Late Quaternary Climate Change in Western Eurasia

A spatio-temporal review of climate proxies

A Dissertation

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Abbreviations used in the text

a.s.l	Above see level
BC	Before Christ
ka BP	Ka before present
GIS	Geographic information system
INQUA	International Union for Quaternary Research
IntCal	Calibration curves
IRSL	Infrared stimulated luminescence
LGM	Last glacial maximum
OSL	Optically stimulated luminescence
OxCal	Oxford calibration curves
QGIS	Quantum Geographic information system
RAN	Russian Academy of Sciences
RF	Reference file
SCV	Comma-separated values
SHP	Shapefile
TL	Thermoluminescence
USSR	Union of Soviet Socialist Republics
UTF	Transformation Format
WG84	World Geodetic System 1984

Abstract

The main purpose of this research project was to develop a comprehensive description of climate change in Western Eurasia during Holocene, using the method of literature review, including reports of palynological, lacustrine, pedological and archaeological site contexts.An inventory of all assembled and collated proxies used for the area between the Vistula River/Poland, the Carpathian Mountains, the Urals Mountains and the Caspian Sea was established (20-60°E, 42-70°N). The northernmost border corresponds to the Barents Sea and White Sea, and the southernmost border is located close to the Black Sea and the Caucasian Mountains.

Over the last decades palaeoenvironmental events have increasingly been put forth by archaeologists as representing at least one important cause of changes in cultures in the East European Steppe over the last 8000 years. Thus, a comprehensive study on the issue "Late quaternary spatial-temporal analysis of palaeoenvironments in Western Eurasia based on climate proxies" can provide a reliable basis in this discussion. Methods used to acquire proxy data for palaeoenvironmental reconstruction vary. However, interpretations of these data, is of often set within a broad framework, with local findings used to explain global changes.

Time-dependent frequency distribution of proxy data from Western Eurasia indicating palaeoclimate conditions clearly show the following:

1. Early Holocene cooling with fluctuations in aridity and humidity occurred between 10,000-8200 BP.
2. Middle Holocene warming with increasing humidity around 8200-5000 BP is known as the Holocene optimum
3. Middle Holocene warming and aridization date to 5000-3000 BP has also known as “xerothermic phase”.
4. Late Holocene cooling and increasing humidity data to 3000-2500 BP and is also known as the Neoglacial period.

The research conducted on the basis of proxy data enables to detect major palaeoclimatic oscillations in Western Eurasiaduring the Holocene. The analysis reveals several shifts in palaeoclimate and palaeoenvironment that may have affected the way of life of prehistoric populations

Zusammenfassung

Ziel dieser Arbeit war die umfassende Beschreibung des Holozänen Klimawandels in West-Eurasien. Dazu wurden im Rahmen einer Literaturrecherche palynologische, lakustrine, pedologische und archäologische Studien ausgewertet und in eine Datenbank überführt. Als Untersuchungsgebiet wurde der Raum zwischen Weichsel und Karpaten im Westen sowie Ural und Kaspischem Meer im Osten festgelegt. Im Norden bildeten die Barentsee und das Weiße Meer und im Süden der Kaukasus und das Schwarze Meer die Grenze.

Ausgangslage der Untersuchung war die Tatsache, dass in den vergangenen Jahrzehnten archäologische Studien verstärkt zu dem Ergebnis kamen, dass eine Veränderung der Paläoumwelt zumindest eine der Hauptursachen für den kulturellen Wandel in der osteuropäischen Steppe innerhalb der vergangenen 8000 Jahre war. Dennoch lagen lediglich lokale Fallstudien zu unterschiedlichen Paläoklima-Proxies vor. Eine umfassende Betrachtung, die alle Fallstudien zusammenführt, existierte bislang nicht. Darüberhinaus wurde oftmals von lokalen Befunden auf globale Landschaftsveränderungen geschlossen.

Mithilfe der Datenbank wurden für die letzten 10,000 Jahre Diagramme erstellt, welche die relative Häufigkeit von Klimatrends in 500-Jahr-Intervallen darstellen. Aus ihnen lässt sich ableiten, dass

1. sich das Klima im Frühholozän (10,000 – 8200 BP) abkühlte und Niederschlagsschwankungen auftraten.
2. im frühen Mittelholozän (8200 – 5000 BP) das Klima wärmer und feuchter wurde (Holozänes Klimaoptimum).
3. im späten Mittelholozän (5000 – 3000 BP) eine weitere Erwärmung mit einer Aridisierung einherging (xerotherme Phase).
4. im Spätholozän (3000 – 2500 BP) das Klima kühler und feuchter wurde (neoglaziale Periode).

Die vorliegende, auf der Auswertung von Proxiedaten und deren Interpretation beruhende Studie erlaubt es somit, die großen holozänen Klimaschwankungen zu erfassen. Die Studie enthüllt mehrere Klima- und Paläoumweltänderungen, welche die Lebensweise prähistorischer Kulturen beeinflusst haben können.

1 Introduction

The investigation of climate changeincreased in relevance in the endof the 20th and 21st century due to the discussion about global warming. It is necessary to reconstructand to understand the climate changes of the past in order to predict the possibility of future global climatic changes. Investigation of Holocene palaeoclimatic fluctuations are of specific use for this purpose as this period covers the time of palaeoenvironment formation providing the basis for the modern environment, including climatic conditions.

Spatial-temporal analysis of the Holocene palaeoenvironment of Western Eurasia is conducted in this work, based on the analysis of published proxy-data.

The reconstruction of palaeoenvironment is a sphere of interest not only for earth scientists but also has great value for other sciences such as biology, zoology, history, archaeology etc. Most recently archaeologists have become more inclined to the opinion that palaeoclimatic fluctuations and changes were one of the controlling factors of cultural changes in Western Eurasia during last 10,000 years. Nevertheless, until now there was no area wide reconstruction of the palaeoclimate made for this territory. Although earlier palaeoclimatic and palaeolandscape researches were conducted they were made on the regional level, using different methodological approaches. The methods used for initial data accumulation for palaeoenvironment reconstruction change and those chosen by archaeologists often concentrate on one site or several sites of one microregion. Interpretations of such selective data can be made in a broader scale and the results of local changes are often used to explain global changes of palaeoenvironment including the palaeoclimate.

The geographical area under investigation is located between the Vistula River in Poland and the Carpthian Mountains in the West, from the Barents and White Seas in the North to the Black Sea and Caucasian Mountains in the South.

The research of this thesis is on the review and analysis of published research. The systemization of literary sources by geographical, biological and archaeological data using GIS-technologies allows a better reconstruction and interpretation of palaeoclimatic fluctuations of the Holocene. The selection and combination of different proxy-data: i.e., pollen, stableisotopes in combination with GIS allows describing the climate of the Holocene.

In accordance with the structure of the work, a brief summary of this work is given atthe beginning in several languages (English and Germany). Further on in the chapter “Introduction”, the characteristics of the research are given: the relevance of this topic, its aims and objectives, the subject and the theme of the investigation, its methodology and scientific novelty. In the second chapter, “The History of Late-Quaternary”, examines the palaeoenvironment of Western Eurasia. In the third chapter the geology, releif, climate, hydrology, soil and vegetation of the territory under investigation is described in detail. The fourth chapter is dedicated to the criterions of source selection, the creation and structure of the data base, the geocoding of sites (QGIS 1.8.0 “Lisboa”) the calibration of radiocarbon dates (OxCal 4.1 Bronk Ramsey 2011), the classification of spatial, temporal, proxy and climatic data and statistical analysis of data for the selected 190 sites taken from literary sources. It appears from this that a literary method was used which is supposed to be retrospective i.e. to give an objective estimation of the position based on all of the analysis of data received from sites. The fifth chapter represents the results of statistical analysis of the 190 sites, the spatial-temporal differentiation of geographical zone: taiga zone, mixed forests zone, forest-steppe zone, steppe zone and Carpathian Mountains and also the reconstruction of the palaeoclimate during last 10,000 years. The results literature analysis 190 sites of palaeoclimatic fluctuations are represented as an atlas with a dotted climatic map, accompanied by a diagramme of climatic conditions trends: "cold and dry", "cold and humid", "warm and dry" and "warm and humid", which also includes a textual description of climatic conditions of every 500 years. The last sixth chapter includes discussion and interpretation based on of the achieved results. This chapter discusses in detail the database data as spatial classification, temporary classification proxy classification and classification of climatic trends, as well as the results of climate change for the following time intervals:*Early Holocene* (10-8.2 ka BP) *Middle Holocene* (8.2-5-3 ka BP) and *Late Holocene* (3-0 ka BP). The discussions of results are at the end of the chapter, debating which could coincide or differ from the commonly established global palaeoclimatic fluctuations during last 10,000 years in Western Eurasia. The conclusion and the bibliography used in this work is provided at the end.

The main purpose of this study is to develop a comprehensive description of climate change in Western Eurasia over the past 10,000 years. In accordance with this purpose it is necessary to solve the following problem;

- Data collection and evaluation of the most relevant research on climate change in Western Eurasia.
- Spatial-temporal analysis of the most relevant published proxy data.
- Reconstruction of Holocene climatic conditions in Western Eurasia.
- The relationship between the change of palaeoclimate in Western Eurasia and the phases of the history of culture.

The advantage of the investigation of Western Eurasian palaeoenvironment development is that on a huge territory a latitudinal zonality is well expressed, and the territory can be divided into several vegetation zones (tundra, taiga zone, mixed forests, forest-steppe, steppe, semi-deserts and deserts). A large number of data about Holocene sediments which can be compared and classified on the basis of the type of archive and the proxy data investigated is concentrated in this area. Also several mountain systems (the Urals, Caucasion and Carpathian Mountains) are located here where a vertical zonality and characteristic natural changes can be observed.

The scientific novelty of the research is that the systematized data base was created by basing it on palynological, palaeozoological, lithological and sedimentological proxy data for climatic conditions trends "cold and dry", "cold and humid", "warm and dry", and "warm and humid" for Western Eurasia during last 10,000 years.

The main practical significance of the work is the proposed analysis of palaeoclimatic century fluctuations, i.e. the reconstrucion of the climate is done in 500 years time steps for the territory east of -20°E, and west of -60°E, and between 42°-70°N (WGS84). Adiachronic atlas is created including 190 sites which determine correlations and differentiations of the palaeoenvironment for the major climate zones into which the whole territory of Western Eurasia isdifferentiated. All these outcomes allow answering some questions of archaeologists concerned with cultural changes, subsistence economy and migrations of prehistoric communities of Western Eurasia in the late Quaternary period during the last 10,000 years of the Holocene.

2 Late Quaternary palaeoenvironmenat researches in Western Eurasia.

The Holocene covers a relatively short period of time in comparison with the geological history of the Earth. Despite this, the history of Holocene investigations indicates that this period (10 ka BP) was and still is one of the most attractive and interesting objects. Archaeologists assume that the development of the palaeolandscape and palaeoclimate is closely related with a complicated history of ethnocultural developments and changes in the Holocene.

2.1 Scope Holocene

The time period analysed is the Holocene, the interstadial or interglacial period after the last big continental surface glaciation. Although well known, this period has bared several names amongst scientists: the post-glacial period, late-glacial period, upper quaternary period, post-Valday period, tektonogen, neo-thermal time, historical time, modern period and Holocene. Such a quantity of names shows that this period has attracted the attention of scientists who have tried to thoroughly investigate it and give a more precise definition for it. In 1846 E.Forbs proposed the term "Holocene" for the determination of the post-glacial period (from Greek *holo* - all, entirely, *kainos* - new, modern). At the 1885 International Geological Congress in Berlin the term "Holocene" – the post-glacial period of time - was approved. Later in 1932 in Leningrad (Saint-Petersburg) by the decision of the 2nd INQUA conference (International Union for Quaternary Research) the term for the common usage of "Holocene" was accepted, covering the period of the past 10,000 years (Neustadt & Gudelis, 1961).

After the definition of the term, a more important question arose the precise age of the Holocene and its lower boundary. Many researchers adhere to the idea of Scandinavian geologists and put the boundary of the Holocene at the time of the decomposition of the glacial cover in two relatively small sheets which took place in Central Sweden near Ragunda. In absolute chronology the beginning of the Holocene can be dated to approximately 8700 years BP, considering as a "0" point the year 1900 (Neustadt, 1957). The increase in the temperature of the surface layers of the ocean occured simultaneously in different regions and can be dated to 10,700±700 years BP (Broecker, 1955). The simultaneous decay of the European glacial sheet dates the lower boundary of the Holocene to 10,000 years BP (Markov, 1965). The beginning of the accumulation of biogenic sediments in the temperate zone of Eurasia determines the lower boundary of the Holocene, in absolute chronology to 12,000 years BP

(Neustadt, 1965). Geochronological data of Scandinavia and the Baltics also describe the beginning of the Holocene to 12,000 years BP. Regarding the Holocene not only as "post-glacial" but also as "late-glacial" periodit can be dated to 12,000-14,000 years BP. Also some of the scientists extend the Holocene boundary to somewhere between X and IX zones, based on the forest development in Sweden due to the findings of L.Post (1916). The beginning of the decay of the Weichsel continental icesheetfrom its boundary is dated to the period between 18,000-12,000 years BP (Neustadt & Gudelis, 1961).

Undoubtedly, all of the palaeoenvironmental researchisvalueable for the determination of the Holocene but only on regional scale. However, the age of the lower boundary of the Holocene, hasto be universally valid, independently from the scale and the region. After many years of scientific discussions about the definition of the lower boundary of the Holocene, was accepted at the 8th INQUA congress in 1969 in Paris M.I Neustadt (1969). It was agreed that the age of the Holocene must be chronostratigraphical and the lower boundary of the Holocene is dated to 10,000 years BP.

2.2 History of research on Holocene palaeoclimate and palaeolandscapes

The investigation of the Holocene palaeoclimate and of the development of the Holocene palaeolandscapes is one of the most important reference points for the forecast of future changes and developments of natural environments. However, anthropogenic factors need to be considered. Many studieson on the quaternary period have been conducted for all world regions. Palaeoenvironmental research has been based on a wide range of different materials, e.g., pollen, minerals, stable isotopes, micro- and macro-fossils, sediment texture and structure, palaeosoils.

In the end of the 19th century palaeoenvironmental research in Western Eurasia started due to the influence of new discoveries in biology and geology of A.A Inostrantsev (1882), V.V Dokuchaev (1879). The availability of a large quantity of palaeovegetation and palaeosoil data for Western Eurasia allowed the reconstraction of the palaeolandscape development, palaeoclimate fluctuations and of the formation of vegetation zones during the Holocene.

The main impulse stimulating the interests in palaeogeography of Western Eurasia came from a classic publication of M.I Neustadt (1957) “To the history of forests and palaeogeography of the USSR in the Holocene”, which compiled a material on pollen spectra plant macroremains. The results of palaeobotanic research on the territory of mixed forests in the European part of the former USSR, are widely represented in the publications of many scientists (e.g., Grichuk, 1951; Khotinski, 1977; Artyushenko, 1982; Kozharinov, 1994;

Bolikhovskaya, 1995; Elina et al., 1996; 2010; Kremenetski et al., 1996; Kühl et al., 2002; Novenko, 2009).

Alsoresearches on the development of the vegetation cover in the Russian plains forest-steppe and steppe zone during the Holocene is manifold (e.g., Khotinski, 1977; Serebryannaya, 1982; 1992; Spiridonova, 1991; Kremenetski, 1995). Only few palaeobotanical data exist for the territory of the steppe zone because here peat-bogs as the most suitable archives for pollen conservation are rare. Despite this, palynological researches of the Holocene were conducted for sediments from the Northern Black Sea area (e.g., Artyushenko, 1970; 1982; Kremenetski, 1991; Pashkevich, 1981; 1989; 1991).

The problem of soil development occupies a special place in the investigation of Holocene palaeoenvironments. Data about soil formation and development are one of the most reliable sources of the palaeolandscapes of Western Eurasia. Numerous publications have been devoted to this problem (e.g., Gerasimov & Markov, 1939; Alifanov & Ivanov, 1984; Ivanov & Vasil'ev, 1995; Aleksandrovski, 2005; Goldberg & Macphail, 2006). Especially palaeosoil research conducted in the early settled areas of the forest, forest-steppe and steppe zone could base on soils under burials which serve as reliable archives for palaeolandscape.

The pioneer analyzing palaeosoils at archaeological sites was the German scientist I.Kornis, whose results were published by P. Köppen in 1845 (Köppen, 1845). The topic of palaeosoil investigation on the base of soil-archaeological data was almost untouched until the beginning of the 1980s and only the monograph of A.L Aleksandrovski (1983) arouse the interest in the investigation of palaeosoils at archaeological sites. Since that time, the soils of the Western Eurasian forest-steppe and steppe zones have been studied repeatedly in the context of palaeoenvironmental studies (e.g., Aleksandrovski, 1983; 2002; Ivanov & Aleksandovski, 1987; 1992; Spiridonova, 1990; Borisov et al., 2006a; Demkin et al., 2007; 2010). At present, lots of factual data have been recorded for the territory of the Western Eurasian forest-steppe and steppe zone resulting from collaborative research between soil scientists and archaeologists allowing the reconstruction of Holocene palaeolandscapes.

The monographs of V.A Demkin (1997) and M.I Dergachev (1997) point outthat the investigations of palaeosoils also provide absolute and relative chronology of the investigated sites. In consequence it has also assistedto correlate the number of primary and secondary burials in the framework of one cultural-historical entity (Demkin et al., 1992).

A great quantity of palaeoclimatic fluctuations is interpreted and reconstructed based on the palynological data. Nevertheless, pollen data should not be regarded as an incontestable fact for the reconstruction of the palaeoclimate, they serve only as an indication of the distribution and change of the vegetation cover. Therefore, in this thesis a qualitative estimation of the climate based on pollen data is conducted, which determines the fluctuations of trends "warm and cold" and "dry and humid"climate conditions.

A method evaluating qualitative data of the climate estimation is based on the mean annual temperature, indicated by the warmest month July and the coldest month January, the sum of atmospheric precipitations, solar radiation and changes of the orbit and axis position. V.P Grichuk (1969) became one of the first scientiusts who reconstructed the Holocene palaeoclimateof Western Eurasia based on this qualitative approach. He reconstructed the palaeoclimate based on the estimation of temperature and atmospheric precipitations. His method isbased on the close ties between vegetation and climatic conditions; the reconstruction of the habitat was based on the ideas of J Iversen (1944) and V Shafer (1946). Additional important contribution to palaeoclimate investigation can be found in the publications of Shnitnikov (1957), Markov (1965), Klimanov (1976, 1978, 1982, 1985, 1996), Budyko (1980), Artyushenko (1988), Velichko & Klimanov (1990) Klimenko et al. (1996), Borisova (2009), Velichko (2009, 2010).

In most cases data about the palaeolandscape and palaeoclimate result from interdisciplinary pedological, geomorphological, palynological and archaeological research. P.M Dolukhanov and A.M Miklyaev (1969) were the first scientists of the former USSR who became interested in the connections between ancient cultures and the conditions of the natural environment. They published research results on the dynamics of Baltic colonization during the Neolithic and Bronze Age and its relation to Baltic Sea transgressions. The influence of palaeoenvironmental conditions on the development of prehistoric societies started to be investigated since the 1970s and 1980s (e.g., Dolukhanov & Pashkevich, 1977; Kremenetski, 1991; Ivanov & Vasil'ev, 1995; Kozlovskaya, 1996; Gerasimenko, 1997; 2004). Palaeoclimate fluctuations and palaeolandscape changes, certainly, could have influenced the adaptive changes of economical activity, migrations and demography of ancient societies.

2.3 Human impacts on the palaeoenvironment

The investigation of humanimpact on the palaeoenvironment is in the focus of many scientists from different countries covering the different periods of time since settlement history began. On the first stages of anthropogenesis the intensity of human impact on the environment did not differ from the influences by other organisms. People received from the environment means for subsistence in quantities which were entirely restored by natural processes of biotic circulation (Efimenko, 1938). The universal ability of microorganisms to destroy organic matter, to transform mineral substance to organic one ensured the inclusion products of human econmic activities into the biotic circulation of the *Homosapiens* history (Efimenko, 1938). It is characterised by the development of productive economy and in Earth sciences is covered by the Holocene period. Some societies with a tribal organisation were acting sustainable, some of them did not. Some tribes cut trees, burned the land and some were responsible for the disappearance of entire animal species or plants. According to T.Roszhak's book "Voice of the Earth", a "sacred" attitude to nature did not guarantee in any case an ecologically pure culture, though today lots of researchers prefer to think that it was like this (Wilber, 2006).

Palaeoclimatic fluctuations are the most important factor of settlement history. They became one of the main reasons for human detachment from the environment. With each abrupt climate change or the appearance of a natural catastrophe, parts of the population died or adapted, survived and reached a new level of development as a society (Markov, 2009). Only in the beginning of the Holocene did humanity mature in its biological and social state for an active reaction on natural changes and further intensive development (Khotinski, 1978).

The main changes in the way of life of prehistroric societies happened during the transition from the Pleistocene to the Holocene and included the change from a specialised hunting for big animals to the use of a broader spectrum of resources including cultivated plants as well as marine and freshwater food (Markova et al., 2008).

In the investigated area the influence of prehistoric societies on the palaeoenvironments can be observed along several zones- the taiga zone, forest, forest-steppe, steppe zone and mountainous regions.

The interrelation of the natural landscapes of the taiga zone and forest zone with regards to the basins of the Baltic, White and Barents seas into which most of northern rivers flow as well as Ladoga, Onega and other big lakes can be noticed. Transgressions and regressions as well as lake oscillating level changes were reactions on the major climatic change and had considerable influences on the life of prehistoric people who lived along the ocean and lake shores and in the river valleys (Aleshinskaya & Spiridonova, 2000). A favourable settlement place was the earlier existing Baltic-Ladoga water ways in Karelian Isthmus which appeared about 9500years BP and remained there until 7000 yearsBP (Dolukhanov, 2009). Initial penetration of human into the taiga zone in the north of the Karelian Isthmus was found at the Antrea-Korpilahti site dating to 8800-7500 years BP. In the course of excavations conducted in 1914 the remains of fishing net twisted from elm fibers, bone tools, antler and stone tools (Subetto et al., 2007) were discovered, showing that people who inhabited this region were surviving on fishing.

The area of the Valday Hills several archaeological cultures (Butovskaya, Ienevskaya and Valdayskaya) lived during the Mesolithic in early Holocene (10-8.2 ka BP) in the Western Eurasian forest zone. These were cultures of hunters-fishers-gatherers (Novenko, 2011). In the boreal period the main directions of economic activities were hunting fishing, gathering firewood from forests and also gathering resources for household goods (Novenko, 2011). Due to the predominancy of fishing and huntingin the forest territory during prehistory it can be concluded, that it was the animal world which became the vulnerable part of the environment in the early Holocene in the Mesolithic. During Holocene key species of phytophagan died out: saiga, bison, aurochs, tarpan and northern deer (Smirnov et al., 2001). At the beginning of the Atlantic period (Middle Holocene (8.2-5 ka BP), the climate became warmer and more humid while for the people inhabiting the forest zones the main activity remained hunting and fishing. In the Bronze age during the Subboreal period (3-2 ka BP), the Fatyanovo culture penetrated the territory of the Valday Hills from the West, bringing agriculture and cattle-breeding. The most ancient findings document that agricultural activities dated not earlier than the 2nd millennium BC in most of the forest zone (Krasnov, 1971). Cattle-breeding was supplemented by fishing, hunting and gathering from the beginning of the 1stmillennium BC and until the middle of the 1st millennium AD (Novenko, 2011). Hunting activities were predominantin the valleys of the forest zone as well as in the mountainous regions of the Urals, including the territory of the Perm area. Here, in the caves named Tikhii Kamen, and in correlative sediments dating back to the Atlantic period (Neolithic age, 8-5.3 ka BP) bones of big animals (northern deers, bisons, rhinoceros) were found which document that hunting in the Urals served as one of the components of ancient people economies (Stenno et al., 2010).

The territories of the forest-steppe and steppe zone are adjacent to the northern shore of the Black Sea. This is of particular interest because cattle-breeding and agriculture occurred here distinctly earlier than in the more northern areas of Russian Plain (Kremenetski, 1991). The appearance of agriculture, of crop cultivation and animal husbandry is connected tothe Neolithic cultures of the Bug-dnestr and Linear decorated pottery Culture which existed in the forest-steppe zone of Northern Black Sea (Zaharuk & Telegin, 1985).First evidences for cattle-breeding and horse domestication in the steppe zone appeared in the Yamnaya culture (Kremenetski, 1991) cattle and horse bones could bedated back to 3100 BC (Parzinger, 2006). *Cattle-breeding "... in this dry region is supposed to be the only worthwile economy able to supply a great amount of people with food". In different regions sheep or cattle were predominantly bred depending on aridity. Search for pastures must have led to a greater* *mobility of the shepherds and in this case a seasonal nomadic life, semi-nomadic or nomadic way of life can be supposed"* (Kaiser & Schier, 2009).

Thus, the influence of cattle-breeding on the palaeolandscape of the forest-steppe and steppe zones can be assumed: in spring, the trampling of the upper layer of the wet and sensitive soil by the animal hooves leads to the increased outflow of the water from the soil surface, as a result of this erosion, little water penetrates in the earth which dries quickly in summer. These observations lead to a change in the landscape (Bostonalieva, 2008).

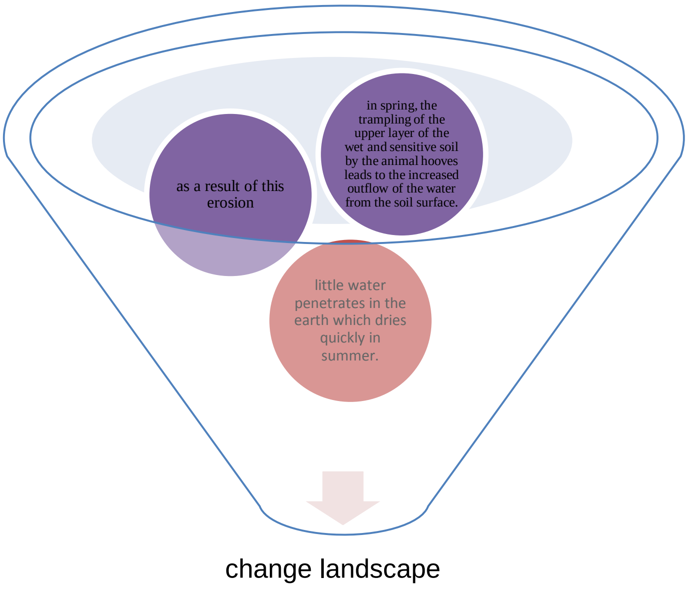


Figure 1: Palaeolandscape change trend (Bostonalieva, 2008)

Later on, the Northern Caspian Catacomb culture appeared (Dergachen, 1986) which replaced the Yamnaya culture, whereas the early Catacomb culture coexisted concurrently to the Yamnaya culture during 2800-2500 BC (Kaiser, 2009). The bearers of the Yamnaya culture started to practice agriculture (Ivanov& Demkin, 1999). The Catacomb culture is dated to 2400 BC (Parzinger, 2006). The later Catacomb culture was replaced by the tribes of Srubnaya culture who practiced a complexe diversified economy with sedentary way of life and high importance of crop cultivation (Ivanov& Demkin, 1999). The Srubnaya culture existed during 1800-1500 BC (Parzinger, 2006); it was the epoch with the highest population density in prehistory. During the early Iron Age in the Western Eurasian steppes a nomadic economy dominated, represented by the tribes of Scythian and Savromato-Sarmatian culture (Ivanov & Demkin, 1999).

The appearance of ancient people in the steppe zone of the Caspian lowlands is dated already to the Mesolithic period. The sites of Early Neolithic settlements demonstrate the small number and high mobility of these groups; this is also reflected by restricted sizes and standardized sets of features of hunting complexes. As observed for the Northern Caspian area, during this period there was an absence of permanent population. Aridisation during the Subboreal period coincided with a decrease of the ungulate animal population in the region which in turn reduced the effectiveness of use of traditional hunting methods (Kozin, 2002). The appearance of sheeps on the sites of the Khvalynsk culture (the site Kata-hukuk dated to 5110±50 BP) shows the passage of the local economy to a productive cattle-breeding economy (Barynkin & Kozin, 1998).

Thus, starting from the Neolithic the territory of Western Eurasia can be divided into two large cultural zones cultural-historical entities of hunter-gatherers situated in the northern forest zone whereas in the southern zone communities with productive economy existed.

3 Physical - geographical researches in the regions of the Western Eurasis

The investigated area is between the Vistula River/Poland, the Carpathian Mountains, the Urals Mountains and the Caspian Sea (20-60°E, 42-70°N; Figure 2). The northernmost border corresponds to the Barents Sea and White Sea, and the southernmost border is located close to the Black Sea and the Caucasian Mountains.

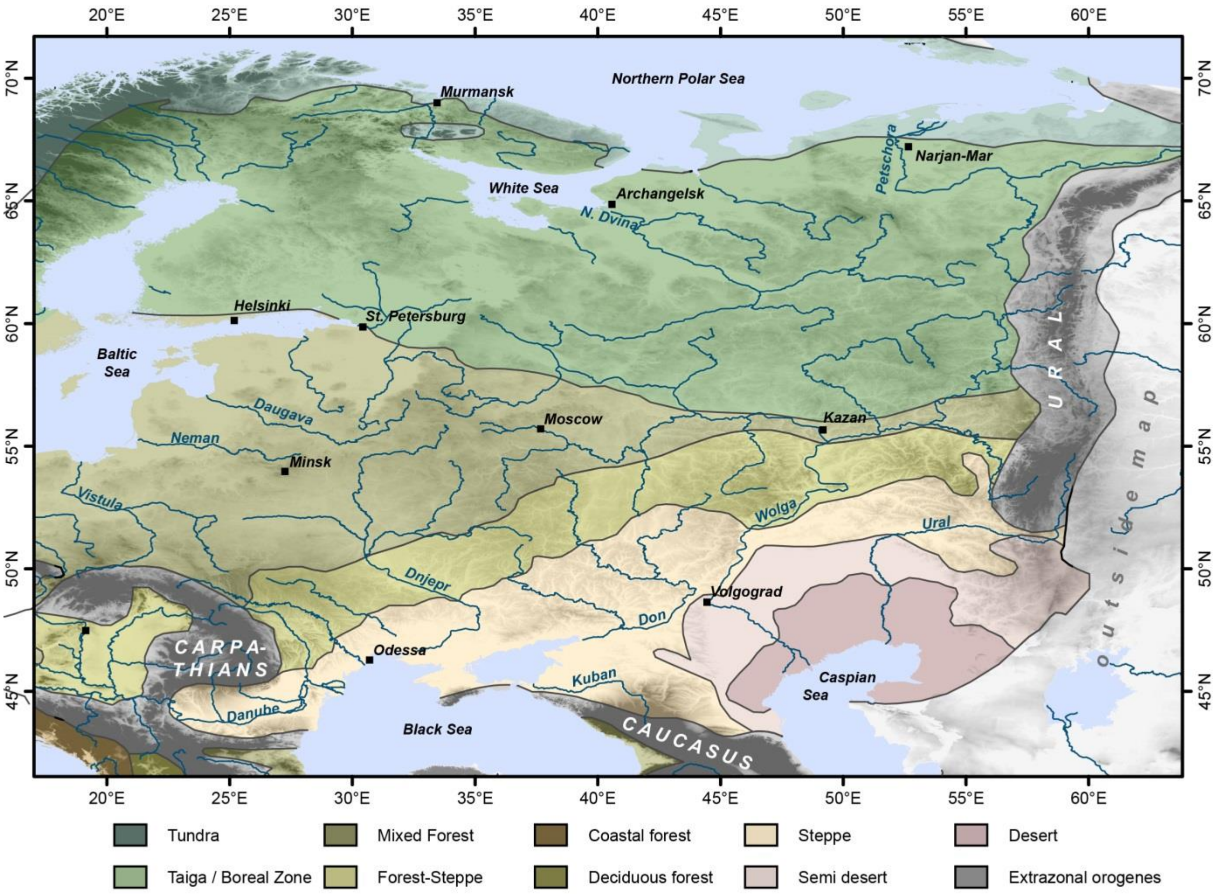


Figure 2: The location map of the landscape zones (taiga, mixed forest, forest-steppe, steppe and Carpathian Mountains) in the study area Western Eurasia (Physical Geographical World Atlas, USSR 1964).

This area is obviously too large to be regarded as a single territory with similar natural conditions. Different terrains occur depending on climatic zone, bedrock, palaeogeography and distance to the ocean.Lakes of different size, elevated mountains, low plains, rich forests and deserted steppes demonstrate the diversity of the regional geography. Large rivers run across the region, physically dividing the terrain, while in due to the high continentality of the region small rivers might be periodically.

Natural boundaries, separating different landscapes occur as wide bands in shape on geographical latitude, relief character, the radiation regime, the degree of continentality, soil, water distribution, and vegetation and animal zones (Alisov, 1936; Berg, 1938; Dokuchaev, 1899; Köppen, 1900; Sukachev, 1926).Based on the above factors territory Western Eurasia will be considered to the landscape zones.

3.1 Zone I – Taiga

The taiga zone, also called taiga, is a zonal type of landscape, a natural-territorial complex (NTC), which appears, due to specific interactions between hydroclimatic, geological-geomorphological and biotic components, regulated by solar activity and is in proportions typical for the midlatitudes of the northern hemisphere (Parmuzin, 1985). The taiga occurs where solar heat averages annually 40-45 *milcal* on 1 km^2 of horizontal surface (Borisov, 1959). This solar heat is sufficient for coniferous forest growth (*Picea*, *Pinus*, *Abies* and *Larix*) (Borisov, 1948). The climate of the continental part of the taiga is characterised by moderate, warm summers and very cold winters with a constant snow cover. The mean annual temperature is not lower than -10°C. The polar extension of the taiga is limited by the average monthly temperature of July, the warmest month of the year: only where the mean monthly temperature of July totals more than +10°C it is warm enough to develop forest vegetation. In the lowlands annualprecipitation totals more than 600 *mm* and increases up to 800 *mm* in mountainous areas. In the taiga zone, the annual precipitation exceeds the annual evaporation by a minimum of 200 *mm* consequently the region can be overall defined as humid. It favours the development of large peat and marsh areas and builds the source area of an extended drainage system. Maximum precipitation appears in July and August due to strong convection process during the summer. (Borisov, 1948)

These factors favorably influence the structure and composition of the taiga zone vegetation cover. Due to the species composition light-coniferous vegetation (*Pinus silvestris, Larix*) and more typical, wide-spread, dark-coniferous taiga (*Picea, Abies* and *Pinus cambra*) occur. Light-coniferous trees frequently occupy poor, sandy and even rocky surfaces, as well as marshy soils (Parmuzin, 1985). Dark-coniferous forests depend on constantly moderate soil humidity In consequence loamy and clayey soils suit them best (Parmuzin, 1985). Wood species can form clear (fir, deciduous) and mixed (fir-silver, fir) forests (Parmuzin, 1985)

Due to soil zonings (Afanas’eva, 1979), the whole taiga zone is included in one soil-bioclimatic zone: predominant soils of the taiga are podzolic, since the litterof the coniferous forests and the humid-cold condition cause a retarded decay and produce anhighly acid humus (Parmuzin, 1985).

The continentality of the taiga zone increases from the west to the east coinciding with an increase of maximum summer temperatures, decreasing minimum winter temperatures, gradually decreasing nebulosity and lessened winds (Borisov, 1948). Regarding these factors, the taiga zone will be further divided into two areas:

3.1.1 The North-western taiga zone

Very unstable weather, frequent occurrence of cyclones, high nebulosity and humidity, cool summers and severe, cold winters characterize this sub-zone (Borisov, 1959). Dominant south-western and western air courses cause precipitation and during winter. Cyclones from the Atlantic cause thaws during winter, resulting in the formation of icecovered ground. Arctic intrusions cause abrupt fluctuations of climatic elements (Borisov, 1959). The interchange of sea and lake breezes can be traced in the summer. Storms are typical for autumn and spring. Nebulosity is overall high due to the high appearance of wetlands allover the taiga zone. Regional landscape pecularities are distinctive since they are caused by the non-uniformity of the geological-geomorphological and the climatic conditions of the taiga zone. (Parmuzin, 1985)

Taiga forests cover the middle and southern part of the **Kola Peninsula**, an area where a high number of palaeoenvironmental studies were undertaken (cf. Berg, 1938). The Kola Peninsula is surrounded by the Barents Sea and the White Sea. The Kola Peninsula is part of the Baltic shield which consists of ancient crystalline rocks, destroyed by faults (Rakovskaya & Davydovy, 2001).

