into the villages. Common weeds found in the harvested millet from the fields are Poaceae family plants like *Setaria* spp. and *Panicum* spp. These wild species are easily found in the modern vegetation within and around the village. However, in archaeobotanical samples, we cannot find any of these species. Thus, it may be logical to assume that use of agricultural practices were simply not part of the Bronze Age period in the Southeastern Urals as not a single example of a domesticate plant has been recovered from any recent projects in the Southeastern Urals. This contradicts earlier publications (Gaiduchenko 2002) for the recovery of millet, wheat and barley within the region.

Besides the domestic plants grown locally today, local villagers also collect wild plant resources from the steppe, meadow and forest zones. The common names for these plant species, which are utilized in modern times, are listed in Table 35. One can easily find local villagers selling these plants along the roadsides, especially in the summer and fall periods. One of the major plants that is targeted in the steppe zone is the wild strawberry (*Fagaria* viridis).

Wild strawberries usually form small patches within the steppe zone and the sizes of these patches can be around 20 sq. meters. The fruit season of the wild strawberry is from July to August, although this can vary depending on the precipitation levels. The duration of the strawberry fruit is less than 2 weeks. Because of the distribution of habitat and environmental constraints these patches usually cluster together in specific locations. For example, in the catchment areas of the Stepnoye and Streletskoye 1 settlements, it was always possible to locate wild strawberry patches in the depressions associated with former Bronze Age house units. Local people usually gather these resources intensively during the fruiting season. Sometimes the gathering activity can last a whole day and only cover the available patches that are within walking distance of the villages or the ancient settlements.

Table 35 Common names of the plant species identified during the ethnographic studies

Genus/Species	Common Name in Russia
Vicia cracca	Mouse Pea
Medicago spp.	Alfalfa
Trifolium/Melilotus spp.	Clover
Carex spp.	Sedge
Eleocharis sp.	Bolotnitsa
Salix sp.	Willow
Lycopus sp.	Zyuznik
Mentha sp.	Mint
Malva sp.	Mallow
Chenopodium spp.	Mar
Atriplex spp.	Goose foot
Polygonum spp.	Knotweed
Stipa spp.	Feather grass
Poa spp.	Blue grass
Fragaria viridis	Steppe strawberry
Pinaceae	Pine
Betulaceae	Birch

If human activities or livestock herding does not destroy the vegetation of the patch locations, the same patch is available for gathering in the following year. Thus, wild strawberries are a relatively stable seasonal plant resource today as they likely were during the Bronze Age. As an easily accessible plant resource with an attractive flavor it is logical that it should be a part of the human diet.

Beside consuming the raw fruit, local villagers also use it for fruit tea following a meal. To preserve these wild strawberries, local families usually make jam or freeze the berries in the refrigerator. However, it is not possible to find evidence for storage practices associated with the use of strawberries by the occupants of the Bronze Age settlements. It is more likely that these were gathered and eaten during their fruiting season in the summer. Importantly, evidence of wild strawberries was recovered in archaeobotanical samples from all three ancient settlements and this strongly suggests that they were a utilized resource. However, the relatively low ubiquity, especially when compared with Fabaceae, also reflects a period of short availability that was seasonal in nature.

Besides wild strawberries, pine nuts and mushrooms are major plant resources that are collected from the forests today within the region. The gathering rate of pine nuts relies on the specific number of pine species within the forest. Compared with other plant resources, pine nuts are rarely found in Uy River valley. First, the coverage of the forest zone is minimal in the river valley and is generally associated with the higher elevations within the region. Second, the number of edible pine nut trees is rare within the region. In the survey area, none of these species were found. Pine nut husks from processing are very hard and generally preserve very well in archaeological soils. However, in archaeobotanical samples from the three settlements, no pine nuts or husks were identified. Therefore, it seems likely that the plant resources that were collected in the forest by the Bronze Age populations were primarily used for fuel and building materials.

Wild mushrooms are a common plant resource in the region today and form an important part of the local diet. In the Uy River valley, one can see people selling mushrooms throughout the year. However, the gathering time is primarily related to the rainy season in the summer and early fall. Mushrooms can be found everywhere within the studied catchment zones. However, many of the species are poisonous and only specific species can be consumed by humans. Thus, proper identification of these species is crucial when gathering mushrooms for human consumption.

This knowledge is usually learned through experience and oral tradition in the local villages. Novices generally collect the species that they can identify as those varieties they have eaten before. According to the morphology and color, they can pick the edible varieties, but generally this is restricted to a rather narrow number of species. Experienced mushroom gatherers are usually the elders of the village and they can identify a wider range of edible mushroom species in the catchment zone. The local knowledge and experience as well as advice from the elders are of critical importance for the identification of edible species.

I had the unique opportunity to join a mushroom gathering activity with local villagers and this provided important information about the utilized of this plant resource in the region. First, the distribution of mushrooms is very much related to the choice of edible species. Usually, one can find more edible species in the forest zone and this contrasts with the choices in the other ecological zones which are fewer and generally poisonous. Second, the best time for mushroom gathering is 1-2 days following a rainy period. New mushrooms usually grow very fast after rain and their duration period is very short. Third, the best location for mushroom gathering is in the forest zone where a higher density of trees can be found and the important humus soils are present. And, it is possible, to always gather mushrooms in same forest zones following rainy days. The location of the main local forest for mushroom gathering is north of the Uy River valley where there is an extensive forested area and higher elevations.

Mushroom gathering can last half a day or more. The gathering rate immediately following rainy days is usually very high. As a beginner, I could gather enough mushrooms in one hour to make mushroom soup (gribnoy sup) for six people. The gathering activity is usually limited by an individual's ability to carry buckets and so a local gatherer usually carries two buckets per round.

Gathered wild mushrooms are usually sold in three ways: fresh, pickled and dried. The duration of the fresh wild mushroom is very short and they can easily rot at room temperature. Therefore, fresh mushrooms are generally only available during the rainy periods. The other two forms of preparation allow mushrooms to be kept/stored for a longer duration. Especially the dried mushroom, which can be stored and used throughout the year and even into the next year. Locally, many people use dry mushrooms and these are considered a very important resource in the diet. The recipe of dried mushrooms can be used in almost every course in a meal. According to the unit price of fresh and dried mushrooms in the Uy River valley, 1kg of dried mushrooms may equal 4-5 kg of fresh mushrooms.

However, no evidence of mushrooms was identified in the archaeobotanical samples from the three Bronze Age settlements. The charred seeds that were recovered and identified in the archaeobotanical samples were usually preserved because of the burning process. Wild mushrooms will be completely consumed during burning and therefore nothing would remain to be found through macrobotanical analysis. As a result, no evidence of mushroom use during the Bronze Age has been identified through the archaeobotanical research in the Eurasian steppes. According to the regional chronology scheme (Table 4), the Sintashta-Petrovka period (BCE 2040-1680) covers approximately 300 years. This was a substantial period of time in which the Bronze Age subsistence economies became well adapted to the local distributions of wild plant resources within their local catchments. Wild mushrooms, as easily seen today, are one of the most important resources within these zones, however, based on presently available data it is not possible to discuss the use of these resources during the Bronze Age. Perhaps in the future more detailed analyzes of ceramic vessels will provide more nuanced information than current macrobotanical studies can.

Vegetables are major plant resources used by the local villagers. None of the common species utilized (cabbage, tomato, cucumber, beet, onion and carrot) are native to the Eurasian steppes and thus were unavailable during the Bronze Age. Sometimes, local villagers collect fresh leaves of specific wild plant species for herbal tea. However, these gathering activities are not common in the survey area and so I did not collect any information concerning these resources.

Grain food is a major part of the human diet of the local villagers today. In the archaeobotanical samples, all charred seeds represent wild plant species from the catchment zones. Based on the ethnographic data, phytogeographic survey, and recent archaeobotanical report, the annual usage pattern of these plant species for human consumption is listed in Table 36. Generally, the edible parts are the fresh leaf, stem, seeds, and fruit.

The listed information represents the maximum potential of the edible parts and does not suggest that these plant species were used in this manner during the Bronze Age. In the table, one year is divided into four seasons. Spring and summer are combined because of the annual fluctuation of the seasons. This season represents the plant budding period and by the end the withering period. Usually, this season starts from April to July, however, the actual beginning depends on the yearly weather conditions.

Autumn usually starts from August to early October. The autumn is divided into early autumn and late autumn because the withering period of the plant species is different. Winter in this table is represented as the season associated with snow precipitation.

From the ethnographic studies, only four plants in the table were mentioned by local villagers as potential food resources. These were Fabaceae, Chenopodiaceae, Polygonaceae and Fragaria viridis. Fragaria viridis is mentioned by every informant because this is a commonly eaten fruit every year.

Table 36 The annual usage pattern of plant species for human consumption based on ethnographic information(X means not use in that season)

Zones	Families/Genus/Species	Spring-Summer	Early Autumn	Later Autumn	Winter
Riparian	*Carex* spp.	x	seed	seed	x
	Eleocharis spp.	x	seed	seed	x
	Salix sp.	x	x	x	x
Meadow	*Vicia* spp.	Leaf, Stem	Leaf, Stem,Seed	Seed	x
	Medicago/mel/Tri spp.	Leaf, Stem	Leaf, Stem,Seed	Seed	x
	Carex spp.	x	Seed	Seed	x
	Lypocus sp.	x	x	x	x
	Mentha sp.	Leaf, Stem	x	x	x
	Malvaceae	x	x	x	x
Ruderal	Asteraceae	x	x	x	x
	Chenopodiaceae	x	Leaf, Stem	Seed	x
	Polygonaceae	Leaf, Stem	Leaf, Stem, Seed	Seed	x
Steppe	*Euphorbia* spp.	x	x	x	x
	Stipa spp.	x	Seed	Seed	x
	Poaceae	x	Seed	Seed	x
	Fragaria viridis	x	Fruit	x	x
varia	Caprifoliaceae	x	x	x	x
	Solanaceae	x	x	x	x

Chenopodiaceae was mentioned by many of the elders I spoke with. According to their memory, Chenopodiaceae was used in difficult socio-economic periods when they were quite young. Most people just related that the Chenopodiaceae seeds were collected for consumption and only a few people mentioned that the leaves and stems were edible. The problem with consuming Chenopodiaceae is that the hard husk often causes digestive discomfort. Therefore, none of the informants expressed a liking for Chenopodiaceae seeds as a food resource.

Based on the description of the plant species, this is probably *Chenopodium album,* which was identified within the catchment zones. Much of the plant of this species is edible but it must be detoxified through cooking, soaking, and other methods (Khasbagan et al.2000; Ruhl 2015). It is easy to gather Chenopodium outside the village near the fields and they generally grow together with Polygonaceae. The seeding rate is very high, so the gathering time to produce enough seeds/plant matter for a family meal is quite fast.

A few informants also mentioned that Polygonaceae can be consumed. Because of the morphology of Polygonaceae the seeds are similar to buckwheat and it is called “wild buckwheat” by locals. It is possible to cook Polygonaceae at the same time with *Chenopodium* and after winnowing the seeds are ready for cooking. Boiling is a common method in which to prepare the seeds. The fresh leaf and stem also can be used to prepare a soup. In a lean year in terms of available foods, *Chenopodium* and Polygonaceae can be considered a minor wild grain food.

A few of the informants claimed that Fabaceae (*Vicia* and *Medicago*) are edible. Today, the Fabaceae plant leaf and stem are still used in some cuisines. One can find them in sandwiches and salads that are sold at supermarkets, yet people seldom recognize it as Fabaceae (Figure 67).

Figure 67 Photo of the Medicago sp

The Fabaceae species identified in the archaeobotanical samples in the survey region represent wild species. A local herder can easily describe the uses of the different parts of the plants. According to my informants, the leaf, stem, and seeds are edible, however, people generally only collect the leaves and stems within the local region. The utilization and use of wild Fabaceae seeds is limited because of toxins. It is no surprise that only the fresh part of *Vicia* and *Medicago* are gathered in the region today. Cooking can remove some of the *Vicia* toxins, and there is evidence of cooked seeds from a Neolithic site in the archaeological record from site Netiv Hagdud(11300 to 10900 cal B.P) (Melamed et al. 2008). This is the earliest evidence for the use of *Vicia* was found in the world.(Melamed et al.2008, Tanno & Willcox 2006; Zohary 1999). The reason for the gathering of these wild species is that they were mixed with other domesticated pulses. In the Southeastern Urals region, such processes are more likely related to herding activities. Because of the long history of using Fabaceae as a major pasture resource, indigenous populations became familiar with their value as a wild resource. The archaeobotanical samples from all the sites have indicated the intensive use of Fabaceae but no evidence of domesticated plants in the Southeastern Urals region. It is no doubt that Fabaceae in this region is the most widely used wild plant resource of the region.