The climate in this zone is severe. The mean monthly temperature at sea level in July fluctuates between 12°C to 14°C. Winter is due to the high latitude long, but due to the high oceanity relatively mild: the mean monthly temperature in January in inland districts totals -13°C. The total annual precipitation averages 350-400 *mm* (Mil'kov, 1977). The Kola Peninsula also shows an altitude zoning of landscapes: Lowlands and depressions are occupied by marshes with peat-bog-gley soils and rarefied northern-taiga fir-woods with mixtures of birch and pine forest on gley-podzolic soils (Rakovskaya & Davydovy, 2001). Mechanic turbation of soils widely occurs (Liverovski, 1974). The distribution of forests is usually limited to a maximum altitude of 300-400 *m* asl. A rather narrow zone of birch krumholz is situated between the upper border of forest and the mountainous tundras (Rakovskaya & Davydovy, 2001).

As the Kola Peninsula, **Karelia** is part of Baltic shield and represents an area of glacial demolition (Rakovskaya & Davydovy, 2001). The climate of the territory is slightly warmer than that of the Kola Peninsula, but with abundant atmospheric precipitation (Parmuzin, 1985). Winter is relatively mildJanuary temperatures are averaging -12°C. Summer is warmer than on the Kola Peninsula, but it still is cool and short with a large quantity of precipitation. The mean temperature in July does not exceed 17°C (Parmuzin, 1985). In the east, near to the White Sea, there is a wide zone of lowland coast. In Karelia, bands of hills, ridges, river valleys and lakes interchange frequently. One of the largest lakes in Kareilia is Onega Lake whose depression originates from glacial-tectonic genesis (Rakovskaya & Davydovy, 2001). The surface area of Onega Lake totals 9,700 km^2 (without islands), its length is 245 *km* and its width is about 90 *km*. The northern shores are rocky, very rugged, and the southern shores are mostly low and don'tdissected (Kislovskij, 1974). Along the northern shore of Onega Lake, and in several other districts of Central and Northern Karelia, selgovy (from Fin. *Selkä* - rocky ridge) type of relief is brightly shown: elevations elongated mostly in a north-westerly direction, alternating with waterlogged lowlands (Rakovskaya & Davydovy, 2001)

This **Dvina-Mezen** is located between Karelia in the west and the Timansky mountain range in the east, the White Sea in the north and the Northern Uvaly in the south. The crystallic rocks of the Baltic shield are abruptly submerged to the east of Onega and the geological base of the territory is formed by Palaeozoic rocks (Carbon bedrock in the west, and Permian bedrock in the central and eastern parts of the region) (Rakovskaya & Davydovy, 2001). The surface corresponds to a low plain, gently sloping to the north-west, in the direction to the White Sea. The plain is divided by wide and ancient (pre-glacial) shallow gully along which deep rivers, the Northern Dvina, the Mezen and their numerous confluents, flow. In the north-western part of the Dvina-Mezen Taiga, the latest traces of Valdai glaciation can be observed: hilly terminal morain ridges, lakes and sandy fields (Rakovskaya & Davydovy, 2001). In the south-eastern part of the province, glacial relief is degraded, and watersheds are much flattened. In the Onega-Dvina watershed and the Kuloi Plateau, where in Palaeozoic carbonate and gypsum karst depressions have developed, big caves are known (Rakovskaya & Davydovy, 2001).

The climate in this region is highly continental: the average January temperature varies from -12°C in the west -16℃ in the east. The monthly July temperatureaverages from 13°C in the north to 18℃ in the south-west. The average precipitation totals more than 500 *mm* and isconsiderably higher than the amount of evaporation (Parmuzin, 1985). In flat terrains the precipitation causes significant waterlogging of the territory, and also causes the domination of podzolic-marshy and gley-podzolic soils in the soil cover. Typical podzolic soils and podzols are only characteristic in the south-western part of this province (Rakovskaya & Davydovy, 2001). Fir and pine are the predominating wood species; however there is also a mixture of Siberian coniferous species, including larch, silver fir and some deciduous species (Parmuzin, 1985).

3.1.2 The North-eastern area of the taiga zone

The North-eastern area of the taiga zone is characterized by a high continentality with a predominance of anticyclone weather, increasing from south-west to north-east. Winter is severely cold and short, and summer is moderately warm. The mean annual temperature is close to 0°C (Borisov, 1959). As well as in western part of the taiga zone, dark coniferous species (fir) are typical. *Picea abies* dominates here until the Urals Mountains, and further to the west *Larix*, *Abies* and *Pinus sibirica* existed (Parmuzin, 1985). Coniferous forests represent the type of complex multilayer plantations lacking moss cover. Layerage is well represented in these forest usually there is a tree layer, then a layer of bushes and then grass cover (Parmuzin, 1985).

The subzone of the **Timanskaya taiga** covers the anticlinal structure of the crystalline base of the Russian platform formed in late Proterozoic as a result of the Baikal folding (Parmuzin, 1985). The climate of the Timansky mountain range is characterised by increased humidity with more than 600 *mm* rainfall per year. The air temperature increases from north to south, with a mean July temperature of 13°-15°C (Rakovskaya & Davydovy, 2001).

In the central part of the ridge, Riphean (upper-Proterozoic) metamorphic rocks come to the surface, and to the west and east, Palaeozoic and Mezozoic sediments cover the Proterozoic base (Parmuzin, 1985). To the south, as the relief descends, the cover of Quaternary sediments becomes thicker (Parmuzin, 1985). The orographic mountain range is build of several parallel, elongated ridges with flat waterlogged peaks. The terrain in the north is more elevated and more dissected. The north-eastern part of the mountain range is formed by the gentle sloping Vymsko-Volskaya Ridge with a maximum height of 353 *m* asl. The wide lowland of the Vym' Valley separates it from the highest massif of Timan-Chetlasskii Kamen on the watershed of the Mezan' and Pizhma River, which rise up to 471 *m* asl (Parmuzin, 1985). Slopes of the massif are covered by fir, by fir-birch and, more rarely, by larch-fir forests (Parmizin, 1985) Podzolic-gleys and podzolic soils are predominant (Liverovski, 1974). In the south-east, the mountain range comes to an end and a gentle, hilly to flat area with vast waterlogged lowlands and lakes can be observed. Silver fir and fir forests exist on gley-podzolic soils and medium podzolic soils, where sometimes larch forest can be found. Also, there exist massive birch and asp-birch forests on humous, loamy soils (Parmuzin, 1985).

The **Pechora taiga** spreads along the margins of the Pechorasyneclise between the Timansky Mountain range and the northern Urals, narrowing to the south. It coincides entirely with the Pechora syneclise with an abrupt depression in downwarp before the Urals (Parmuzin, 1985). The climate of the Pechora taiga is highly continental. The mean July temperature totals 14°-16°C, and in January, the temperature averages -18°-20°C, with a large snow cover of up to 80-85 *cm* that remains from 6 to 7 months a year (Mil'kov, 1977). On the territory of the Pechora lowland sandy fluvialglacial plainsinterchange with lake clays in a highly waterlogged terrain; locally occurring hilly ridges correspond to moraines (Prohorov, 1969). The Palaeozoic bed-rocks underlying the plain are covered by thick Quaternary deposits of glacial, lacustrine and fluvial origin. The highest point of the valley is the Lum'unskaya elevation (250 *m* asl*)*; elevation of the remaining area is located between 90 to 140 *m* asl. In the centralpart of the Pechora lowland the PechoraRiver flows, originating from the Northern Urals and discharging into the Pechora gulf. The length of Pechora River is 1809 *km*, the corresponding drainage basin area totals 322 km^2.

In the north of the Pecherskaya taiga, fir forests on loamy podzolic-gley and podzolic illuvial-humus soils dominate. Fir forests and birch forests grow in depressions on gley-peat-bog and peat-bog soils. Small areas of pine forests exist on the sandy substrata of the lowlands. To the south, larch, silver fir and sometimes cedar appeared as a mixture in fir forests; the surface area of fir forests increases gradually (Parmuzin, 1985).

The **northern Uvaly Taiga** is an area of low elevation (200-250 *m* als) the watershed of the Northern Dvina and Volga Rivers. The relief of northern Uvaly taiga is dominated by slightly wavy, steeply-sloping well drained plains, which sometimes become vast watershed marshes (Rakovskaya & Davydovy, 2001).

The northern Uvaly taiga is formed by slightly compacted Mezozoic ground layers, deposited on top ofsolid Perman sediments (Mil'kov, 1977).The area is a tectonically determined elevation: the Sukhonsku tectonic bar is shown in the western part of the elevation complicated by local arched elevations (Mil'kov & Gvozdetski, 1986). Glacial relief forms are degraded, and a very small number of morainic lakes are preserved. Only in the western part of the area, where the Galichsko-Chuhlomsky elevation is located, remnants of the south-eastern extension of the Moskovskoye glaciation occur (Mil'kov & Gvozdetski, 1986). Sources of numerous tributaries of the Northern Dvina and Volga originate from the northern Uvaly taiga and penetrate deep into the plateau. Summer in the taiga of northern Uvaly is short, cool and humid: The mean temperature in July totals 17°-18°C, annual average of precipitation is 550-

600 *mm*. The typical highly podzolic soils are mostly widespread. The main tree species are fir, silver fir and larch (Mil'kov, 1977).

3.2 Zone II – Mixed Forest

The mixed forest zone is situated between the taiga forest in the north and the forest-steppe in the south. Mixed forests are absent in Siberia where the taiga immediately changes into forest-steppe. It is very difficult to determine the southern boundary of the mixed forest zone; the southern boundary is supposed to be in the area where fir distribution finishes, also coinciding with the increasing appearance of chernozems as soil type (Davydova et al., 1989).

Theterritory of mixed-forest varied due to the character of landscapes its relief, geological structure and soil forming processes. Depositional plains formed out of alluvial, lacustrine, glacial and (more rarely) sea detrital deposits are mostly located in the western part of the zone, while hilly area with bedrock outcropping appear in its eastern part (Rakovskaya & Davydovy, 2001).

Mixed forests, corresponding to the zone of forests of temperate climate, are distinguishable from the taiga by a lower degree of continentality (Borisov, 1948). In the area of the mixed forests a frequent interchange of arctic air masses with the air masses of temperate and subtropical latitudes occurs (Berg, 1938). This causes the increase of continentality from west to east. Winters are relatively mild (-5° -10°C) though the whole area is covered by snow. Summer in the mixed forest area shows mean temperature of 18°-22°C. The annual amount of precipitation exceeds the level of evaporation and averages 600-800 *mm*. Annual precipitation, nebulosity, and humidity of air and soil decrease from west to east and from north to south (Borisov, 1959).

3.2.1 The mixed forest of the Primor'e region

The mixed forest of the Primor'e region a narrow, low-land region that stretches along the shore of the Baltic Sea and the Riga and Finland Gulfs, as well as adjacent low-lying plain. The northern part is situated on the slope of the Baltic shield, and the southern part within the Baltic syneclise (Rakovskaya & Davydovy, 2001).

The relief of the plainsis that of marshy lowlands alternatying with well-rounded uplands up to 200 *m* in height. On the plains positive small landforms correspond to tidges and dunes formed under the influnce of tides and winds (Mil'kov & Gvozdetski, 1986). In the north of the territory from the Gliptom or Baltic-Ladoga ledge with, several tens of meters in height can be highlighted as a structural form (Mil'kov & Gvozdetski, 1986). The line of the ledge coincides with the existence on the outcropping of the Ordovician limestone and sandstone. To the south of the ledge is a limestone-dolomite plateau passing to the west into the plains. Herein the accumulative landforms of the last (Valdai) glacier are well defined. The surface is dotted with numerous small lakes of glacial origin, intensely overgrown by marsh vegetation (Mil'kov & Gvozdetski, 1986). The larger of these lakes, lakes Chudskoe and Pskov, are very shallow and are located in swampy hollows (Rakovskaya & Davydovy, 2001). Locally, due to the occurring of limestone, karst phenomena are developed (the northern elevated part of Estonia area) (Mil'kov & Gvozdetski, 1986). From the north-west the territory is bordered by the Baltic Sea, which forms here four Gulfs: Finland, Riga, Curonian and Vistula, which are shallow, highly desalinated with the Curonian and Vistula Gulfs are isolated from the sea by sand spits (Mil'kov & Gvozdetski, 1986).

Due to the oceanity the climate is humid and temperate. The summers are cool and humid, with the mean temperatures in July 17°-18°C. Winters are warm with mean January temperature of -3°- -5°C as the coldest month of the year, frequently accompanied by an unstable and thin snow cover. Average annual precipitation totals 600-800 *mm* predominantly occurring as rainfall (Rakovskaya & Davydovy, 2001).

Main soils are sod-podzolic, often containing a substantial share of boulders, impeding their plowing. In addition, sod-calcareous soils and brown soils can occasionally be found. In the northern parts of the area and on the Estonian islands, areas with thin, immature-soils on limestone covered by scarce tree, shrub and herbaceous vegetation are known as *alvar*. Pine dominates as a part of the *alvar* forest groves with a mixture of birch and fir; shrubs of hazel and juniper are also common. *Alvars* are predominantly used as pastures (Mil'kov & Gvozdetski, 1986).

3.2.2 The mixed forests of the Belarusian-Valdai Lakeland

The mixed forests of the Belarusian-Valdai Lakeland include the Baltic ridge, and the Latgale, Nevel-Gorodok, Vitebsk, Bezhanitsky and Valdai Uplands.The Belarusian-Valdai Lakeland is located in the marginal zone of the Valdai glaciations (Mil'kov, 1977).The widely preserved edge-moraine ridges and numerous moraine lakes are a distinctive feature of this landscape.Hills and ridges of varying heights and genesis including drumlins, eskers and kames, reach 25 *m* and more in relative height. In the lowlands in between glacial sand are accumulated. Ancient valleys formed by the runoff of meltwaters. The modern river system is young, characterized by slightly incised rivers (Mil'kov & Gvozdetski, 1986)

The Valdai Hills peak to the north-east of Ostashkov 343 *m* in absolute altitude. In the west the hills terminate in the direction of the Priilmenskoy lowlands (Mil’kov & Gvozdetski, 1986). The Priilmenskoy lowlands lie below 100 *m* and the Valdai Hills near the cliff reach a maximum elevation of almost 300 *m* asl (Kamennik Mountain). Consequently, the height of the ledge itself totals 150-200 *m*, which is a rare phenomenon for the East European Plain. The ledge of Valdai Hills is usually described as a carbon limestone cliff, which forms a semicircle around the southern edge of the Baltic Shield (Mil’kov & Gvozdetski, 1986). The sources of the Volga and the Western Dvina River are in the Valdai Hills. The largest lake in the Hills is Seliger, which is of glacial origin; the lake lies at an altitude of 205 *m* asl; its surface area totals 260 km^2, and it contains 160 scattered islands, the largest of which is Khachin.

The climate of the Belarusian-Valdai Lakeland is humid, and the monthly July temperature averages 17°C (Mil’kov, 1977). January temperatures in the west average -5°C, in the east they average -10°C, with a thin cover of snow appearing all over the area (Rakovskaya & Davydovy, 2001)

The hilly terrain and frequent alternation of loam and sandy moraines with fluvioglacial sands cause an unusual diversity of soil and vegetation cover. The Belarusian-Valdai Lakeland is located in the sub-zone consisting of oak and coniferous forests. The sandy lowlands are mostly wooded where swampy pine forests grow. On the lower-moraine plains there are fir and broadleaf-fir forests, whereas in the swampy depressions the forests consist of black alder and birch occur (Shamyakin, 1988). Wet meadows and marshes, mostly occurring in the uplands, are spread along the bottoms of basins and the shores of lakes. Sod-podzolic, loamy and boulder soils build the main soil in the uplands. In the lowlands the sod-podzolic soils are mostly loamy, to sandy; additionally sod-bog and peat soils are located in the silted lake basins; and in the inter-ridge depressions and valleys alluvial soils occur (Martsynkevich, 1989).

3.2.3 The mixed forests of Predpolesia

The mixed forests of Predpolesiaare located between the Belarusian-Valdai Lakeland in the north and Polesien in the south. Its territory nearly conicides with the Belarusian ridge and its southern reduced flatland frame. The terrain contains large and small hills, which makes it very different from the corresponding types in the Belarusian-Valdai Lakeland relief.It is an older landscape, higher in altitude than in the north that has been reworked by erosionanddenudation processes. River valleys are more mature, the number of lakes is small, and along the watershed there appear wavy secondary moraine plains, covered by loam. Predpolesiengradually lowers towards Polesia in the south, forming an area that consists of a flat low-lying band, which is represented by sandy sandur or smooth moraine plains formed by loesslike loam (Rakovskaya & Davydovy, 2001).

The climate in this province is warmer and more moderate than in the Belarusian-Valdai Lakeland. The mean July temperature rises to 18°C. In winter the snowcover appear only for short duration, due to the relatively high air temperature. Due to a relatively high evaporation high the precipitation evaporation-ratio decreases and runoff reduces accordingly (Mil'kov, 1977). The number of upland bogs decreases and transitional types of marshes dominate in the area.

Close to the north-eastern borders the territory is covered by pine, birch and fir forests, with a large array of black alder swamps, wet meadows and marshes, and a high number of small lakes. Fir and broadleaf forests are typical for the north Predpolesia region, while the southern territory is covered by forest dominated by fir, hornbeam and oak. In the far south west, along the border to the Polesia region, a fairly large array of pristine mixed forests is preserved (Mil'kov & Gvozdetski, 1986).

3.2.4 The mixed forests of the Polesia region

The mixed forests of the Polesia region are located between the Belarusian ridge and Podolsk upland, in the river Pripyat basin. The lowland left bank of the Dnieper River to the lower sections of the Desna River is treated as a part of it. The Polesia is a flat-bottomed basin, with an altitude in its center ranging from 100 up to 150 *m* asl. Its existence is correlated to tectonic deflection (Rakovskaya & Davydovy, 2001). Although during Last Glacial Maximum most of the Polesia was covered by the Dnieper glacier, its moraines are poorly preserved, and are washed out (Rakovskaya & Davydovy, 2001). When the glacier receded a vast glacial lake was formed in the Polesia region. Its drainage is associated with the formation and incision of the rivers Dnieper, Pripyat and Desna. Flow velocity of the rivers is due to the low relief very slow; at present the river-beds are almost overgrown by lake and marsh vegetation. Watersheds, slightly elevated above the flood plains, are composed of sands of fluvioglacial and fluvial origin. Locally dunes occur (Mil'kov & Gvozdetski, 1986)

In flat, sandy drainage basins the plan level directly above the floodplan often corresponds to fluvial terraces. The second level above that fluvial terrace is frequently formed by loesslike loams and is interpreted as the edge of the Polesia region (Mil'kov & Gvozdetski, 1986). In the Ukrainian part of the Polesia region, the OvruchMountains range rise sharply (up to 316 *m* absolute hight). At its base it Ovruchskyi mountains are composed of crystalline rocks.

Occasionally, in the Polesia regionterminal moraine ridges occur that were not washed out (Davydova et al., 1989).

The Polesia region occupies the remote south-west of the mixed forest zone.The average annual temperature is above 10°C, and during winter the thin snow cover only short time occurs. The area is altogether poorly drained and a high degree of waterlogging occurs (Mil'kov, 1977). Swamps are mostly lowlying, grassy area, corresponding to low-level (Mil'kov, 1977). The low lying marshes in Polesia predominantly are covered by sedge and hypnum-sedge. Tallgrass marshes are typical for the right bank of the Pripyat River; they are formed of reed scirpus, cattails, lanceolate reed grass,glyceria and calamus.Hypnum and sedge marshes are most common in the low-lying parts of the northern Polesia interfluve. Forested, low-lying marshes occur in Polesia as alder and birch thickets. Upland Polesia swamps, mostly slightly convex in shape, are predominated by sphagnum peat locally interpersed by pine wherever sandy and sabulous soils prodominate, and patches of cotton grass and wild rosemary covering (Mil'kov & Gvozdetski, 1986). Sticky alder forest is spread on the low-lying bogs.

3.2.5 The mixed forests of the Central Russian zone

The moxed forests of the Central Russian zone include the northern forests of the Central Russian uplands, which reach maximum altitudes of 319 *m* asl. Devonian limestones build the bedrock of the Central Russian uplands, mostly covered by a layer of sandy clay Jurassic and Cretaceous (Rakovskaya & Davydovy, 2001). Karst phenomena occur widespread in the limestones whereas landslides occur in the Mesozoic sediments (Mil'kov & Gvozdetski, 1986)

In the northern part of the territory (including the Smolensk-Moscow upland) there is an undulating plain build of moraine material formed during the Moscow glaciation (Rakovskaya & Davydovy, 2001). In the southern part of the territory character of relief is slightly rolling. Here flat secondary morainic plains resulting from the Dnieper glaciations predominate, which have been transformed by erosive processes. A network of deeply incised, asymmetric river valleys and well developed ravine gullies drains the area (Rakovskaya & Davydovy, 2001)

The climate in the Central Russian zone of mixed forests is continental. Winters are cold with the mean January temperature dropping to -11°C; a stable snow cover occurs all over winter time (Mil'kov, 1977).The relief is highly dissected and well. Soil texture is mostly loamy sod-podzols are the main soils. Locally patches of grey forest soils and partly even podzolized chernozems appear in the southern part on carbonate bedrock and loess-like loamy substratum (Afanas'eva et al., 1979).

The vegetation cover consists of fir-deciduous forest and oak forests. Birch forests occur wherever; natural potentialfir-deciduous forest and oak forests that had been cleared by humen are widespread (Davydova et al., 1989). Steppe species penetrate deep into the region, mostly covering the south-facing slopes. Complex fir forestsare preserved in the most northern part of the Central Russian uplandsalong the borders of the mixed forests of the Central Russian area and Belorusian-Valdai Lake district. Landscapes predominatedby pine and mixed forests, sphagnous marshes and water meadows are situated in the south of area on the left shore of Oka River (Mil'kov & Gvozdetski, 1986).

3.2.6 The mixed forests of Meshera

The mixed forest of Meshera can be found north of Moscow in a lowland area that can be ascribed to pre-glacial tectonic relief lowering. Carboniferous limestone from the bedrock in higher location changes to Jurassic and Cretaceous sediments (Rakovskaya & Davydovy, 2001). Temporarily the Meshera lowlandsserved as a glacial basin, filled with melt-water deposits (Popov, 1970). The loamy morain deposits of the Meshera lowlandscan be found at the elevated parts of the watershed and at the strongly pronounced hills in the western part of the lowland (Mil'kov & Gvozdetski, 1986).

The Meshera lowlandsare located in the eastern part the mixed forests zone. It can be characterized by relatively cold and snowy winters with snow covers reaching 50-60 *cm* in depth; the January temperature averages -12.5°C (Mil'kov, 1977).

Because of the low altitude valleys are only shallow, their current is slow, and they are intensively overgrown (Rakovskaya & Davydovy, 2001). The flat drainage basins of the Meshera area are covered by pine forests, while a third of the area is covered by marshes (Mil'kov, 1977). Forested birch marshes occur in the south-eastern part of Meshera alternating with ordinary marshes and sedge-hummocky marshes. Upland bogs and transitional bogs correspond mostly to peat-bogs with a thickness of up to 8 *m* and severallayers of high-quality peat (Davydova et al., 1989). Bogs and waterlogged forests are ridded by shallow lakes.

3.3 Zone III – Forest-steppe

The area of forest-steppe considered in this study stretches in the west from the eastern foothills of Carpathian Mountains to the Urals Mountains in the east. Corresponding to Berg (1955) the northern boundary runs along from Kiev, Gor'ky, and Kazan'to the foothills of the Urals Mountains. Its southern boundary passes through the southern edge of the Donetsk mountain range, to the south of Saratov and through the northern slope of Obshy Syrt to the foothills of the Urals.

In the forest-steppe forests and steppe are mixed, notching in one natural zone. The vegetation of the forest-steppe includes forests, shrubs bushes, steppes, humid meadows and cultivated fields building a complex ecosystem (Rihter & Mil'kov, 1956). Since settlement started the vegetation cover on the forest-steppe has been vastly changed and to a great degree was destroyed by human impact; the forest-steppe and steppe belong due to its easily cultivatable soils to the earliest settlement regions and until today belong to the most densely populated areas of the Russian plain (Rihter & Mil'kov, 1956).

From north to south three subzones can be distinguished:

The northern forest-steppe zone was natural-potentialy covered by oak forests and fields of steppe meadows. The main soil types in the northern forest-steppe are grey forest and podzolized chernozems.

The typical forest-steppe in its natural-potential state can be characterised by the alternation of open mixed-herb meadow steppes with oak forests, where the vegeation of one typedoes not dominate over another. Their location depends on bedrock and relief conditions. The dominant soil of the typical forest-steppe is formed of leached and typical chernozems and also by partly podzolized chernozems and grey forest soils.

The southern natural-potential forest-steppe can be characterised by the predominance of mixed herbs-fescue feather grass steppes in combination with oak forests, which predominantly occur in the dissected uplands. The dominant soils of the southern forest-steppe are chernozems and grey forest soils, locally leached chernozems (Rihter& Mil'kov, 1956). The climate of the forest-steppe is due to the missing oceanic influence moderately continental, with a dry-subhumid character. In comparison to the climate in the taiga and the mixed forest zones, the climate of the forest-steppe is warmer and dryer (Borisov, 1948). Annual precipitation averages 600 *mm*. In wintersare mild with a stable snow cover, and an average January temperature varying between -5° in Moldaviain the west to -16° in the Cis-Urals region in the east. Summers are warmand dry with the mean July temperaturesranging from 20°C in the north to 21-22°C in the south (Borisov, 1959).

Fir forests are almost completely absent in the forest-steppe zone, and only occasionally can be found in the Volga uplands. Pine is widespread among coniferous forests, and in sandy soils. Deciduous forests, composed mainly of oak, dominate most of the forest-steppe of the Russian plains. This feature distinguishes the forest-steppe of the Russian plain from the forest-steppe of western Siberia, where deciduous forests are absent (Vorob'yova, 2012). The composition of deciduous forests varies across different areas of forest-steppe. Deciduous forests have a western origin; they do not get along well with the continental Siberian climate, and that is why the eastern border of their distribution (excluding lime trees) does not come further than the Urals Mountains (Rihter & Mil'kov, 1956). Shifting from the west to the east of Russian plain we are going to observe several provinces.

3.3.1 Forest-steppe of Volyn-Podolsky Upland

In forest-steppe zone of the Podolsky Upland is located in the southern of Russian plain. Its maximum heights reach 471 *m* asl in the north-western part. The Podolsky Upland descends in the north-west to Maloye Polesia, further merging into the Volyn Upland. In the eastern part of the Dnieper Upland, bedrock of the Ukrainian cristalline block emerges from sandy to clayey deposits (Rakovskaya & Davydovy, 2001). In the south-western part of the area, in Moldavia, the Codru Upland is located, which is deeply dissected by tributaries of the Dniestr and Prut Rivers. The valleys canyon like with multiple of ravines on their slopes (Mil'kov & Gvozdetski, 1986). In the divide area relief is plateau-like. Both relief characters document the tectonic uplift of the Volyn-Podolsky Upland as part of the Ukranian crystalline massif (Mil'kov & Gvozdetski, 1986). During Pleistocene the area was covered by a thin loess coating which is preserved in position of the plateau divide. Karst landforms appear left of the Middle Dnieper (Mil'kov, 1977)

The climate is humid and moderate: summers are long, with the mean daily temperature exceeding 15°C; winters are short and warm, January averages -5°C and the snow cover is unstable. The annual amount of precipitation in reaches more than 600 *mm* (Rihter & Mil'kov, 1956).

The elevated and dissected relief, the high amount of annual precipitation and the local appearance of loess build the frame conditions for grey forest soils and podzolized chernozems as main soils in the central part of the region (Rihter & Mil'kov, 1956). Burozems were formed under the beech forests of Codru in Moldavia. Podzolized chernozems are widespread in the southern forest-steppe of the Volyn-Podolsky Upland (Krupenikov, 1982). The relatively high humidity also builds favorable conditions for forest development. North of the forest-steppe along the boundary to Polesye, and south of the Volyn-Podolsky Upland, steppe areas result from human activity. These territories of forest-steppe are entirely ploughed and only small islands of forest with oak as the dominant species were preserved (Dobrovol'skogo, 1979).

3.3.2 Forest-steppe of the Dnieper lowland

The Dnieper lowland is situated to the east of the Dnieper River, between the Volyn-Podolsky and the Central Russian Uplands. The altitude of the Dnieper lowland ranges between 100 to 150 *m* asl. In this area Dnieper-Dvina depression already started to form during the lower Palaeozoic (Rakovskaya & Davydovy, 2001). Geomorphologically the whole lowland left of the Dnieper, can be divided into three parts: 1) the Dnieper flood-plain with meadows and flooded forests; 2) a low, sandy terrace located above the flood-plain, with small islands of pine forests and 3) plains of loess covered terraces above the flooding level where chernozems are developed (Mil'kov & Gvozdetski, 1986). The lowlands were covered by a glacier (Dnieper tongue) during the Last Glacial Maximum (Grigor'ev, 1962). Only small parts of the lowland south of the Vorskla River were free of ice. The Dnieper lowland is dissected by the shallow valleys of Sula, Psela, Vorskla, Orel', Chorol' and other rivers originate in the Central Russian Uplands.

The climate of the Dnieper lowland differs from that of the Volyn-Podolsky lowland and can be characterized by a higher continentality: The mean temperature in July is 1-1,5°C higher than that of the Volyn-Podolsky forest-steppe at the same latitude; correspondingly winters are colder, and snowcovers more stable. Annual average precipitation is less than 400 - 450 *mm* (Rihter & Mil'kov, 1956).

Due to the shallow relief drainage is insufficient; correspondingly waterlogging and salinization can be traced in the soils (Liverovski, 1974). Typically thick or very thick chernozems occur, transforming into podzolized types to the north and ordinary middle-humus chernozems to the south. Meadow-chernozems are formed in the west of the province, on the Dnieper terraces. Grey forest soils can be found only rarely and only narrow band situated on high right shores of the rivers. In many of the flood plains marshes rich in peat occur (Liverovski, 1974).

3.3.3 Forest-steppe of Central Russian Uplands

The central Russian Uplands occupy the central position of the Russian plain. From the right shore of the Oka River valley it spreads to the southeast. The Dnieper and Oka Don lowlands form its western and eastern boundaries. The forest-steppe of the Central Russian Uplands occurs in evelations below 290 *m* asl. In the north the Central Russian Uplands north of Voronezh and Kursk, Devonian limestones build the parent material while underlying crystalline rocks of Voronezh anticlise descend rapidly to the direction of Moskovskaya syneclise (Karandeeva, 1957). Karstic landforms occur widespread in the Devonian limestones.

Valleys are narrow with abrupt bends and alternating dissymetry of slopes. On the watersheds Jurassic and Cretaceouos sediments crop out, overlying the Devonian limestones (Rakovskaya & Davydovy, 2001)

The south of the Central Russian Uplands is characterised by crystallinebedrock of the Voronezh anticlise locally covered by Cretaceous. The valleys are well developed, marquee like isolated hills rise along the right side of the river banks (Rakovskaya & Davydovy, 2001).

Due to the dissected character of the relief and the large forest coverage, grey forest soil and podzolized chernozems are widespread in the north-western part of the uplands, while in the central part-leached chernozems occur (Liverovski, 1974). Summer is cooler and highly moisture supply. The western parts of the upland receive 500-600 *mm* of precipitation annually (Rihter & Mil'kov, 1956).

3.3.4 Forest-steppe of Oka-Don lowland

The forest-steppe of the Oka-Don lowlands areencircled by the Central Russian Uplands, the Calachskaya and Volga Uplands. To the north, the Oka River valley reaches the northern boundary of forest-steppe zone (Flerova, 2010). Watersheds of Oka-Don lowlands do not exceed an average altitude of 160-180 *m* asl and only in some parts do they reach 200 *m* asl. Loose sandy-to clayey Mezozoic-to Cainozoic deposits form the bedrock of the Oka-Don lowlands (Rihter & Mil'kov, 1956).

During Last Glacial Maximum the area was covered by the Dnieper glacier. Today widevalleys drain the glacial deposits. The shallow cut of the valleys and the loose character of the bedrocks favour a dissymetric relief development (Liverovski, 1974). Ravines and gullies are rare. The position of Central Russian uplands west of the Oka-Don lowlands cause the decrease of annual presipitation to 500-400 *mm* in the central and south-eastern part of the latter. Climate is highly continental. Winters are long and cold, with a snow cover occuring. The shallow relief and the high continentality of the climate favourthe development of chernozems and meadow chernozem as main soils (Rihter & Mil'kov, 1956). Grey forest soils and podzolized chernozems only occur rarely; meadow solonetz and solods can be found in depressions (Liverovski, 1974). Broad-leaved forests can be found on the deeply dissected and well drained right shores of the rivers. Tellermanovsky forest is the biggest upland oakforest which is situated on the right shore of Khopyor River (Rihter & Mil'kov, 1956).

3.3.5 Forest-steppe of Volga upland

The forest-steppe of the Volga uplands are located along the right shore of the Volga River between Nizhny Novgorod to Volgograd. The Volga upland is an eroded dissymmetric plateau with flat inclining western slopes and steep eastern slopes. Maximum height of the upland is 375 *m* asl on the northern outskirts of Zhygulevsky ridge. The upland is dissected by tributariesof the Volga and Don Rivers. In addition to erosive dissection, tectonics plays an important role in the formation of the Volga Upland relief. The Volga syneclise is well developed, it spreads on the right shore of the Volga River in the meridional direction towards area with Cretaceous, Jurassic, and Tertiary sediments (Rakovskaya & Davydovy, 2001). The occurrence of dolomite, limestone and chalk in the Volga upland causes karstic landform (Liverovski, 1974).

The north-western area of the Volga uplands is moist with annual precipitation exceeding 500 *mm*. In the south-eastern part, annual precipitation decreases to 400 *mm* and lower. Average July temperature is 18°-20°C (Rihter & Mil'kov, 1956).

Soil types vary locally due to the high level of relief dissection and frequently interchange between initial soils in highly erosive locations, grey forest soils, and podzolized chernozems (Liverovski, 1974). The dissected relief and sandy to loamy soil texture cause well drained soils and are favourable for forest growing. Pine is the main forest-formative species. Taiga species are widely represented among forest shrubs and herbs. The forest-steppe of the Volga upland in general is densely covered by forests (Rihter& Mil'kov, 1956).

3.3.6 Forest-steppe of lowland Transvolga

The forest-steppe of lowland Transvolga includes the alluvial plains of the Volga valley with altitudes of less then 100 *m* asland its left shore between the Volga Upland and High Transvolga with altitudes of 100-200 *m* asl The Melekesskaya and Bolgarskaya synclines are the dominating geological structures of the lowland Transvolga (Rakovskaya & Davydovy, 2001). Both synclines are infilled by Palaeozoic sediments covered Quaternary and late Tertiary sandy-clayeydeposits (Rihter & Mil'kov, 1956). The relief of the whole area is shallow and can be characterized by flat-lying slopes and flood-plain.

The climate of the area is dryer and more continental than climate of the forest-steppe of the Volga Upland. Winters are cold and the average January temperature totals -13°C. Precipitation-evaporationratio is with an annual precipitation of c. 400 *mm* and an annual average evaporation of c. 700 *mm* distingtly smaller than, indicating an overall arid climate (Mil'kov, 1977). The arid continental climate and flat relief favours steppe formation in this region. Correspondingly, steppes are significantly more widespread in the forest-steppe of lowland Transvolga than in the Volga lowlands. Typical forest-steppes dominate in the landscape of lowland Transvolga, which is an important distinction from low upland, where major parts are occupied by northern and southern forest-steppes, and only few areas can be ascribed to the typical forest-steppe (Liverovski, 1974).

3.3.7 Forest-steppe of High Transvolga

The Bugulma-Belebey upland and the northern slopes of Obshchy Syrt build the forest-steppe of High Transvolga. To the east they are margined by the Urals Mountains. Both uplands, the Bugulma-Belebey and the Obshchy Syrt, are of Neogene tectonic genesis formed by Permian and Permian Triassic clays, sandstones, marls, and more rarely, by limestones. Mesozoic to Cenozoic sediments occur (Rihter & Mil’kov, 1956).

The divides of the Bugulma-Belebey uplands reach 350-400 *m* asl with elevations increasing to the east reaching 479 *m* asl. Deeply incised, dissymmetric valleys such as Sok, Kinel, Tok, Samara and Buzuluk dissect the area into many dissymmetrical ridges (Rakovskaya & Davydovy, 2001). Young ravines in the High Transvolga are rare and solid bedrocks outcropping impede their formation (Rakovskaya & Davydovy, 2001). Karstic land forms are widespread on the Bugulma-Belebey Upland wherever limestone builds the parent material. In the middle course of the Ik River subrosion features are developed in the gypsum (Rihter & Mil’kov, 1956). Karstic landforms increasingly appear to the east, in Cis-Urals, where besides the Kungursky gypsum, coal limestones occur (Rihter & Mil’kov, 1956).