First, livestock are much less affected by the toxins of wild Fabaceae seeds and so these plants are used as a major resource for livestock forage and fodder. Second, the use of different parts of Fabaceae varies because of the toxin problem. However, the major part of these plants is toxin-free and the toxins in the seeds also can be removed by cooking.

In addition to the plants that were mentioned by my informants, the use of *Stipa* sp. is well documented through ethnographic and archaeobotanical studies (Bieniek 2002; Bieniek & Pokorny 2005; Hillman 2000). Hillman (2000) has discussed how *Stipa* is easily collected and dehusked for further processing. The seeds of Cyperaceae and Polygonaceae also can be processed in a similar manner (Hillman 2000).

In the archaeobotanical samples I collected through my dissertation research, the total number and ubiquity of these charred seeds was high among the plants from the same ecological zone. They were major plant resources used in these ecological zones by the Bronze Age communities and part of this likely related to human consumption patterns. As food resources, the seed is the only edible part of these plants. In comparison to the plants mentioned by the informants, the overall use value is relatively lower. The harvesting time is also constrained to only the withering season. Maybe this is one of the reasons why the distribution of these species is uneven in the three Bronze Age settlements. There is also no evidence to prove that they were major plant resources used to supplement the human diet at that time.

The ethnographic studies I conducted regarding the use of local botanical resources to supplement human diets has contributed important information for evaluating the choices and use of wild plant resources in the South Urals region. Most of these plant species overlap with both human and livestock dietary patterns and therefore the question remains as to whether it is possible to distinguish between them. In the following section, the results of my studies of local herding patterns is presented and discussed in response to this question.

7.2 HERDING PATTERN

The time of the indoor corral season (November-April) and open rangeland herding season (May- October) varies due to annual snow fall. The major differences are the sources of fodder and the location of herding and grazing activities. During the indoor corral season, livestock are fed with harvested wild grass hay (fodder). During the rangeland herding season, livestock will graze within the open rangeland areas during the day and then be returned to the villages for the night. They are either kept in indoor or outdoor corrals and fed with collected fresh fodder at night. The general annual herding pattern of the Southeastern Urals region is presented in Figure 68.

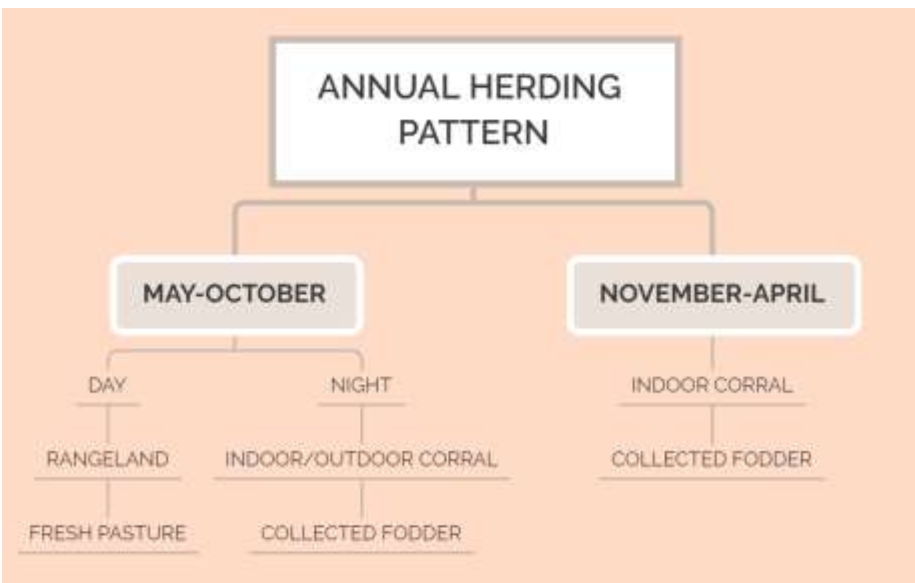


Figure 68 The general annual herding pattern in the Southeastern Urals region

The herding pattern studies that were part of my dissertation research were focused on the modern Stepnoye village, which is located along the Uy River valley and is 2.5 km to the east of the Bronze Age Stepnoye settlement. There were two herding camps used during 2017 in my defined survey zone. The location of the herding camps is shown in Figure 69.

My research indicated that the herding camps typically have a small shelter associated with them that may be used as a convenient place for the herders to rest, eat, and take shelter during rain storms and the daily activity of managing the cattle herds. However, these sites are not used every day. The actual open rangeland is the surrounding areas around the camps. The herding pattern studies included observation of daily herding activity and interviews with the local herders.

Figure 69 Location of the herding camps near the modern Stepnoye village

Herding camp 1 is situated 2.5 km in a north-west direction from the modern Stepnoye village (Figure 70). This location is adjacent to an artificial pond with a large surrounding area with meadow zones for grazing. This location is elevated above the riparian zone of the river and allows the herder to easily monitor the livestock. Usually, the herding season begins in the spring and lasts until the first snows in late fall. The size of the livestock herd from the Stepnoye village is around 100 cattle, 10-20 horses, and the rest are sheep, which results in a mixed herd of approximately 180 animals.

Figure 70 Photo of herding camp

Herding camp 2 is 2.08 km away from the eastern edge of the Stepnoye village (Figure 71). This camp is situated in a large meadow zone along the Uy River and there is a river ford nearby that allows for movement of livestock from one side of the river to the other. The daily herding schedule for this camp is similar to Camp1. The size of the herd is around 160, with around 150 cattle and the rest are horses. During heavy rain, livestock will shelter in the tall vegetation within the riparian zone, which is located near the camp. The location of the camp is actually situated very close to a modern road but the herder never crosses this road to graze the animals there.

Figure 71 Photo of herding Camp 2

The livestock herd in both camps is an aggregate of animals owned by different families in the village. These families hire a full-time herder to manage the livestock. The herder starts work at 7 am and after picking up the livestock from different families he moves them out of the village around 8 am. The actual time varies somewhat due to weather conditions. The daily herding activity can last for around 10 hours and after 6 pm the herder moves the livestock back to the village. By 8 pm, most of the livestock have been collected by the owners.

There are occasions with the herder may change the specific camp, and associated grazing zone, that he uses. This typically depends on the rate of grazing in the surrounding area and the route he is uses to move the livestock. In addition to the rangeland surrounding the herding camps, the herders also push the livestock through the meadow zones that are situated adjacent to the main river course. The meadow zones that are situated on the opposite of the river from the camps can be accessed by using the shoals (fords) to cross the river and these are usually 500 m or so from the herding camps. During heavy rain, the herder will sometimes move the livestock into the forest or the riparian zone for protection and this depends on the distance to these areas from where the livestock are being grazed.

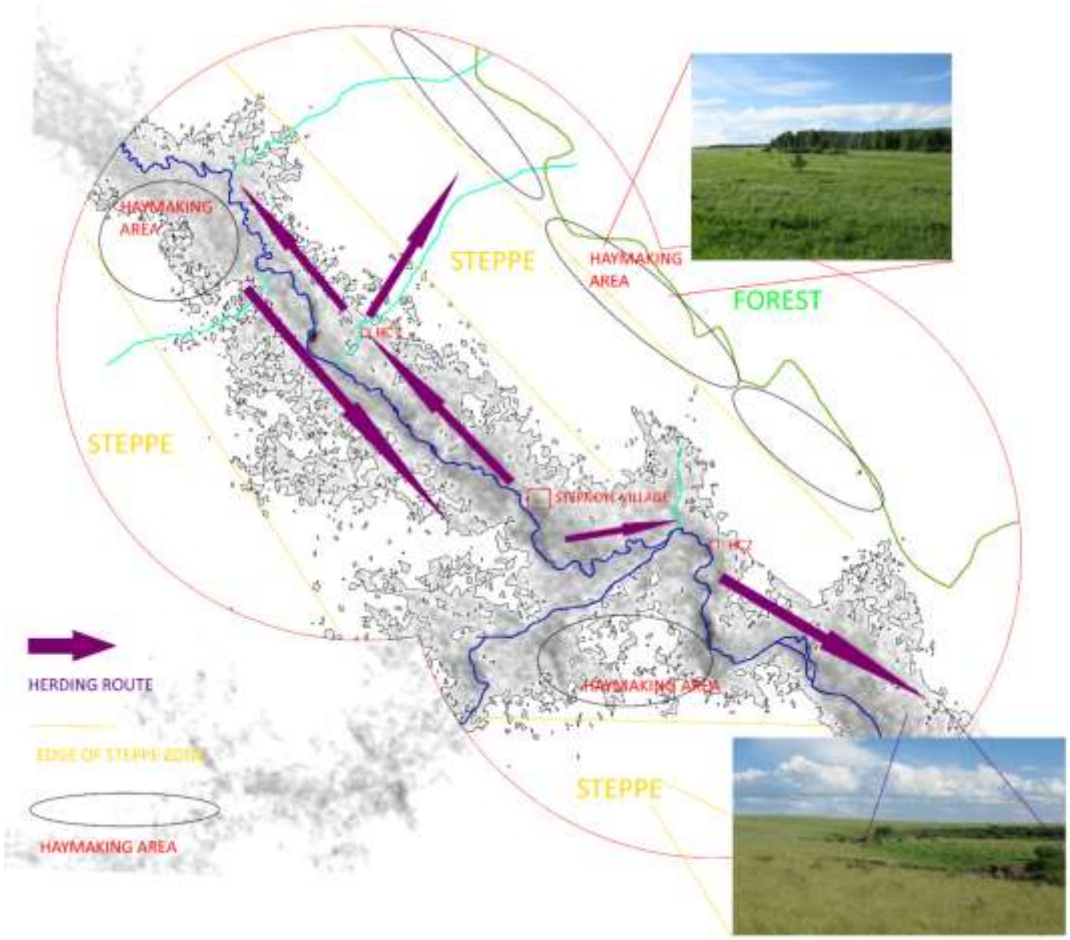


Figure 72 Map showing the general herding pattern during 2017 survey period

According to my observations and interviews with the herders, I determined that there are some basic rules that structured the herding activities around the Stepnoye village (Figure 72). First, the areas utilized for grazing the livestock typically avoid the zones where haymaking is carried out. As a result, daily grazing activities are closer to the main village and the haymaking locations are usually further away from the herding camps and often separated by another ecological zone.

Second, the herding route is always along routes that are well supplied with water (main river or its tributaries). For example, from the Stepnoye village to Herding Camp 1, the shortest route is to cross the steppe zone. However, this route is never used. Instead, the herder will move the livestock along the river or stream in the direction of the herding camp. It is same for Herding Camp 2 in which the herding route also follows the river without any shortcut being taken.

Third, the highest priority for the rangeland is always the meadow zone. During the spring and early summer the herder may stop in the steppe zone, however, after the ripening of the Stipa sp. the herding route will avoid this zone.

Fourth, the distance between the herding camps and the Stepnoye village is less than 4 km. According to ethnographic studies in Africa, the mean daily herding distance of adult cattle can be up to 20 km (Bollig et al. 2013; Fratkin et al. 1994; Homewood 2009). The daily herding distances that I observed at Stepnoye were much less than this and generally occurred within a 5km radius of the village. This ensured that the livestock were well watered, were not stressed by being pushed a farther distance away, and the rich meadow zones provided ample vegetation for grazing within the defined catchment.

Fifth, the choice of herding is strongly influenced by the surrounding vegetation, distance to easy accessible water resources, and elevation. One major limitation to the location of rangeland is the distance to water, which should not exceed 8km for cattle or 4km for sheep (Asanov et al. 1994; Dahk and Hjort 1976). Thus, both herding camps are located next to consistent water resources. The higher elevation of the camps provides better visibility for watching over the herds while they are grazing. As discussed above, the best ecological zones for grazing the livestock are the meadows and the rangeland immediately surrounding the two camps contain a significant proportion of meadow vegetation. And, also as noted above, the offer areas in which fording the river is relatively easy.

The best choice of herding camp and the route to it can increase the quality and rate of forage intake for the livestock. Forage intake is crucial to determining successful herding activity. The herding camps associated with the Stepnoye village are in perfect locations within the catchment zone. The pattern of Bronze Age herding activities, within a similar environmental setting, should be relatively the same as it is today. Thus, the basic rules governing modern herding practices can aid in the interpretation of Bronze Age herding patterns.

Besides the ethnographic data that I collected during the herding season I also observed the use of corrals and herding during the winter season. In summer, adult cattle are taken out of the village for open rangeland grazing, however, infant cattle are kept in corrals or are left to wander in the village. After several months, they also will be taken out to graze in the open rangeland. The dairy cows also are taken out for grazing after milk has been collected from them in the morning. Usually, milking is undertaken twice per day, once in the morning and once in the evening. Beside being grazed in the open rangeland during the day the livestock also are fed at night. Village families typically use crops and chaff for night time feeding. Other families will gather fresh fodders from around the village or use remaining fodder that was stored during the winter.