The climate of the High Transvolga is due to the elevated and extreme eastern location of the area highly continental. The summers are hot and with average July temperatures of 20.3°C. The wintersare cold with average January temperatures-14°C -16°C. During winter snow covers large parts of the north-eastern High Transvolga (Mil’kov, 1977)

Main soil types developed show a strong zonality: grey forest soils and podzolized chernozems dominate in the north while ordinary middle humus chernozems dominate in the south of the High Transvolga (Liverovski, 1974). Landscape of the region consists of stony, shrubby steppes. Big differences in heights between river valleys and syrts tops reveal a clear vertical differenciation of landscapes.

3.4 Zone IV – Steppe

In general, steppe is regarded as a plain covered by grassy vegetation, in temperate and subtropic zones of northern and southern hemispheres. The steppe zone is delimitedby the with forest-steppe zone and to the south by the zone of semi-deserts. In Eurasia the steppe zone spreads from the Carpathian Mountains in the west to the Altai Mountainsin the east, and from the Oka and Kama Rivers in the north to the Black, Azov, and Caspian Seas in the south.

Small forested areas locally occur characterized by an abundance of grassy vegetation. The steppe zone can be divided into three main zones in its natural state: a) the meadowtransitional to forest zones with motley grass and hygrophilous herbs appearing; b) typical cereal steppes; c) southern wormwood-cereal steppes without thorough close vegetation cover (Rihter & Mil’kov, 1956).

Climate of the steppe zone reaches from moderate-continental to hightly-continental, with very hot, dry summers, rather cold winters with frequent thaws and snowstorms, and then short spring. High summer temperatures are brought by south eastern winds and low winter temperatures are caused by north-eastern winds. Average annual July temperature totals 20°C and January temperatures range from 0°C to -20°C. Maximum rainfall occurs in early summer (Berg, 1941) with annual average precipitation of 200 to 450 *mm* (Borisov, 1959).

Main soils of the steppe zones of the Russian plain can be subdivided into three zonal soil types: a) grey forest soils; b) chernozems; c) chestnut soils; in the chernozems and chestnut soils below the humus horizon carbonate and saliferous horizons with gypsum predominance might occur (Dokuchaev, 1948). Steppe solonetz are spread spotty among southern chernozems and dark chestnuts soils. Saline lands occur locally. Different flood plain alluvial meadow soils are developed in the river flood plains (Rihter & Mil’kov, 1956).

3.4.1 Steppe of Black Sea lowland

The steppes of the Black Sea lowlands occupy the most southwestern part of the steppe zone. During Neogene most of the area was inundated repeatedly (Mil’kov & Gvozdetski, 1986). Marine Neogenic deposits reach thickness up to 40 *m* and are covered by Quaternary loess (Bondarchuk, 1946). The lowlands gradually decrease to the south dipping into the Black Sea and Azov Sea. The southern slopes of Dnieper upland reach evelation of 200 *m* asl and overlap with the northern part side of the Black Sea lowlands. To the north-west the Black Sea lowlands border with the SouthMoldavian and Podolian Uplands. To the east the Black Sea lowlandsreach the Azov Sea which is connected with the Black Sea by the Strait of Kerch; in the east the Azov Upland margins reach elevations of 300 *m* asl and higher (Mogila-Bel’mak - 325 *m* above sea level). Several big and small rivers drain through the Black Sea lowlands. Almost all rivers tributary to the Black Sea flow in meridional direction.Danube, Dniester and Dnieper are the biggest rivers of the Black Sea lowlands; their mouthes are flooded by the sea and turned into the shallow Dniesterovskii, Dnieperovsko-Bugskii, Utlyukskii, estuaries

(Rakovskaya & Davydovy, 2001). Some of the estuaries are separated from the sea by sandy spits forming lagoons (e.g., Molochnoe and Sasyk lagoons).

The Dnieper originates from the small marshes of the Akseninskii mokh, located on the southern slope of Valdai Hills. It flows after 2,285 *km* into the Dnieper-Bug Estuary of the Black Sea and drains an area of 504,000 *km²*. Dniester originate from the Carpathian Mountains and discharges into Dniester liman which is connected to the Black sea. The river length total 1352 *km* and drains an area of 72,100 *km²*. The flood-plains in the lower course of Dnieper and Dniester as most of the lowland of the larges rivers were for a long periodcovered by wetlands (Palamarchuk, 1992)

The climate of the Black Sea steppes is warm and, despite, the coastal lowlands continental and dry. The mean January temperature total -1°- +6°C with a thin, inconsistent snow cover of less than 5-8 *cm* occurring. The annual amount of precipitation total 300-400 *mm* (Liverovski, 1974)

Soil-vegetation zonality is clearly expressed in the territory of the province. From north to south, the following zones can be found: 1) grassland-fescue-feather grass steppes on ordinary (middle-humus) chernozems; 2) fescue-feather grass steppes on the southern (little-humus) chernozems and 3) fescue-feather grass steppes and wormwood steppes on dark chestnut and sometimes solonetzic soils(Rakovskaya & Davydovy, 2001). Chernozems build soil type all over; their humus horizon reaches up to 80 *cm* thickness (Rihter & Mil'kov, 1956). Saline soils occur azonal in the coastal lowlands, in the limans and the alluvial plains (Rihter & Mil'kov, 1956). Dark chestnut solonetzic soils can be found in the margins of the coastal zone.

3.4.2 The Low-Don Steppe

The low Don steppe includes the lower course of the Don River, located between the Donetsky Ridge in the west, the Volga in the east, the Boguchar and Kalach in the north, and the Rostov-on-Don in the south. The area corresponds to the lower parts of the Central Russian, Kalch and Volga uplands and the lower Don area. Altitudes reach maximum values of 200-250 *m* asl. The uplands are formed by Cretaceous and Palaeogene sediments, frequently incuding chalk (Rakovskaya & Davydovy, 2001).

Climate is more highly continental. The steppes of the low Don steppe are influenced by the humid oceanic climate from the west and the dry continental climate from the east. Summers are hot with, average July temperature of 20°C. In winters mean January temperature ranges from -5°C in the south-west to -11°C in north-east (Rihter & Mil'kov, 1956). The annual average precipitation descends from 450 *mm* in the north-westto 300 *mm* in south-east where the area transfers into the semi desert zone (Rihter & Mil'kov, 1956).

The changes of natural conditions from south-west to north-east are clearly documented in the distribution of the main soil types of the low Don steppe: humus chernozems mostly dominate the soil types in the north-west of the area while dark chestnut soils dominate to the south. Dark chestnut soils can be found predominantly in the drainage basin of the Don right of its main course, in the basins of Tsimlya and Chira Rivers, in the Salskie steppes and in the basin of Ilavlya in the Volga uplands (Rihter & Mil'kov, 1956). Dark chestnut solonetzic soils, among which solonetz are rather frequent are patterned in the band of dark chestnut soils (Rihter & Mil'kov, 1956). Natural potential vegetation was preserved only in few areas because this territory has been long term and intensively influenced by human impact. Grassland-fescue-feather and fescue-feather steppes and old fallow land used for pastures were partly saved from ploughing. Wormwood-leban and pyrethrum groups have developed in the band of dark chestnut soils on solonetz (Liverovski, 1974). Oak ravine forests are typical for the northern part of the area. Steppes with thyme are located on the chalky steeps of the Central Russian and Volga uplands. Sand deposits in the Don Lowlandsand Seversky Donets are frequently covered by pine or by thin steppe herbage (Rakovskaya & Davydovy, 2001).

3.4.3 The Steppe of lowland Transvolga

The steppe of lowland Transvolga is located in an area of tectonic depression between the Volga upland and the Obshchy Syrt; its western part corresponds with to the ancient Volga valley (Rakovskaya & Davydovy, 2001). The steppe part of the lowland Transvolga in the north is bordered by forest-steppe and in the south by semi deserts. The tectonic depression is filled by thick late Tertiary and Quaternary sediments (Rihter & Mil'kov, 1956). Yellow-brown carbonate loess-like loams and clays with interstratified sands build the youngest layer (Rihter & Mil'kov, 1956). The steppe of lowland Transvolga is of low valley density, though the most significant rivers are the tributaries of the Volga the Chagra, Malyi and Bolshoy Irgiz Rivers. The Bolshoy UzenRiver is archaic, its sources are located in the south of the area and it dries up on the Caspian lowlands. Most of the rivers are periodically and dry up completely during summer (Rihter & Mil'kov, 1956). Climate is highly continental. Its low altitude and the vicinity to the semideserts of Kazakhstan make the summer hot and not favourable for vegetation due to frequent droughts and hot winds (Mil'kov, 1977). The annual precipitation averages 350 *mm* and is 2-3 times lower than the annual average of evaporation (Rihter & Mil'kov, 1956).

The steppe lowland Transvolga is the most woodless area of the whole steppe zone of the Russian plains. Ravine forests are almost absent (Rihter & Mil'kov, 1956). Zonal vegetative is formed by grassland fescue feather grass steppes and is associated with chernozems as main soil types while fescue feather grass steppes coincide with dark chestnut soils as the main soil types. Solonetzic soils occur widespread due to the dry climate, flat relief and salt grounds represented by syrt clays (Rihter & Mil'kov, 1956).

3.4.4 Steppe of High Transvolga

The high Transvolga is located the east of lowland Transvolga and extends to the foothills of the Urals Mountains. It includes the southern and south-eastern slopes of Obschy Syrt.In the east it reaches maximum altitudes with 400 *m* asl. The plain is highly dissected by the river valley and syrt, both of tectonic genesis (Rakovskaya & Davydovy, 2001).

The steppes of high Transvolga are a transitional district from the temperate-warm, humid steppes in the west to temperate-warm and dry steppes of the western Siberia. Due to the fact that this region is bordered in the east by the Cis-Urals uplands, there is enough humidity to form a steppe landscape. In summer, winds blowing from central Asia cause high aridity and in winter they cause snow storms (Borisov, 1948). Thus, aridity increases and precipitation decreases from north-west to south-east (Borisov, 1948). Annual precipitation averages 300-350 *mm* while annual average evaporation exceeds precipitation by 125-150 *mm.* Average January temperature totals -15°C, and snow cover melts quickly causing spring floods (Borisov, 1948).

Main soils types correspond to middle to slightly humic chernozems with low thickness. Solonetzic chernozems and dark chestnut soils are spread in the south and south-west of the region near Uralsk (Rihter & Mil'kov, 1956). Vegetation cover consists of grassland-fescue-feather grass steppes but changes into fescue-feather grass in the south-west. Shrubby and stony steppes occur on steep slopes distinguishing high Transvolga from lowland Transvolga (Rihter & Mil'kov, 1956).

3.5 Zone V - Carpathian Mountains.

The Carpathian Mountainsare located territories of several European countries such as Hungary, Romania, Moldova and Ukraine. The Carpathian region includes next to the mountaneous area foothills and valleys. Consequently, differentiation of climate and landscape follows more an altitudinal differentiation than a zonal differentiation. That is why this region is examined according to its vertical zonality.

Altitudinal differentiation follows like the zonal differentiation by temperature and precipitation changes. The following climatic zones are distinguished in Carpathian zone:

- very cold - above 1800 *m* above sea level
- cold - 1800-1100 *m*
- moderatery cold - 1100-800 *m*
- moderatery warm - 800-250 *m*
- warm - below 250-300 *m* above sea level (only in Transcarpathia) (Krupski, 1979).

The zone of the Carpathian Mountains should be regarded as two separate parts, the Transcarpathian and Precarpathian areas, joining the piedmont and valley territories.

3.5.1 The Precarpathian region

The Precarpathian region is located in foothills of the Carpathian Mountains. The majority of the region is situated in the territory of the Ukraine. The Precarpathian region is an elevated denudation plain which spreads along the north-eastern slope of the Carpathian Mountains, only separated from it by a ledge of fleshevoy ridges with an approximate altitude of 500 *m* asl. Quaternary sedimentsconglomerates of glacial, or fluvioglacial origin, loess like loams and alluvial sediments build the outcropping bedrock (Liverovski, 1974). The climate of the area is more continental than the climate of adjacent steppes documented by severe winters with thick snow cover, fluctuating from 35 to 65 *cm* whilesummers are temperate warm (Borisov, 1959).

The air temperature falls as the latitude increases, it decreases more quickly during summer than in winter, and in east quicker than in west. The maximum atmospheric precipitation is about 1000 *mm* per year. Precipitation increases with altitude by about 50 *mm* every 100 *m*.

3.5.2 Transcarpathian area

The Transcarpathian plain was formed by alluvian drifts the majority of the surface relates to the terraces of the Tisza River. The highest part of the Transcarpathian area is formed by the Poloninsky ridge which has an altitude of more than 1800 *m* asl. Brown forest soils are the main soil type of the Eastern Carpathian area and can be found under beech forests (Liverovski, 1974).

The climate of the Transcarpathian area is more continental than that of the Precarpathian area. Hot summers, warm winters and significant moisture are typical for the Transcarpathian area. July temperature averages 18°-20°C, average January temperatures fall to slightly lower than 0°C (Borisov, 1959). The plain is protected from cold wind originating from the north since the plain is surrounded by mountains. Annual precipitation in the Transcarpathian foothills averages 500-700 *mm*. The natural potential vegetation cover of the area consists of oak and beech forests (Borisov, 1948).

The Transcarpathian area can be divided into three main vegetation bands (Liverovski, 1974):

- A mountainous forest band at the altitude of 500 *m* asl where small squares of oak and oak-hornbeam forests are situated. From 550-1000 *m* aslbeech forests are predominant.
- A subalpine band at the altitude of 1200-1300 *m* asl. The lower part of this belt is occupied by thicket shrubs; its upper part is occupied by typical subalpine meadows.
- The alpine belt is located at an altitude above 1800 *m* asl here there is a narrow band covered by short grasses.

4 Sources and Methods

The main research is predominantly based on a literature review. Publications of palaeoenvironmental studies based on various types of archives such as lake sediments, river sediments, peat bogs or soil and various types of proxy data such as pollen, stable isotopes or sediment texture serve as sources.

The different steps of research included:

1) Compilation of literature, considering
    - sample sources
    - criteria of selection
2) Design and implementation of the database structure to contain all the information study
3) Classification and statistics
    - Spatial classification
    - Temporal classification
    - Classification by proxy data
    - Classification by environmental conditions
4) Geocoding, i.e. visualization and calculation off all the data using the QGIS program (Version 1.8.0 "Lisboa")
5) Statistical analysis of the proxy data.

4.1 Literature Compilation

4.1.1 Collection of literary sources

A systematic literature review was conducted considering publications on palaeoenvironmental reconstruction of western Eurasia on the following websites:

- http://www.sciencedirect.com/;
- http://www.elsevier.com/wps/find/homepage.cws_home;
- http://elibrary.ru/defaultx.asp.

On these websites only publications in English language are available, which is not sufficient asa lot of additional information is in literature published in Russian. Due to the different way to organize scientific publications in the countries of the former Soviet Union until today for scientific publications in Russian language a joint or common internet platform for systematic search does not exist. Thus, the major part of scientific journals, bulletins, collected books etc. had to be examined in libraries in Russia. Journals and Bulletins systematically revised in this way are: Izvestiya RAN Seriya Geograficheskaya (Geographical

Series), Mezhdunarodnya Chetvertichnyi (Quaternary International), Pochvovedenie (Soil Science), Dinamika Klimata (Climate Dynamics), Otzyvychetvertichnoi nauki (Quaternary Science Reviews), Arkheologicheskiy almanakh (Archaeological Almanach).

In addition, articles were found in proceedings of conferences that have taken place in the Commonwealth of Independent States, as well as in series of collective works, and monographs where archaeological, palaeobotanical, palaeozoological and palaeolandscape researches of single or several regions are presented. From the whole body of accessible literature revised, the following sources published during last 20 years were studied:

- 4.234 article for the territory of Russia,
- 734 articles for the territory of Ukraine,
- 159 articles for the territory of Belarus,
- 64 articles for the territory of Moldova,

In addition, several articles regarding the territory of Romania, Hungary, Bulgaria, Lithuania, Poland and were revised.

4.1.2 Criteria for selection of references

From the altogether revised 5191 scientific contributions on Holocene palaeoenvironments in western Eurasia, 119 articles were selected (see Table 6 in appendix). The main emphasis was given to data which allow aadequate interpretation. Criteria to identify the most useful and most important studies were:

- the focus is on palaeoenvironmental reconstruction with maximum information on climate conditions
- the study area is located within western Eurasia
- the study includes absolute age data and covers a time period within the last 10,000 years
- the study does not include marine archives, e.g. of the Black Sea, as they could give signals from outside Western Eurasia
- the methodological approach is clearly described
- if one site was published several times, only the study is in which the most current and complete information ig given, was sellected

The most attention was paid on palaeoclimate data. In the revised publication partial or complete data about palaeoclimatic conditions of the whole Holocene period of 10 ka BP is represented. However, before integrating these articles into the database and ongoing data analysis, it was screened it could be integrated into the objectives of this work.

4.2 Structure of the database

In order to ascertain that these sources contained major information about the palaeoenvironment it was necessary to develop a data base. The data base was designed applying MicrosoftExcel (Table1).The structure of the data base is divided into five key criteria, the information of each criterium supplement each other and are in a permanent interaction. They contain detailed information about sites of the research.

- The first criterium "reference information"contains the complete citation of the publication including author names, the country of origin and the location of the sites as coordinates (*X*, *Y*)
- The second criterium covers the "dating information" and includes if absolute dates are available, dating technique was used (*con.*^{14}*C/AMS/TL/OSL/IRSL/210-Pl/Dendro*)the dating technique date material (*direct*, *nodirect*) and which timespans were achieved (*minimumka BP*, *maximumka BP*).
- The third criterium covers the "palaeoenvironmental information" and includes the archives analysed (e.g., *writtenarchive, lakedeposits, fluvialdeposits, colluvialdeposits, dunedeposits, soils, stalagmites*) and information on the kind of proxy data used (e.g., *pollen, microfossils, carbonates, grainsizeanalysis, sediment chemistry, clayminerals, oxygen-isotopes*).
- The fourth criterium covers the "climate information" and contains all kind of data from the papers concerning the Holocene climate and palaeoenvironmental conditions during the last 10,000 years outlined in 500 years-intervals; climate categories are sketched qualitatively as *cold, warm, dry and humid.*

The selected 119 references of Holocene palaeoenvironmental research in western Eurasia deal with a total of 190 different sites (see Table 6 in appendix).

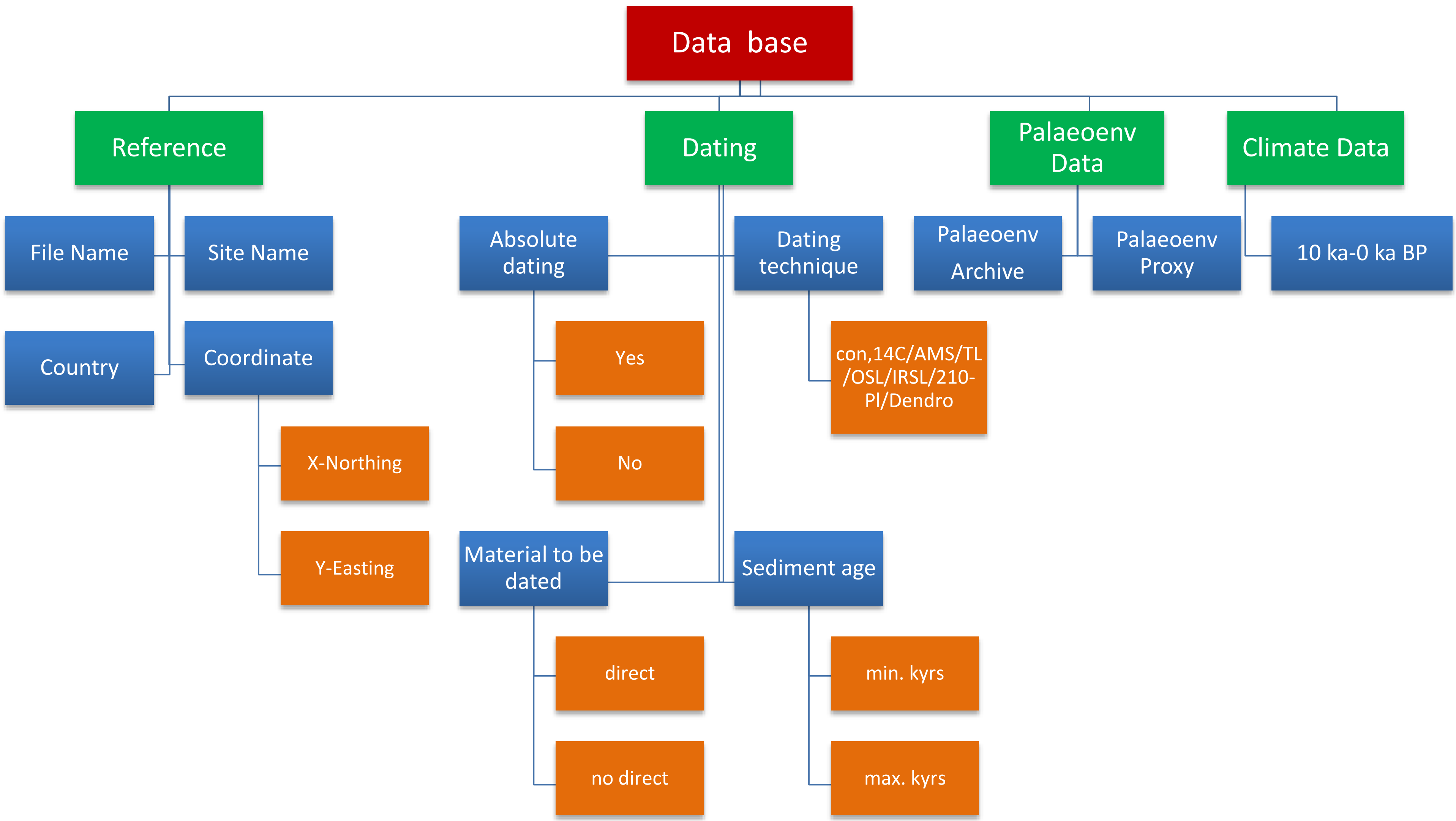


Table 1: The structure of database.

4.3 Classification and statistics

4.3.1 Spatial classification/Geocoding

For the spatial analysis the ample region of western Eurasia was clustered into subregions as also documented in the regional introduction (chapter 3). Vegetation provides a significant amount of information regarding present and past environmental conditions. Palynological data within the database concern mostly the forest zone, whereas the steppe zone has been less investigated palynologically since the typical archives of palaeobotanists' investigations of peat-bogs are absent there.

Soils as a palaeoenvironmental archiveare characterised by their age and evolutionary and poly-genetic character. For the most part, the soils of the Russian plain are dated to the Holocene period (about 10,000 years BP). Though lots of factors affect soil evolution-climatic changes, vegetation developments, relief modifications (tectonic movements, development of geomorphology of river valleys), erosion, and human activity-the main factor of soil evolution is supposed to be the climate (Aleksandrovski, 1983). Climatic changes influence soil formation both directly (changes of warm and water regimes, intensity of cryogenesis) and indirectly (by the changes of vegetation cover, the amount and content of biomass being incoporated into the soil) (Aleksandrovski, 2002). This does not exclude the fact that changes in palaeosoil development can be caused by other factors; however these other factors are assumed to be insignificant as they are only apparent locally.

Ongoing all data containing information about the palaeoclimate and the palaeoenvironmental during a definite period of time were systematized. As a result, landscapeswere used for spatial classification (modified from the map “Physical Geographical Zoning of the USSR”, in: Physical Geographical World Atlas, USSR 1964), allocating the coordinate of each site to the respective landscape. The five major vegetation zones as descrided in chapter 3 were taken as landscapes for ongoing statistical analyses: taiga zone, mixed forest, forest-steppe, steppe and mountain region of the Carpathians (Figure 3).

X and Y values of the coordinates were included in the data base. All geographical coordinates of the 190 sites considered needed to be identified, because in the different sources different information about site locations was available:

- in ° degrees as a decimal fraction (e.g., 25°)
- in ° degrees and 'minutes to a decimal (e.g., 25°25')
- in ° degrees' minutes' and 'seconds, with a decimal fraction (e.g., 25°25'25'')

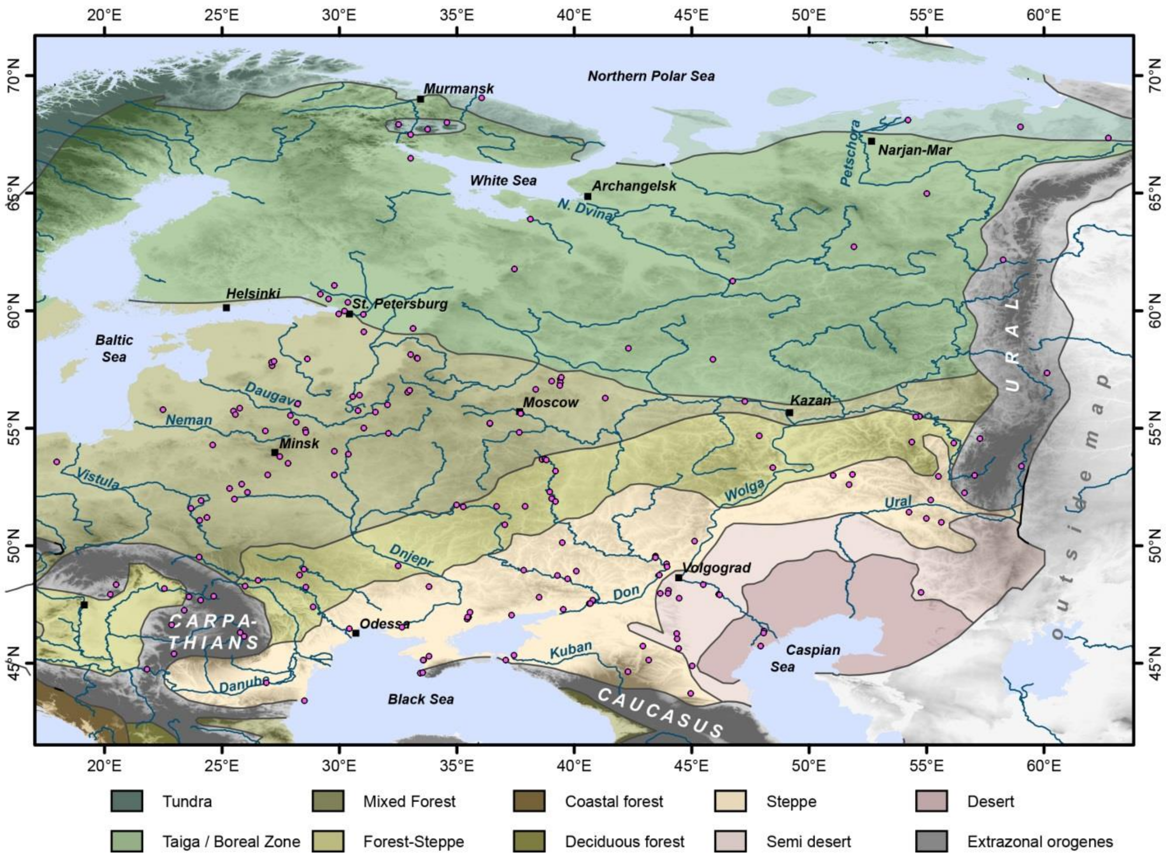


Figure 3: Landscape zones with sites. Dots mark locations of palaeoenvironmental archives considered in this study (Physical Geographical World Atlas, USSR 1964).

From EXCEL table all data were transferred to the textual format SCV (Comma-Separated Values) and were saved in UTF-8. SHP files were created for the textual format of SCV of the database using the programme QGIS 1.8.0 where the information on site location was saved as a point layer.

The resulting point layer was overlay to the landscape map and provided next to the information about sites location (geographical coordinates *lat/lon*) all information compiled in the database. On this map basis also data base analysis and visualization took place.The palaeoclimate maps created allowed the classification and interpretation of proxy data of the different zones; on the purpose of palaeoclimate analysis age data were arranged in 500 year steps. For ongoing statistical analysis information of characters (attributes) was numerical scaled. In comparison earlier palaeoclimatic maps for the Holocene optimum (6-5 ka BP) were constructed on the base qualitative description of July temperature and an estimation of the annual precipitation for the northern part of Eurasia by Velichko (2010) based on palynological data for the Northern hemisphere Muratova & Suetova (1983).

4.3.2 Temporal classification

For 190 sites of the integrated 180 sites absolute dating was conducted by the application of the radiocarbon method (see Table 6 in appendix). Absolute ^{14}C dates are based on the decay of radioactive decay of the ^{14}C isotope. For 90 sites radiocarbon dates are provided as calibrated values. For 86 remaining sites radiocarbon ages are given without any calibration. All these dates were calibrated in over to make them comparable with the other datings. Thus, the calibration of absolute ^{14}C dates is made in order to match the different data sets. Calibration programme OxCal 4.1 (Bronk Ramsey 2011) and calibration curve IntCal 09 for sea and surface samples with a standard deviation of 95% (2σ criteria) were used for data calibration. Calibration curve IntCal 09 was applied in order to convert radiocarbon age into calibrated (cal) age (Before Present, 0 cal BP = AD 1950) (Reimer et al., 2004).

4.3.3 Proxy data classification

The database (see Table 4a-e in appendix) documents that archives and correspondingly proxy are highly variable (soils, peat, wood, pollen, bones, carbonates etc.) Summarizing, eight types of proxy data (Figure 4) were obtained as a result of calculation and assessment of all the proxy data analyses compiled for this study.Examinating the methods applied in the reviewed studies it was found out that in all cases multi-proxy were surveyed (see Table 4a-e in appendix). Palaeoenvironmental information provided by the different proxy-data is highly different (Table 2)

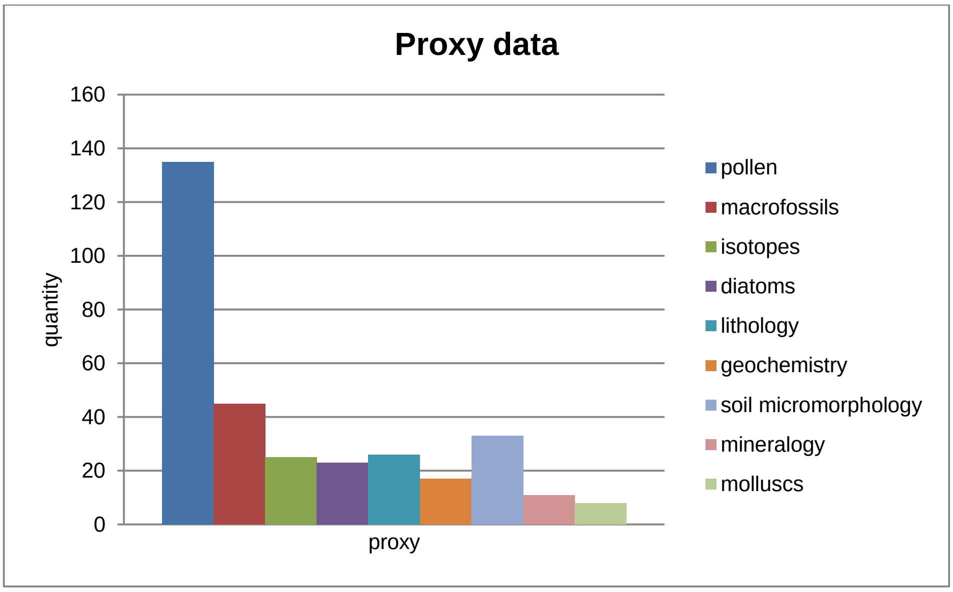


Figure 4: Proxy data of the analyses with sites.

№	Methods	Object of analyses/Proxy	Palaeoenvironmental information
1	Geomorphological methods	landforms processes	erosion and accumulation processes
2	Lithological methods	lithology	erosion and accumulation processes
3	Physical and chemical analyses	oxygen isotope, chemical composition minerology	temperatures, weathering processes, pedogenic processes
4	Palaeobotanical analyses	spore-pollen macrofossil	vegetation cover, flora and fauna
5	Palaeofaunistic analyses	malacofauna (molluscs)	lacustrine or river environmental (aquatic)
6	Mossbauer analyses	magnetite maghemite	humidity soils
7	Microfossil analysis	diatoms	lacustrine or river environmental (aquatic)
8	Palaeosoil analysis	soils, soil sediments	soil forming processes

Table 2: Methods and analyses for reconstructions palaeoenvironmental with sites (Data source Table 6).

In the following methods and analyses most frequently applied for palaeoenvironmental reconstruction at sites in western Eurasia are briefly introduced:

Applying **geomorphological** methods, forms and materials of the relief are studied to reconstruct relief forming processes and its controlling factors.

Investigating **palaeosoil** mostly micromorphological analysis of soils was conducted (at 33 sites), and features as soil thickness, color, structure, genesis, granulometric composition, inclusions, new formations, interstices, plant roots, solidity and plasticity were described and analyzed. Changes in the structure and character of soil formation occurred in the Holocene according to the conditions of climate and vegetation zone where the respective soil developed. Climatic changes and human impact were the major factor for changes and disturbances in soil evolution during the Holocene; it caused significant soil transformations under the influence of erosive and sedimentary processes (Aleksandrovski, 2002).

One of the most frequently used methods for palaeoenvironmental reconstruction is the **lithological** analysis of sediments including the determination of their composition, structure, conditions of formation, changes and distribution of sedimentary rocks. This approach was applied at 26 of the investigated sites. It allows complimentary to the geomorphological analysis to reconstruct erosion and accumulation processes and by this to draw conclusions which palaeoenvironmental conditions provided influence, e.g., weathering and runoff processes.

Geochemical analysis includes the analysis of stable isotopes as well as the analysis of major, minor and trace elements. Analysis of stable isotopes, predominantly of oxygen isotopes to reconstruct temperature regimes (Motuzka, 2003), has been increasingly applied during the most recent years. It was conducted at 25 of the reviewed sites. Chemical analysis of sediments or soils, were conducted at 17 of the reviewed sites. Sediments and soil chemical composition predominantly allows drawing conclusions on synsedimentary weathering processes (Dobrovol'skogo, 1979). In the most recent studies chemical analysis of sediments frequently was conducted applying XRF-scanners; however, resulting data give only relative information on chemical composition and, in general, are only fragmentary interpreted and discussed.Mineralogical analysis of sediments and soils was conducted at eleven of the reviewed sites; mineral composition allows either conclusion on weathering and soil forming processes as well as it might provide information on the origin of sediments (Romanovski, 1977). In lacustrine environments data on mineralogical composition might also provide information on lake salinity and temperature (Lavjorov & Medvedev, 2011).

Palaeobotanical analyses are the mostly frequently based on pollen analysis, applied at 135 of the reviewed sites, pollen data serve to reconstruct vegetation cover. Due to palynological proxy data latitudinal zonal and vertical altitude types of vegetation can be reconstructed for a special time period and area of investigation from which coarse temperature and humidity regimes can be concluded. For example, coniferous forest (*Cedrus*, *Pinus*, *Picea*, *Abies*, *Larix*, *Juniperus*) indicate the "cold and humid" climate of the zone I (taiga zone). The appearance of deciduous forests (*Quercus*, *Acer*, *Tilia*, *Fraxinus* and *Ulmus*) is typical for the moderate climate of zones II (mixed forests) and III (forest steppe). Grass and sparse woodland (*Picea*, *Larux* and *Betula*) mark the "warm and dry" climate of zone IV (steppe). The Carpathian Mountains (zone V) has due to its altitudinal differentiation a high variety of vegetation zones comparable to the latitudinal zones.

Macrofossil analysis was also conducted at 25 of the reviewed sites, mostly based on the macro remains of leaves, pine needles and stalks to identify which plant types grew. Microfossil analysis mostly focused on diatoms and was conducted at 23 of the reviewed sites. Diatoms allow conclusions on the milieu of aquatic depositional environmens such as water dupth, pH and salinity.

Palaeozoological analysis plays a significant role in the reconstruction of palaeoenvironments. As well as vegetation, animal habitats have its own dynamic of distribution depending on climat. The investigation of different fauna remains allowsto create a qualitative and quantitative description of complexes bearing information about the palaeoenvironment. Palaeozoological data remains of big mammals are provided at four of the reviewed sitesand based on the remains of small mammals are provided at eight of the reviewed sites. They describe the distribution of animal groups and based on this allow to draw conclusions on their habitat.

The remains of **malacofauna** were analysed at eight of the reviewed sites. The geographical distribution of remains of malacofauna can be used for palaeoenvironmental reconstruction, predominantly those of the depositional environmental such as water depth, salinity and pH (Philippenko, 2012). Qualitative estimations of subterranean water were conducted at five of the reviewed sites analyzing the shell ameba which allows reconstructing the environmental conditions on a quantitative level (Mittchel et al., 2008). The remains of amphibia and reptiles found at three of the reviewed sites, in the caves of the Southern Urals (Danukalova et al., 2008; 2011), like the remains of macrofossils the reconstruction of habitats.