In Stepnoye, most families use indoor corrals. Livestock like milk cows and younger livestock are kept inside the corrals year-round. Indoor corrals also can be used for the storage of fodder. This largely depends on the number of livestock owned by the families and in some cases additional outdoor corrals will be used. If the outdoor corral is abandoned, this place may also be used for hay storage.

I observed that there were some large outdoor corrals located at the edge of the village and these were used for large herds. During the more prosperous periods of the Soviet Era, livestock herds were much larger and huge indoor corral buildings were located outside of the village. Following the collapse of the Soviet Union, and a decline in collective socio-economic organization, these structures were abandoned. According to the informant I spoke with, all the cattle were kept indoors during the winter months at that time. Thus, sufficient indoor corral space was especially important during the Soviet Period.

Today, most families in the village only raise 2-4 cows and in most cases livestock can be held within indoor corrals all year round. During the survey, I also visited a small commercial herding company located outside the Stepnoye village. The corrals being used at this company also were divided into indoor and outdoor sections with the outdoor corrals being located several hundred meters away from the main structure.

The location of outdoor corrals usually contributes to the formation of ruderal zones and Chenopodiaceae and Polygonaceae plants typically colonize these areas. Corrals need to be cleaned seasonally and the local villagers usually shovel the manure deposits from the indoor corral and dump them into the outdoor corral. The deposits in the outdoor corrals are then usually a mixture of fresh fodder, animal dung and hay. Sometimes, refuse from the houses is also dumped in the outdoor corrals. Therefore, the deposits in the indoor corrals and outdoor corrals are quite different and associated botanical remains and seed assemblages differ as well.

Indoor assemblages usually comprise seeds associated with the human collection of fodder and animal dung. The outdoor assemblages usually comprise seeds from human collection of fodder, animal dung, ruderal plants, and human refuse. The Stepnoye archaeobotanical samples also indicate a substantial difference in the recovered seed assemblages between the internal areas of the enclosed settlements and the outside midden deposits. If we link the location of the outdoor corral and seed assemblages from that context, the ethnographic data collected on corral use may provide an analogy for how the midden deposits formed outside the Bronze Age settlements (Figure 73).

Livestock corralling has not been discovered through archaeological research of the Bronze Age settlements in the Southeastern Urals region. However, according to ethnographic studies, indoor structures are essential for weak and young livestock and milk cows. It may be suggested that some areas within the Bronze Age settlements, and/or the related houses, were utilized for corralling/containing some livestock. And, by association, some of the charred seed assemblages recovered from within the houses at the settlements may have been associated with livestock fodder and dung.

In the Stepnoye village, hay is an essential plant resource during the annual herding cycle. For a better understanding of the use of hay in the Southeastern Urals region, I collected ethnographic data from different villages in the region to use for comparative studies. The results of this research are discussed in the next section.

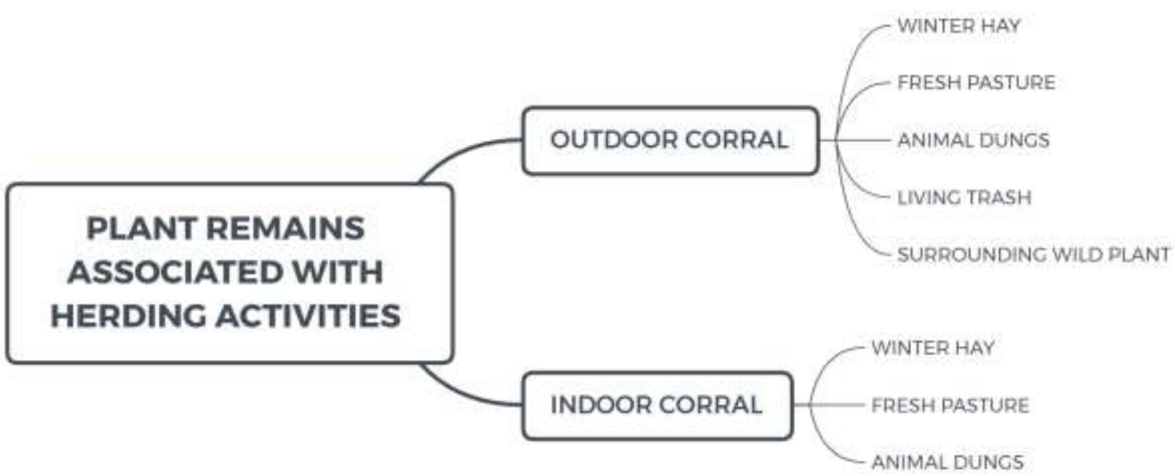


Figure 73 Figure showing the plant remains associated with herding activities from indoor/outdoor corrals

7.3 Haymaking cycle

Based on my ethnographic research that was carried out in different villages, I observed that the preparation and storage of hay (fodder) is a crucial resource for sustaining livestock in the Southeastern Urals region. Every family with livestock must prepare fodder for the long winter season in this region. This fodder also is used for the weak and young livestock that remain in the corrals nearly year-round. Remaining winter fodder may be used in the next year to feed livestock at night. Thus, one can easily find such fodder in a local villager's home.

Stobbe (2016) and Sharapov (2017) have suggested that large-scale haymaking seems unlikely in this region (Stobbe et al. 2016; Sharapov 2017). Ethnographic data have indicated that historic Kazakh and Bashkir pastoralists did not practice hay-making but used river valleys as winter pasture (Guirkinger and Aldashev 2016; Yanguzin 2002). However, Stobbe and Sharapov agree that winter fodder is important for risk minimization in the subsistence economy of Bronze Age societies.

At the Kamennyi Ambar settlement, 27 of the 70 taxa identified in the archaeobotanical record may have entered the cultural layer as fresh cut forage or hay (Ruhl et al. 2015). In the Bronze Age, the effect of the environment and weather factors may have been fatal to these sedentary non-agro-pastoralist societies. Thus, hay-making was likely practiced by these societies but the scale of this may have varied between different settlements.

Chechushkov (2018) has reported that the present-day haymaking cycle in the Karagayli-Ayat valley begins in mid-June to early July. The fresh forage must be cut and left to dry before September in order to prepare it for winter fodder. With the help of modern machinery, a nuclear family can collect enough hay for 5-10 cows in 2-3 weeks (Chechushkov 2018).

The following description from the dissertation research, outlines the major factors associated with the hay-making cycle. The first key factor is the location. Hay is usually cut and dried in the same location. As discussed above, haymaking locations never overlap with herding rangeland as the grazing decreases the gathering potential of the hay for winter fodder. Compared with herding camps, these places are usually further away from the villages. For example, in the Uy River valley, the distance of the haymaking locations can be up to 20km from the villages. The reason for the long distance is because of the quality of the fodder as the best occurs within the meadow zones (Figure 74).

The gathering rate of fodder can be up to 3 times the difference between meadow zones and other zones (Stobbe et al. 2016). As mentioned above, the best location near the Stepnoye village is the meadow zone near the forest, which is separated by the steppe zone. Similar areas were also observed during my research at the Ust'ye settlement.

Figure 74 Photo of a good quality haymaking zone with abundant growth of Fabaceae plants in a meadow zone

The specific time of harvesting and precipitation are important in the haymaking process. The harvesting time is always related to precipitation from spring to summer and generally no later than July. The growth rate of forage increases in the high precipitation season. However, at the same time, the loss rate of the haymaking process can occur because of rainfall. Thus, local villagers need to make a decision based on the weather conditions. According to the informants I spoke with, harvested hay requires one week to be dried. After one week, the loss rate from rain is slightly decreased. The end of the haymaking season is usually before September as the weather during this month can be unpredictable and change rapidly. Local villagers, therefore, try to collect enough hay to sustain their livestock through the winter before the month of September.

The amount of hay and preparation time is closely associated with the annual herding pattern. The preparation time depends on the availability of machinery, labor, number of livestock, and the availability of haymaking locations. According to my informants, the amount of hay required for a single milk cow in the winter is around 1 to 1.3 tons. This estimate is similar to those produced from ethnographic data (Frachetti 2008; Stobbe 2016; FAO website). The availability and distance of the haymaking location can affect the total preparation time. Meadow zones typically provide the highest harvesting rate for fresh forage. In some villages, because of the impact of overgrazing, the availability of the meadow zone near the village is low. In this case, they may choose to collect forage from the steppe zone. According to Stobbe (2016), the fresh forage in the steppe zone is 4.5 tons per hectare, as compared to 8 tons per hectare in the meadow zone. Thus, this will slightly increase the harvesting time for the cutting of winter fodder. With the help of modern machinery, the harvesting rate of hay is greatly increased and the labor input of a nuclear family is also decreased substantially.

Once the fresh fodder is cut, it is accumulated into a "stack". Every stack is around 1ton of hay. The stack is left in the same location where the hay has been cut for the drying process, which takes around 1-2 weeks depending on the weather. After that, the haystack is collected with trucks or wagons and transported to the village. For families with less livestock, the haystack is usually piled in the garden and covered with a plastic sheet. For families with more livestock, the haystack can be stored in the outdoor corrals. In one village next to the Bronze Age Sintashta II settlement, some families put the haystacks on the flat roof of the buildings. However, this is not a common practice in the Uy River valley.

During the ethnographic studies, which I completed on the haymaking cycle, information was also collected on the plant species that were identified in the archaeobotanical samples. Just as for the human diet, the seasonal usage of plant species for livestock was also different. Based on the major charred seeds identified in the archaeobotanical samples, the seasonal nutrient values of the fresh pasture resources are listed in Table 32. These results were collected during interviews, observation of livestock behavior, and the FAO database.

Table 37 Information about the seasonal nutrient value of fresh pasture resources collected from ethnographic studies

Zones	Families/Genus/Species	May-July	July-August	September- October	Snowing season
Riparian	*Carex* spp.	Low	x	x	x
	Eleocharis spp.	Medium	Low	Low	x
	Salix sp.	x	x	x	x
Meadow	*Vicia* spp.	High	High	Medium	x
	Medicago/mel/Tri spp.	High	High	Medium	x
	Lamiaceae	Low	Low	Low	x
	Malvaceae	medium	Low	Low	x
Ruderal	*Asteraceae*	medium	Low	Low	x
	Chenopodiaceae	Low	Low	Low	x
	Polygonaceae	Low	Low	Low	x
Steppe	*Euphorbia* spp.	Low	x	x	x
	Stipa spp.	Medium	x	x	x
	Poa sp.	High	High	Medium	x
	Fragaria viridis L.	Medium	Medium	Low	x
varias	Caprofoliaceae	Low	Low	Low	x
	Solanaceae	Low	Low	Low	x

Fabaceae are the best plant resources to provide high nutrient value for livestock in every season before winter. In May to August, the fresh leaves and stems are the best fodder for livestock in the open rangeland. In September to October, the nutrient value of the withering leaves and stems decrease, but the bean pod and seed can provide extra nutrients for the livestock. Therefore, Fabaceae is a very valuable year-round fodder and it is also suitable for haymaking. It is no surprise the that the Fabaceae seed has the highest ubiquity and absolute number in the archaeobotanical samples that were studied for my dissertation research.

Poa spp. is a major fodder resource in spring and summer. The availability of Poa is very high because the proportion of the steppe zone is the highest in the local environment. The fresh leaves and stems are very good food for livestock but the nutrient value of Poa decreases after the withering period from September to October. *Poa* spp. is also frequently used in the haymaking process.

Eleocharis spp., Malvaceae, Asteraceae, and *Fragaria viridis* are valuable resources from May to July. The fresh leaves and stems provide good fodder. The nutrient value also decreases after the beginning of the withering season. These species are not typically targeted for haymaking but may be gathered if available within the chosen haymaking location.

Polygonaceae, Chenopodiaceae, and *Stipa* sp. can be used for fresh fodder from May to July. During the withering season, these species are not used for fodder. Their seeds all have a hard husk, which can make the livestock sick, and so these are typically not collected during the haymaking process.

The rest of the species that were identified in the archaeobotanical samples also can be used for fresh fodder from May to July. However, the nutrient value is relatively low and some species (*Euphorbia* spp.) can be poisonous for livestock. After July, the nutrient value is reduced even more and generally they are not productive for haymaking.

In comparing the seasonal plant resource usage for human and livestock diets there are many overlapping species that are abundant in May to July. In these months, the fresh leaves and stems from many species are edible for humans and livestock. In September to October, leaves and stems become too withered to be of productive value for livestock consumption. If the nutrient value of the seeds is not high, the value of this plant in the catchment zone will slightly decrease. The herding and haymaking activities will therefore focus on specific ecological zones.

Archaeobotanical samples do not provide evidence of the fresh parts of these plants. Through the ethnographic observations, it was clear that many potential plant parts that are found and utilized within the catchment zone are not recovered in the archaeobotanical samples. Most of the preserved charred seeds that were identified in the samples are related to plant productivity from July to August. This results in the charred seeds providing evidence for specific plant use only during certain seasons or parts of the seasons. For example, from the ethnographic studies, it is possible to confirm that Fabaceae is a high value year-round wild plant resource for humans and livestock. It is no surprise then that Fabaceae were an essential element in the Bronze Age subsistence economy. In order to better understand and interpret the formation of charred seed assemblages in the archaeobotanical samples, it is possible to draw on the important information that was gathered through my ethnographic studies. This included data on the seasonal nutrient value of livestock open range grazing and winter fodder production as well as the seasonal use of wild plants that can supplement human diets.

Ethnographic studies also raised some new questions about the use of plant resources in the annual herding pattern. First, in the Southeastern Urals region, the diet of livestock is different between seasons. The winter diet relies heavily on hay (fodder) and in other seasons the livestock are sustained mainly through grazing in the local open rangelands. Also, livestock are kept within indoor or outdoor corrals depending on the season. Therefore, based on these patterns, is it possible to distinguish the difference in the seed assemblages associated with these practices and by extension is such patterning identifiable in the archaeobotanical samples?

Second, there is a substantial difference in the technology that would have been employed in the Bronze Age for haymaking (fodder cutting and collecting) as opposed to those practices I observed being used by modern villagers today. Also, the harvest rate of fodder varies significantly depending on the ecological zone that is chosen. Therefore, how is it possible to generate a more accurate estimation of harvest rates within the local catchment if collection is done primarily through hand tools as it would have been during the Bronze Age?

Third, it has been shown that plant seeds are mainly collected in July to August and that most of them are not used for feeding to the livestock. Also, as has been shown, the number of some charred seeds is relatively high in the archaeobotanical samples. If these are related to human subsistence practices, then how can we better understand their use as wild plant resources in the daily life practices of the Bronze Age occupants of the villages?

In order to address these important questions, I pursued three different experiments. The results of these studies, and a discussion of their importance in the context of Bronze Age pastoralism and human subsistence patterns, are presented in the next chapter.

8.0 EXPERIMENTAL ARCHAEOLOGY AND PASTORALISM

As noted at the end of Chapter 7, the ethnographic studies I completed raised several questions about patterns of plant exploitation in the Uy River valley by human and animal populations – both in prehistory and in the modern era. To answer some of these important questions, I developed three experiments: (1) a dung and hay burning experiment, (2) a hay (fodder) harvesting experiment, and (3) a plant processing experiment.

8.1 DUNG AND HAY BURNING EXPERIMENT

Dung burning experiments have been undertaken in many archaeological projects (Hastorf and Wright 1998; Miller 1984; Shahack- Gross 2011; Spengler 2013). There is no doubt that the results of such experiments can provide information that aids in the interpretation of seed assemblages from archaeobotanical samples. Based on the specific research question, the set of experiments may vary.

Based on the archaeobotanical results from the Kammennyi Ambar settlement, Ruhl (2015) has suggested that dung burning may not have been practiced during the Bronze Age by the occupants of the settlements. In this dissertation, as discussed in the previous chapters, I recovered numerous archaeobotanical samples from midden deposits that were located outside the enclosed settlements. The ethnographic studies I completed on modern day herding in the region suggested that these areas may comprise outdoor corral areas that were filled with hay, living trash from the enclosed settlement, and animal dung. To further examine this possibility, I undertood a dung burning experiment in order to recover plant remains from the manure.

The dung burning experiment was carried out at the modern Stepnoye village. In Stepnoye, cattle dung can easily be collected in the village area. Those locations include the corrals, the route between the herding camp and the village, and the open rangeland areas. The seed assemblages recovered from the collected dung varied depending on the location in which it was collected.

Comparing the seed assemblages recovered from dung collected between the rangeland and village corrals I found that the percentage of fresh fodder from the rangeland was decreased. The fodder or hay within the corrals is representative of what is usually harvested by herders. Also, there are differences between the seed assemblages in the indoor and outdoor corrals. The outdoor corrals often contain mixed botanical remains with ruderal plants growing there (Figure 75).

Figure 75 Upper- Photo of abandoned outdoor corral in Stepnoye village; Lower- Photo of abandoned outdoor corral in the Stepoye village

The purpose of the dung and hay burning experiment was to collect information about the seed assemblages that were recovered from the archaeobotanical samples. In the Stepnoye and Ust'ye samples, the seed assemblages collected from inside and outside (midden) outsidet the settlements was slightly different. The cultural layer from the outside midden deposit was usually filled with a thick ashy layer (Figure 76). The location and the distance of these middens may be related to the outdoor corrals of the settlements and, therefore, the development of the dung burning experiment was aimed at answering this question.

Figure 76 Upper Left- Photo showing the ashy layer in the Stepnoye midden deposit; Upper Right- Photo showing the ashy layer in the Ust'ye midden deposit. Lower-Photo showing the ashy layer in the Streletskoye 1 midden deposit

From the 2016 and 2017 seasons, I collected 40 pieces of cattle dung in the modern Stepnoye village. Since the vast majority of livestock herded at Stepnoye are cattle it is easy to collect dung produced from these animals within the village. The location in which I collect the dung “patties” was the outdoor corral. In the autumn of 2016 (August-September), I collected 20 pieces from different corrals and in the summer of 2017 (May- July) I collected another 20 pieces from the same locations.

The dung burning process was carried out in a large metal bucket. The dung from 2 years was burned separately. Since all of the dung collected were from outside areas exposed to wind and sunlight they were dry and easy to burn. The entire process took about 1.5 hours, and the fire was left smoldering until the next day when it was collected.

In the 2017 season, I also collected 15 hay samples from the Uy River valley. These locations included the corral (13) and the haymaking area (2). The two samples from the haymaking area were fresh harvested fodders that had been placed in haystacks for drying. The samples collected from the corrals were all from dry haystacks. The weight of the samples was around 50g each**.**The burning process for these samples was also carried out in a large metal bucket and every sample was burned separately. The entire process took around 1 hour and was then collected after a half day.

The collected samples were not floated because there were no heavy fractions to be separated. I used four geological sieves of 2mm, 1mm, 0.7mm, and 5mm to separate the samples. In most samples, the 2mm sieve collected the unburned dung fragments and the charred plant stems. According to my experience with analyzing the archaeobotanical samples from the ancient settlement, it was necessary to use multiple sieves down to the 5mm size. The basic information for the dung burning experience samples and identification of the botanical remains is detailed in Tables 38 and 39.

Table 38 Results of the dung burning experiments

Zones	Families/Genus/Species	May-July	August- September
Agriculture	Wheat		23
Meadow	Vicia spp.	1	5
	Medicago spp.	20	7
	Fabaceae	20	3
	Lamiaceae	9	5
Ruderal	*Chenopodium* spp.	1709	29
	Polygonum spp.		4
Riparian	*Carex* spp.		2
Steppe	*Poa* spp.	2	4
	Filipendula ulmaria		3
	Asteraceae		1
Varias	*Solanum* sp.	1	
	unknown	6	5
	Total	1768	91

Table 39 Results of hay burning experiments indicating number of recovered charred seeds

	Samples with Charred seeds
Haymaking Area	2/2
Outdoor Corral	6/13

Zones	Families/Genus/Species	Haymaking Area	Outdoor Corral
Meadow	*Vicia cracca*	13	2
	Medicago spp.	12	3
	Bean Pod	21	11
Riparian	*Carex* sp.	1	
Ruderal	*Polygonum* spp.	4	3
	Rumex spp.	13	
Steppe	*Campanula* sp.	5	
	Filipendula ulmaria	4	
	Asteraceae		1
Varias	Brassiceae		1
	Unknown		3
	Total	73	24

From the dung burning samples, I identified around 15 different plants (genus and species level) of 9 plant families. The total identified seed count was 1,869, and 11 seeds were unidentified. Chenopodiaceae (92%) was the most common plant families among the charred seeds (mainly represented by *Chenopodium* spp.). Fabaceae (*Medicago* spp. and *Vicia* Spp.) is about 5%, and the other families were all less than 1%.

From the hay burning samples, I found 9 different plants (genus and species level) of 7 plant families. The total identified seed count was 126, and 3 seeds were unidentified. Fabaceae (75%) was the most common plant families among the charred seeds (mainly represented by (*Medicago* spp., *Vicia* spp.). Polygonaceae (*Polygonum* spp., *Rumex* spp.) was about 14%, and the other families were all less than 1 %.

Based on these experiencs and subsequent macrobotanical analysis it is clear that some characteristics of the *dung burning experiment* correlate with the archaeobotanical samples recovered from the three Bronze Age settlements:

1. The remains of the ashy material recovered from the dung are comparable to the soil samples taken from the midden deposits.
2. Most seeds recovered were from herbaceous plants.
3. All plant species can be related to the local vegetation.
4. Most seeds recovered were collected with the 1mm and 0.5mm sieve.
5. There is a high number of ruderal plant seeds represented (*Chenopodium* spp.)

Some characteristics of the *hay burning experiments* also correlate with the archaeobotanical samples recovered from the three Bronze Age settlements:

1. Most seeds recovered were from herbaceous plants.
2. The most abundant species are the same.
3. All plants species can be related to the local vegetation.
4. Most seeds recovered were collected with the 1mm and 0.5mm sieve.

The results of the dung and hay burning experiments proved that all charred seeds grow within the local catchment zone. Many plant species are the same in both results and suggest the strong overlap of the fodder chosen by the livestock themselves while grazing and the human collection of fodder for haymaking.. The abundance and similarity of herbaceous seeds in both experiments suggsts that the seed assemblages identified in the archaeobotanical samples were at least partly related to herding activities.

When comparing the two dung burning samples, the number of *Chenopodium* seeds was slightly different. First, the count was very high for the samples collected in May- July, however, this is not the growing season for local *Chenopodium* species and *Chenopodium* seeds are not specifically collected to feed the livestock. Livestock also do not prefer the *Chenopodium* seeds in the open rangeland when grazing. Thus, the high number of *Chenopodium* species may be related to the contamination of *Chenopodium* that grow naturally within the corral contexts as these areas are continually disturbed zones due to both livestock and human activities there.

As a long-term ruderal zone, *Chenopodium* can always be identified in the outdoor corrals. Sometimes, the soil in the outdoor corral is turned over by local villagers when it is removed . Sometimes, they will use these places as gardens. This activity allows the preserved seeds to mix with the animal dung and it can be suggested that the higher number of *Chenopodium* seeds in the midden deposit may also relate to the growth of wild plants there.

The seed assemblage of the dung samples taken in August- September is similar to the archaeobotanical samples from the midden deposit. More plant species appeared in these samples because it is the seeding season for most plant species that grow within the catchment zone, thus livestock will graze on these plants (and associated seeds) when hereded in the open rangeland and this contributes to their dung. The use of domestic crops (wheat) was also detected in the animal dung for the sampled collected in August-September. This reflects the feeding of livestock at night in the corrals within the village.

The total numbers of *Chenopodium* and Fabaceae seeds were highest in the samples. The Fabaceae may be related to the fresh fodder or hay collected by local villagers. The *Chenopodium* may also be related to the wild plant growth in the outdoor corrals, as discussed above. We can find many other seeds that do not grow in the outdoor corral area. During August- September, the livestock can bring in plant species from different ecological zones to the outdoor corral through the process of grazing and the dropping of their dung in the corrals.

In the midden deposits, the seed assemblages that were identifeid are similar to those encountered through the dung burning experiments and remaining ashy materials from the dung burning experiment is very similar to the deposits encountered in the middens during excavations at Ust'ye, Stepnoye, and the Streletskoye 1 settlements. Dung is probably one of the major components in the midden deposits but it is also mixed with other refuse materials (e.g. pot sherds, animal bone remains, slags from copper production, etc.). Therefore, it must be suggested the the ancient midden deposits did not form only from the results of dung burning. On the contrary, it is more representative of a variety of depositional processes associated with the the functioning of the settlement and the possible use of outdoor corral areas.

Comparing the hay burning samples, the number of seeds identified is higher in the fresh hay samples than the hay that was collected and stored from the previous year. Besides the 2 fresh hay samples I collected, I also collected 8 dry hay samples from hay that had been collected the previous year and transported to the village. Of these samples, half of the dried hay samples did not contain any seeds and this is likley due to loss of seeds during transport, stacking and storage. As discussed in Chapter 7, most of the haymaking locations associated with the modern Stepnoye village are situated in the local meadow zones. Thus *Poa* sp. is found in dung samples but not in the hay samples.

There were many bean pods (*Vicia* spp *and Medicago* spp.) identified in the hay samples. However, I only found one bean pod (*Vicia* sp.) in the archaeobotanical samples from the three settlements and it was identified at the Ust'ye settlement. The lack of pod representation at the sites may be related to preservation conditions and burning processes. Bean pods do not preserve well in the steppe soils and they are entirely conumed during the burning process. Therefore, it is no surprise that the number of charred pods is very rare in the recovered archaeobotanical samples.