Informational statistical analysis andanalysis Mössbauer spectroscopy were used in the studies so they are treated as separate, the results of which are also of signals about the climatic conditions of the past.

The **informational-statistical** analysis developed by Klimanov (1976) was used to determine the quantitative characteristics of a series of climatic indicators at 20 of the reviewed sites. The informational-logical analysis proposed is put into the basis of this scheme (Puzachenk, 1969). Based on the pollen data climatic characteristics are derived from transfer functions, which describe the present situation of plant cover and environmental characters. Climate reconstruction (mean temperature of July, January, year and annual total of precipitation) is based on tables of correlations of a pollen and spore composition and the composition of pollen of wood species (Klimenko et al., 1996)

The analysis of **Mössbauer spectroscopy** was also applied at four of the reviewed sites in order to examine the quantity of magnetite and maghemite in the buried soils under burial mounds of zone IV (steppe). The quantitative content of magnetite and maghemite in the soils indicates the moisture content. In the steppe soils of zone IV the development of hydromorphism is accompanied by an increase in magnetite quantity, as a result of which the mean value of the “magnetite to maghemite” ratio increases from 0.8-0.9 to 1.1 (Vodyanitskii et al., 2009). Sod podzol and the dark-humus soils of Cis-Urals are characterized by a low value of magnetite (0.5 on average) which indicates the predominance of maghemite. Hydromorphism in the humid conditions of the northern taiga zone I is accompanied by a significant increase in the “magnetite to maghemite” ratio up to 4-9 (Vodyanitskii et al., 2009).

4.3.4 Climatic trend classification

Before using climatic data presented in the literature, it is important to understand how the proxy data was obtained. None of the given data was interpreted or reinterpreted.All information about the climatic conditions was taken from the discussion and conclusion of the literature sources. In connection with the various proxy data and a variety of methodological approaches the database appeared to be heterogeneous. In some literature absolute values of temperature or precipitation are given. Other sources provide only relative statements, such as "- becaming warmer after the Pleistocene." Therefore it is necessary to summarizeunity and classify all these values and statements on climate. As a result, it was developed four classes of "climate trends," which represent the different information about the climatic conditions coming from different sources, different methodological approaches and different proxy data.These trends are: “cold and humid”, “cold and dry”, “warm and humid”and “warm and dry”. These trends do not provide absolute information about the climatic conditions, and only show the relative changes.

4.4 Statistics

Statistical analysis, the compilation and interpretation of various information was conducted for the 190 sites documented in the 119 publications selected during the reviewing process. Proxy data about the palaeoenvironmental conditions “cold and humid”, “cold and dry”, “warm and humid” and “warm and dry” for the 190 sites during the past 10,000 years with time intervals of 500 years each were transferred into absolute values and summarized: $\sum=A_1+A_2+A_3$, where $\sum$-sum, A-box and 1,2,3-absolute values, applying MicrosoftExcel 2010. The results of palaeoclimatic fluctuations are presented in histograms and cartograms (see chapter 5).

4.5 Data visualization.

It is necessary to systematize and visualize the data before analyzing the data base, for which the geographic information system QGIS was applied (Version 1.8.0 “Lisboa”). The programme QGIS allows the representation and visualization of the information, including tabular data and information about the map. As a result different maps including information from the whole data base were developed.With the help of the program Microsoft Excel, all proxy data were analysed and diagrams were created.For the diagrams absolute values were taken which are based on quantitative data (proxy, archives, climate conditions and others). Summarizing, the following character of the archives (Figure 5) used in the selected studies is as follows: Proxy data were obtained from soils of different ages, attributed to the Holocene sediments in 69 of the reviwed sites. In 60 of the reviewed sites proxy data were obtained from lake sediments. In 30 of the reviewed sites proxy data were obtained from river sediments (alluvium) mostly from flood-plains of the rivers. In 27 reviewed sites proxy-data were obtained from peat-bogs, in four sites from sea sediments and in three of the reviewed sites from cave sediments.

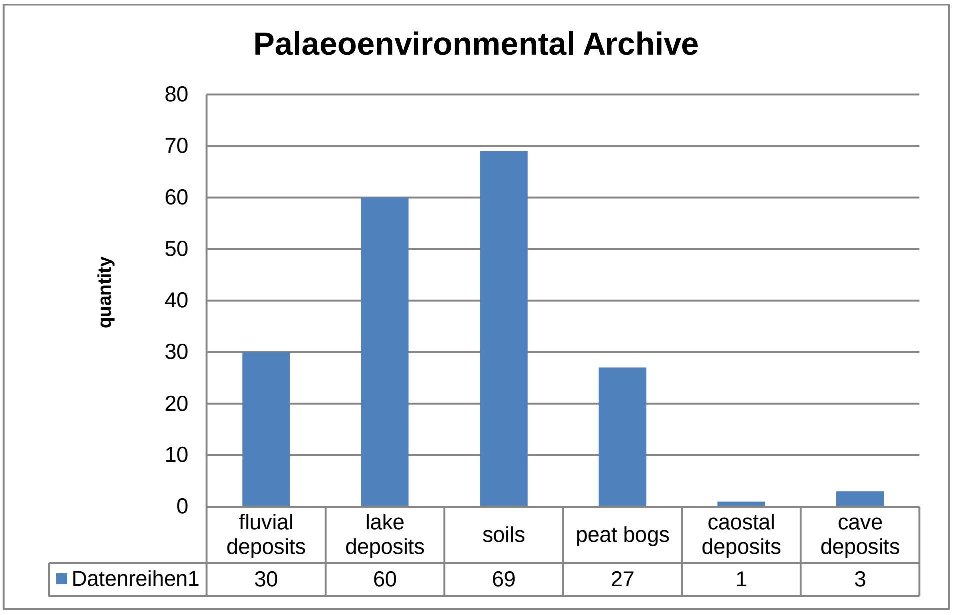


Figure 5: Archives paleoenvironmental (Data source Table 6)

Soils, lake deposits, alluvial and peat-bog sediments, contained plants pollen and spores, macro and micro remains, diatoms etc, which serve as the most favourable natural “archives” for the reconstruction of palaeolandscape-climatic changes in the Holocene.

5 Literature analysis

The main sources for the reconstruction of palaeoclimatic and palaeolandscape development were literary sources that have been re-viewed. In total, 190 literary sources were the object of this research, allowingreconstructing the main fluctuations in the palaeoclimate and palaeolandscape of the Holocene in Western Eurasia.

A brief overview of the database, including dating, proxy data and spatial-temporal data is required to understand toe heterogenety of the data analysed.

Palaeoclimatic conditions are presented in absolute numbers in the diagrams (Figure 17a-d) and as a relative value (Figure 18a-d) as well in all diagrams displaying data about the supraregional palaeoclimatic fluctuations (Figure 19a-e). The data in Figure 17(a-d) allow to determine time borders, palaeoclimate change from “cold and dry” 10 ka BP to “warm and humid” in 8.2 ka BP, from “warm and dry” in 4 ka BP to “cold and humid” in 2.5 ka BP. The relative data in Figure 18(a-d) show differences of palaeoclimatic development in the five zones identified Figure 9(a-f) presents differences in the development of palaeoclimatic conditions in zones: I (taiga), II (mixed forest), III (forest-steppe), IV (steppe) and V (Carpathian Mountains) at 500-year intervals.

In intervals summarizing always 500 years the palaeoclimatic development of Western Eurasia during the last 10,000 years is shown, including palaeoclimatic maps and diagrams. Analysing palaeoclimatic conditions 500 years-step it is trend to determine whether climatic fluctuations over the centuries took place in the different zones.

5.1 The database

5.1.1 Literature list

After an extended review of publications in English and Russian language on palaeoenvironmental reconstruction for sites located in Western Eurasia, a total 119 publications were finally selected for the spatio-temporal analysis of Western Eurasia during the Holocene, As a result 190 sites were distinguished from these 119 selected articles which contain sufficient relevant information about the palaeoenvironment in Western Eurasia during 10 ka BP (see Table 4a-e in appendix).

Most of the data was obtained from archaeological sites (hill forts, settlements and burial mounds). By investigating the life of ancient people, archeologists found material traces which saved information about the palaeoenvironments. Complex methods of investigation provided reliable information about the past of ancient people and the conditions of their habitat, including information about palaeoclimate.

5.1.2 ^{14}C dating

^{14}C dating was carried out for 176 sites of the 190 sites. At the remaining 14 sites ages are based on other radiometric data or archaeological findings (Figure 6).

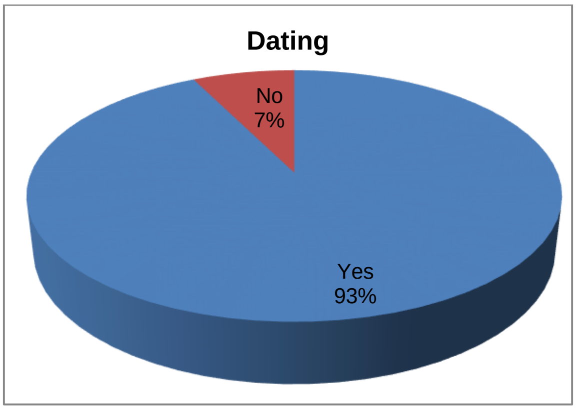


Figure 6: Quantity [%] absolute data with sites.

For 86 of the 176 sites where radiocarbon ages are published, dates are calibrated. For the remaining 90 sites radiocarbon ages are given uncalibrated in conventional absolute radiocarbon dates based on the radioactive decay of carbon isotope ^{14}C.

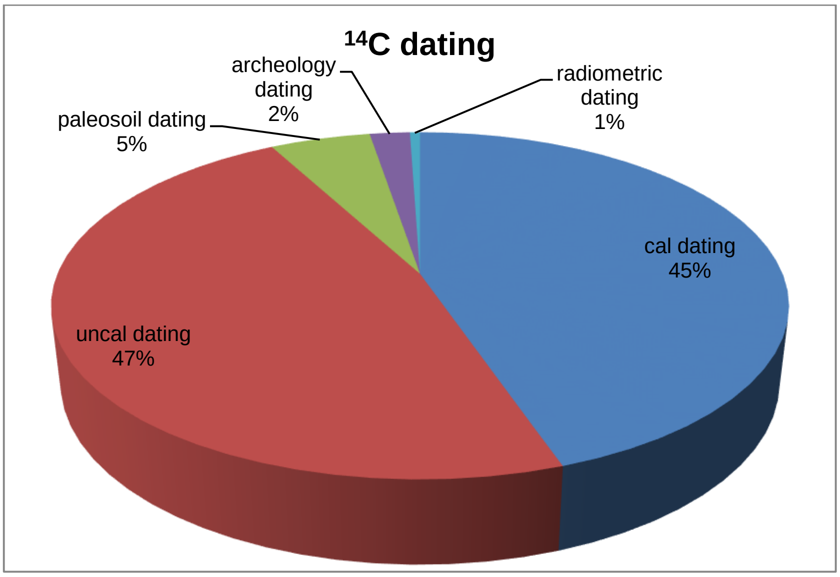


Figure 7: ^{14}C radiocarbon dating with sites

Absolute dating was conducted in order to date archaeological dwellings and different materials which contained carbon. Preference is given to such materials as wood, bones, charcoal, peat, mollusks, vegetation remains etc. These materials are marked in the data base as “direct materials”. Also there are “indirect materials” such as gyttja, limestone, clay, sand, fish scales, stones, carbonates, salts etc. These materials were found at the sites, but in general they were not analyzed or dated. In addition, the ages of 9 sites (RF42; RF68; RF95; RF96; RF103; RF103(a); RF106; RF109; RF111) were not assessed, because the dated material was organic matter from buried soils. When multiple dating of soil organic matter and cultural layers is conducted, a correlation of datafrom soil organic matter and archaeologists' conception about site age can be observed (Khakhlova, 2010). The material age (human remains) for four sites (RF16; RF16(a); RF16(b); RF77) was received based on their relative archaeological age; these dates were supposed to be reliable and were used in further research. For site RF21 the dates provided were obtained using radiometric dating, which estimates the radioactivity of uranium, absorbed from subsoil waters, contained in the animal bones.

5.1.3 Distribution of sites per zone

Spatial distribution of the 190 sites from the 119 articles is unevenly distributed over the area of research in five areas.

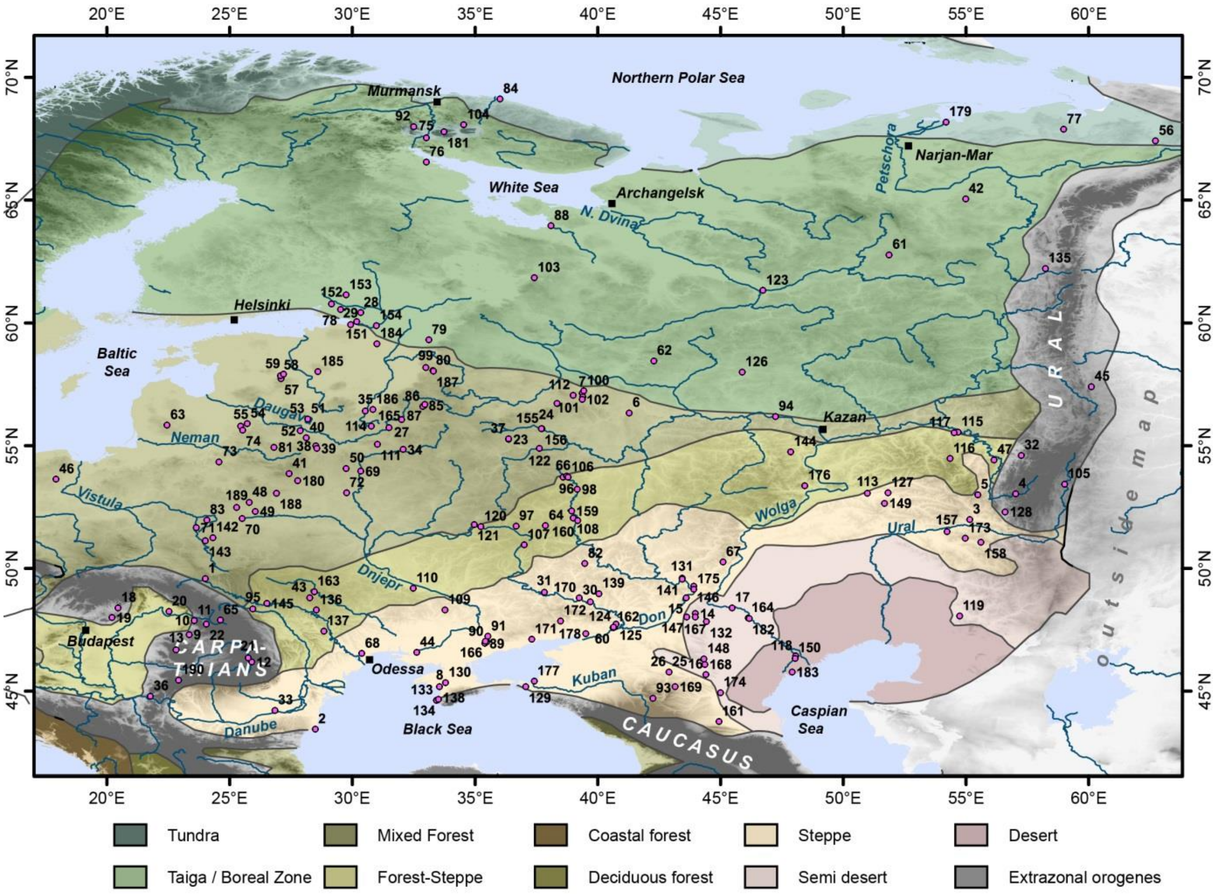


Figure 8: Landscape zones and localization of the sites (Physical Geographical World Atlas, USSR 1964; site names are in Table 6)

The largest number of sites is located in the steppe zone IV with 66 sites this means that in this area were the largest number of study. In the zone II are mixed forests 61 sites database, the area is the zones is the largest in size when compared with other zones. Zone I taiga zone are 24 sites, and in the forest-steppe zone III 26 sites by the number of sites, these two bands are almost the same. Zone V Carpathian Mountains are located smallest number of sites with 13 sites.

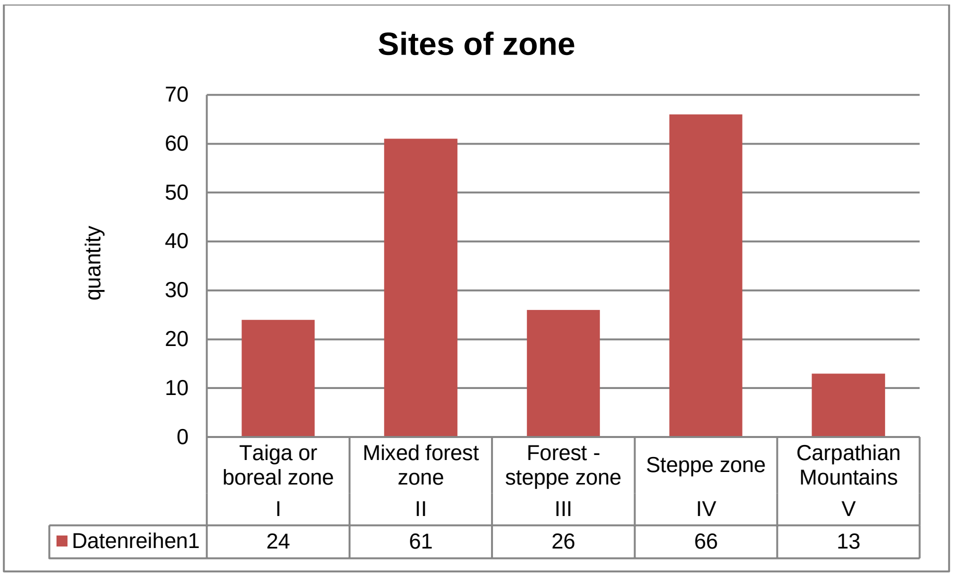


Figure 9: Location of the sites in the landscape zones

According to the classification Köppen-Geiger climate in Western Eurasia is divided into five climate zones (Table 3). This classification differs from a spatial climate classification which was subdivided this area of my work. The main difference is slight confusion on the boundary between the zones, particularly between mixed forests, forest-steppe and steppe.

Region	Köppen & Geiger Climate classification	Zone	Vegetation	Soil
Region I	Dfs-snow fully humid cool summer	Taiga	coniferous forests	podzols, podzolic and bog soils
Region II	Dfs-snow fully humid cool summer Dfb-snow fully humid warm summer	Mixed forest	temperate deciduous forest	sod-podzolic, brown and forest soils
Region III	Dfa-snow fully humid hot summer Cfb-warm temperate fully humid warm summer	Forest-steppe	broad leaved-coniferous and different herbaceous	chernozem and chestnut soils

Region IV	Cfb-warm temperate fully humid warm summer BSk-arid steppe cold arid	Steppe	grasslands	chernozem and chestnut soils
Region V	Cfb-warm temperate fully humid warm summer	Carpathian Mountains	1300-1800 *m* coniferous forests 500-1200 *m*broad-leaved	1300-1800 *m* sod-podzolic soil gleyed 500-1200 *m* mountain brown and mountain gray forest soils

Table 3: Definition of the Region I-VI according to characteristics of climate, vegetation and soil (Kottek et al., 2006; Physical Geographical World Atlas, USSR 1964; soil map of the World, FAO/UNESCO 1978)

5.1.4 Proxy data

Palaeoenvironmental proxy data, in general, allow only restricted insight into palaeoenvironmental conditions, mostly focusing on narrow palaeoenvironmental characters such as temperature or humidity. Therefore, many studies rely on multiple proxy data analyzes (Figure 10).

n = 323 proxies from 190 sites

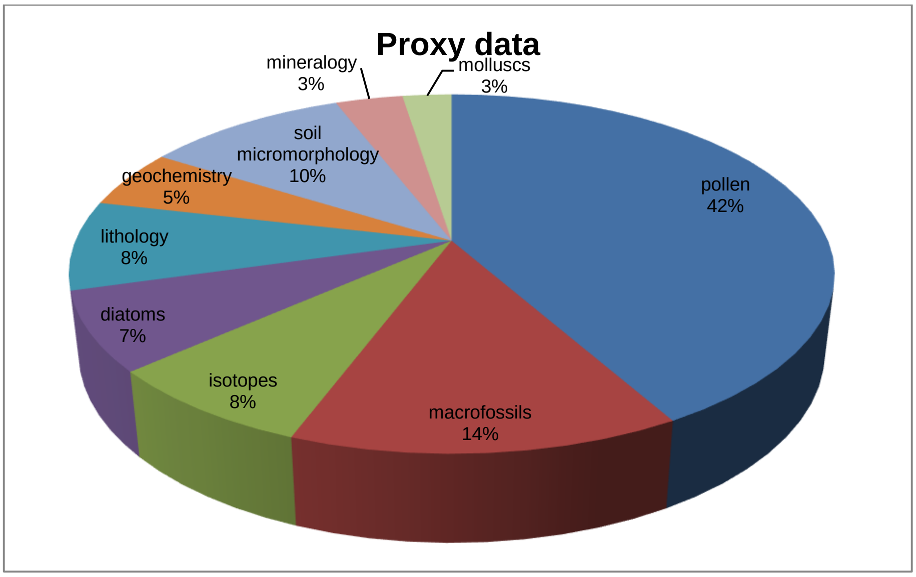


Figure 10: Classification of proxy data with sites

The most common proxy data used are based on pollen analysis with 42% of the proxy data 12% of the studies rely on macrofossils analysis, 10% on palaaeosoil analysis. In 8% of the studies isotope analysis are conducted, diatoms were analysed in 7% of the studies, geochemical analysis were conducted in 5% of the studies, minerals mollusks and amoeba are used to receive proxy data only in few cases (each less than 3%).

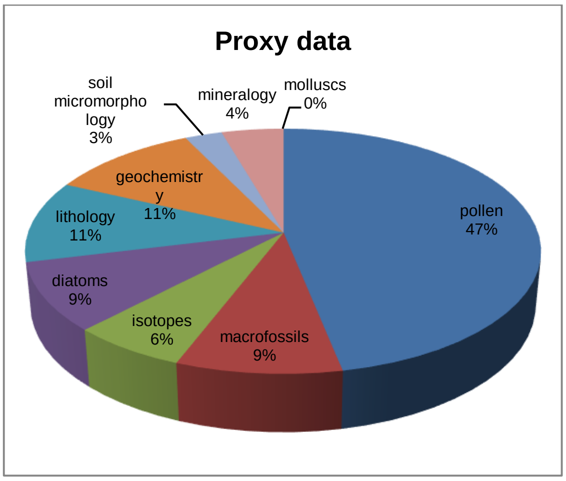


Figure 11: Classification of proxy data, applied zone I (taiga zone)

According to the calculations in the zone I (taiga zone) of 55 proxy data for 24 sites.The largest number of proxies in this zone pollen 54%, then 20% of diatoms, macrofossils 14%, 13% sedimentary rocks, 4% of the isotope, and 2% minerals and geochemical proxies. Here was that there was no proxy analysis of the soil is due to the fact that in the taiga zone in the most historical data are presented from peat bog

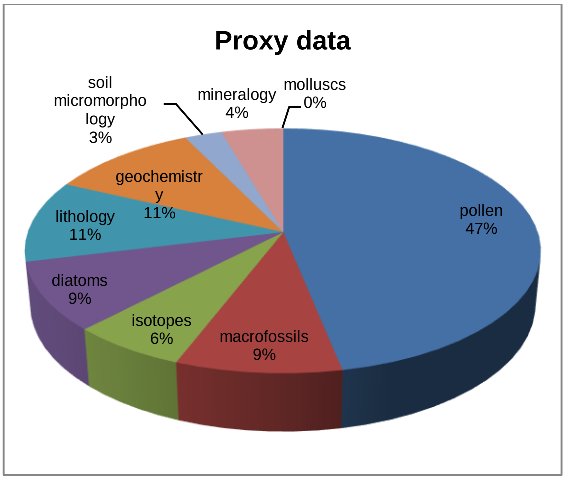


Figure 12: Classification of proxy data, applied zone II (mixed forest zone)

In zoneII (mixed forests zone) was carried out the largest number of 111 proxy data for 61 sites. Accordingly, the greatest number pollen proxy data from all other area sobservedin this zone pollen 47%, further 11% of sedimentary rocks and geochemical, followed by 9% macrofossils and diatoms, 6% isotopic, 4% minerals and 3% soils.

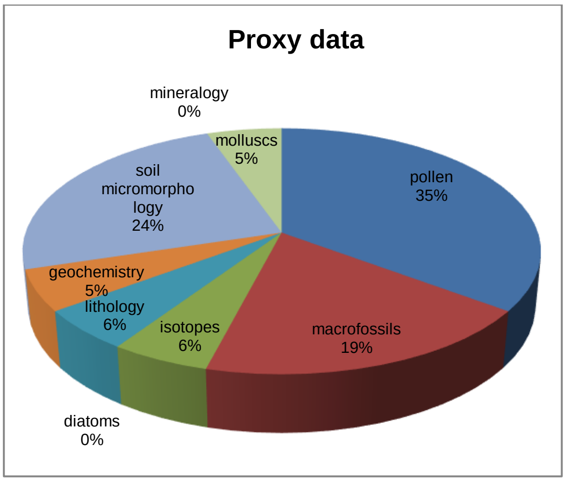


Figure 13: Classification of proxy data, applied zone III (forest-steppe zone)

The zone III (forest-steppe zone) only 37 proxy data for 26 sites. As in the (mixed forests zone) in the first place by the number of proxy pollen is 35%, then 24% of the soil should be noted that most forest carried morphological analyzes. In the next place 19% of macrofossils, 6% sedimentary rocks and isotope, 5% geochemical and shellfish.

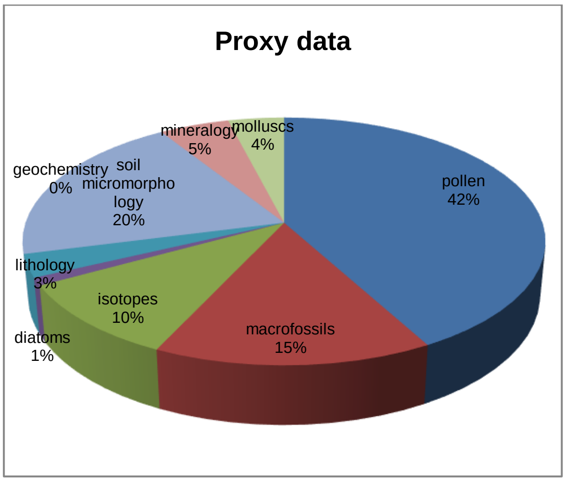


Figure 14: Classification of proxy data, applied zone IV (steppe zone)

In the zone IV (steppe zone) is estimated there are 100 proxy data for 66 sites. Of course, with the largest number of sites which falls on the steppe zone 45% of all pollen is very small, it is because it is virtually absent in the steppe most important material for analysis “peat”. The proxy data is the soil 20%, 15% macrofossils 10% isotope, 5% minerals, 4% molluscs 3% sediment and 1% diatoms.

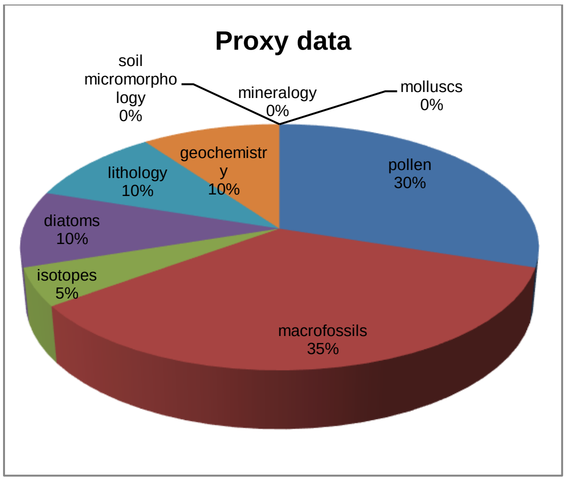


Figure 15: Classification of proxy data, applied zone V (CarpathianMountains)

Zone V Carpathian Mountainsas expectedin the zone most grafting macrofossils proxy is 35%, followed by 30% of pollen, the same number of percentage ratio of 10% diatoms, sediment geochemical and then 5% isotope.

Among the numerous methods and analyses applied, lithological, palaeobotanical and palaeofaunistic analysis proved themselves to provide the most reliable and comparable palaeoenvironmental information. The adequacy of these approaches in the research is central to solving the problems posed in this work.

5.1.5 Palaeoclimate and palaeoenvironmental development

Palaeoenvironmental proxy data allowsdifferentiatingthe Holocene into three major time periods. Because periodisation of the Holocene differs considerably between sources, a periodisation with a low number of fragmentations was used. An archaeological scale is used for every time interval as well as a geochronological one (Table 5).

The entire data base is analyzed according to the three time periods:

- EarlyHolocene(corresponding to Mesolithic 10 - 8.2 kaBP)

- Middle Holocene (corresponding to Neolithic and Bronze Age 8.2-5-3 ka BP)
- Late Holocene (corresponding to Iron Age 3 - 0 ka BP)

These three periods are clearly distinguished by the progression from the palaeobotanical defined Boreal to the Atlantic period, from the Atlantic to the Subborealperiod and from the Subboreal to the Subatlantic periods. Climatic conditions during this time were prone to abrupt and critical fluctuations. Palaeoclimatic conditions are discussed in the following categories:

- “cold and dry”
- “cold and humid”
- “warm and dry”
- “warm and humid”

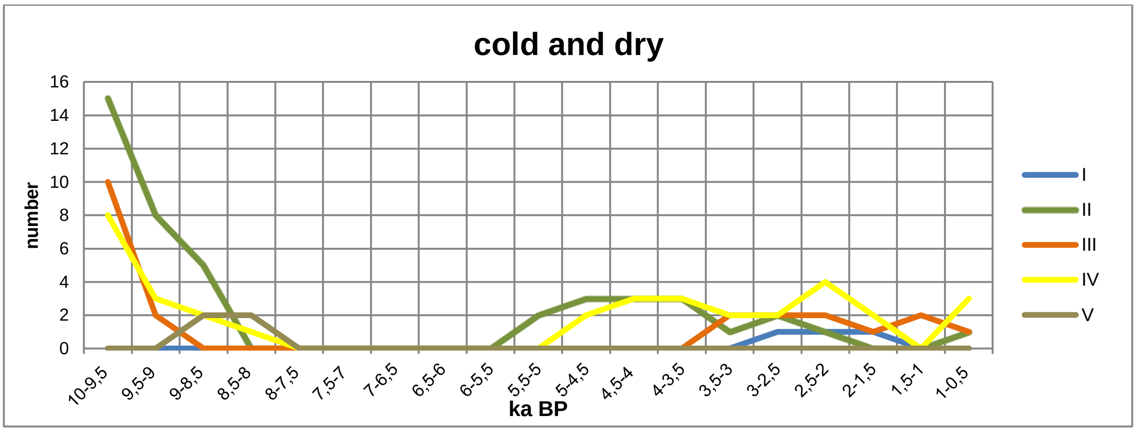
Information on palaeoclimatic conditions is not continuous and does not cover the entire Holocene as during some periods there is no evidence. In the following charts presented this circumstances are documented by "no data".

Figure 16 documents changes of palaeoclimatic fluctuations measured against time in absolute numbers (Figure 16a-d). Figure 17 show the same palaeoclimatic fluctuations against time as relative data (Figure 17a-d). All these diagrams clearly show three major palaeoclimatic changes during the Holocene in Western Eurasia.

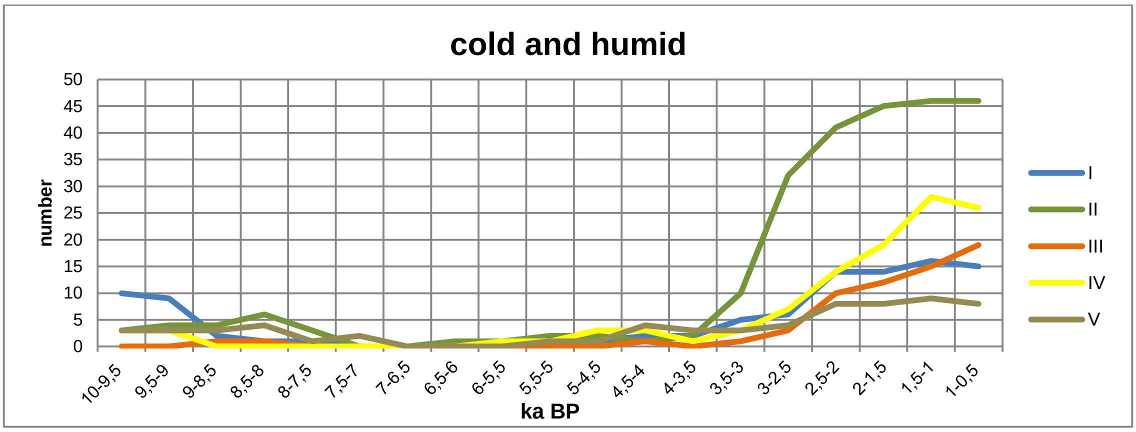
- During the early Holocene, in 10-8.2 ka BP, and in the beginning of the Preboreal period 10-9.5 ka BP, a cold climate predominated, which is also named the “Pereslavskoe” cold event. Later, temperature regime became warmer, differentiated by fluctuations of humidity. During the Boreal period (9-8.5 ka BP) climate can be characterized by a distinct warming across the whole territory of Western Eurasia.
- Starting from the middle Holocene, climate all over Western Eurasia changed to “warm and humid” and lasted until the early Subboreal period (5 ka BP). The early Atlantic period (8-7.5 ka BP) can be regarded as the beginning of this optimal climatic condition; according to the data base, the time period of 7-6.5 ka BP was the warmest and the most humid in Western Eurasia. Such favorable living conditions lasted until the early Subboreal period around 5 ka BP. The Boreal period (5-3 ka BP) can be overall characterized by arid conditions.
- The Subatlantic period, corresponding to the late Holocene during its last 3000 years, is characterized by gradual changes from “warm and dry” climate in the beginning to “cold and humid”.

Subdivision scheme Holocene (Neustadt, 1957)		**Subdivision scheme Holocene (Neustadt, 1957)**	**Blytt-Sernander system (Khotinski, 1982)**			**Aleksandrovski, 1983**		**Archaeological periods (Bader, 1974)**
period		**period**	**period**		**lower border**	**period**	**lower border**	**era**
Early Holocene (HL-4)	0-2500	Subatlantic	Subatlantic	SA-3 SA-2 SA-1	800 1800 2500	Subatlantic	0 2500	Iron Age
Middle Holocene (HL-3)	2500- 7700	Subboreal	Subboreal	SB-3 SB-2 SB-1	3200 4200 4600	Subboreal	2500 5300	Bronze Age
		Atlantic	Atlantic	AT-3 AT-2 AT-1	6000 7000 8000	Atlantic	5300 7900	Neolithic
Late Holocene (HL-2)	7700- 9800	Boreal	Boreal Prebboreal	BO-3 BO-2 BO-1	8300 8900 9300	Boreal Prebboreal	7900 9000 9000 10300	Mesolithic
Ancient Holocene (HL-1)	9800- 12000	Subarctic	Dryas Allered	Dr Al	11000 12000			Paleolithic

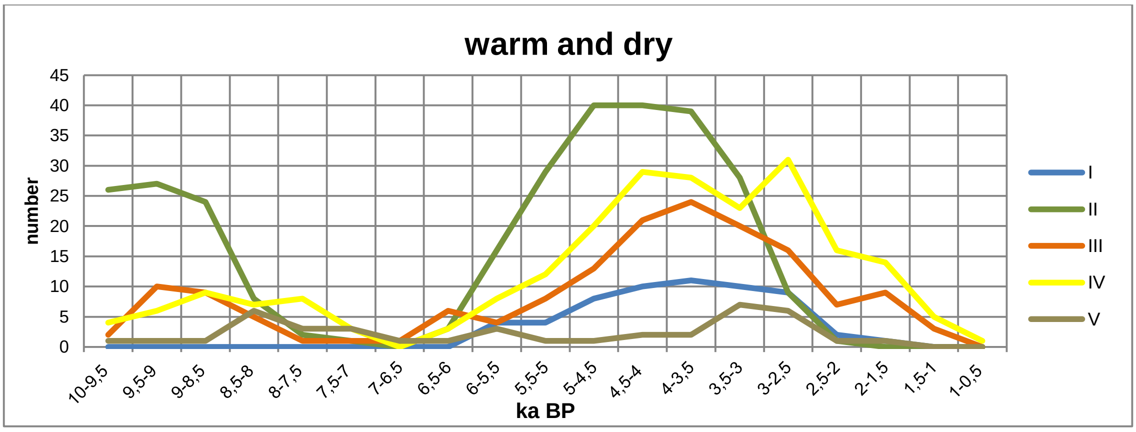
Table 5: Correlation of geochronological and archaeological periodisation of Holocene for Western Eurasia (modified after Aleksandrovski, 1983).