The overall seed assemblages from hay samples are very similar to the archaeobotanical samples from the Stepnoye enclosed settlement. Fabaceae(N=62) is the only dominate species and Polygonaceae(N=20) is second but is much lower in comparison with Fabaceae. The rest of the species identified had small total numbers.

Since the choice of the haymaking zone is related to its distance from the village and overall availability of fresh fodder at that location, the hay samples used in this experiment may reflect very specific decisions made by the villagers in terms of using these resources. In other villages that undertake commercial herding, the haymaking locations are generally extended into the steppe zones. At the same time, the schedule for cutting and gathering fresh fodder also startes earlier for those areas within the steppe zone due to increasing aridity in the late summer and the drying out of steppe vegetation.

The data collected from the burning experiments can help to better understand local herding patterns and use of site catchment resources in the past. The dung burning experiments strongly suggest that the ashy layer in the midden deposits outside the settlements are associated with the function of the outdoor corral in the local village. The dung burning experiments cannot, of course, provide a direct link with the archaeobotanical samples recovered from these contexts but the do provide important comparative data considering plant resource exploitation more carefully.

The dung samples collected in over the two seasons suggests that seasonal factors were essential for interpreting the charred seeds in the seed assemblages. The diversity of plant species was high in the dung samples that were collected during the seeding season. And, it can be suggested that understanding these plant growing patterns, and seasons, is essential for an improved understanding of the seed assemblages identified in the archaeobotanical samples.

The results of the hay burning experiments also have provided important comparative data for understanding the decision-making process that structures the local haymaking cycle (Figure 77). The good locations for this, such as the meadow zones on the edge of the forests and the undisturbed rangeland on the opposite side of the Uy River, are available within the Stepnoye catchment zone. High nutrient fodder comes from the meadow zone with the abundance of Fabaceae plants.

The reasonable schedule for collection of these resources is after the rainy season (May to July) and before September. This is a relatively short period of time that also overlaps with the seeding season of many of the Fabaceae plants. It may, therefore, be suggested that the archaeobotanical samples from the Stepnoye and Ust'ye settlements reflect these same criteria for resource collection that were used to produce good quality hay. Some of the archaeobotanical samples may be related to stored hay that was used in the winter. Thus, the haymaking process may have been an important activity associated with livestock herding during the Bronze Age in the Southeastern Urals region.

The decision making related to the rate of harvest of hay and fodder is an important one and is related to the density of pasture and the efficiency of the tools used for cutting and collection. A presentation of the results connected with my hay cutting and collecting experiments is presented in the next section.

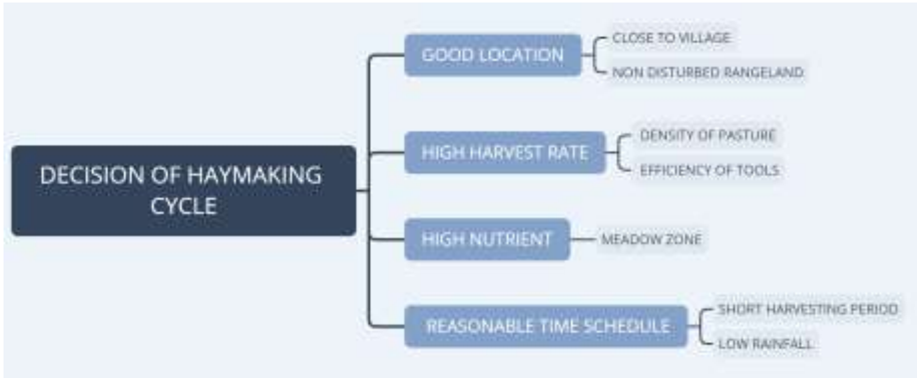


Figure 77 Figure showing the decision making process for the haymaking cycle in the Southeastern Urals region

8.2 FODDER HARVESTING EXPERIMENT

According to the FAO database, until the middle of the nineteenth century, all fodder was hand-cut (FAO website). The sickle and the scythe are the basic hand tools that are used for cutting fodder (Figure 78). The time and gathering rate is somewhat conditional depending on the tool used. In the South Urals region, the scythe is the traditional grass-cutting tool that was used prior to the introduction of mechanized tools.

Today, some local families still use scythes for cutting winter fodder. Sickles are designed for cutting cereal stalks but they are very inefficient in comparison to scythes. Recent archaeobotanical results, and combined stable isotope analysis of human and animal remains, have not indicated any evidence that agro-pastoral economies were present during the Bronze Age in the Southern Urals region (Ruhl et al. 2015; Stobbe 2016; Ventresca Miller et al. 2014; Hanks et al. 2018; Popova 2006; Anthony et al. 2005). As there is no direct evidence of agriculture, the function of the sickle-shaped tools recovered from Bronze Age settlements may relate to the cutting of fodder (Epimakhov 2010; Hanks and Doonan 2009; Koryakova and Epimakhov 2007; Krause et al. 2010; Krause 2013; Zdanovich and Zdanovich 2002).

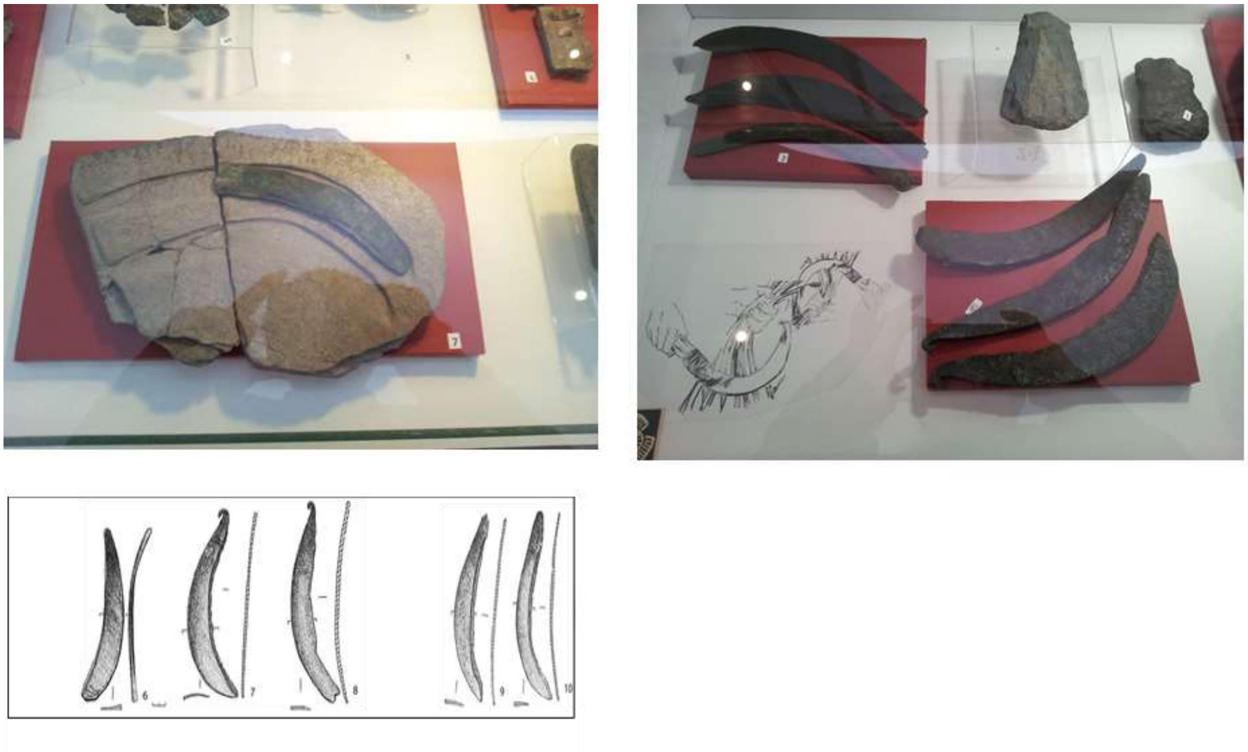


Figure 78 Upper Left- Photo of the MBA sickle from the Arkaim Museum; Upper Right- Photo of LBA sickles from the Arkaim Museum; Lower- Figure of five LBA sickles associated with LBA dwellings (Petrova 2004)

Stobbe et al. (2016) have calculated that 100 individuals gathering hay with hand held sickles can cut 25 hectares of meadow zone within 1 day. The yield rate would therefore be up to 75 tons and would provide fodder for around 60 dairy cows over a 120 day period. The average daily yield rate per person then would be 0.75 tons of hay from 25 hectares of meadow zone. This would be enough to feed 1 dairy cow for 72 days.

This estimated intake rate of hay for cattle is similar to Frachetti's estimation of the daily nutrient value required for 1 cow (Frachetti 2008:96). He suggested that 630 kg of nutrients is required for 1 cow for a 90-day period. Frachetti's data also indicates that the basic year-round rangeland requirement per cow is from 5.6 to 16 hectares depending on the season. The estimations suggested by Stobbe et al. (2016) are specifically related to the yield rate of the steppe and meadow zones, however, the basic year-round rangeland requirements would vary by ecological zone and not just in the steppe and meadow zones.

In the last chapter, one of the questions stimulated by my ethnographic studies is related to the harvest rate of fresh fodder from within the local catchment zone around the contemporary Stepnoye village. According to the data discussed above, the aim of fodder harvesting experiments should be to focus on variation in harvest rates by individual seasons, ecological zone productivity, tools used for collection, and overall labor requirements. My ethnographic studies have produced important data about the haymaking cycle that may be used to address this question. Furthermore, my catchment zone analysis provided an estimation of the fodder availability that potentially exists with the Stepnoye catchment zone. In the following section, I discuss experiments I conducted that focused on the cutting and stacking of hay.

From interviews with local families, I learned that 1 haystack represents around 1-1.3 tons and provides enough subsistence for 1 milk cow through the winter(October to late April). Based on this information, I measured the harvesting size of different haymaking locations that could be used to produce 1 haystack. During the 2017 field season, I observed some herders who were cutting and gathering hay. While observing their activities I used a laser distance measurer to estimate the area that was cut to produce the haystack. Table 35 lists the approximate measurements of the size of 2 major vegetation areas that were used to produce 1 haystack. The area required was approximately 5 hectares for 1 haystack that was produced in the meadow zones near the forest.

The measurement of the size of the area to produce 1 haystack in the steppe zone was nearly 18 hectares. From these measurements, the yield rate of fodder is significantly different when comparing the two zones. All the herders I observed used machinery for cutting the green hay and trucks for transporting the stacked hay back to the villages for storage for the winter. Based on my observations, the ethnographic data concerning labor input and preparation cannot be used for calculations of Bronze Age hay cutting and collecting.

Table 40 The required harvesting size for 1 haystack in meadow zone and steppe zone

Haymaking location	Harvesting size for 1 haystack(m)
Steppe zone	250x200
Meadow zone	450x400

To produce a more accurate gathering rate estimation for botanical resources I initiated a fodder harvesting experiment. Based on the description and measurement of copper alloy sickle-shaped tools, which have been recovered from excavations at settlements, I used a knife with a similar blade length to simulate the sickles that may have been used during the Bronze Age. The gathering experiment was carried out in June 2017. During this month, the potential yield rate of fodder is high. Also, this is the preferred haymaking season of the villagers living in the modern Stepnoye village.

Figure 79 illustrates the five gathering locations in the Stepnoye settlement catchment, which I used for the experiments. These were situated in different ecological zones. The gathering time was set at five minutes per experiment. The workers who assisted me were asked to cut and collect as much fodder as possible during this time. No specific plant species were assigned for collection and the workers themselves choose what plants to cut and collect. The short duration of collection ensured that this would be done at a rapid rate and partly counteracted possible differentiation between beginner and more experienced herders.

In every location, I asked different people to gather fodder with the same time limit and this helped to neutralize the differentiation between the labor force. Also, hand collection without knives was used as a gathering method in location 4 for comparative purposes. After gathering, the fodder was weighed in the laboratory. Table 41 outlines the results of these experiments. Based on the experiments, the highest yield rate was found to be in the meadow zone next to the river, and the lowest yield rate was the steppe zone.