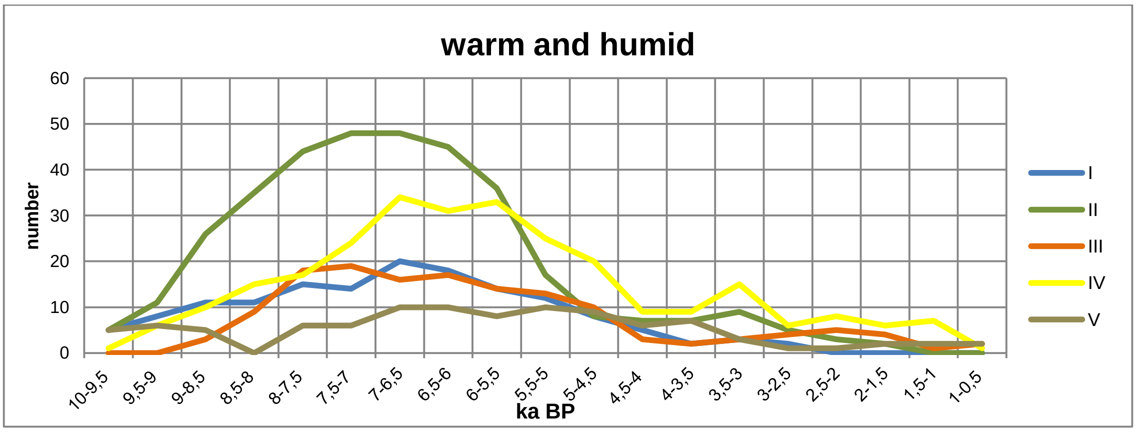
16(a)



16(b)

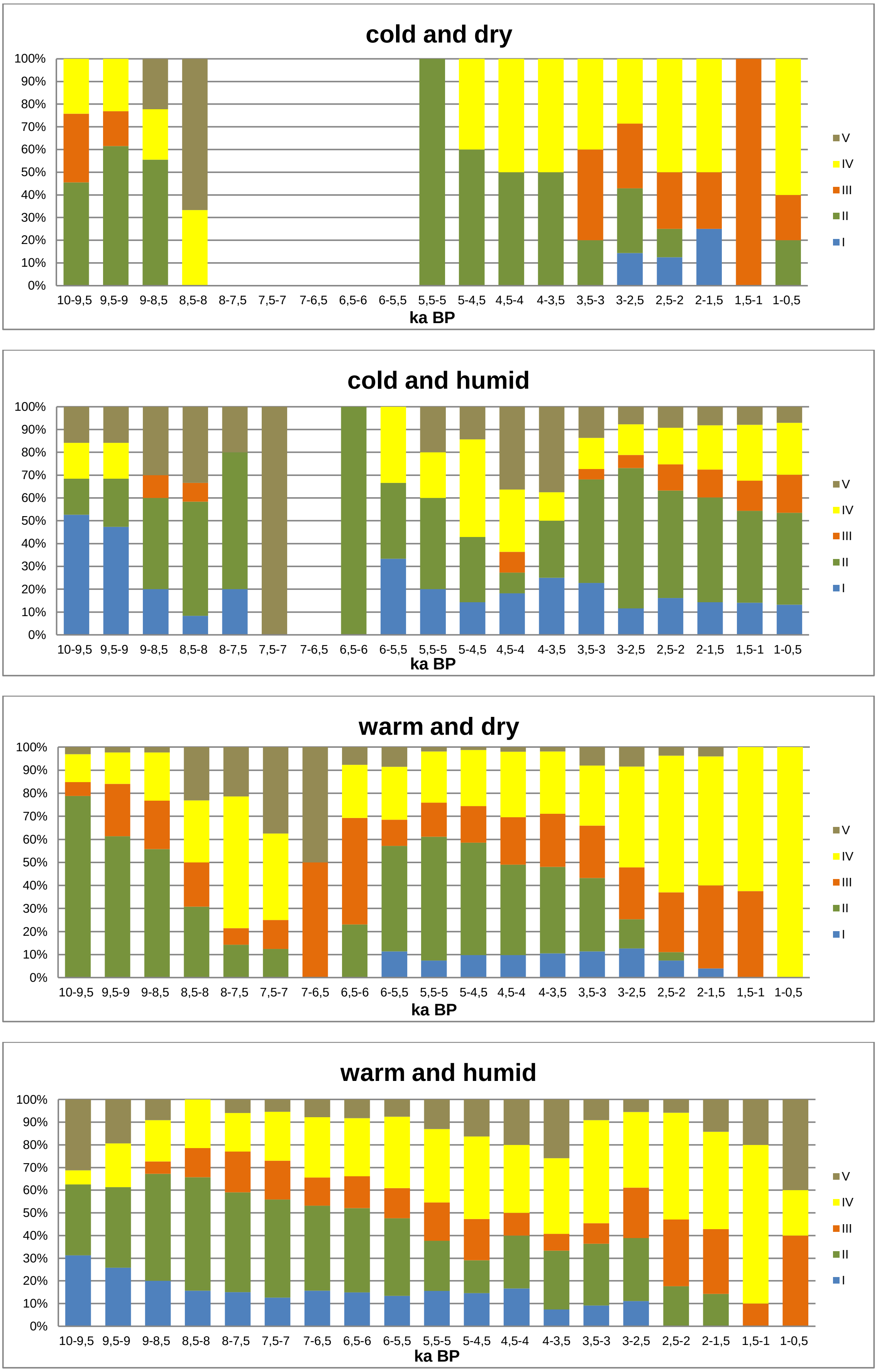


16(c)



16(d)

Figure 16(a-d): Time-dependent changes of palaeoclimate with the absolute number of sites in the five zones.(— I – the taiga; —II – mixed forest; — III – forest-steppe zone, — IV - steppe; —V – Carpathian Mountains) (Data source Table 4a-e in appendix)



17(a) 17(b) 17(c) 17(d)

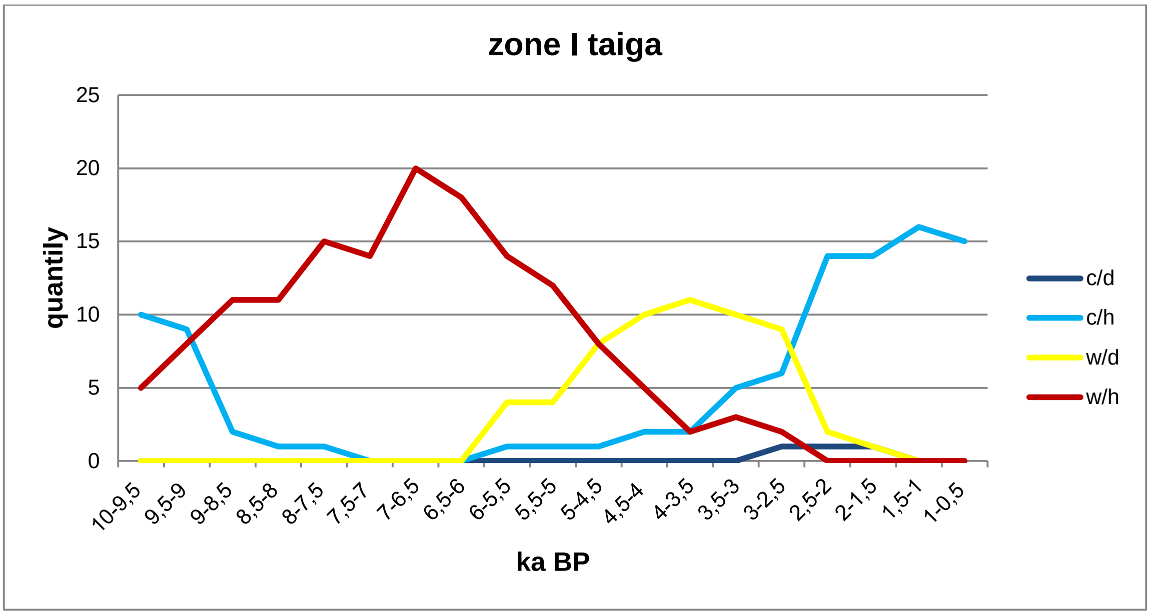
Figure 17 (a-d): Time-dependent changes of palaeoclimate trends with the percentage of sites in the five zons. (I - the taiga zone, II - mixed forest; III - forest-steppe, IV - steppe; V - Carpathian Mountains) (Data source Table 6)

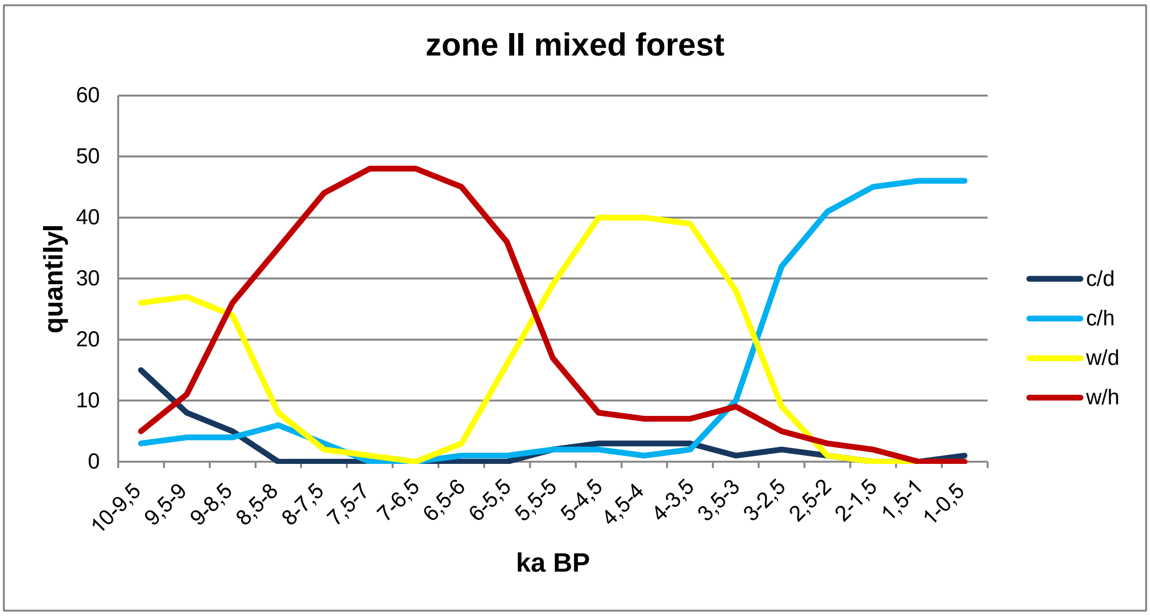
Data documenting “cold and dry” climateare missing in the diagram show by Figure 17a for the period 7.5 ka BP to 5.5 ka BP. The palaeoclimatic fluctuations have their own dynamics and character in each of the zones examined; this will be described in detail in the next paragraphs.

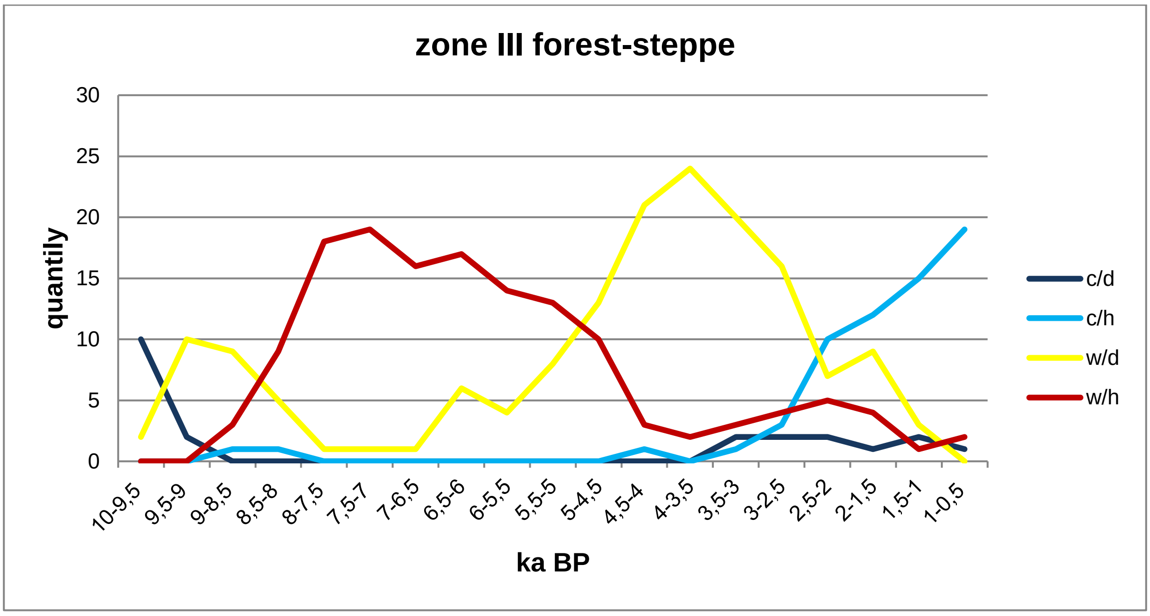
5.2 Zone differentiation of palaeoclimatic changes

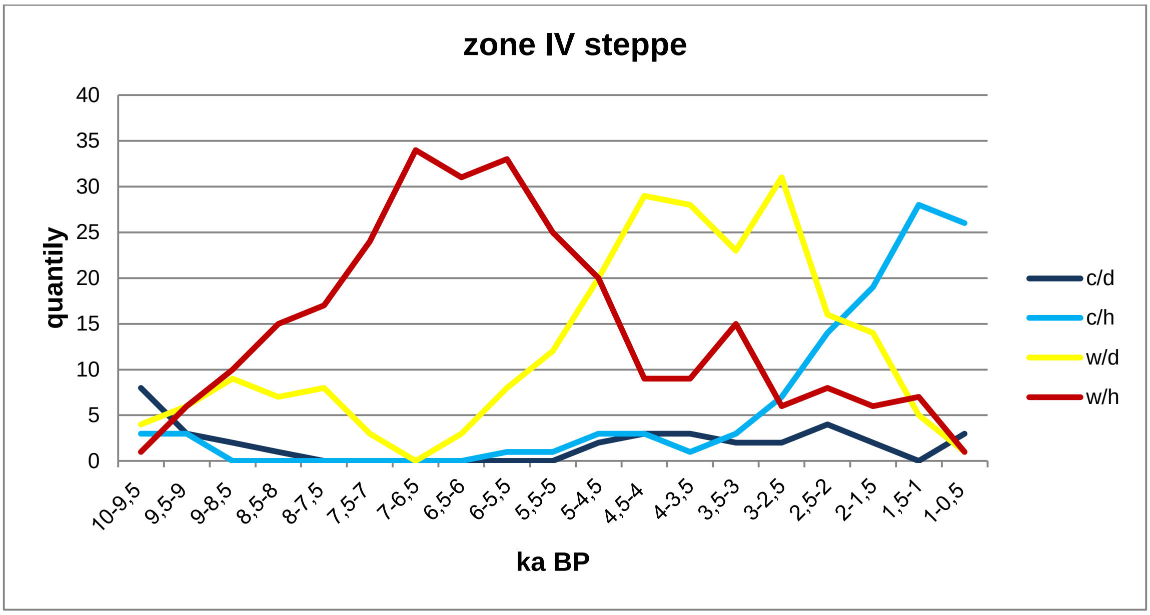
The results on palaeoclimatic fluctuations show clearly differences across five zones examined: in during the Holocene in Western Eurasia, in absolute numbers (Figure 18a-f).

- Even during the first 1000 years of the early Holocene (10-9 ka BP) it is possible to trace differences in palaeoclimatic conditions between the five zones examined. Whereas in zone II (mixed forest) (Figure 18b) a “warm and dry” climate dominated, in zone III (forest-steppe) (Figure 18c) climatic conditions can be described as “cold and dry”.
- With the beginning of the middle Holocene, a humid climate appeared (8.2 ka BP) in all five zones, and climatic conditions can be described as “warm and humid”. This period lasted until about 5 ka BP.
- Around 5 ka BP, with the beginning of the Subboreal period, in zones I (taiga), II (mixed forest), III (forest-steppe) and IV (steppe) climatic conditions became “warm and dry”, only in zone V (Carpathian Mountains) a humid climate still existed (Figure 18e).
- In the late Holocene, beginning from 3 ka BP, climatic conditions changed to “cold and humid”. These changes occurred generally in the taiga forest and mixed forest regions about 500-1000 years earlier than in steppe and forest-steppe zones. Due to its mountainous landscape the zone of Carpathian region cannot be included in this general statement.

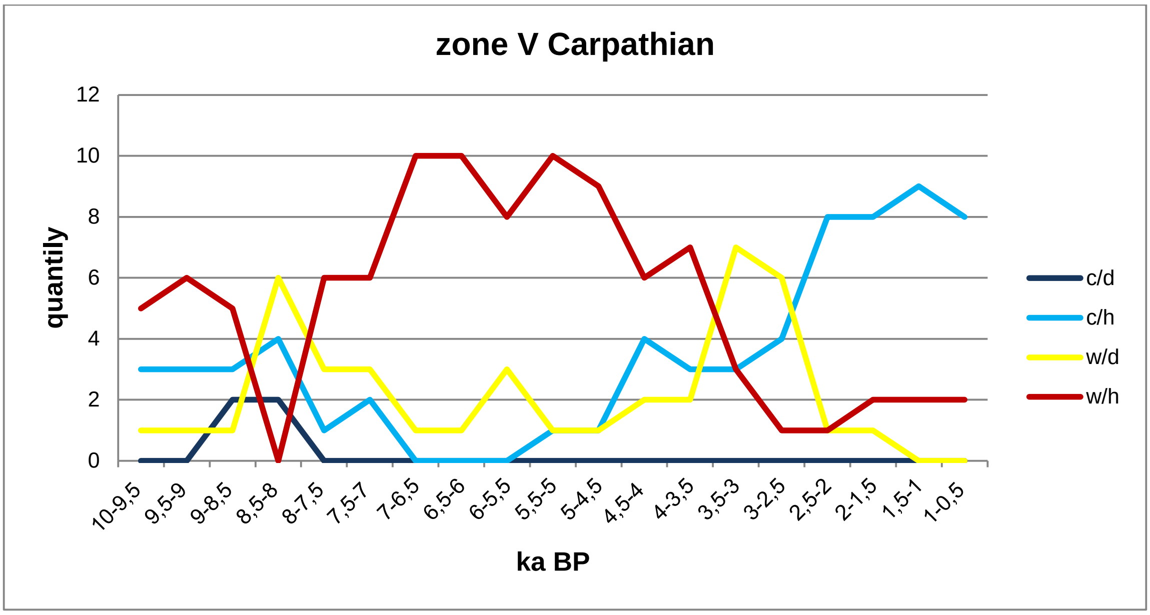

zone I taiga
quantily
25
20
15
10
5
0
10-9,5
9,5-9
9-8,5
8,5-8
8-7,5
7,5-7
7-6,5
6,5-6
6-5,5
5,5-5
5-4,5
4,5-4
4-3,5
3,5-3
3-2,5
2,5-2
2-1,5
1,5-1
1-0,5
ka BP
c/d
c/h
w/d
w/h
18(a)


zone II mixed forest
quantilyl
60
50
40
30
20
10
0
10-9,5
9,5-9
9-8,5
8,5-8
8-7,5
7,5-7
7-6,5
6,5-6
6-5,5
5,5-5
5-4,5
4,5-4
4-3,5
3,5-3
3-2,5
2,5-2
2-1,5
1,5-1
1-0,5
ka BP
c/d
c/h
w/d
w/h
18(b)


zone III forest-steppe
quantily
30
25
20
15
10
5
0
10-9,5
9,5-9
9-8,5
8,5-8
8-7,5
7,5-7
7-6,5
6,5-6
6-5,5
5,5-5
5-4,5
4,5-4
4-3,5
3,5-3
3-2,5
2,5-2
2-1,5
1,5-1
1-0,5
ka BP
c/d
c/h
w/d
w/h
18(c)



18(d)



18(e)

Figure 18(a-e): Relative frequency of the palaeoclimatic proxies for the Holocene -warm and humid, - warm and dry, - cold and humid, - cold and dry.

Additional results of the investigation of Holocene palaeoclimatic proxy data from Western Eurasia are also presented in maps, where each dot marks a single site (Figure 19.1-19), facilitated by diagrams showing the spatial differentiated distribution of sites with respective climate conditions (Figure 20.1-19).

5.3 Palaeoclimatic fluctuation Holocene in Western Eurasia

5.3.1.1 Early Holocene (10 ka – 9.5 ka BP)

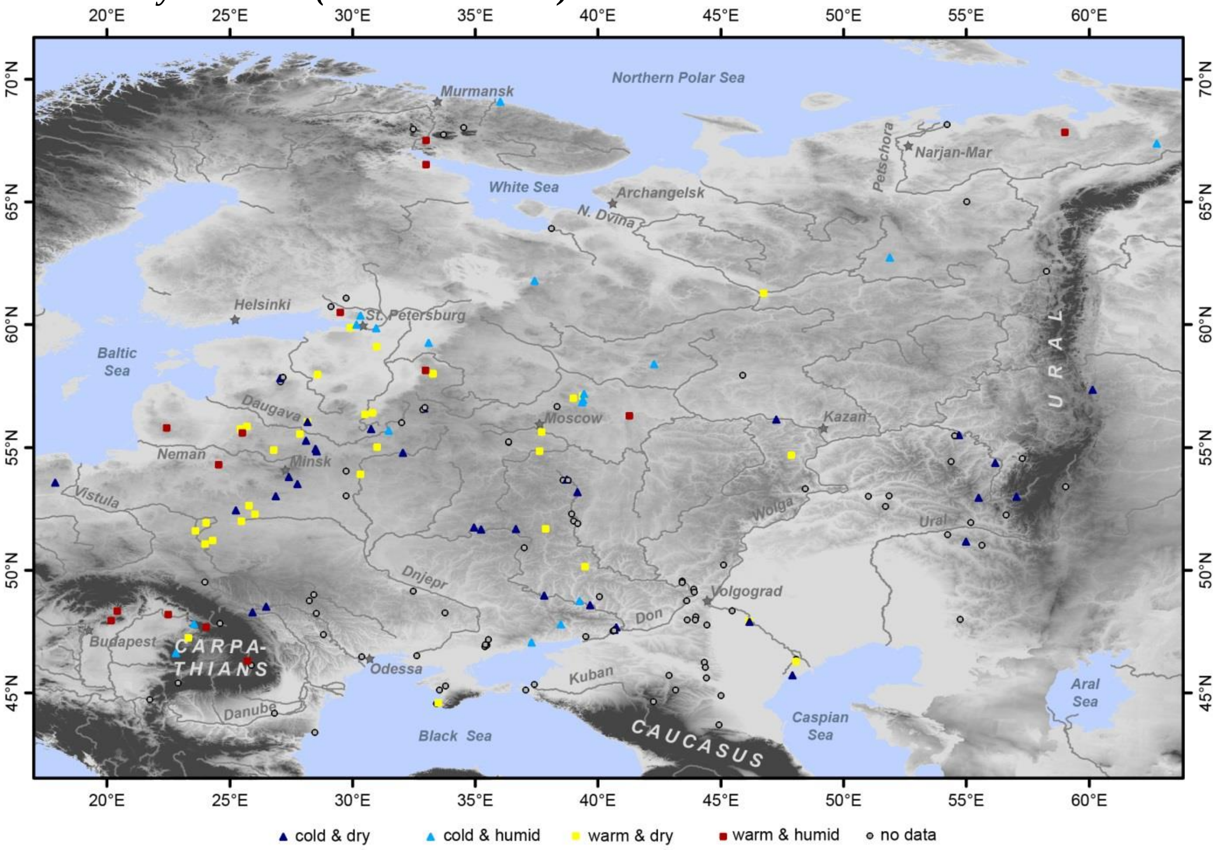
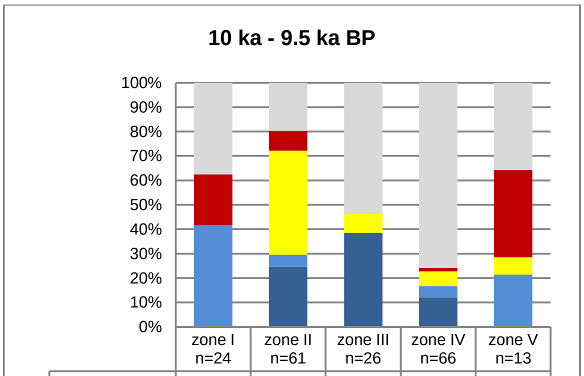


Figure 19.1: Palaeoclimate in Western Eurasia from 10 ka -9.5 ka BP. Each dot marks a site corresponding to Figure 20.1 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	9	12	14	50	5
warm & humid	5	5	0	1	5
warm & dry	0	26	2	4	1
cold & humid	10	3	0	3	3
cold & dry	0	15	10	8	0

Figure 20.1: Palaeoclimate differentiated by landscape zones from 10 ka – 9.5 ka BP.

Figure 19.1 shows thepalaeoclimatic conditions from *10 ka - 9.5 BP*. Supporting

Figure 20.1 documents distinct differenceexists between zone II - mixed forest where “warm and dry” climatic conditions occurred andthe remaining zones gets obvious. In zone III (forest-steppe zone) there is evidence for a “cold and dry” climate. In zone I (taiga zone), a cold climate dominated although warm conditions were also locally observed. In zone IV (steppe zone) some climatic fluctuations occurred dominated by “cold and dry”climate. In zone V (Carpathian Mountains) a “warm and humid” climate dominated.

5.3.1.2 Early Holocene (9.5 ka – 9 ka BP)

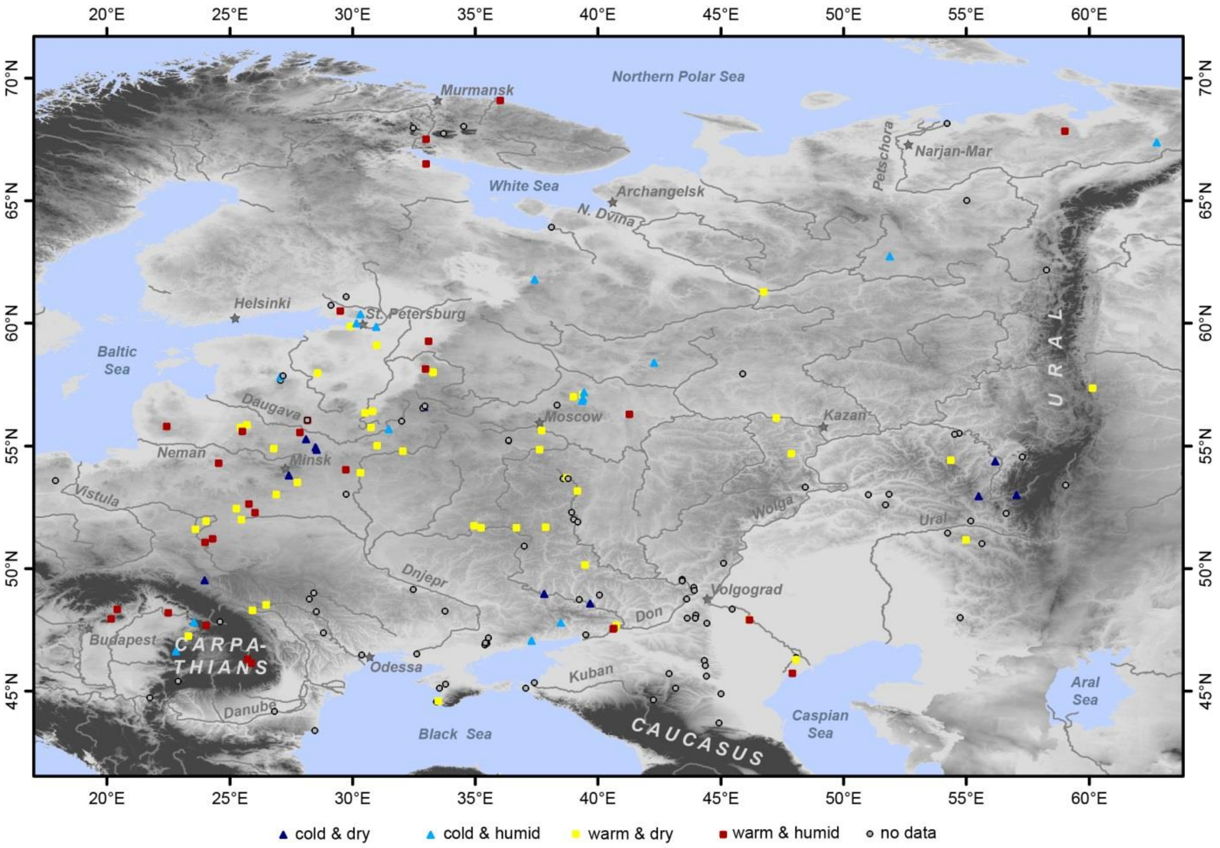
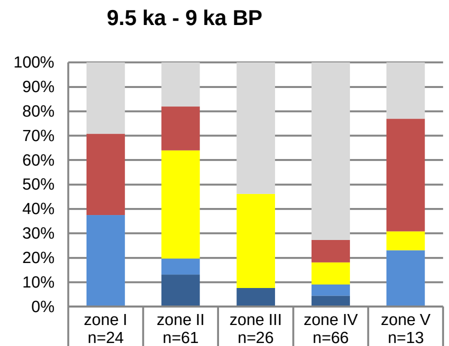


Figure 19.2: Palaeoclimate in Western Eurasia from 9.5 ka - 9 ka BP. Each dot marks a site corresponding to Figure 20.2 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	7	11	14	48	3
warm & humid	8	11	0	6	6
warm & dry	0	27	10	6	1
cold & humid	9	4	0	3	3
cold & dry	0	8	2	3	0

Figure 20.2: Palaeoclimate differentiated by landscape zones from 9.5 ka – 9 ka BP.

During the early Boreal period (*9.5 ka - 9 ka BP)*, overall warming occurred (Figure 19.2, Figure 20.2).Zone I (taiga zone this corresponded windespread to a "warm and humid" climate. In zone II (mixed forest) "warm and cold" climate with fluctuations in humidity can be observed. A "warm and dry" climate dominated in zone III (forest-steppe zone) despite the continuation of a "cold and dry" climate in several areas. In zone IV (steppe zone) it was warm with fluctuations in humidity, and in the Carpathian Mountains a "warm and humid"climate dominated.

5.3.1.3 Early Holocene (9 ka – 8.5 ka BP)

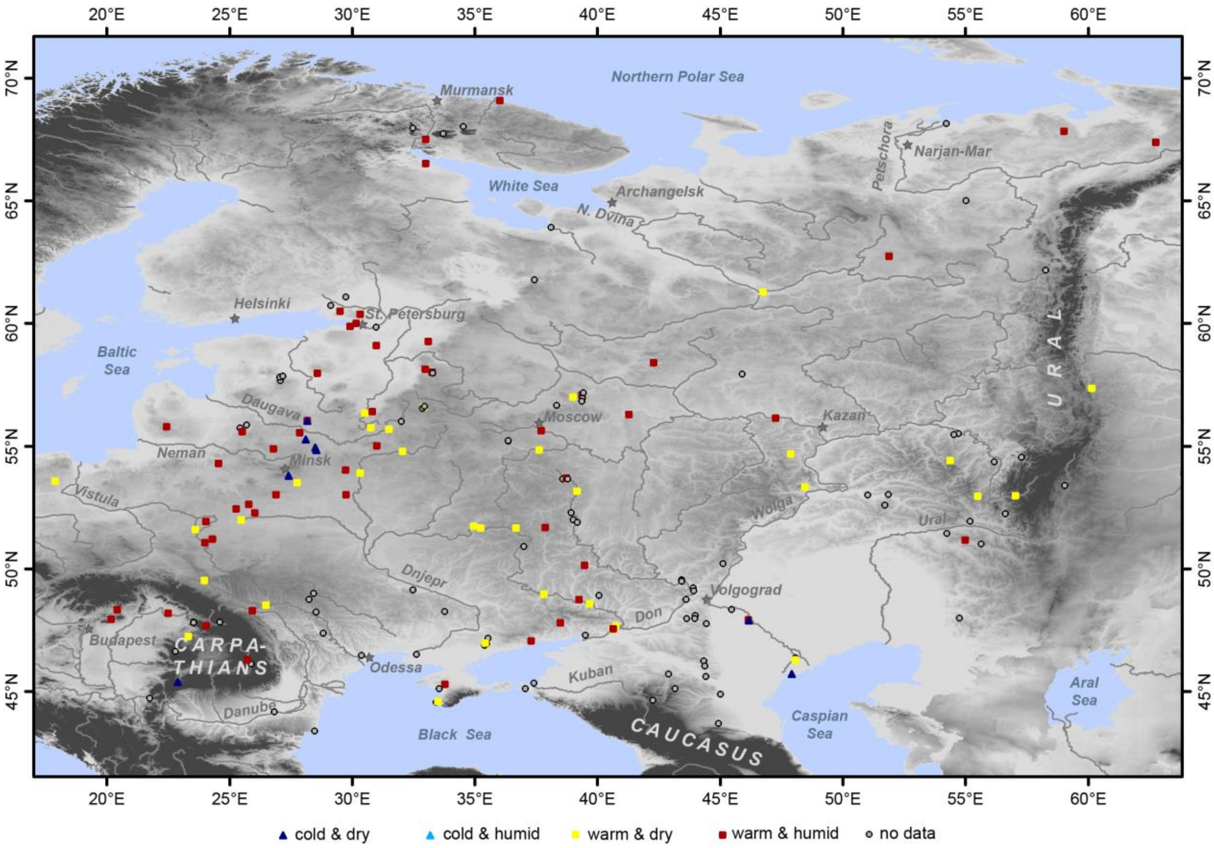
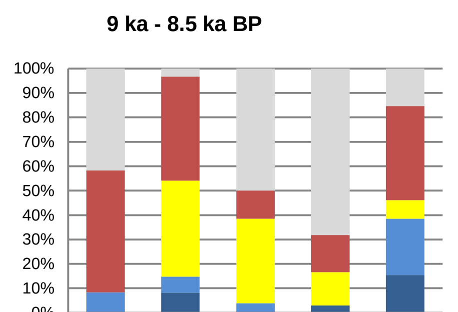


Figure 19.3: Palaeoclimate in Western Eurasia from 9 ka - 8.5 ka BP. Each dot marks a site corresponding to Figure 20.3 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	10	2	13	45	2
warm & humid	12	26	3	10	5
warm & dry	0	24	9	9	1
cold & humid	2	4	1	0	3
cold & dry	0	5	0	2	2

Figure 20.3: Palaeoclimate differentiated bylandscape zones from 9 ka – 8.5 ka BP.

During the Boreal period (*9 ka - 8.5 ka BP)* distincr warming occurred in all five zones while humidity was instable (Figure 20.3). Such climatic conditions were typical for zone IV (steppe zone), while inzone I (taiga zone) climate changed to “warm humid” condition. In zone II (mixed forest zone) “warm and humid” conditions predominated, though a “warmand dry” climate can be traced in many areas as well as a cold climate. In zone III (forest-steppe zone), a “warm and dry” climate dominated despite some locally occurring indicators for also increased humidity. In the zone V (Carpathian Mountains) a “warm and humid” climate continued almost the same amount of data is given on the cold climate with fluctuations in humidity.

5.3.2.1 Middle Holocene (8.5 ka - 8 ka BP)

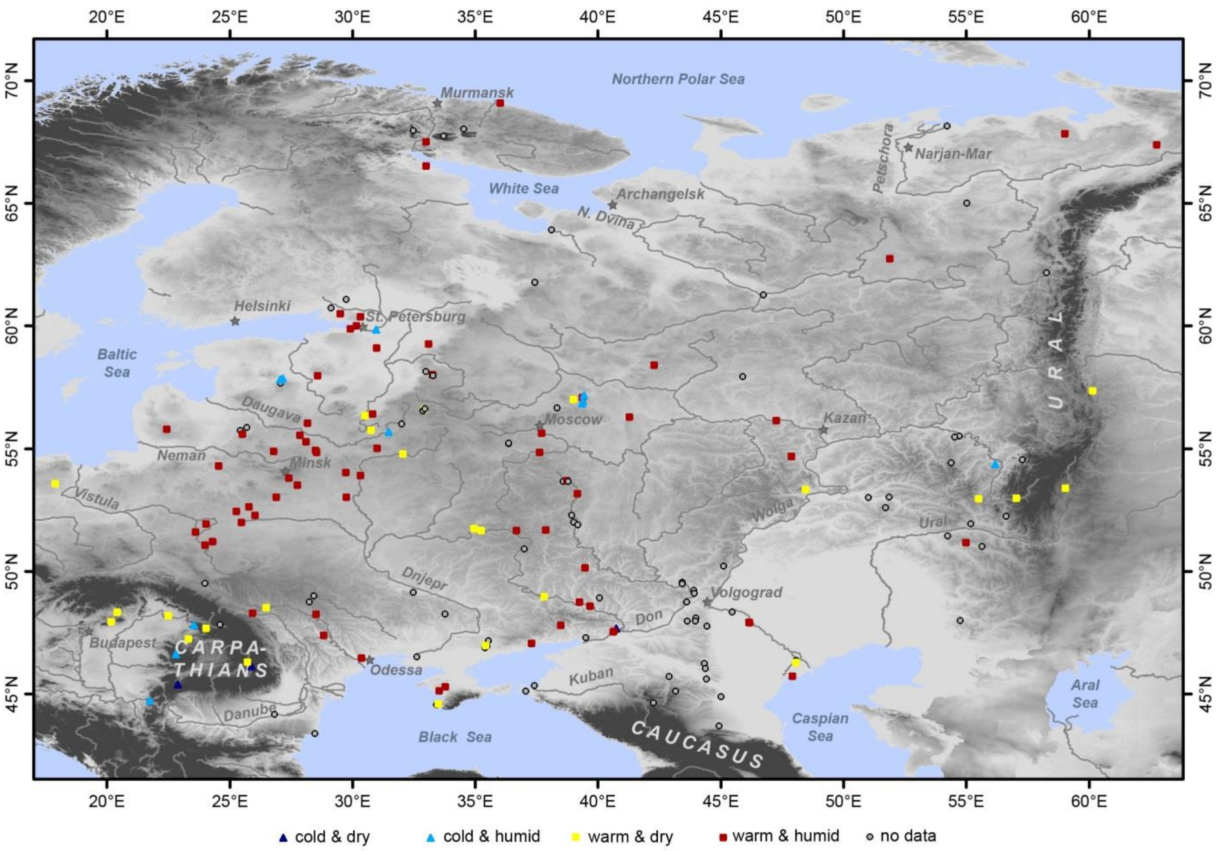
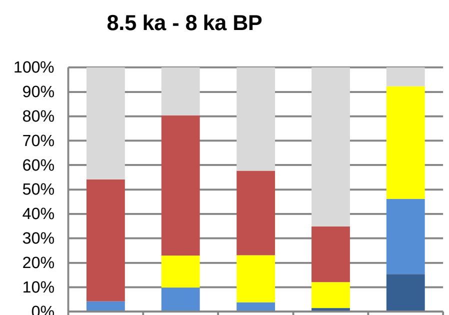


Figure 19.4: Palaeoclimate in Western Eurasia from 8.5 ka - 8 ka BP. Each dot marks a site corresponding to Figure 20.4 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	11	12	11	43	1
warm & humid	12	35	9	15	0
warm & dry	0	8	5	7	6
cold & humid	1	6	1	0	4
cold & dry	0	0	0	1	2

Figure 20.4: Palaeoclimate differentiated by landscape zones from 8.5 ka – 8 ka BP.

The transition from the Boreal period to the Atlantic took place around *8.5 ka - 8 ka BP*, by gradual changes of climatic conditions. Proxy data indicate for the zone I (taiga zone) that a relatively stable, warm climate prevailed. According to the map (Figure 19.4) glaciation did not occur in almost all five zones. A “warm and humid” climate with small fluctuations in humidity was practically settled in zones I (taiga zone), II (mixed forest zone) and zone IV (steppe zone). Fluctuations in humidity can be observed in zone III (forest-steppe zone) whereas in the zone V (Carpathian Mountains) parallel a “warm and dry” and cold climate began.

5.3.2.2 Middle Holocene (8 ka – 7.5 ka BP)

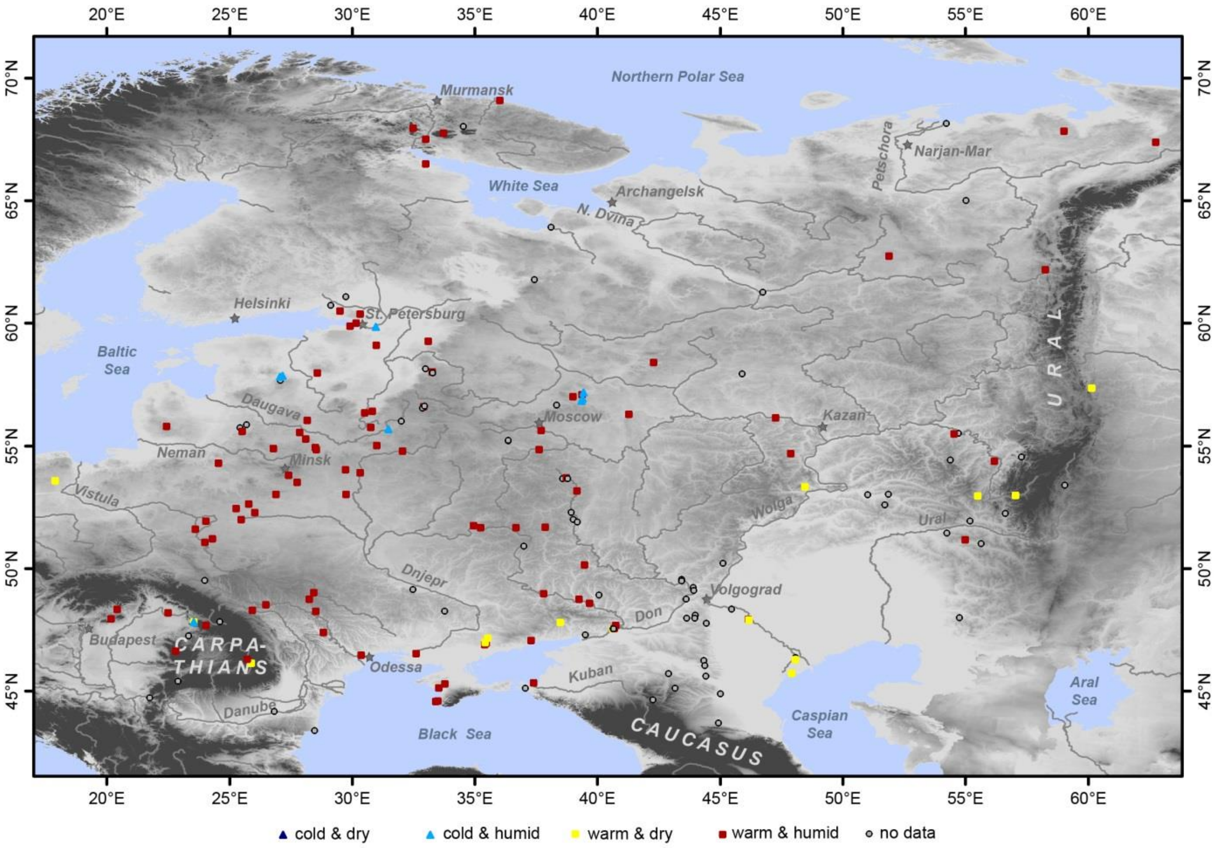
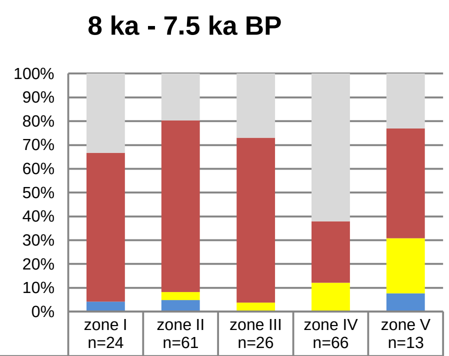


Figure 19.5: Palaeoclimate in Western Eurasia from 8 ka - 7.5 ka BP. Each dot marks a site corresponding to Figure 20.5 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	8	12	7	41	3
warm & humid	15	44	18	17	6
warm & dry	0	2	1	8	3
cold & humid	1	3	0	0	1
cold & dry	0	0	0	0	0

Figure 20.5: Palaeoclimate differentiated by landscape zones from 8 ka – 7.5 ka BP.

In the early Atlantic period *8ka - 7.5ka BP* (Figure 19.5 and 20.5) show that an unambiguously “warm and humid” climate prevailedin the zone taiga. Beginning from the Middle Holocene data about other climatic conditions were tlack-in the taiga zone climate stayed more or less stable until present. In zone II (mixed forest) “warm and humid” climatic conditions existed although there occur, some proxy data indicating a “cold and humid” climate. In zones III (forest-steppe) and IV (steppe) the climate is supposed to be “warm and humid” though a small amount of data exists indicating humidity fluctuations. In zone the warm climate with slight humidity fluctuations can be observed as well observed as well as locally some cold condition

5.3.2.3 Middle Holocene (7.5 ka – 7 ka BP)

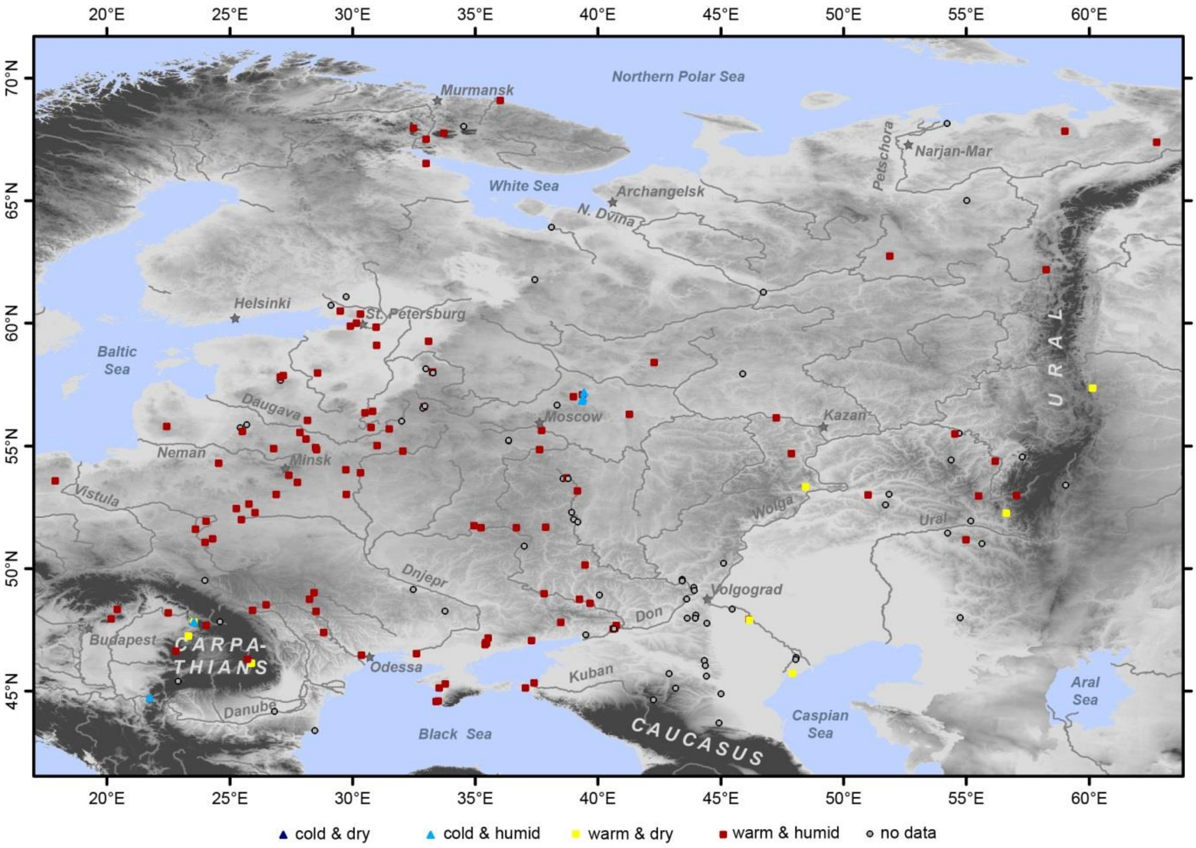
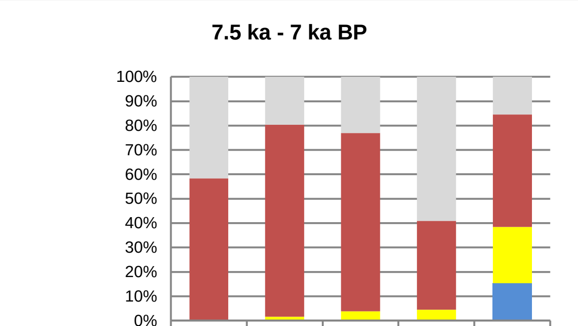


Figure 19.6: Palaeoclimate in Western Eurasia from 7.5 ka – 7 ka BP. Each dot marks a site corresponding to Figure 20.6 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	10	12	6	39	2
warm & humid	14	48	19	24	6
warm & dry	0	1	1	3	3
cold & humid	0	0	0	0	2
cold & dry	0	0	0	0	0

Figure 20.6: Palaeoclimate differentiated by landscape zones from 7.5 ka – 7 ka BP.

During the middle Atlantic period (*7.5 ka - 7 ka BP)* a warm climate prevailed, (Figure 19.6). Figure 20.6 shows that in zone I (taiga zone) an unambiguously “warm and humid” climate existed as before. It is exactly this time that is regarded as the most humid period during the Atlantic in zones II (mixed forest zone) and III (forest-steppe zone). In zones IV (steppe zone) and V (Carpathian Mountains) the climate also remained “warm and humid”, although slight humidity fluctuations can also be observed. Beginning from 7.5 ka BP, any information indicating a “cold and dry” climate lack for all five zones.

5.3.2.4 Middle Holocene (7 ka – 6.5 ka BP)

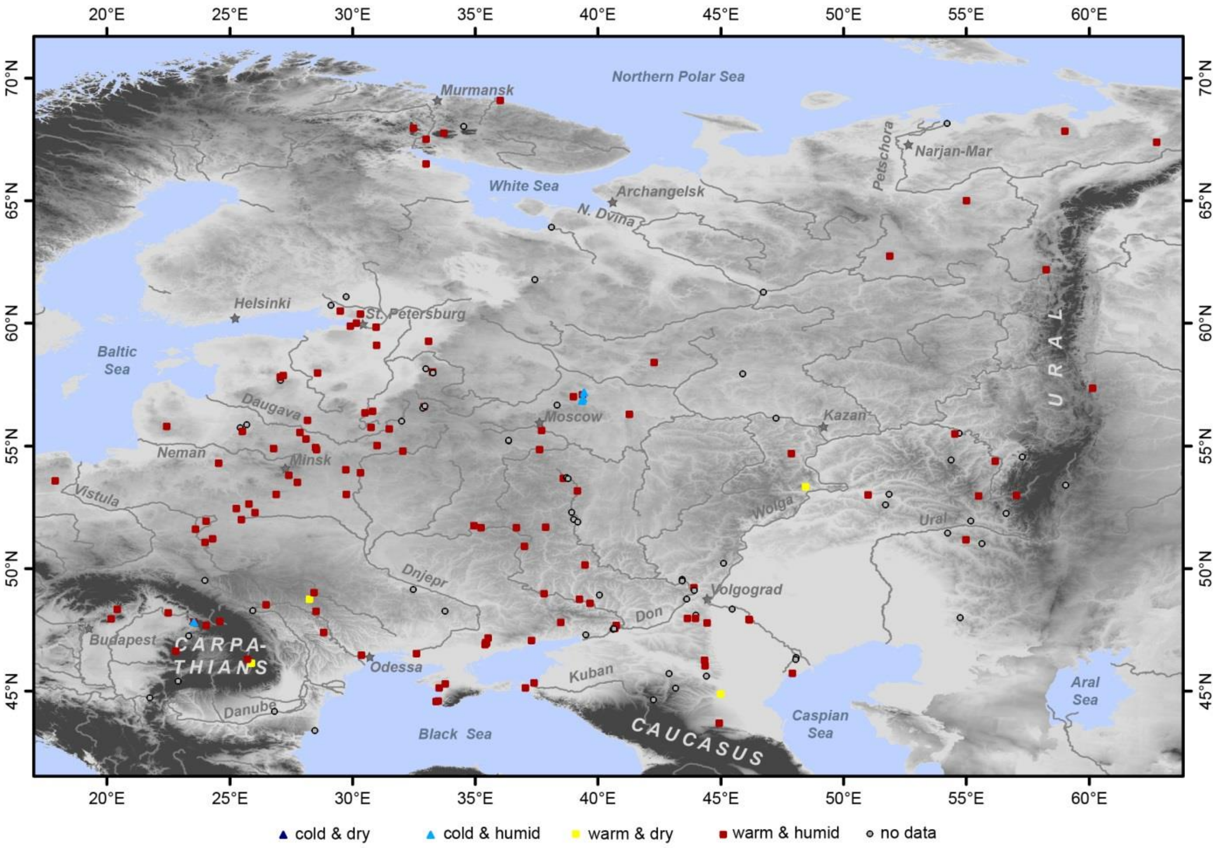
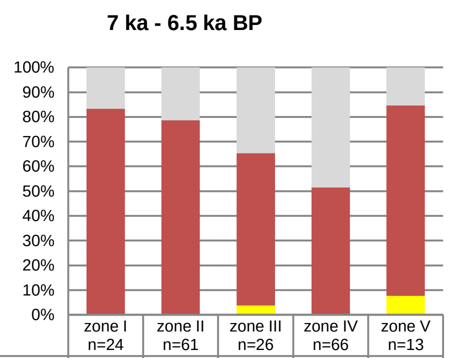


Figure 19.7: Palaeoclimate in Western Eurasia from 7 ka – 6.5 ka BP. Each dot marks a site corresponding to Figure 20.7 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info	4	13	9	32	2
warm & humid	20	48	16	34	10
warm & dry	0	0	1	0	1
cold & humid	0	0	0	0	0
cold & dry	0	0	0	0	0

Figure 20.7: Palaeoclimate differentiated by landscape zones from 7 ka – 6.5 ka BP.

During late Atlantic period (*7 ka - 6.5 ka BP)* histograms document that this period is characterized by maximum temperatures across all five zones (Figure 19.7, Figure 20 7). Data analysis document that the extremes of “warm and humid” climatic conditions in Western Eurasia can be dated to this time (7.0-6.5 ka BP), which is evident for the optimal Holocene climate conditions. There do not occur any indications for cold climate conditions in any of the zones examined

5.3.2.5 Middle Holocene (6.5 ka – 6 ka BP)

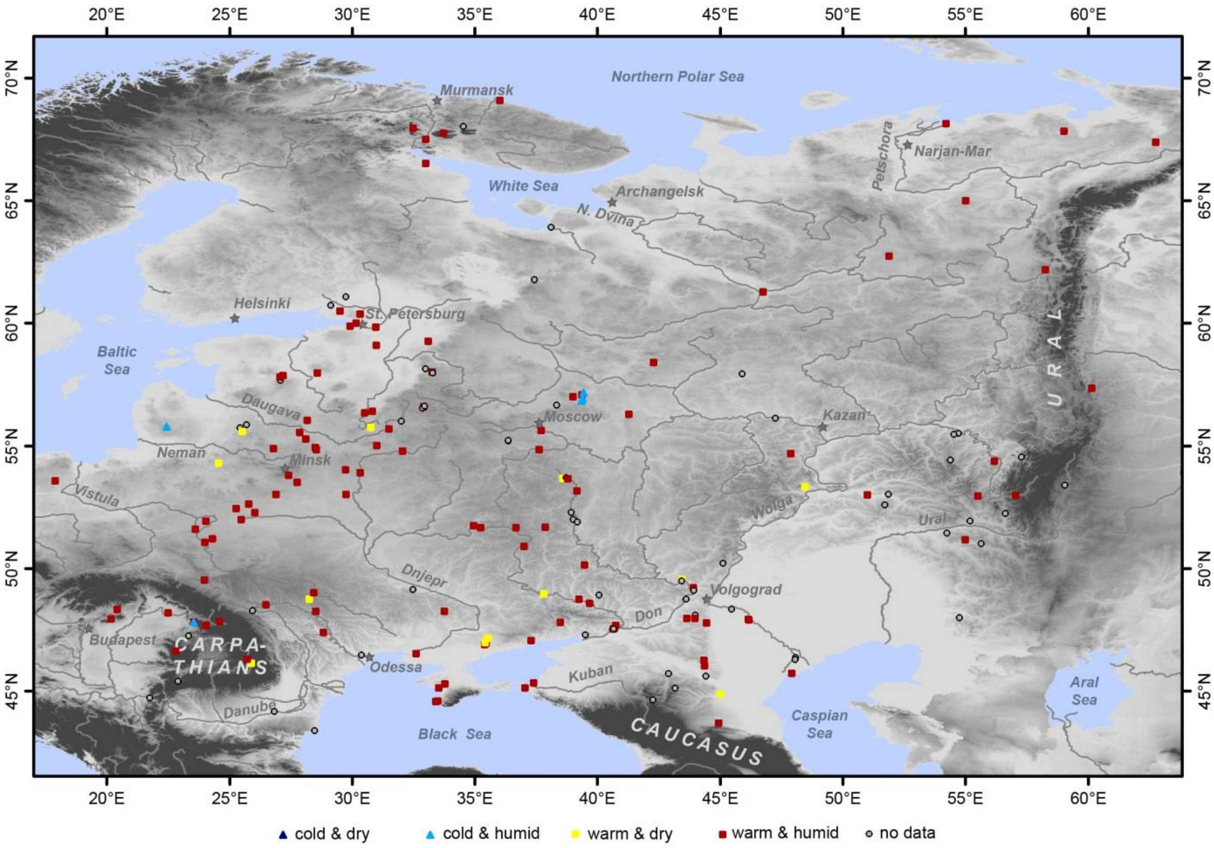
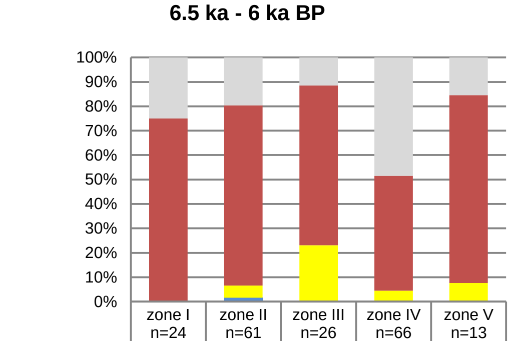


Figure 19.8: Palaeoclimate in Western Eurasia from 6.5 ka – 6 ka BP. Each dot marks a site corresponding to Figure 20.8 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	6	12	3	32	2
warm & humid	18	45	17	31	10
warm & dry	0	3	6	3	1
cold & humid	0	1	0	0	0
cold & dry	0	0	0	0	0

Figure 20.8: Palaeoclimate differentiated by landscape zones from 6.5 ka – 6 ka BP.

During the late Atlantic period (*6.5 ka - 6 ka BP)* a stable, warm climate continued. Proxy data (Figure 19.8), document the on going "warm and humid" climatic conditions in all five zones, despite the existence of some proxy data indicating humidity fluctuations. Figure 20.8, shows that in zone I (taiga zone) a "warm and humid" climate continued; data suggesting "cold and dry" climatic conditions are still absent for this period. The same situation is observed for zones III (forest-steppe zone) and IV (steppe zone).

5.3.2.6 Middle Holocene (6 ka – 5.5 ka BP)

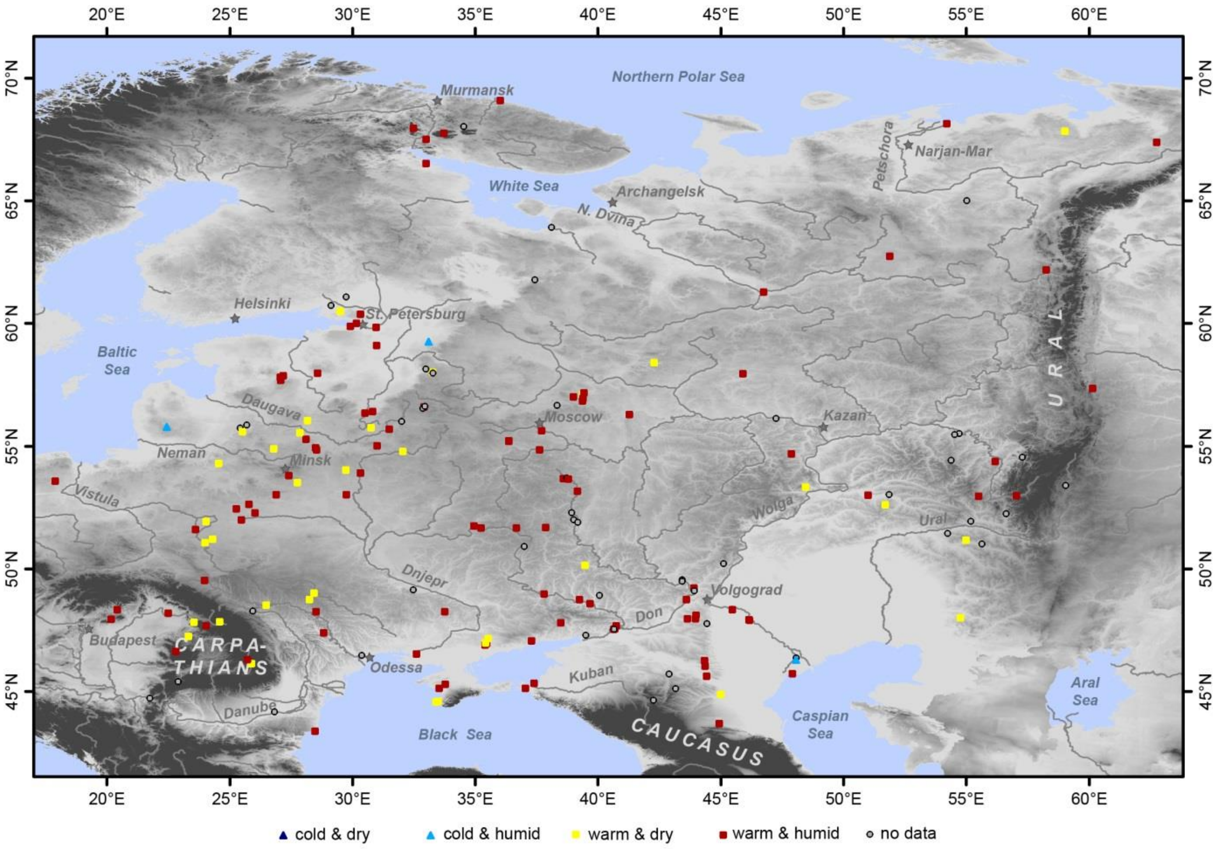
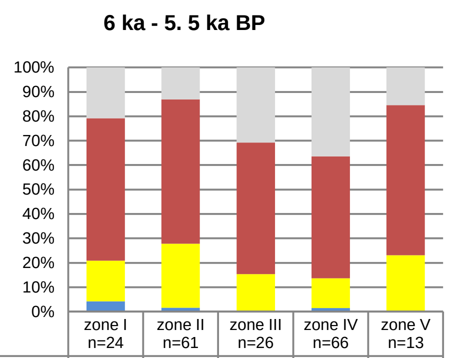


Figure 19.9: Palaeoclimate in Western Eurasia from 6 ka – 5.5 ka BP. Each dot marks a site corresponding to Figure 20.9 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	5	8	8	24	2
warm & humid	14	36	14	33	8
warm & dry	4	16	4	8	3
cold & humid	1	1	0	1	0
cold & dry	0	0	0	0	0

Figure 20.9: Palaeoclimate differentiated by landscape zones from 6 ka – 5.5 ka BP.

For the transition from Atlantic to Subboreal (*6 ka - 5.5 ka BP)* the palaeoclimatic map (Figure 19.9), shows significant climate changes. Figure 20.9 documents that climate changes predominantly occurred as fluctuations in humidity. Proxydata suggest that “cold and humid” or “cold and dry” climatic conditions are absent, in zones I (taiga zone), zone III (forest-steppe zone), and zone V (Carpathian Mountains). In zone II (mixed forest zone) and IV (steppe zone) humidity fluctuations can be traced, and as in the other three zones “cold and dry” climatic conditions are absent but “cold and humid” climatic conditions can be viewed locally in each of the zones.

5.3.2.7 Middle Holocene (5.5 ka – 5 ka BP)

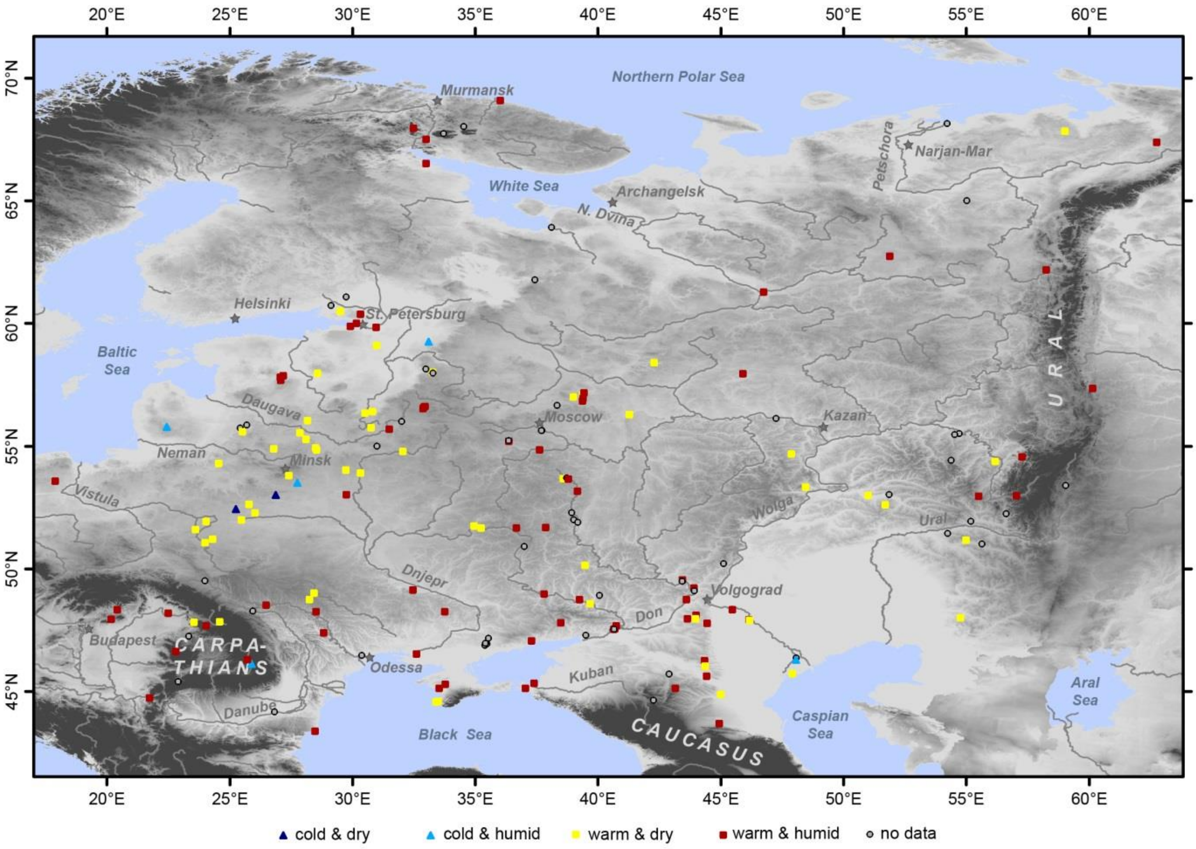
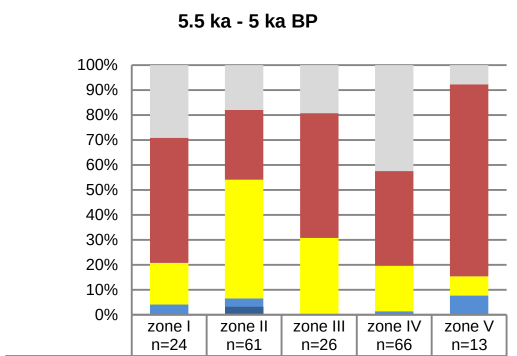


Figure 19.10: Palaeoclimate in Western Eurasia from 5.5 ka – 5 ka BP. Each dot marks a site corresponding to Figure 20.10 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	7	11	5	28	1
warm & humid	12	17	13	25	10
warm & dry	4	29	8	12	1
cold & humid	1	2	0	1	1
cold & dry	0	2	0	0	0

Figure 20.10: Palaeoclimate differentiated by landscape zones from 5.5 ka – 5 ka BP.

The early Subboreal period began in the interval *5.5 ka - 5 ka BP* in Figure 19.10 significant climate changes can be seen in the zone II (mixed forest). Data Figure 20.10 an overall abrupt climate change.In zone II (mixed forest zone) the climate became rapidly “warm and dry”. In zone IV (forest-steppe zone) humidity fluctuations occure while still cold conditions are lacking. In zones I (taiga zone), IV (steppe zone) and V (Carpathian Mountains) where “warm and humid” climatic conditions still prevailed.

5.3.2.8 MiddleHolocene (5 ka – 4.5 kaBP)

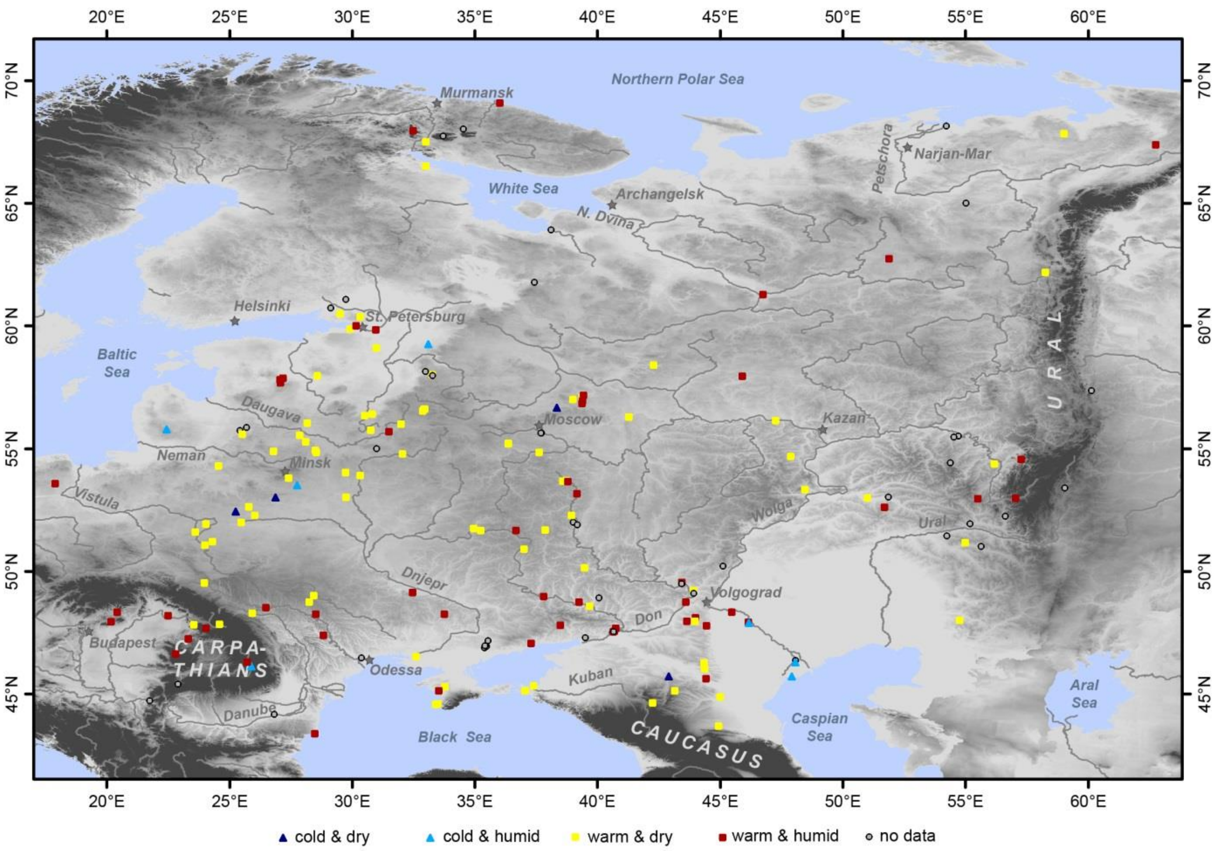
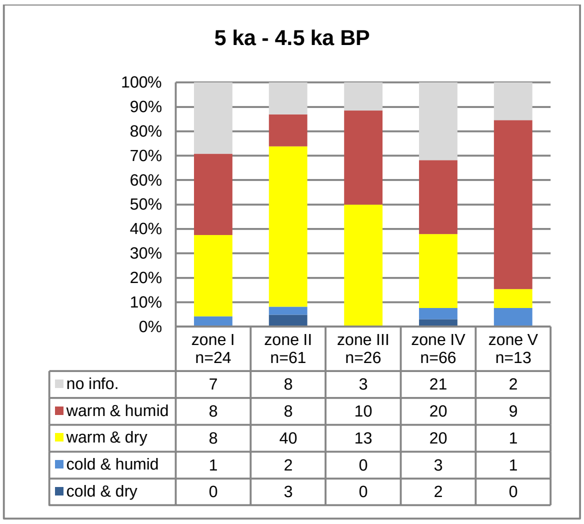


Figure 19.11: Palaeoclimate in Western Eurasia from 5 ka – 4.5 ka BP. Each dot marks a site corresponding to Figure 20.11 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	7	8	3	21	2
warm & humid	8	8	10	20	9
warm & dry	8	40	13	20	1
cold & humid	1	2	0	3	1
cold & dry	0	3	0	2	0

Figure 20.11: Palaeoclimate differentiated by landscape zones from 5 ka – 4.5 ka BP.