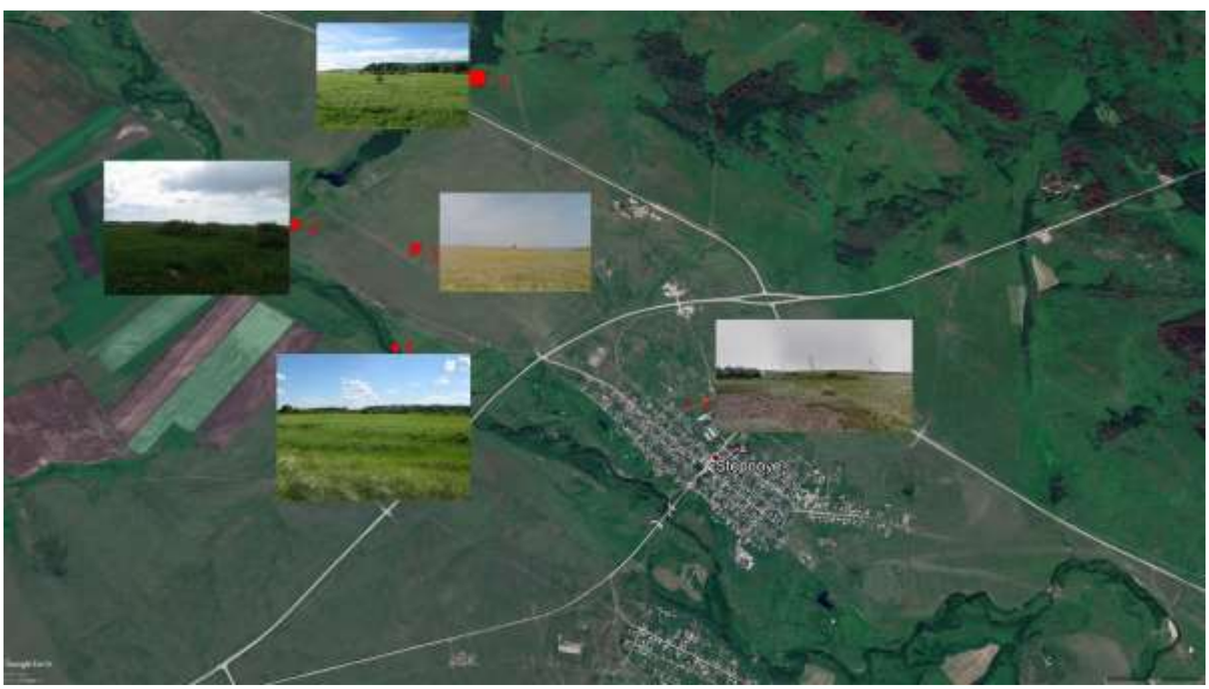


Figure 79 The locations of the fodder harvesting experiments

Table 41 Data on harvest rates in four different ecological locations using both knives and hand collection (in zone 4)

Location	Method	Weight(kg)
1 steppe zone	knife cut	150
2 meadow zone next to stream	knife cut	650
3 Rudural zone	knife cut	400
4 meadow zone next to river	knife cut	1000
4 meadow zone next to river	hand pull	800
5 meadow zone next to forest	knife cut	750

It is surprising that in location 4, where hand collection experimentation was done, this produced the second highest yield rate among all 5 sample locations. Based on my observations, and communication with the participant workers, the reason for this probably relates to the height of the plant species. The plant species in this zone that were selected for fodder were usually taller and easier to hand pull for stacking.

In other types of vegetation, if the grass is not tall, it is very difficult to pull and detach by hand. Hand pulling is also tiring when compared to knife cutting. Some large stocks of grass need extra force to pull and detach for gathering. As a result, pulling grass for collection by hand cannot be sustained for a long duration to collect a large amount of fodder. The thorns on many local plant species also constrain the ability to use the hand gathering technique without the use of knives as well.

Fodder collection was likely a daily activity for families dwelling within the settlements during the Bronze However, the recovery of bronze sickle-shaped tools, as noted above, is relatively low compared with the estimated number of families that would have occupied the settlements in the region. Based on my experiments with fodder collection, it is not suggested that hand pulling was a major gathering method in the Bronze Age. This method is quite limited but may have been a supplementary method to gather specific parts of plant species from the various ecological zones within the catchment. This may partly explain the relative lack of evidence for metal cutting tools in the Bronze Age.

Based on my observations, the major factors affecting the yield rate of fodder is the different vegetation density and average yield rate per single plant. Here, density represents the number of plants within a defined area. For example, the yield rate of the single Fabaceae plant is high among local plants. This results in the meadow zone producing one of the highest yield rates among the ecological zones. When we compare meadow zones in different locations, the yield rate does vary because of the density of the same plant species that occupy these zones.

With the aid of large machinery, the steppe zone can be a suitable place for gathering fodder. However, the yield rate with hand mowing is slightly decreased, because of the grass density. Although substantial haymaking activities probably did not exist during the Bronze Age, fodder collection was still an essential part of the daily and seasonal resource exploitation practices associated with their economies. Based on the significant gap that exists between the fodder yield rate in the steppe zone and meadow zone it is possible to understand why the meadows were so intensively used. The results obtained through the archaeobotanical studies of the Bronze Age settlements appear to confirm this as these are the types of seed assemblages that have been identified.

8.3 PLANT PROCESSING EXPERIMENT

In the archaeobotanical samples, as discussed earlier in the dissertation, none of the recovered charred seeds represented domesticated plant species. The recovered charred seeds of wild plant resources are most likely associated with human and animal subsistence activities human diet and herding activities. Kohl (2007:128) points out that herding and wild plant gathering are complementary economic systems. However, other scholars have suggested that there is limited archaeological evidence for wild plant gathering in the Southeastern Urals region (Chechushkov et al. 2018; Ruhl et al. 2015; Fedorov et al. 2017) Compared with the archaeological record from other regions in the Eurasian steppe (Charles & Bogaard 2002; Harris 2010; Popova 2006; 2007; Anthony et al. 2005; Spengler & Willcox 2013) it is possible to see regional differentiation in seed assemblages associated with wild plant resource use in the region.

In the Southeastern Urals region, based on my research and that of the team at the Kamennyi Ambar settlement, there appears to be a dominance of Fabaceae. The high ubiquity of this resource is enough to prove the importance of Fabaceae for Bronze Age societies. If wild plant species at Stepnoye, Ust'ye, and Streletskoye 1 were used for human subsistence, then seed density at these sites is relatively low. For a better understanding of the plant resource uses, I initiated a processing experiment to collect additional information.

My plant processing experiment included wild grain food gathering and processing. The targets were the major plant species (Fabaceae, Poaceae, *Chenopodium*, and Polygonaceae), which were recovered and identified in the archaeobotanical samples. In the autumn of 2017, I started to gather wild plants in the catchment area of the Stepnoye settlement. Autumn is the withering season for these plant species and is a suitable time for gathering their seeds for subsistence needs.

There are large varieties of plant species encountered in the Stepnoye catchment zone. Thus, all the gathering activities focused on hand picking specifically targeted plants and plant parts. In archaeological records, we cannot find clear evidence of storage facilities at the Bronze Age settlements. The workload of hand picking is acceptable for daily food gathering and this method also saves time on processing the plant materials. For each plant species, I started my collection search at the edge of the settlement. After locating the target plants, I spent 1 min gathering the resources then returned to the settlement to estimate the time required for the collection round.

The collected plants were brought to the laboratory in Stepnoye and processed. This processing method varied by type of plant resource. Most of the plants are processed by hand-peeling or hand-rubbing. The final step of this process was weighing the edible parts. Table 42 provides a listing of the gathered plants, parts of the plants, seasonal availability, processing times and the weight of the edible part following processing.

Table 42 Plant parts, seasonal availability, processing time and weight of edible parts after processing

Genus	Availability	Parts	weight of edible part(g)	Processing time(m)
***Vicia* spp.**	April-August	leaf and stem	40	1
	August-September	seeds	20	6x10
***medicago* spp.**	April-August	leaf and stem	40	1
	August-September	seeds	8	6x10
***Stipa* sp.**	Late July- September	seeds	50	4x100
***Poa* sp.**	Late July- September	seeds	10	4x100
***Polygonum* sp.**	April-July	leaf	40	1
	August-September	seeds	100	4x100
***Chenopodium* sp.**	April-July	leaf	40	1
	Late August-September	seeds	100	4x100

All the plant species can easily be found in the local catchment zone. They usually form a large patch or a significant area of the vegetation zone. The time spent searching for the target resources was generally less than 1 minute. Thus, the amount of time searching for the resources to collect was not a factor and this also did not affect the choice of plant resource. Compare with the other plants, the time spent searching for wild strawberry (not in this particular experiment) was relatively longer (Figure 80).

Figure 80 Photo showing a small patch of wild strawberries in the Southeastern Urals region

For leaves and stems(*Medicago* sp.)**,** I could gather roughly around 40 grams per min (Figure 81). The processing time was nearly zero because during gathering it is possible to pick the fresh part to save time. After washing, these parts are ready to cook. During the spring and summer, the gathering rate per plant is higher because of the availability of the fresh part. In Autumn, the searching time will increase, and the gathering rate per plant will decrease. Some species like *Polygonum* and *Chenopodium*, the stem is much too hard for the human diet. Thus, the limitation of fresh leaves and stems may be related to the seasonal availability and this can be partly solved by drying. However, there is little likelihood of such resources being preserved and identified through archaeobotanical sampling at the ancient settlements.

Figure 81 The amount of fresh Fabaceae leaves and stems collected in 1 min

The processing method for Fabaceae included the removal of the pods by hand. The time per pod collection was around 5-7 seconds. Every pod contained 3-5 seeds. For *Vicia*, 10,000 seeds weighed roughly 100g. For *Medicago,* 25,000-30,000 seeds weighed roughly 100g. The time to process 100g of Fabaceae was around 5 -10 hrs. Based on my experience cooking millet, a comparable seed size, this amount would provide one meal for 2 people.

The processing method for *Polygonum* and *Chenopodium* were the same. I rubbed the seeds on a hard surface and blew away the chaff. For both species, the time to process 100g of seeds was roughly 7 hours. This time could be reduced with mass processing or the use of specialized tools, however, such production rates and volumes would leave the associated chaff and tools (big mortars or grinding stones) in the archaeological record. However, such evidence is nonexistent in the Southeastern Urals region.

I used different methods to process the *Stipa* and *Poa*. Removing the husk by hand is very slow and this takes around 1 min per seed. Rubbing the seeds on the hard surface does not remove the husk of the *Stipa* plant. Smashing the seeds with a hard stone and subsequently removing the husk is a more expedient method. However, there are still lots of husks attached to the seed after this process. Hillman (2000) has described how *Stipa* can be collected and roasted to easily remove the husk (Hillman 2000). Following Hillman's description of roasting the seed first I found that this increased the processing time substantially.

The gathering productivity per plant for *Stipa* is around 30 seeds per plant (Figure 76). Since *Stipa* is a major species found in the steppe zone it is very easy to recognize and collect. For *Stipa*, there are roughly around 7,000 seeds for every 100g. I found that the processing time during experimentation was long and that it took 7 hours to produce 50g of seeds. This is probably related to the specific method and experience of the gatherer but there is no doubt that processing *Stipa* is more difficult and time-consuming.

The size of the *Poa* sp. seed is very small among those I identified in the catchment zone. During processing, I rubbed the seed on a hard surface and it was possible to separate the husk from the seed. However, I found it difficult to remove the chaff from the seed assemblage. Winnowing and blowing, unfortunately, also removed many of the seeds at the same time. Thus, the output from processing *Poa* sp. seeds is quite low because of the seed size. Since the yield rate of edible seeds from these plants is among the lowest, it was probably not used extensively in the human diet.

Figure 82 The amount of Stipa seeds gathered from 1 plant

Compared to the seasonal availability of the plants discussed above, Fabaceae has the highest potential as a food resource in the human diet. Besides winter, the edible part of Fabaceae is available year around. The seeds can be collected as a resource after the withering period of the leaves and stems. Fresh bean pods of some Fabaceae species are also edible. These characteristics can increase the potential of Fabaceae as a food resource.

In the spring and summer, *Polygonum* and *Chenopodium* can provide similar yield rates for the leaves and stems. The processing time for both species is longer than Fabaceae. The seeds of these three species without some form of special treatment or cooking can cause health problems from human consumption. Thus, the potential of *Fabaceae*, *Chenopodium* and *Polygonum* seeds is lower when compared with the fresh parts of these plants.

Stipa may be used as a form of wild seed grains in the human diet, however, the seasonal availability of this plant is constrained. This can be solved through collection and storage, but thus far no evidence can support the use of such storage systems in the Bronze Age settlements within the region. The processing time is also relatively higher, when comparted to the product of this effort, and so this would appear to decrease this plant as a viable food resource.

The yield rate of the *Poa* spp. is also very low as a wild grain resource. Overall, the size of the seed is too small and this contributes to the difficulty of processing this plant. Thus, it is likely that *Poa* was not intensively used as a wild resource in the Bronze Age human diets. The number of identified *Poa* in the archaeobotanical samples was quite low at the Stepnoye and Streletskoye 1 settlements and these results match my experience with collecting and processing these plants.