Between *5 ka - 4.5 ka BP* abrupt humidity fluctuations occurred, this is especially distinctive for zones II and IV. The data in Figure 20.11 demonstrate that the climate changed from “warmand humid” to “warmand dry” in zone I (taiga zone). In zone II (mixed forest zone) a “warm and dry” climate dominated despite some data suggest a “warm and humid” climate; cooling can already be traced for this period at several sites of this zone. A warm climate was developing in zone III (forest-steppe zone) underthe presence of humidity fluctuations. In zone IV (steppe zone) “warm and dry” climatic conditions dominated.In zone V (Carpathian Mountains) a “warm and humid” climate still prevailed

5.3.2.9 Middle Holocene (4.5 ka – 4 ka BP)

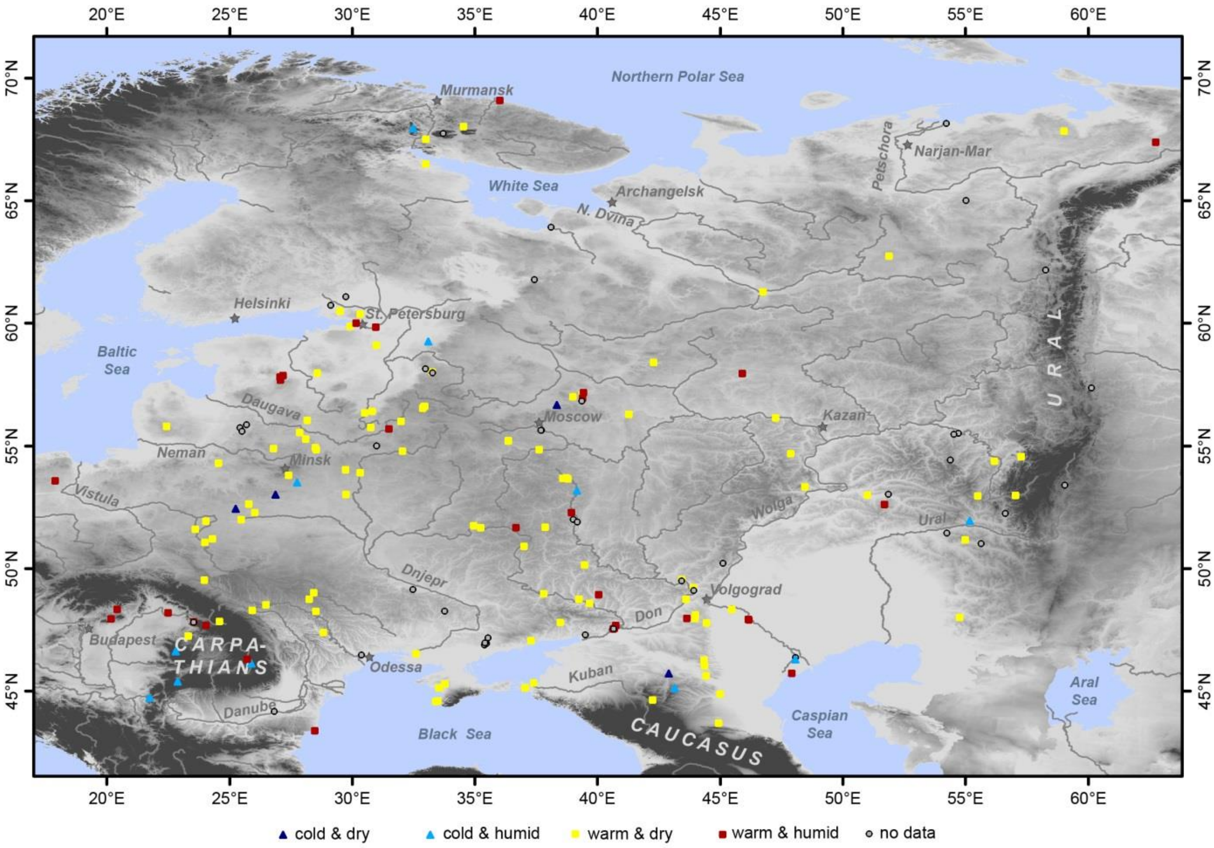
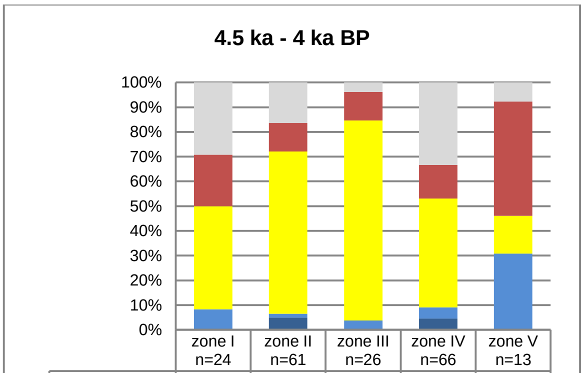


Figure 19.12: Palaeoclimate in Western Eurasia from 4.5 ka – 4 ka BP. Each dot marks a site corresponding to Figure 20.12 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	7	10	1	22	1
warm & humid	5	7	3	9	6
warm & dry	10	40	21	29	2
cold & humid	2	1	1	3	4
cold & dry	0	3	0	3	0

Figure 20.12: Palaeoclimate differentiated by landscape zones from 4.5 ka – 4 ka BP.

The data in Figure 20.12 indicate that in the middle Subboreal period (*4.5 ka - 4 ka BP)* “warm and dry” climate began; this is also documented on the palaeoclimatic map (Figure 19.12) “warm and dry” climatic conditions dominated in zones II (mixed forest zone), III (forest-steppe zone) and IV (steppe zone). Arid conditions locally can be observed in zone I (taiga zone). Despite widespread arid conditions, a “warm and humid” climate still prevailed in the zone VI Carpathian Mountains.

5.3.2.10 Middle Holocene (4 ka – 3.5 ka BP)

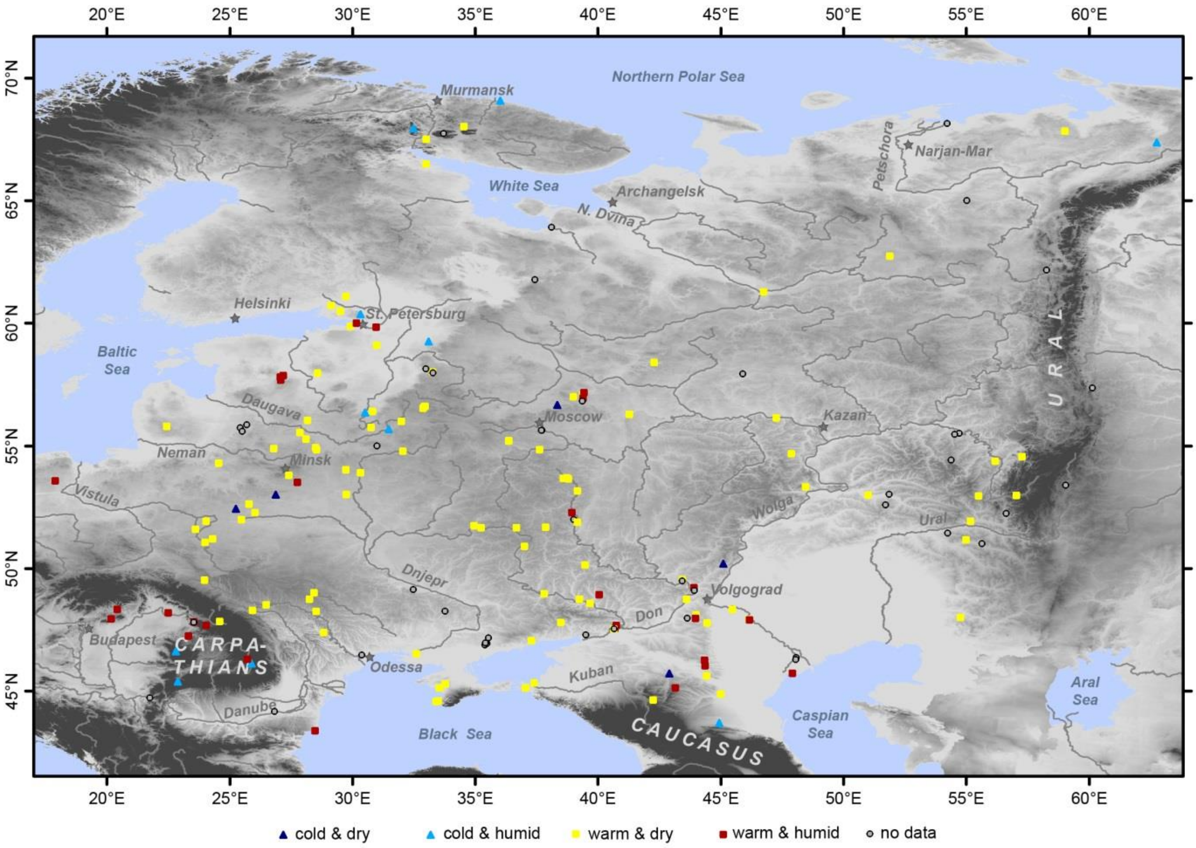
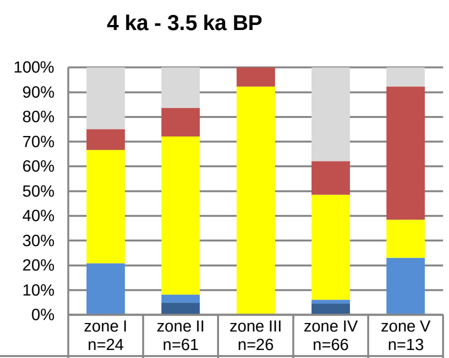


Figure 19.13: Palaeoclimate in Western Eurasia from 4 ka – 3.5 ka BP. Each dot marks a site corresponding to Figure 20.13 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	6	10	0	25	1
warm & humid	2	7	2	9	7
warm & dry	11	39	24	28	2
cold & humid	5	2	0	1	3
cold & dry	0	3	0	3	0

Figure 20.13: Palaeoclimate differentiated by landscape zones from 4 ka – 3.5 ka BP.

During *4 ka - 3.5 ka BP*, the beginning of the late Subboreal period, the climate became “warm and dry” in almost all zones. Except zone V (Carpathian Mountains), as indicated by palaeoclimatic map in Figure 19.13 shows aberrations from this trend. The data in Figure 20.13 shows that in zones I (taiga zone), II (mixed forest zone), III (forest-steppe zone) and IV (steppe zone), crucial climate conditions began when the climate reached its “warm and dry” extremes. The so called "xerothermic" period started, which was characterized by a “warm and dry” climate. The climate in zone V (Carpathian Mountains) was, as before, contrary to common patterns and was changing to “warm and humid”.

5.3.2.11 Middle Holocene (3.5 ka – 3 ka BP)

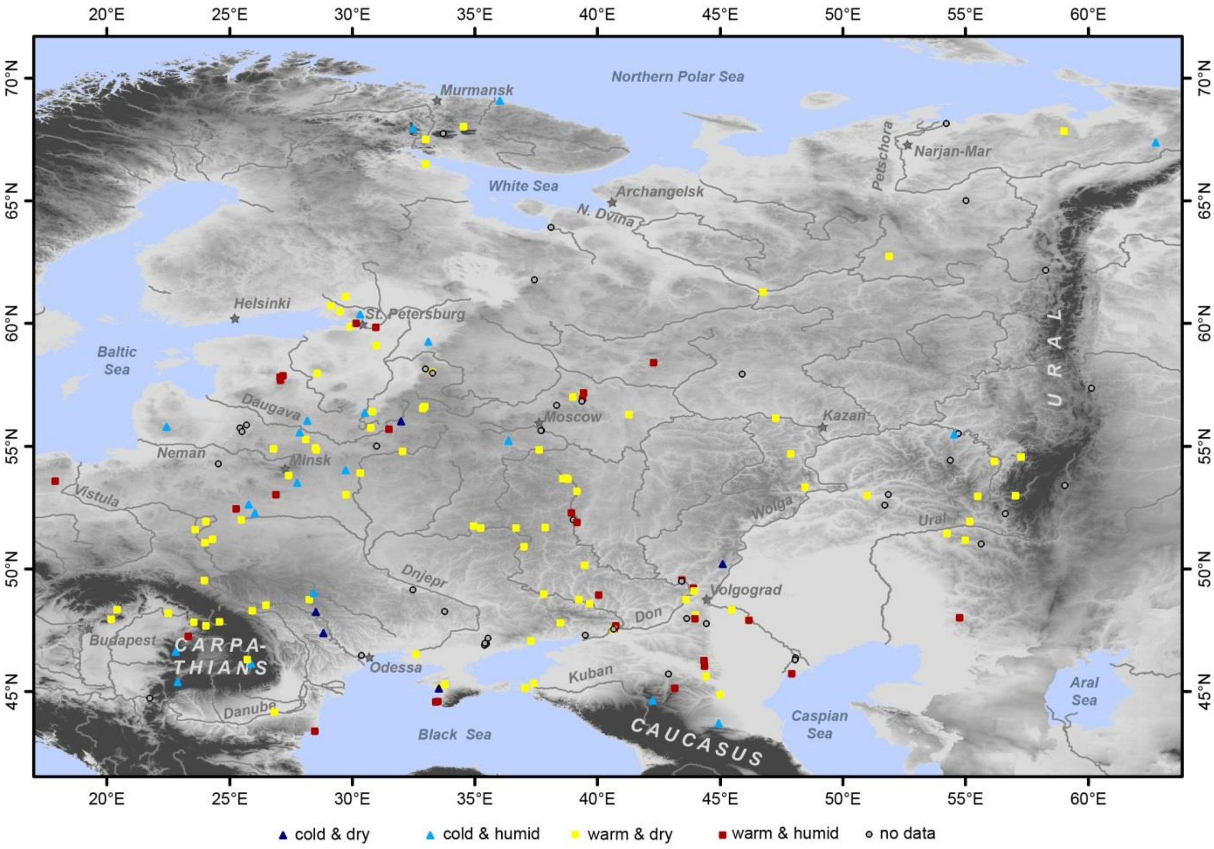
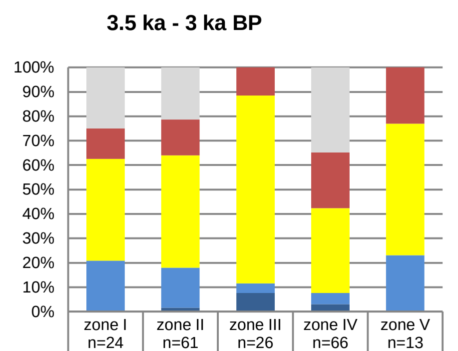


Figure 19.14: Palaeoclimate in Western Eurasia from 3.5 ka – 3 ka BP. Each dot marks a site corresponding to Figure 20.14 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	6	13	0	23	0
warm & humid	3	9	3	15	3
warm & dry	10	28	20	23	7
cold & humid	5	10	1	3	3
cold & dry	0	1	2	2	0

Figure 20.14: Palaeoclimate differentiated by landscape zones from 3.5 ka – 3 ka BP.

The period *3.5 ka – 3 ka BP* is characterized by the process of non-simultaneous climatic changes, when in different zones different climatic fluctuations can be observed. In Figure 20.14 documents that a warm climate dominated in zone I (taiga), but despite this the amount of data indicating a “cold and humid” climate increased. The increase in data suggesting a “cold and humid” climate can be noticed for zone II (mixed forest), although a warm climate with humidity fluctuations still dominated. In the zone III (forest-steppe) dominated “warm and dry” conditions.The climate in zone IV (steppe) remained warm with slight humidity fluctuations, and in zone V (Carpathian) the climate became “warm and dry”

5.3.3.1 Late Holocene (3 ka – 2.5 ka BP)

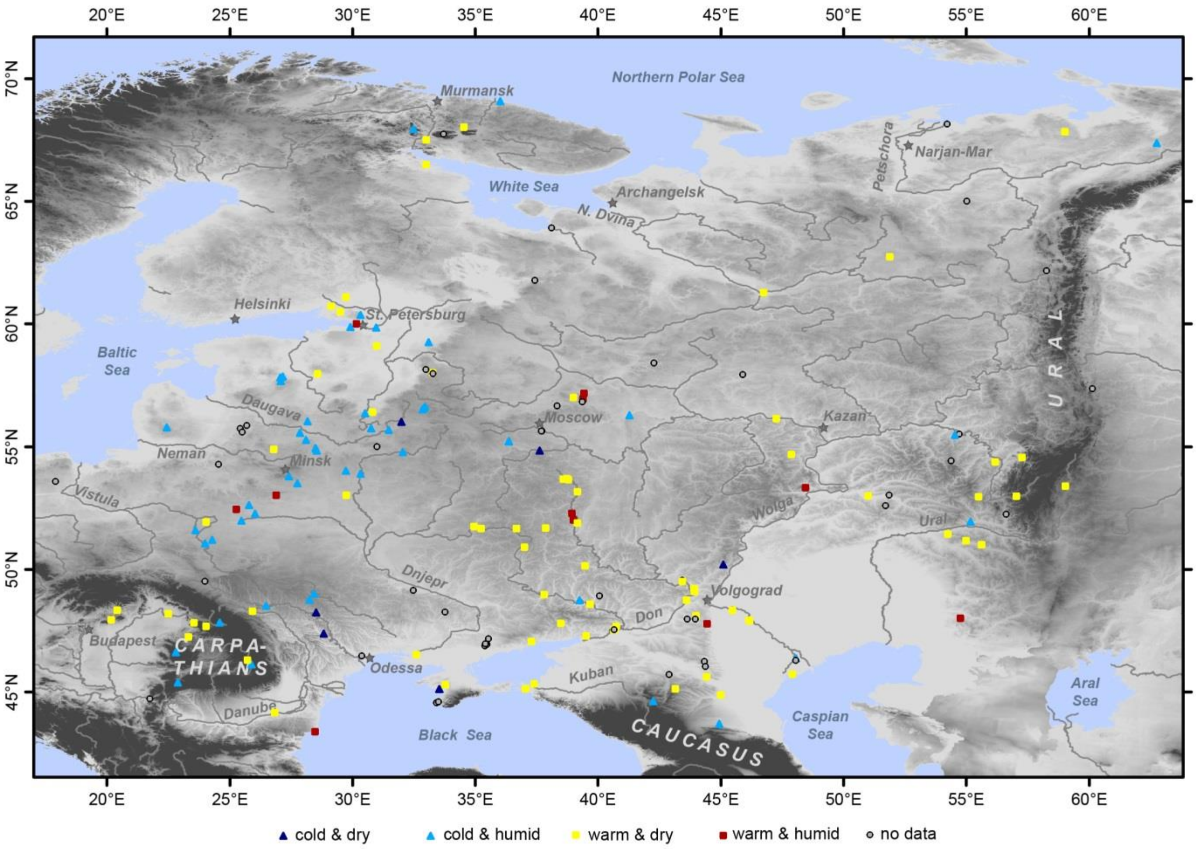
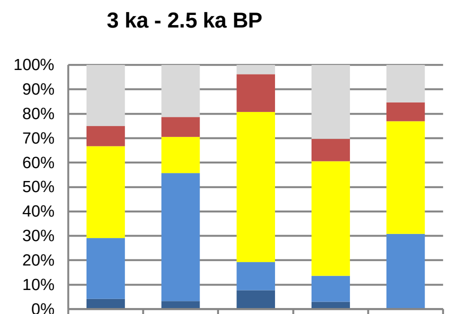


Figure 19.15: Palaeoclimate in Western Eurasia from 3 ka – 2.5 ka BP. Each dot marks a site corresponding to Figure 20.15 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	6	13	1	20	2
warm & humid	2	5	4	6	1
warm & dry	9	9	16	31	6
cold & humid	6	32	3	7	4
cold & dry	1	2	2	2	0

Figure 20.15: Palaeoclimate differentiated by landscape zones from 3 ka – 2.5 ka BP.

The time interval *3 ka - 2.5 ka BP* corresponds to the transition from the Subboreal to the Subatlantic period. Change of climatic conditions can be clearly observed on palaeoclimatic map (Figure 19.15), mainly in zones I and II. The data in Figure 20.15 indicate that extremely slight climatic fluctuations between "warm and dry" and "cold and humid"doccurred in zone I (taiga zone). A "cold and humid" climate developed in zone II (mixed forest zone). Climate remained "warm and dry" in zones III (forest-steppe zone) and IV (steppe zone); in both zones also increrasingly sites with "cold and humid" climatic conditions can be observed. In zone V (Carpathian Mountains) a "warm and dry"climate dominated.

5.3.3.2 Late Holocene (2.5 ka – 2 ka BP)

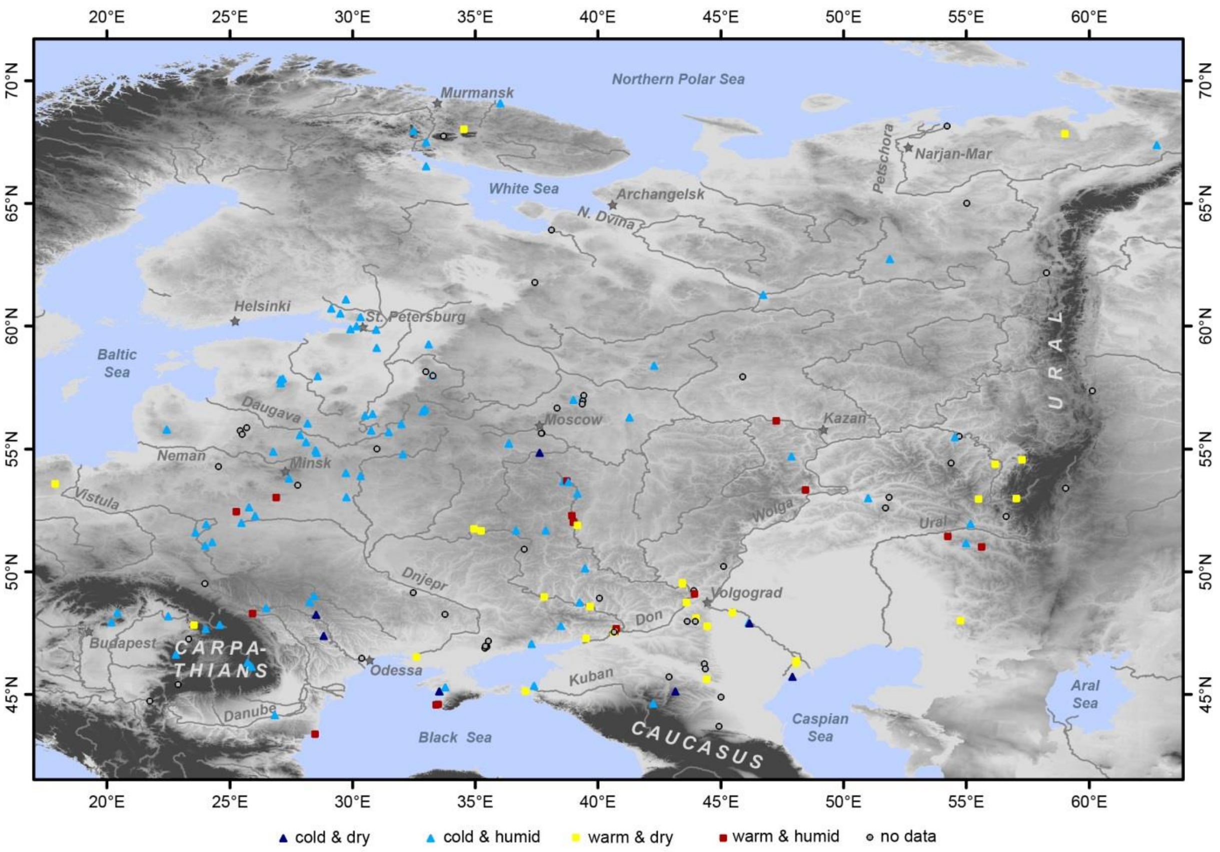
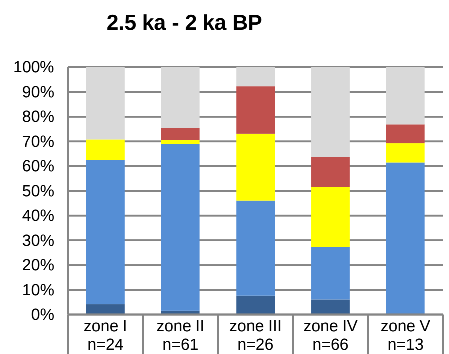


Figure 19.16: Palaeoclimate in Western Eurasia from 2.5 ka – 2 ka BP. Each dot marks a site corresponding to Figure 20.16 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	7	15	2	24	3
warm & humid	0	3	5	8	1
warm & dry	2	1	7	16	1
cold & humid	14	41	10	14	8
cold & dry	1	1	2	4	0

Figure 20.16: Palaeoclimate differentiated by landscape zones from 2.5 ka – 2 ka BP.

Figure 19.16 documents the further development of a cold climate from *2.5 ка - 2 ка BP* (early Subatlantic period) across almost all five zones. Figure 20.16 testifies that in zones I (taiga zone) and II (mixed forest zone), "cold and humid" climatic conditions began. The climate became "cold and humid" in zone III (forest-steppe zone), though there is alsoa large number of data indicating a "warm and dry" climate. Considerable climatic fluctuations can be observed for zone IV (steppe zone): a "warm and dry" climate prevailed here but a "cold and humid" climate developed concurrently. In zone V (Carpathian Mountains) a "cold and humid" climate dominated.

5.3.3.3 Late Holocene (2 ka – 1.5 ka BP)

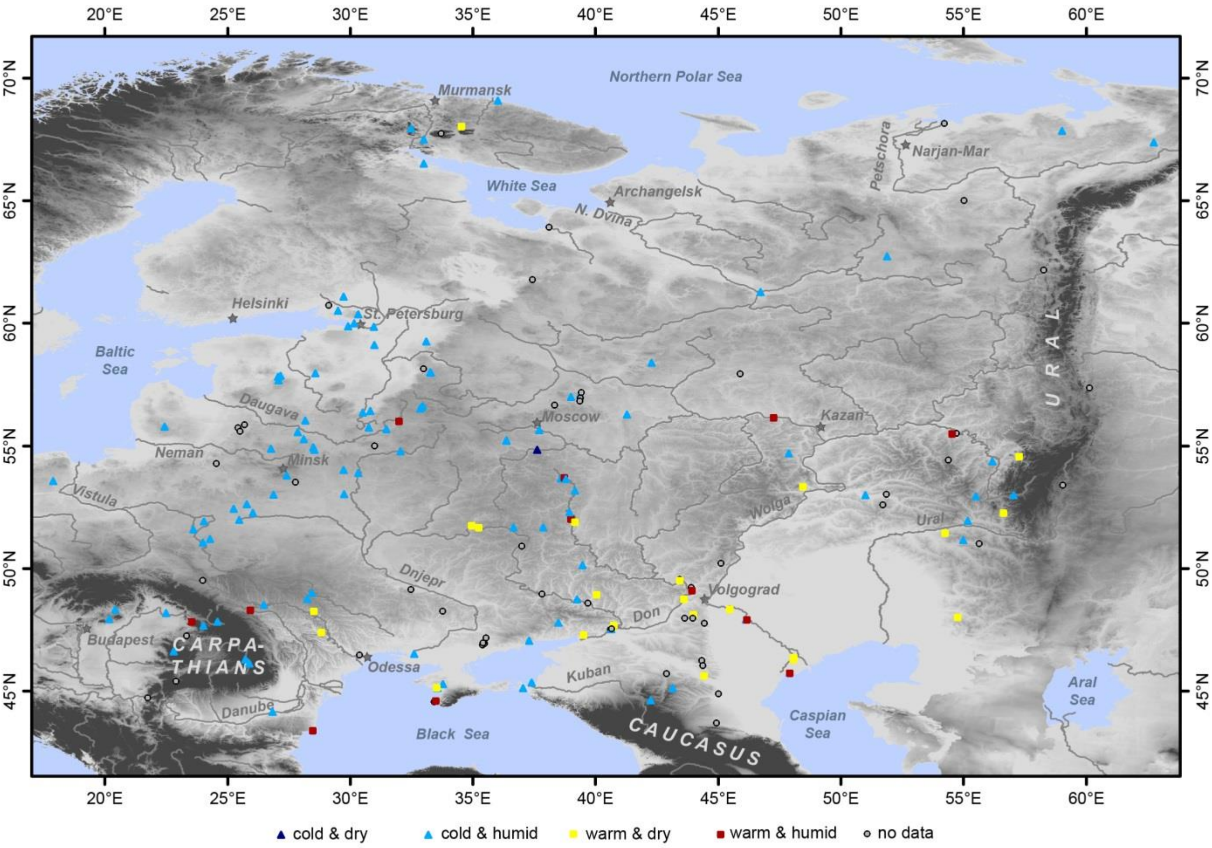
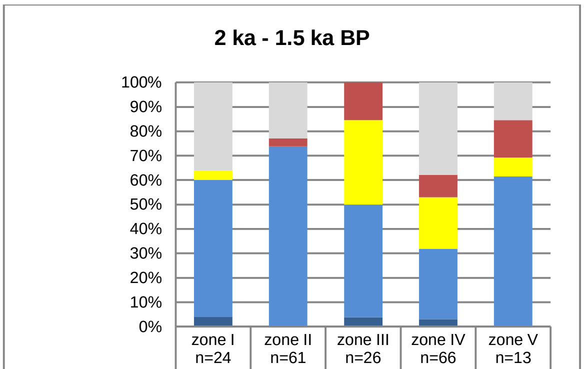


Figure 19.17: Palaeoclimate in Western Eurasia from 2 ka – 1.5 ka BP. Each dot marks a site corresponding to Figure 20.17 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	9	14	0	25	2
warm & humid	0	2	4	6	2
warm & dry	1	0	9	14	1
cold & humid	14	45	12	19	8
cold & dry	1	0	1	2	0

Figure 20.17: Palaeoclimate differentiated by landscape zones from 2 ka – 1.5 ka BP.

From *2 ka - 1.5 ka BP* corresponding to the Subatlantic period, a cold climatic conditions occurred almost all over Western Eurasia (Figure 19.17). Figure 20.17 testifies that in zones I (taiga zone), II (mixed forest zone) and V (Carpathian Mountains) a “cold and humid” climate entirely dominated. The increase of “cold and humid” climatic conditions can be traced in zone III (forest-steppe zone), although a “warm and dry” climate persevered to a certain extent at several sites. Trends of warming and cooling developed simultaneously, and humidity fluctuations can be observed for zone IV (steppe zone)

5.3.3.4 Late Holocene (1.5 ka – 1 ka BP)

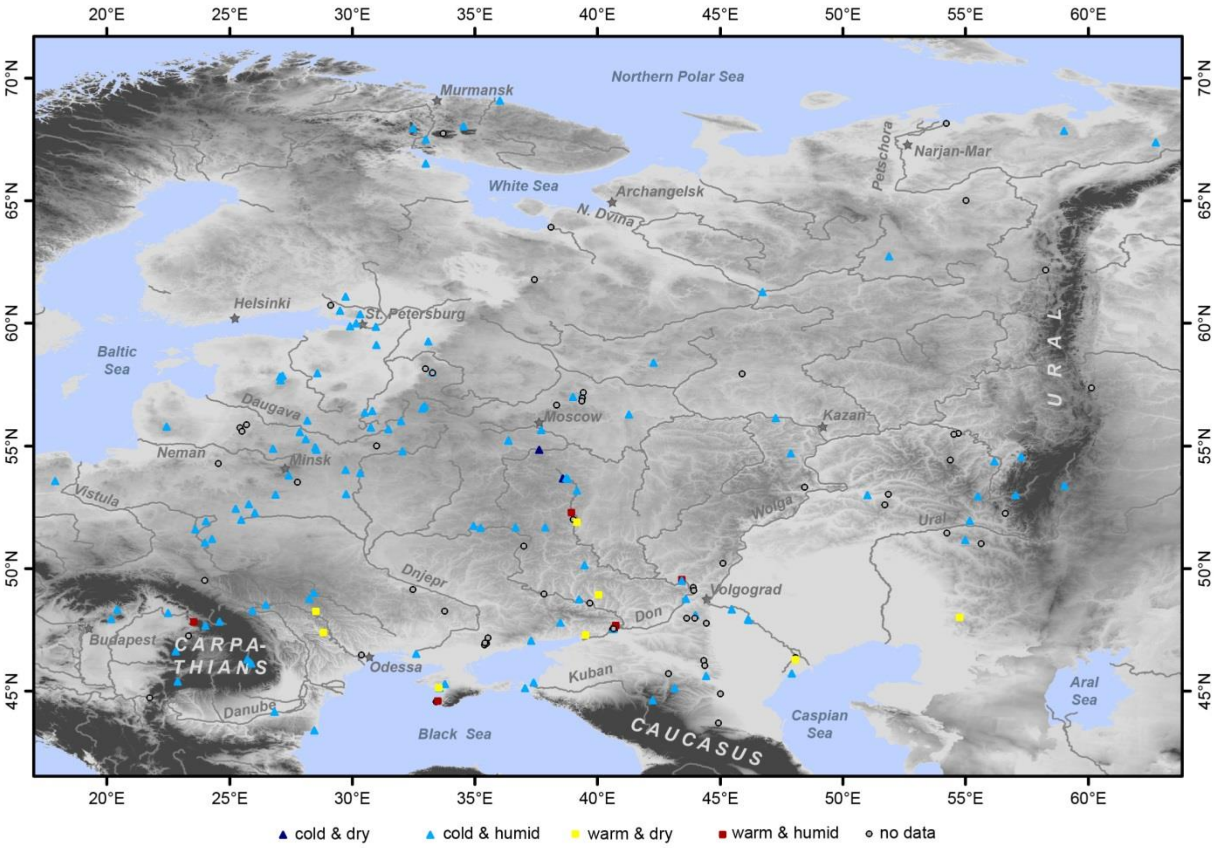
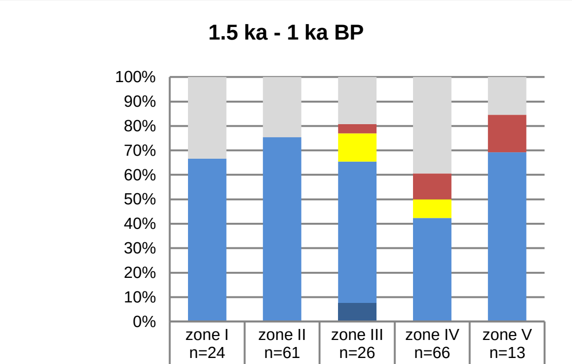


Figure 19.18: Palaeoclimate in Western Eurasia from 1.5 ka – 1 ka BP. Each dot marks a site corresponding to Figure 20.18 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	8	15	5	26	2
warm & humid	0	0	1	7	2
warm & dry	0	0	3	5	0
cold & humid	16	46	15	28	9
cold & dry	0	0	2	0	0

Figure 20.18: Palaeoclimate differentiated by landscape zones from 1.5 ka – 1 ka BP.