Overall, the plant species that I focused on through my experimental studies indicate that they could have been used as human dietary resources but with different constraints. These results also are reflected through their representation in the archaeobotanical samples and low seed densities. Also, the experiments proved that the plant leaves and stems are better resource choices and are much easier to process for human consumption. Unfortunately, it is unlikely that the charred remains of leaves and stems would be identified in archaeobotanical samples due to poor preservation characteristics. My ethnographic studies provided important information from local informants on the practices and choices associated with the use of wild plant resources. For the collection of seeds (wild grains), I found that these are typically gathered after they have matured and the seeds are at their largest extent.

I also compared the size of modern *Vicia* obtained through hay experiments with the charred seeds that were identified from the archaeobotanical samples from the three Bronze Age settlements. Table 43 provides a listing of 61 measurements of *Vicia* seeds from the Stepnoye archaeobotanical samples. All the charred seeds identified in the archaeobotanical samples are much smaller than the modern seeds. The size of the charred *Vicia Cracca* seeds from the burning experiment were usually 3mm in diameter while the size of most *Vicia* seeds from the archaeobotanical samples was less than 2.5mm in diameter. According to other published experimental studies, the length of the seeds can be decreased (change to width varies) because of the burning process (Carakuta et al. 2015). Besides the burning process, modern fertilizers used in the agricultural fields can change the nutrients within the local catchment soils and this can result in increasing the sizes of wild plant seeds as compared to the charred seeds recovered from the archaeobotanical samples. Most of the seeds recovered through excavations at the Bronze Age settlements are clustered in the smaller size group.

The potential value of leaves and stems continues to decrease through the withering period. At the same time, the potential value of the seeds continues to increase into the withering period. If the size of the charred seeds in the archaeobotanical samples is related to plant maturity then this would suggest that most of the seeds were gathered before they reached full seasonal maturity. This period represents the last moment for the gathering of leaves and stems and the process of haymaking. This comparison does not suggest that the wild plant seeds were not useful in supplementing the human diets. Quite the contrary, this result suggests the seasonal differentiation for plant resource use.

Table 43 Measurements of Vicia seeds collected from the Stepnoye archaeobotanical samples

Sample Number	Length(mm)	Width(mm)
77	2.1	1.98
367	2.16	1.76
335	2.14	1.94
266	2.34	2.25
266	2.21	2.21
266	2.02	1.77
204	2.32	2.3
204	2.05	1.84
204	2.5	2.29
204	2.13	2.07
204	2.19	1.97
336	1.97	1.89
336	1.98	1.86
221	2.42	2.25
402	2.53	2.21
247	1.94	1.72
224	1.93	1.84
360	2.33	2.27
360	2.15	2.13
287	1.97	1.81
287	2.16	2.08
287	2.54	2.21
287	2.42	2.1
287	1.93	1.83
287	1.85	1.74
287	2.28	2.26
287	2.69	2.32
287	2.6	2.42
287	2.12	1.8
374	1.86	1.81
374	2.23	1.95
374	1.88	1.72
400	1.93	1.86
369	2.78	1.73
337	2.52	2.32
337	2.2	1.91
365	2.16	2.1
307	2.06	1.99
70	1.91	1.81
309	1.94	1.77
309	1.98	1.81
405	1.92	1.77
405	2.38	2.02
405	1.94	1.84
405	2.19	2.05
405	2.02	2.01
405	2.01	1.93
405	1.94	1.88
308	2.31	2.25
359	2.03	1.92
315	2.08	2.06
346	2.06	1.98
317	1.9	1.81
317	2.31	2.28
317	2.15	2.06
351	2.16	2.04
351	2.17	2.06
351	2.43	2.37
351	2.16	1.92
351	1.92	1.91

The interpretation of archaeobotanical samples is crucial for the reconstruction of wild plant resource use by Bronze Age communities in the Southeastern Urals (Figure 83). However, as the last two chapters have indicated, there is considerable information missing in which to more comprehensively understand these socio-economic patterns and subsistence strategies.

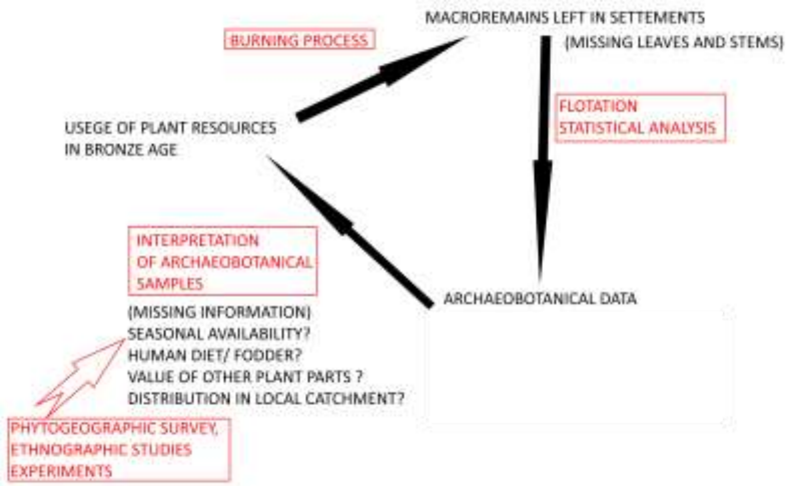


Figure 83 Figure showing the relationship between the use of plant resources in the Bronze Age, macrobotanical remains within the settlements, and the recovered archaeobotanical data through excavation

Most of the recovered macro remains during the settlement excavations are represented by charred seeds associated with burning processes. There can be no doubt that the high number and ubiquity of charred seeds do represent an essential component within Bronze Age subsistence economies and are related to human and livestock activities. But the remains of leaves and stems are missing from the sampled collected during archaeological excavation.

In a multi-resource pastoralism model, leaves and stems are one of the main sources of fodder for livestock(Chang and Koster 1986, Rosen 2003, Salzman 1972, Spengler 2013)For human diets, the potential of leaves and stems as food resources is higher than is indicated by the number of charred seeds identified in the archaeobotanical samples. In the Southeastern Urals regions, the growing season for most plants from the archaeobotanical samples is May through August and the withering season for seed gathering only lasts for 1 to 2 months. The total number of the recovered charred seeds, therefore, is difficult to interpret as evidence of a society that would have relied on wild seed grains as a significant component of their subsistence economy. Therefore, we can assume that the missing plant parts (leaves and stems) were also essential in the subsistence economy of the Bronze Age communities.

Compared with other archaeobotanical projects, it is crucial that more information be obtained about these missing components before an interpretation can be formulated about the use of wild plant resources. The results of my phytogeographic survey, ethnographic studies, and experimental research has provided essential data in which to examine these gaps in our knowledge. Based on the data that has been discussed thus far within the dissertation, the next chapter will focus more intently on wild plant usage patterns that may have been connected with multi-resource pastoral subsistence patterns during the Bronze Age in the Southeastern Urals.

9.0 CONCLUSIONS AND IMPLICATIONS FOR FUTURE STUDIES

From the dissertation research discussed in the previous chapters, I have examined various patterns of multi-resource economies among the Bronze Age communities that lived in the Southeastern Urals region. My studies have focused on the complexity associated with human-environment interactions, which can be defined as relationships that exist between social systems and ecosystems (Marten 2001). The exact nature of the local human-environment interaction is essential for understanding the decision-making processes and patterns of sedentism and mobility connected with late prehistoric pastoralist societies in the Eurasian steppes.

Recent archaeological evidence, which has documented the use of nucleated, enclosed settlements and the importance of cattle herding, supports previous interpretations of sedentary pastoralist communites during the Bronze Age in the Southeastern Urals. Based on this foundation, this dissertation research has focused on examining the use of local plant resources to better understand the crucial linkages that formed between pastoralist communities, herding activities, and the local catchment zones.

After collecting and analyzing archaeobotanical samples from three archaeological settlements (dating from the MBA to LBA), a substantial macrobotanical database has been achieved that may be used to examine the exploitation of local catchments connected with these sites. The comparison of these data collected from the three sites has stimulated new questions about the nature of human-environment interactions associated with these communities. The common characteristics of the archaeobotanical samples can be considered important supplementary background data within which to examine wild resource exploitation patterns. The differences that have been documented among the settlements, in terms of archaeobotanical data, also are critcial for exploring local catchment zone use. Understanding these differences also provides an important empirical foundation for examining the decision making patterns of these communities for the exploitation of local resources.

9.1 ADDRESSING THE DISSERTATION RESEARCH QUESTIONS

The primary goals of the dissertation have focused on two main areas of research:

(1) The empirical evaluation of human-environment relationships and subsistence economies of the Bronze Age communities in the Southeastern Urals region.

(2) The assessment of the development of multi-resource pastoralism in the context of Bronze Age socio-economic organization.

The archaeobotanical research that was presented in Chapters Four and Five has provided essential first-hand data in which to better understand the nature of plant resource exploitation during the Bronze Age.

Chapters Six, Seven and Eight have presented important new data that were achieved through phytogeographical survey, ethnographic research, and experimental archaeology. These studies have produced solid comparative data in which to explain the interactive relationships that occur between human activities, livestock herding, and the exploitation of surrounding catchment zone resources.

In this final chapter, it is important, initially, to return to the original questions that structured the dissertation research and that were supported by the National Science Foundation DDRIG award I received:

(1) What is the spatial distribution of natural resources in the different vegetation units that have been identified for the Bronze Age settlement catchment zone?

The results from the archaeobotanical samples and their analysis, combined with local catchment zone survey, has identified the main plant resources that may have been utilized by the Bronze Age communities occupying the three settlements studied through my research. All of the plant species identified related to specific vegetation units visible in the catchment zone. This result, and the character of the nucleated, sedentary settlements, suggest a more locally focused subsistence economy.

There were five major vegetation units identified within the catchment zones: meadow, ruderal, riparian, forest and steppe. These different vegetation units were found to vary in terms of their resource potential. Through my phytogeographic study of plant distribution in the catchment zone (Table 44), it was possible to further explore the seasonal use of these plant species and related vegetation units that were exploited during the Bronze Age.

Table 44 The proportion of seasonal fodder from different sources in the Uy River valley catchment zone

Season	Rangland	Fodder(human collect)	Hay
Spring-Summer	High	Low	Low
Autumn	High	Low	Low
Winter	Very Low	x	High

(2) What is the importance of grazing and foddering in conjunction with the availability of botanical resources in different seasons within the Bronze Age catchment zone?

Based on the archaeobotanical data and ethnographic studies it has been confirmed that grazing was a significant method for nutrient intake during the spring, summer, and autumn seasons for livestock herds. During these seasons, fodder is only used at night for feeding livestock and so the intake rate of these resources is low. During the winter season, because of the environment, the storage of fodder is a primary dietary resource for livestock. As ethnographic studies indicated, grazing in winter is very rare.

Based on my dissertation research, it can be argued that the annual herding pattern during the Bronze Age was closely related to the seasonal availability of botanical resources in the catchment zone. During the spring, summer, and autumn seasons, the plant resource availability is high because of the growing and ripening season of the plants (Table 45). In the growing season, the fresh leaves and stems of most plant species are high in nutrient value. During the ripening season, there is still sufficient plant resources available for daily herding. Furthermore, haymaking activities are also carried out in the three seasons to cut, dry and store enough fodder to sustain the livestock during the long winters.

Table 45 The harvest rate and potential of plant parts in the different growth stages

Zones	Families/Genus/Species	Parts	Growing	Ripening	Withering	Hervesting rate
Riparian	Cyperaceae	Leaf,Stem	M	L	L	M
		Seed	X	X	X	X
Meadow	*Vicia* spp.	Leaf,Stem	H	H	L	H
		Seed	X	H	H	H
	Medicago/Mel/Tri spp.	Leaf,Stem	H	H	L	H
		Seed	X	H	H	H
Ruderal	Polygonaceae	Leaf,Stem	M	M	L	M
		Seed	X	X	X	X
	Chenopodaceae	Leaf,Stem	M	M	L	M
		Seed	X	X	X	X
Steppe	*Stipa* spp.	Leaf,Stem	M	X	X	M
		Seed	X	X	M	X
	Poaceae	Leaf,Stem	H	H	L	M
		Seed	X	X	X	X

X= NONE	Growing=April-July
H=HIGH	Ripening=July-August
M=MIDDLE	Wither= September-April
L=LOW	

In contrast to other published opinions (Stobbe 2016, Sharapov 2017), my research has indicated that haymaking and foddering was an important activity in the Bronze Age and was essential for minimizing the risk to livestock herds. Grazing was a major fodder resource for livestock and the winter season substantially reduces the availability of plant resources due to the open rangeland being covered by snow. Because of these conditions, it is highly likely that Bronze Age herders used stored fodder to supplement the dietary needs of the livestock herds.

My research has shown the meadow zone to have the highest potential for plant resources during the growing season. The plant species with the highest nutrient value usually grow in this zone. The size of the meadow zone can vary substantially due to precipitation in the growing season and proximity to consistent sources of water. The locations of meadow zones also fit well with animal behavior. The herding route of livestock should always be close to water resources and as my research indicated herding camps and herding routes are usually oriented towards the meadow zones. When compared with other ecological zones, the meadow zone is relatively stable in any given year and a crucial resource (Figure 84).

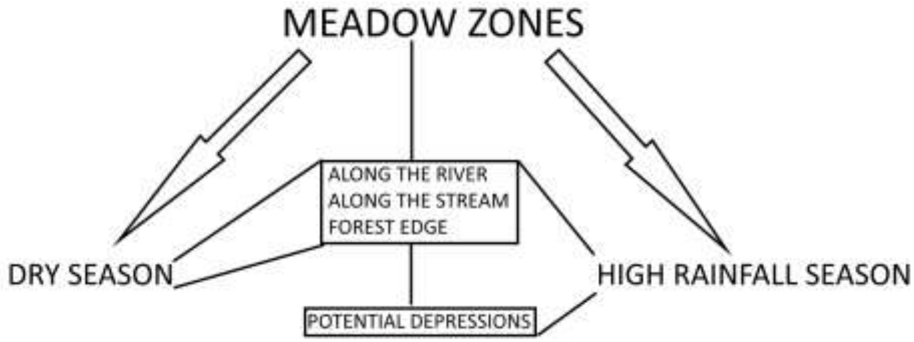


Figure 84 The distribution of meadow zones in different seasons

(3) What is the relationship between the distribution of macro-botanical remains and different zones of anthropogenic activity associated with the enclosed vs. non-enclosed areas of the Bronze Age settlements? How does this variability relate to activities associated with animal husbandry (penning, foddering, manuring), possible burning of animal dung for fuel, and human plant consumption, as identified through midden deposits external to the enclosed area of the settlement and botanical remains recovered from within the enclosed area?

Based on the results of the archaeological experiments and archaeobotanical samples analysis, the enclosed areas of the Bronze Age settlements were associated with residences and daily human activities. The enclosed area also may have been utilized to contain milk cows and young and weak livestock during the harsh winter months.

The macro-botanical remains recovered from the enclosed space likely reflect a combination of plant resources used for both animal and human dietary needs. According to the results of the archaeological experiments and ethnographic studies, part of the non-enclosed areas (external middens) may have been used as an outdoor corral area. The ashy layers encountered in these zones during excavation are very similar to the remains produced through the dung-burning experiments. Outdoor corrals also may have been used for the storage of fodder and the dumping of refuse from the enclosed residential area of the settlement – similar to what I observed in the modern Stepnoye village during my experimental and ethnographic research.

The identified archaeobotanical seed assemblages recovered from the non-enclosed area may comprise many sources including: livestock dung, hay, human refuse, and wild plant species that colonized the distrubted areas. The seed assemblages also reflect the use of plant species that may have been associated with the residential area within the settlement. Comparison of the archaeobotanical samples from these two main locations indicate some important differences but also the overlap of certain plant species. While the enclosed area of the settlement is easily related to daily activities of the Bronze Age occupants there is evidence of wild plants that may have been processed and consumed there also appearing in the external midden deposits. While the exact function of the midden and external non-enclosed area is debatable (Chechushkov 2018 and Sharapov 2017) it likely reflects a zone of multiple functions. However, based on my dissertation research, I suggest that this area was primarily linked to livestock-related activities and that these were responsible for the formation of the midden deposits.

9.2 FINAL CONCLUSIONS

This dissertation study has provided a theoretical framework for the future evaluation of the subsistence economy among early pastoralist societies in the Southeastern Urals region and adjacent territories. The study has focused intensively on wild plant resource exploitation to demonstrate the complexity of human-environment interactions of early pastoralist societies. It has provided important new comparative data and a different theoretical perspective that may be used to address one of the main outstanding questions for the region: How did sedentary pastoralist societies maintain sustainable economies without producing and/or using agricultural products?

The answer to this question is multi-resource pastoralism and its ability to maximize available resources within the catchment zones and minimize the risks from the environmental factors common to the Southeastern Urals region (Figure 85).

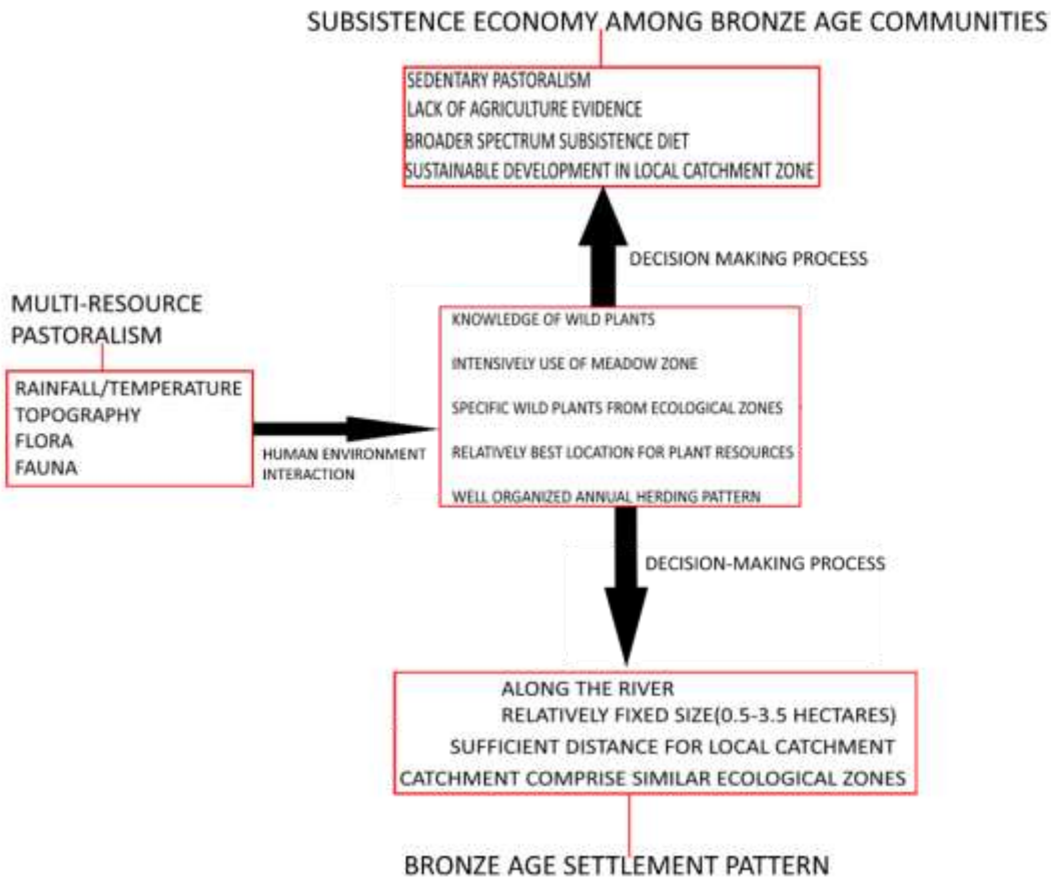


Figure 85 The role of multi-resource pastoralism in the Southeastern Urals region

I suggest that social complexity and regional change in settlement patterns during the Bronze Age in the Southeastern Urals region was highly related to the development of multi-resource pastoralism. Plant resource exploitation was one of the primary methods in which to support the core herding socio-economic system. This pattern affected the seasonal herding patterns and daily human lifeways of these early societies and helped to determine the annual carrying capacity of the local catchment zones. The MBA (2100-1700 BCE) and LBA (1700-1500 BCE) phases lasted around 600 years in the Southeastern Urals region and research to date has indicated that a relatively consistent subsistence pattern was practiced. This indicates that this form of herding and plant resource exploitation was a reliable and sustainable development for these early pastoralist societies.

9.3 FUTURE DIRECTIONS FOR RESEARCH

This dissertation study has provided a theoretical and methodological framework, and database, for future archaeobotanical research and evaluation of early pastoralist societies in the Southeastern Urals region. However, gaps remain in our current knowledge about this region that require additional research.

One of the essential requirements is a more precise chronology for changes that have been observed at the individual settlement site level. Most chronological models for the region rely on established ceramic typologies. With additional AMS dating it may be possible to more precisely compare subtle differences in subsistence strategies between MBA settlements, and their associated catchments, and the broader transitions in the LBA when there appears to be a disaggregation of the centralized MBA Sintashta settlements. The archaeobotanical samples that have been collected to date provide a substantial amount of charred seeds that can be used to build a more comprehensive radiocarbon database.

Another potential development would be the use of computer simulation models to explore the various mechanisms of the subsistence economies and related social organization and change. The data collected through this dissertation provides an important new foundation for modeling herding patterns in the Southeastern Urals region. These data may be used to build reliable simulation models.

The final area of future research relates to the expansion of archaeobotanical research within the Southeastern Urals region. In the past 10 years, there has been an important increase in regional studies that are incorporating this method with archaeological excavation. In addition to my dissertation research activities over the past several years, I have worked with several research teams in the Southeastern Urals as the team archaeobotanist and the geographical scale and diversity of Bronze Age sites has been increased substantially (Figure 86; Table 46).

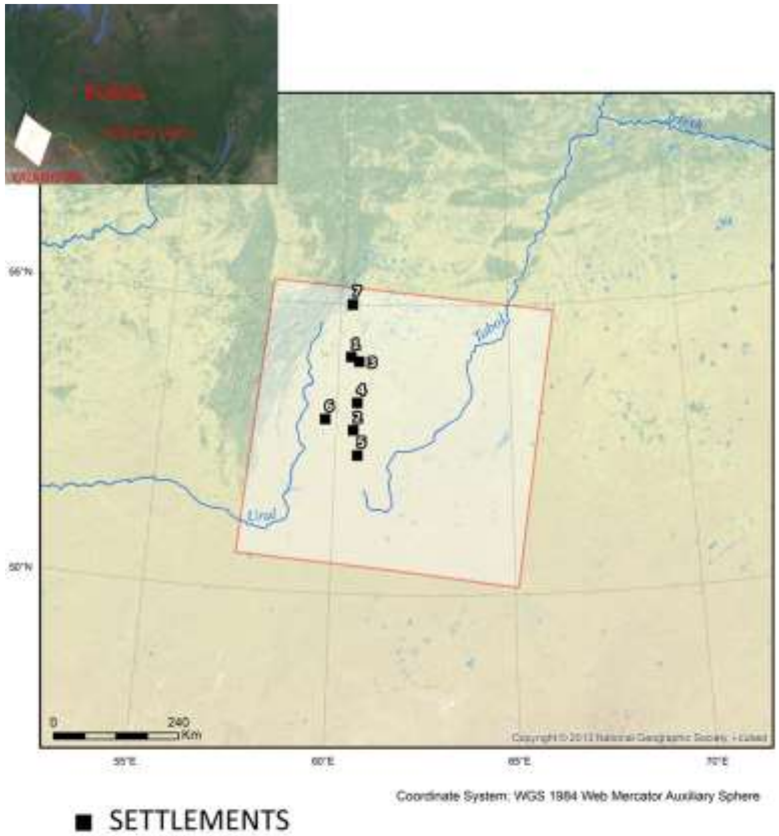


Figure 86 Map of Bronze Age sites in which systematic archaeobotanical work in the Southeastern Urals region has been conducted (modified from Chechushkov 2018) Settlements: 1. Stepnoye; 2. Kamennyi Ambar; 3. Streletskoye 1; 4. Ust'ye; 5. Sintashta II; 6. Sarym-Sakly; 7. Chebarkul 3

Table 46 Archaeological project(Bronze Age) with systematic archaeobotanical samples in the Southeastern Urals region

Sites	Major Chronology	Major species related to human diet/fodder
Stepnoye	MBA	Fabaceae, Pologonaceae, Chenopodaceae, Cyperaceae, Rosaceae
Kamennyi Ambar	MBA	Fabaceae,Poaceae, Chenopodaceae, Polygonaceae, Cyperaceae,Rosaceae
Streletskoye 1	LBA	Fabaceae, Rosaceae, Chenopodaceae
Ust'ye	MBA	Fabaceae, Chenopodaceae, Poaceae, Cyperaceae, Rosaceae,Polygonaceae
Sintashta 2	MBA	Fabaceae, Poaceae, Cyperaceae, Chenopodaceae
Sarym-Sakly	MBA-LBA	Fabaceae
Chebarkul 3	LBA-FBA	Fabaceae,Chenopodaceae, Poaceae,Polygonaceae
(Aleava et al. 2016; Peterov et al. 2017; Ruhl el al. 2015; Dissertation works)		

My experiences on these projects, and the completion of my own doctoral dissertation research, has provided an important foundation of regional knowledge for me and added crucial new archaeobotanical data in which to explore the important developments of early herding societies in the late prehistoric Eurasian steppes.

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