A “cold and humid” climate occurred from *1.5 ka - 1 ka BP* (the beginning of the late Subatlantic period) in zones I (taiga zone), II (mixed forest zone) and V (Carpathian Mountains). Though a “cold and humid” climate dominated in zones III (forest-steppe zone) and IV (steppe zone), small and isolated indications of “warm and humid” climatic fluctuations can also be seen (Figure 20.18)

5.3.3.5 Late Holocene (1 ka – 0.5 ka BP)

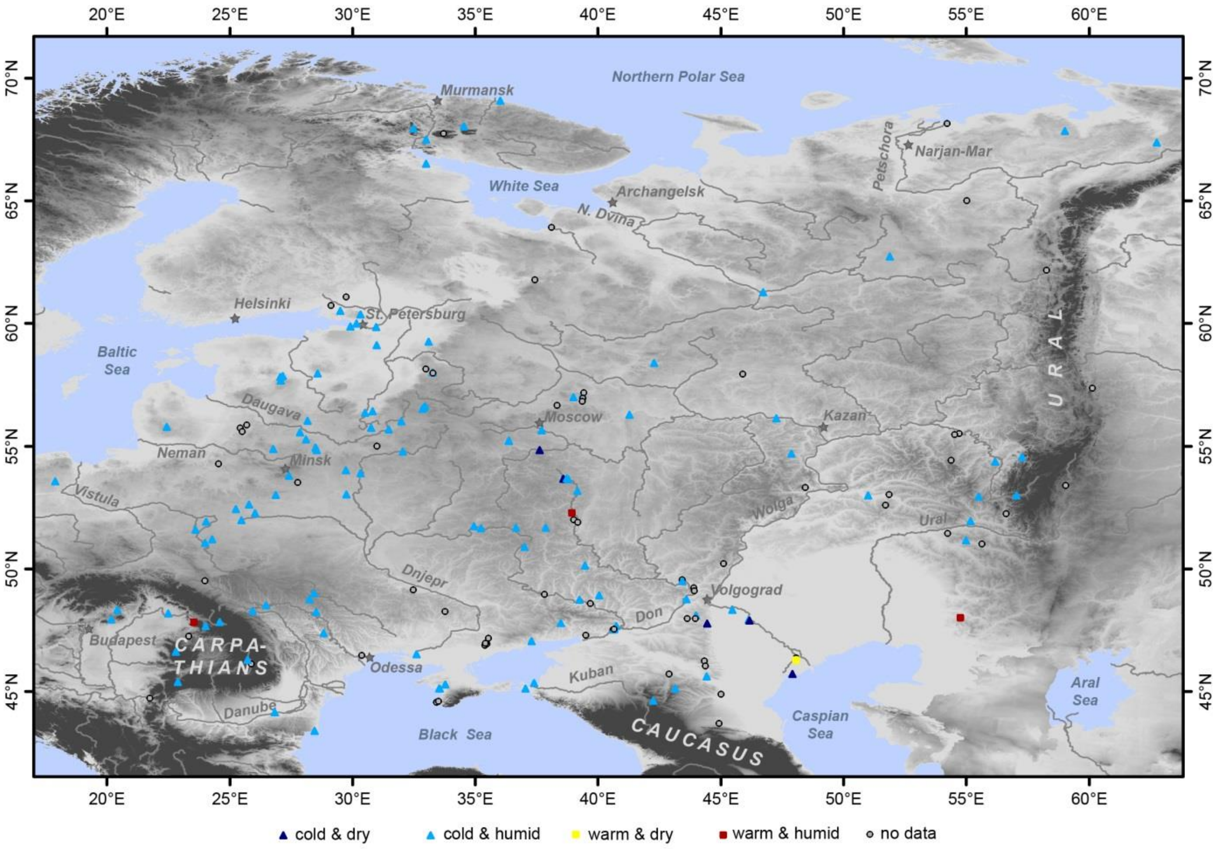
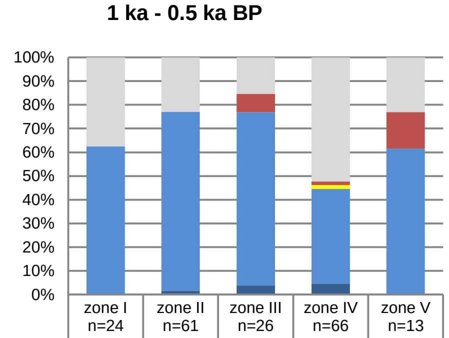


Figure 19.19: Palaeoclimate in Western Eurasia from 1 ka – 0.5 ka BP. Each dot marks a site corresponding to Figure 20.19 (Bostonalieva, 2013 and data source Table 6)



	zone I n=24	zone II n=61	zone III n=26	zone IV n=66	zone V n=13
no info.	9	14	4	34	3
warm & humid	0	0	2	1	2
warm & dry	0	0	0	1	0
cold & humid	15	46	19	26	8
cold & dry	0	1	1	3	0

Figure 20.19: Palaeoclimate differentiated by landscape zones from 1 ka – 0.5 ka BP.

The end of the late Subatlantic period *1 ka - 0.5 ka BP* is characterized by a “cold and humid” climate across all five zones, (Figure 19.19). Figure 20.19 shows that “cold and humid” climatic conditions were preserved in zones I (taiga zone), II (mixed forest zone) and V (Carpathian Mountains). Evidence of other climatic conditions such as “warm and humid”, “warm and dry” and “cold and dry” are not known for these regions. In zones III (forest-steppe zone) and IV (steppe zone) there are some data indicating other climatic conditions, such as locally “warm and humid” climate on one objects; “warm and dry” and “cold and dry” climate at four other sites.

6 Discussion Spatiotemporal environmental evolution of Western Eurasia during the Holocene

The comparative analysis of the literature investigating and concluding on the 190 sites compiled in the database allows a reliable interpretation of the spatial-temporal evolution of the overall character of the palaeoenvironment of Western Eurasia during the last 10,000 years. First the results of spatial-temporal, proxy and climatic classification of the database are discussed. Ongoing, the description of palaeoclimatic conditions based on proxy data is temporally represented and divided into three parts - *Early Holocene* (10-8.2 ka BP), *Middle Holocene* (8.2-5-3 ka BP) and *Late Holocene* (3-0 ka BP). Due to the obtained results, these time periods cover the three big periods of climatic change during the Holocene of Western Eurasia.

6.1 Discussion of the database

6.1.1 Temporal classification – the geochronology

The ^{14}C dating, which is supposed to be the most widespread method of absolute dating, was applied to date most findings of the 180 sites considered. However, some cases are known when contradictions between archaeological and radiocarbon dates appear (Aleksandrovski et.al., 1997). That is why the calibration curve should be used for more precise and reliable dates (Khokhlova et al., 2010).

Radiocarbon dates from 90 sites out of 190 were not calibrated which forced us to construct calibration curves for these dates. Above, for another 86 sites the primary literature mentions that the dates were calibrated but it is not specified which calibration curves were used and their laboratory indexes are not mentioned (see Table 6 in appendix).

For 14 sites, the age of the sediments analyzed was determined using other dating methods: For nine of the sites included in the analyses dates corresponding to “proper ages” and were determined based on the development of the soil profile, a technique first described by V.V Dokuchaev (1926). Based on the degree of development of genetic horizons the duration of soil development can be derivated therefore the age of a buried soil can be determined more or less precisely. At four of the sites included in the study dating correspond to “cultural ages” determined by archaeological methods. Most likely, the authors used historical-cultural, stratigraphical or radiocarbon methods as well as more complex methods of dating, radiometric analysis was used for archive dates for one site which is why the “cultural age” was further used in analysis.

Large differences might exist between dates obtained due to soil profile analysis and those proposed based on archaeological evidences and calendar years (Iacumin et al., 2004).

Summarizing, all dates provided in the primary sources based on differentmethods of dating. Some of them are criticized in spite of their theoretical background and their long history of being used in science. All of the dates given in the primary sources were used in this work as they are represented by the authors of the selected 119 articles as no other possibility exists for obtaining more reliable dates.

However, it is important to point out that time classification refers to 19 five hundred-years-intervals covering the Holocene period the last 10,000 years. 19 classes i.e. intervals of time of 500 years also have a generalized character.

6.1.2 Spatial classification – the landscape zones

Landscape zones were, defined on the basis of modern landscape characters as they are displayed in the map “Physical Geographical Zoning of the USSR”,(Physical Geographical World Atlas, USSR 1964). The five landscape zones: I taiga, II mixed forests, III forest-steppe, IV steppe and V Carpathian Mountains were the first tome characterized and their boundaries defined by V.V Dokuchaev (1899) using there characters of zonality:

1. The latitudinal zonality is expressed distinctly, naturally determined changes from equator to pole and uneven incoming of warmth and moisture, accompanied by moderate continental climate and plain relief.

2. Altitude zonality is expressed distinctly with a change of thermal balance corresponding to changes of altitude as the main character. For example, in the zone V Carpathian Mountains the air temperature changes according to the height above sea level. The distinction of altitude zonality from latitudinal zonality is negligible and has an inner zone character. For example, in the zone of broad leaved forests in the Central Russian Upland the natural vegetation cover is composed of broadleaved forests whereas on the Meshchera lowland it is represented by pine-coniferous forests. It is worth noticing that such differences exist only within one zone.

3. Longitudinal zonality is characterized by the differences between the maritime climate in the west and continental climate in the east which is distinctly expressed on this vast territory. Due

to west-east increasing continentality to the east the boundaries of the natural shift northwards: alongthe latitude of Volyn-Podolsky elevation zone III forest-steppe and low-level Transvolga zone IV steppe adjoins to the south the semidesert. Consequently it can be concluded that in the west of Western Eurasia semideserts are absent and in the east there is no zone of mixed forests.

All five zones were assessed in regard to climate and corresponding landscape changes during the last 10,000 years. It gets obvious, that 10,000 years ago the palaeolandscape boundaries in Western Eurasia were different from today, and it was only about 2800 years ago that modern landscapes formed (Spiridonova, 1991). For example, during the Middle Holocene in comparison to the Early Holocene zone I taiga shifted 400 *km* to the north in the west of the study area and was stable in the east (Neustadt, 1957). During the Atlantic period (7000-5000 years BP) the whole forest zone on the Russian plain advanced greatly to the north (Evseeva & Zhilina, 2010). Respectively, the steppe zone moved in the same direction. At the same time the forest-steppe zone decreased greatly because the position of the southern border of the forest zone was, relatively, only slightly changed (Serebryannyi, 1980). In the late Holocene the southern boundary of the broad-leaved forest shifted 200-400 *km* to the north and in the formerly area covered by broad-leaved forest vegetation cover changed to a steppe and semidesert-type. The northern boundary shifted to the south 300-700 km away, the taiga forests were formed on the place of broad-leaved forests with fir (Neustadt, 1957; Serebryannyi, 1971).

6.1.3 Proxy data classification

Information on past environmental and climatic conditions at the 190 sites included in this review is based on the proxy data. The analysis shows that pollen is the most widespread palaeoevnvironment proxy used, as pollen were analysed in the sediments of 135 sites out of the 190 sites. Macro remains were analysed from the sediments of 45 sites. Other palaeoenvironment proxy were used on less than a fifth of the sites included soil characteristics were included 33 sites, overall lithostratigraphic characters were included at 26 sites, analysis of stable analysis was conducted for the sediments 25 sites, diatoms were analysed for the sediments of 23 sites and mollusks of 8 sites, chemical analysis was conducted for the sediments of 17 sites and mineral analysis for 11 sites.

The reconstruction of palaeoenvironmental and palaeoclimatic conditions derived from palynological data has advantages as well as restrictions as the vegetation, the occurrence of special species and their socialization give only clues on the overall climatic characters (Borisova, 2008). Pollen from different trees have different characteristics, for example, the trees have different productivity and different processes of pollen displacement (migration), have different levels of preservation which complicate the estimation of concentration and distribution of one or another species on different territories. In spite of these disadvantages palynological analysis is still one of the most reliable and affordable analysis for the reconstructions of palaeoclimatic conditions.

Organic remains (macro and micro remains) were predominantly analysed for the sediments from sites located in the steppe zone. Organic remains of vegetation and animals are preserved as fossilized, such as mummified, frozen or carbonized specimens, or as imprints of a part of the organism (bones, egg shard, leaves, seeds etc.) rarely they are preserved as whole organisms or traces of life-sustaining activity (fecal concretions, traces left by legs or crawling, traces of drilling, bacterial destruction etc) (Kozlovsky, 2010). Animal bones found at archaeological sites, as well as grains or seeds, are also a valuable source of information about palaeolandscape conditions. For example, amphibian and reptilian remains of *Rana arvalis* Nilsson.*Lacerta* cf. *agilis* L. found in the caves of South Urals indicate the forest-steppe conditions in Early Holocene. Remains of *Bufo bufo* (L.), *Rana temporaria* L., A. *fragilis* L., *Lacerta vivipara* Jacq., C. *austriaca* Laurenti, N. *natrix* (L.) and *Vipera berus* (L.) indicate the forest conditions in Middle Holocene, and remains of *Bombina* sp. and *Triturus cristatus* (Laurenti) indicate forest-steppe conditions in Late Holocene (Danukalova et al., 2008; 2011).

Buried soils found under burial mounds of different agealso give valuable information on the palaeoenvironment (Aleksandrovski, 2004) especially for forest environments (Velichko, 1973). Most of the morphological analyses of the soils were conducted in the zone III forest-steppe. The lithostratigraphic analysis of sediments gives information on the geomorphological processes causing their deposition. For example, moraines are formed and deposited by glaciers advances (Zinatulina, 2013). The majority of lithostratigraphic proxies were used in the zone II mixed forests.

Diatoms studied on 23 sites as proxy bear information about the aquatic milieu where they were deposited.The advantage of diatoms is that they are spread in all biotopes and are adapted to extreme environmental conditions (Novoselova, 1989).

The analysis of minerals predominantly focuses on Mineral analysis was conducted for sites all over the different landscape zones. in zones III forest-steppe and IV steppe, as well as nival climate (landscape with cold climate) in zone I taiga zone, favour accumulation of unstable minerals in precipitations (ferrum oxides, ink-stone, gypsum,potash alumen, jarosite, alaunstein, sulfates of heavy metals), while the humid climate (landscape with humid soil all year round and landscape with periodically humid soil) of the zone II mixed forests favour accumulation of stable minerals (carbonates, phosphates, ferrum and manganese compounds). Clay minerals serve as a good indicator of the climate (Logvinenko, 1974).

Mollusks are often analysed in river sediments and give information on water depths and salinity (Donukalova et.al, 2011). The remains of mollusks were studied for the sediments of eight sites. Mollusk species indicate a decrease in humidity during the end of the Atlantic period 6000 years BP ago and at the beginning of the Subboreal period 4500 years BP in the zone III forest-steppe. During these periods the number of shells attributed to the families *Lymnaeidae Rafinesque and Planorbidae Rafinesgue* decreased. Additionally, shucks belonging to the species *Armiger crista* (Linné, 1758) entirely disappeared as this species cannot withstand the drying out of basins. From this it can be concluded that a temporary aridisationwithout cooling occurred, as species *Lymnaea (Stagnicola) palustris* (Müller, 1774), *Anisus vor*tex (Linné, 1758), *Sibirenauta sibirica* (Westerlund, 1876), *Gyraulus gredleri Gredler* are sensitive not only to the degree of humidity but to the warmth as well (Lebedeva, 2011).

6.2 Location of the landscape zones

6.2.1 Early Holocene (10 ka - 8.2 ka BP)

Systematic literature review shows that climatic conditions during early Holocene (10-8.2 ka BP) are characterized by instability, including short-term interchanges of cold and warm climate. The early Holocene can be divided into the Preboreal (10-9.5ka BP) where cold climate with the predominance of arid conditions occurred, while during the subsequent Boreal (9.5-8.2 ka BP) warm climate with partial humid fluctuations in all five zones occurred all over the study area.

Zone I – Taiga zone:

With in the climate conditions of 10-9 ka BP, two tendencies can be traced - “cold and humid” and “warm and humid” (Figure 21a). From 9-8.2 ka BP, climate became more “warm and humid”. Climate changes as a determined factor of environment influenced the evolution of soils, vegetation, and landscape formation. Favourable climatic conditions for peat accumulation occurred 8780±35 years BP (Zemtsov, 2000). For example, on Kola Peninsula, pine forests (*Pinaseae*), as well as fir (*Picea*) and birch (*Bétula*) (Golubeva, 2007) became widely distributed. Suffruticose-mossy tundra with birch elements spread throughout the northern taiga of Karelia in the Preboreal period (10.1-9.3 ka BP), the Boreal period (9.3-7.9 ka BP) is marked by the spread of pine-birch forests and tundras in combination with suffruticose-mossy tundra (Elina, 2010). The changes of the landscape led to "-… drastic changes in the composition and distribution of phytocenosis…" (Markov, 2008). After the last glacial maximum (LGM) warming occurred, causing the retreat of continental glaciers and the retreat of natural zones to the north (Velichko, 2009). The initial stage of warming 10-8 kaBP is called Subarctic, and is marked by the reduction of the tundra square and tundra-steppe and the subsequent spread of birch-pine and taiga forests (Borisov, 1979).

***Zone II - Mixed Forest zone**:*

In the Mixed Forest zone our results showed (Figure 21b) between 10-9 ka BP, two microstages of aridization are observed: an early Preboreal cold stage and a late Preboreal warm stage. The period of 9-8.5 ka BP is characterized by the maximum warming of Boreal period. *Pinus* and *Betula*are the dominating pollen in early Holocene sediments found the territory of the mixed forests, the total amount of pollen of these wooden species reached 90 %, whereas pollen of *Picea* averages only 5% (Neustadt, 1957). In the region of Polesye, pollen of *Pinus* dominates the sediments, with the pollen of *Artemisia* come second. The amount of *Betula* pollendecreased and pollen of *Picea* is absent. The appearance of broad-leaved forest pollen is observed (Neustadt, 1957). In the Early Holocene in mixed forests of Primorye, pollen of *Pinus* is close to maximum, the amount of *Betula* pollen is 62% on average, and *Picea* pollen is about 3% (Stancikaite et al., 2006). For the mixed forest zone palaeoenvironmental reconstructions are predominantly based on palynological data. Contemporaneously, soil formation of Early Holocene is characterized by the development of intensive illuvial processes, which modify deeply underlying sediments (Gerasimenko, 1997); however, early Holocene palaeosoil are rarely investigated.

Zone III – Forest-Steppe zone:

Our results showed in the forest-steppe zone (Figure 21c) 10-9 ka BP, two different palaeoclimatic stages can be traced: in the beginning climate was "cold and dry", from 10-9.5 ka BP. Subsequently, "cold and dry" climate was detached by a "warm and dry" climate in 9.5-9 ka BP. The period from 10.5-8.5 ka BP is characterized as an arid period due to buried black soils in flood plains and terraces above flood-plains (Aleksandrovski, 2005). Palynological proxies provide for 35% of the sites of the forest-steppe zone palaeoenvironmental information

(Figure 14), additionallyfor 24% of the sites palaeosoils were used as palaoenvironmental proxies. Some pedologists believe that black soils are resistant to outer influences and those other soils of forest steppe changed slightly in Holocene (Belgard et al., 1983). Others believe that the soils of the forest-steppe zone evolved easily, for example, from black soils to gray forest soils (Bork, 1983). The Boreal period in the forest-steppe zone is described in the works of Chotinsky (1977) and Spiridonova (1991) as the period of “warm and humid” climate, a statement which does not correlate with the results of the overall literature review.

After the glacial retreat, the lowland of the forest-steppe zone was largely inundated, swamped, and salinized. Along the Dnieper entrenchment meadow-bog soils developed into mixed herbs black steppe soil, solonetzic soils degraded into soloniform and solodic soils, and broad-leaved forests appeared on the dissected right shores of the rivers (Rakovskaja& Davydova, 2001). Consequently, during the Early Holocene (10-8.2 ka BP), the forest-steppe zone can be characterized by gradual climate warming, vegetation cover development, soil development, weakening of denudation accumulative processes, and the beginning of the formation of the landscape zonality.

Zone IV - Steppe zone:

In the steppe zone the spatial-temporal development of climate changes during the Preboreal (10-9 ka BP) and Boreal (9-8.2 ka BP) have been studied poorly (Figure 21d), as it is indicated by the literature analysis. Accordingto our results palaeoclimatic conditions between 10-9.5 ka BP followed the tendency of “cold and dry” followed by warming and an increase in humidity. At the end of the Boreal period (8.5 ka BP), the climate became “warm and humid”. There were periodic increases of annual temperatures and the amount of annual precipitation occurred, fluctuations of annual temperatures around ±1°C occurred in steppe zone (Ivanov, 2010). Although the number of sites located in the steppe zone are the largest in quantity compared to the other zones, palaeoenvironmental and palaeoclimatic conditions of the steppe zone during the Holocene have been reconstructed poorly. This is probably due to the fact that palynological studies are rare, since peat-bogs are almost absent in this zone. It is also known that the most of the soil under burial mounds are dated to the middle to young Holocene (Ivanov, 1992: Demkin, 1997). The investigations of flood plain buried soils in the steppe zone (Stavropol) documents an increasing intensity of alluvial accumulation around 8 ka BP (Aleksandrovski, 2003).

Zone V - Carpathian Mountains

The development of palaeoenvironmental and paleoclimatic conditions during the Early Holocene isalso documented according to vertical zonality.According toour results it can be concluded that across the different altitudinal zones palaeoclimatic conditions during the Preboreal period (10-9 ka BP) were constantly oscillating within “warm and humid” climate (Figure 21e). Most parts of the forests were represented by *Picea* and *Pinus* (Neustadt, 1957). During 10.2-8.3 ka BP in the altitude of 730-790 *m* asl on the territory of the Romanian Carpathian mountains, pollen of *Ulmus, Quercus, Tilia* and *Fraxinus*occur widespread. From this it can be concluded that annual temperatures and annual amount of precipitation were higher than today (Feurdean, 2008). During the late Boreal period 8.5-8 ka BP “warm and dry” palaeoclimatic conditions dominated, though also “cold and humid” conditions locally remained. Pollen of *Corylus* increased in Carpathian Mountains zone on the territory of Romania in 275 *m* asl (Feurdean, 2007a).

6.2.2 Middle Holocene (8.2 ka - 3 ka BP)

The Atlantic period (8.2-5.5 ka BP) is universally recognized as the altithermum, the thermic maximum, of the Holocene (Velichko, 2009). It was during the Atlantic period that the most favourable palaeoclimatic conditions appeared in western Eurasia (Velichko, 2009). As is shown in Figure 17a, palaeoenvironmental information indicating “cold and dry” climatic conditions lack emphasizing the favourable thermic conditions. Figure 18a also shows that there are localindications for a “cold and humid” climate. From 7 ka BP in all zones of Western Eurasia, “warm and humid” climatic conditions Figure 17d peaked and lasted until 6.5 ka BP. Proxy data distinctly show that in Western Eurasia the peak of climatic optimum occurred from 7-6.5 ka BP, until the middle Atlantic period.

Above, “cold and dry” climatic conditions also lack locallybetween 7.5-5.5 ka BP in all five zones Figure 17a. According to the outcomes of the literature review, this phase was the warmest during of the Holocene in the territory of Western Eurasia. Most of the palaeoenvironmental records investigated cover the period from 8.2-3 ka BP, consequently the deductions on the temporal limits and the climatic conditions of the altithermum in Western Eurasia can be taken as valid. According toour results thebeginning of the end Subboreal period 4-3.5 thousand years ago, a time when in creased aridity which is known as"xerothermic stage". Such environmental conditions can be especially well detected in the forest-steppe zones (zone III) and the steppe zone (zone IV) (Figure 20.13). Aridisation caused the shift of the northern boundaries of the steppe zone and consequently its enlargement while simultaneously the northward adjoining forest-steppe zone diminished.

Zone I – Taiga zone:

In the areas of the White Sea and Karelia occurrence of swampy areas on the continental cratons decreased during the 8.2 ka BP period. In return, the recurrence formations of soil horizons are documented for during the Early Holocene (Aleshinskaya & Spiridonova, 2000). During the transition from Boreal to Atlantic pine pollendominatesin the pollen spectra from the northwestern and central Russian plains, as well as at Cis-Urals and in the Middle Urals (Khotinski, 1991). The territory of present day taiga was in its northern and central part covered by southern taiga vegetation, characterized by a mixture of broad-leafed forests (Elina, 1980). Climate changes during the Holocene period caused essential geographical transformations of environmental conditions in the taiga zone. Podsols, principal soils of the taiga soils developed in the today tundra area in latitudes about 300 *km* further north than today (Velichko & Morozova, 2010). During the Atlantic period (8.2-5 ka BP) principal taiga soils spread greatly to the North Pole while simultaneously and the area where principal tundra soils occurred decreased. In the present day tundra zone during the altithermic period both, gleysolic-podzolic soils and podzolic soils, predominated as principal soils, documenting the northward spreading of the taiga, while simultaneously gleyed soils, typical for the tundra zone, only sporadically occurred. Also, the intensity of bogging was in various areas reduced. In the northern and middle taiga principal podsolic soils developed moderately while in the southern taiga a pronounced polygenesis is linked with boundary migration of natural soil zones (Aleksandrovski, 2005). A “warm and humid” climate dominated during the time period 7.5-6 ka BP in the taiga (Figure 21a). On the Pechora taiga territory temperatures exceeded modern temperatures by 2.5-3.5°C (Golubeva, 2007). Due to palynological data, *Pinus* pollen dominated in the sediments of altithermic tajga locally replaced by *Betula* pollen. It is also typical to find broad-leaved pollen species with low concentration, not exceeding 5% (Neustadt, 1957).

According to our results 4.5 ka BP, climatic conditions deteriorated (Figure 21a) temporarily interrupted by the Subboreal warming. For example, on the eastern slopes of the Karelia and in the Pechora valley, July temperatures fell in the end of the middle Holocene abruptly by 2.5-4.5°C (Arslanov et al., 2001; Golubeva, 2007).

Zone II - Mixed Forest zone:

Also in the mixed forest zone according to our results the period from 8.2-5.5 ka BP was the most favourable climatic period with (Figure 21b) an efficient warming, humid conditions and an overall stable climate. In the middle Holocene sediments the amount of *Pinus* and *Betula* pollen decreases, whilepollen of broadleaved species occur more often and pollen of *Alnus* reaches 25% in average. Only in the area of Polesye *Pinus* pollen dominatethe Middle Holocene sediments, while simultaneously the contents of pollen from broad-leaved species total 5-10% and *Picea* pollen only occurs rarely. In the area of Primorye pollen of broad-leaved species (*Quercus, Tilia, Ulnus*) reach in middle Holocene sediments 16-40% and pollen of *Alnus* reaches aconcentration of 42% (Stancikaite et al., 2006).

Our resultsshowed in 5.5 ka BP an abrupt change of climatic conditions occured, succeeded by an aridisation between 4.5 and 3.5 ka BP (Figure 21b). Annual temperature amplitude increased due to an increase of summer temperatures and a decrease of winter temperatures while simultaneously the amount of annual precipitation decreased. These changes varied in intensity in the northern and southern parts of the forest zone: The vegetation period extended in northern part of the present day forest zone, whereas in southern part of the present day forest zone prevalence of mixed forest and hydrophilous mixed herbs meadows decreased (Aleshinskaya &, Spiridonova, 2000). Spiridonova (1991) reconstructed a xerothermic phase for vegetation for the time interval between 4170±100 and 3970±160 BP. It is also most likely that the reduced soil forming intensity during this early Subboreal period is due to the widespread aridisation (Kovalyuh, 1995). Kremenetsky (1991) also determines that between 4.2 and 3.7 ka BP climates had most distinct continental characters. Forest soils with indices of browning and with strong humus accumulative horizon were widespread in the Atlantic period (Ivanov et al., 1994).

Zone III - Forest-steppe zone:

According toour results during Middle Holocene (8.2-5-3 ka BP) in the forest-steppe zone (Figure 21c) two stages of climatic conditions can be traced: from 8.2-5 ka BP climate was “warm and humid” changing to a more arid climate between 5 and 3 ka BP. Several intensive coolings were marked between in early Subboreal 4.5-4 ka BP and 3.5-3 ka BP which led to the maximum displacement of forest vegetation to the south (Spiridonova, 1991; Khotinski, 1982). During 4-3.5 ka BP the present day forest-steppe zone is characterized by a “warm and dry” climate with mean annual temperatures and annual average precipitation close to that of modern times (Serebryannaya, 1982). Meadow type soils indicate processes of salinization, solonization and high calcareousness dominated on lowland plains (Ahtyrtsev et al., 1997). Black soils are known to be the principle soil of the forest-steppe zone (Aleksandrovski, 2005). However, some researches suppose that black soils slightly transformed in Holocene (Madanov et al., 1967; Belgrad et al., 1983), while others insisted that they evolved (Yakovlev, 1914; Bork, 1983). The investigation of soils shows that palaeoblack, carbonated, salinized soils under the meadow-steppe vegetation and gray forest-steppe palaeosoils in oak forests occurred on the well drained watersheds of the uplands. Black-meadow soils and meadow-black carbonated, solonetzic salinized palaeosoils were spread in the poorly drained lowland plains as well as the poorly drained watershed parts of the uplands (Ahtyrtsev et al., 2003).

Zone IV - Steppe zone:

In opposite to the vegetation zones discussed up to now, the present day steppe zone underlie during the Middle Holocene, according to results of the literature review, three distinct climatic phases (Figure 21d): The first phase, lasting from 8.2-7 ka BP, is characterized by a warm and continental climate. Annual temperatures were higher than those of modern times by 1-1.5°C though sometimes they were similar to modern thermic conditions. Annual amount of precipitation has no distinct tendency and varied between aberrations from present day annual amounts of precipitation by -25 and +75 *mm* and was more variable than the temperature (Ivanov, 2010). Deterioration of climatic conditions led to a decrease of broad-leaved forests in the lower reaches of the Don River (Kremenetsky, 1999). The characteristicalfeatures of soils of the steppe zone during the Atlantic period were similar to those of present day, however, solonetzicity was lower (Velichko & Morozova, 2010). During the second phase, lasting from7-4.5 ka BP climatic conditions were more favourable with an increase of annual precipitation by 100-150 *mm* compared to the present day annual rainfall (Kremenetsky, 1999). During the third phase, scheduled for 4.5-3 ka BP, aridisation caused a more arid climate compared to present day conditions, the middle Subboreal (4-3 ka BP) is characterized by an overall warming (Velichko, 1991), causing the drying out of the peat-bogs, the decrease of lake and sea levels, and most likely the northward shift of the northern boundaries of the steppe zone into the forest-steppe zone (Velichko & Klianov, 1990). During this time, according to palaeosoils research, the mean annual temperatures in the steppe zone varied within ±1°C in comparison to modern times (Ivanov, 2010). Annual average precipitation in the Don basin, for example, decreased and totaled annually approximately 50 *mm* less than nowadays (Kremenetsky., 1991; Khotinski et al., 1991). The regressive stage of the Caspian Sea is dated to 4000±50BP and 3800±60 BP

(Varushenko et al., 1987). Indices of increasingly humid climatic conditions exist also for the phase of 4.2-3.2 ka BP (Ivanov & Demkin, 1978; Spiridonova, 1990; Ahtyrtsev & Ahtyrtsev, 1997; Chendev, 2005; Aleksandrovski, 2002; Ivanov & Vasil'ev, 1995).

Zone V - Carpathian Mountains

Change of palaeoenvironmental conditions in the Carpathian Mountains during theMiddle Holocene (8.2-3 ka BP) do not differ significantly from the respective change of global palaeoclimate conditions (Figure 21e). The favourable climatic conditions of the altitherme caused that thermophilic flora expanded into the Carpathian Mountains from Central and Southern Europe. Thermophilic oak trees with rich species composition were widespread on the mountain slopes. Pollen of *Quercus, Tilia* became widespread in the sediments of the Carpathian Mountains, whereas *Picea* pollen is poorly represented (Feurdean, 2007a). This species composition was possible due to a "warm and humid" climate. At the beginning of the Atlantic period our resultsshowed 5.5-5 ka BP, climate began to cool. Late Holocene xerothermic phases occurred in the zone of the Carpathian Mountains around 3.5-2.5 ka BP (Figure 18e).

6.2.3 Late Holocene (3 ka - 0 ka BP)

There were no abrupt palaeoclimatic conditions fluctuations and palaeolandscape changes since the Subboreal period in 3 ka BP. Landscape had gained its present-day characters (Aleksandrovski, 2005). According to literature review, palaeoclimatic conditions gradually changed from a "warm and dry" climate to a "cold and humid" climate. Such stable climatic conditions can especially be observed for the northern part taiga zone and the mixed forests zone. Our results showed in the forest-steppe zone and steppe zone in Late Holocene climatic conditions changed from "warm and dry" to "cold and humid", whereas in other places, short periodic transformations could be traced inside of the zone. The Carpathian Mountains, due to strong altititunal changes, does not always exhibit the same climactic changes as the other Western Eurasian vegetation zones.

Zone I - Taiga zone:

In 3-2.5 ka BP according toour results "cold and humid" climate began to replace the relatively warm climate in the present day taiga zone (Figure 21a). Climate cooling and the increase of annual precipitations triggered bogging and the activation of bog-transformation processes, as well as peat-accumulation in the taiga, suppressed by the decay of vegetal remains (Klimanov & Sirin, 1997). *Betula* pollen dominate in the Subboreal and Subatlantic sediments of the taiga zone (80 %), *Picea* pollen dominate the sediments of the southern taiga zone adjoining to the mixed forest zone, though sometimes *Pinus* pollen appeared (Neustadt, 1957). In the beginning of the Subatlantic period, around 2.5 ka BP, the tendency to a gradual climate cooling started, lasting throughout the whole Subatlantic period (Figure 20.16-20.19).

Zone II - Mixed Forest zone:

Our results showed during during 3-2.5 ka BP cold climatic conditions intensifiedin the mixed forest zone (Figure 21b), despite some tendencies to warmer conditions and humidity fluctuations. In the late Holocene sediments pollen of *Pinus* dominates, while pollen of *Picea* occurs with stable concentrations reaching maximum values of 50%. Locally small amounts of *Betula* pollen and broad-leaved forests pollen can be traced in the late Holocene sediments (Neustadt, 1957). In sediments from Polesye pollen of *Pinus, Picea* and *Betula* dominate in the late Holocene sediments whereas the amounts of pollen from broad-leaved species decrease (Stancikaite et al., 2006). In 2.5-0.5 ka BP according to our results climatic conditions got “cold and humid” (Figure 21b). The Subatlantic period is characterized by a dynamic vegetation development, and an alternation between phases of fir forests typical for taiga zone (early Subatlantic) and phases of mixed broad-leaved-coniferous forests with a high portion of elm and lime (early and late Subatlantic) (Novenko et al., 2009).

Zone III - Forest-steppe zone:

In the forest-steppe zone according to our results the tendency of the climate to “warm and dry” (Figure 21c) continued in the beginning of the late Holocene 3-2.5 ka BP; during this phase the forest-steppe landscape had nearly gained its present-day characteristics. Beginning in 2.5 ka BP, our results showed with the onset of the Subatlantic period, an increased cooling can be observed, palaeoclimatic conditions overall became increasingly “cold and humid” 500 BP (Figure 21c). During the late Holocene on the Middle Russian Plain, for example, black soils developed (Chendev, 2005). However, in most areas of the forest-steppe zone since the beginning of the Subatlantic period gray forest soils began to form along the northern boundaries (Aleksandrovki, 2005).

Zone IV - Steppe zone:

According to our results in the steppe zone the beginning of the Subatlantic period 3-2.5 ka BP is characterized as the most arid period of the Holocene, for this zone also labeled as the "xerothermic phase" (Figure 21d). Our results show 2.5-2 ka BP, it became distinctly colder (Figure 21d) this also correlates with the data of A. L Aleksandrovski (2003) about this period. The tendency to a humid but cooler climate began to develop in the steppe zone after the arid period considered marking the beginning of the Subatlantic period. Increasing humid conditions are also documented in the research of L.G Bezusko et al. (1988), A.T Artushenko et al. (1982), and T.A Serebryannaya (1982). Temporary coolings and periods of increasing humidity interspersed with short arid periods (Ivanov, 2010). A.A Aleksandrovski (2005) and I.V Ivanov (2010) consider the beginning of the Subatlantic period to be a favourable period for the formation of black soils.

Zone V - Carpathian Mountains

In the Carpathian Mountains the late Holocene our results showed began with "warm and dry" climatic conditions. According to our results after a distinctly warmer period during the middle Holocene, beginning about 2.5 ka BP, the climate became gradually colder and more humid (Figure 21e), favoring the distribution of vegetation species adapted to these new conditions. Pollen of *Abies*, *Fagus* isincreased in the late Holocene sediments, while *Pisea* pollen are partially conserved (Tolpa, 1927). The conservative warm climate of Transcarpathian turned out to be ideal conditions for beech forests, whose distribution have a zonal character (Neustadt, 1957). The cool north-eastern exposed slopes of Ciscarpathian best suited silver fir, particularly in the Beskid Mountains. The fir, which dominated in the Carpathian Mountains at the end of the early and beginning of the middle Holocene, gradually became widespread in Gorgany, Montenegro, Marmaroshski cristallic massive and Chivchin. Here it forms compact zonal massives (Feurdean, 2007a). Mountain pines, green alder and low juniper became widespread in highlands on mountainous slopes. Thermophilic black pine was preserved on lime in the Romanian Carpathian mountains zone (Feurdean, 2007a).

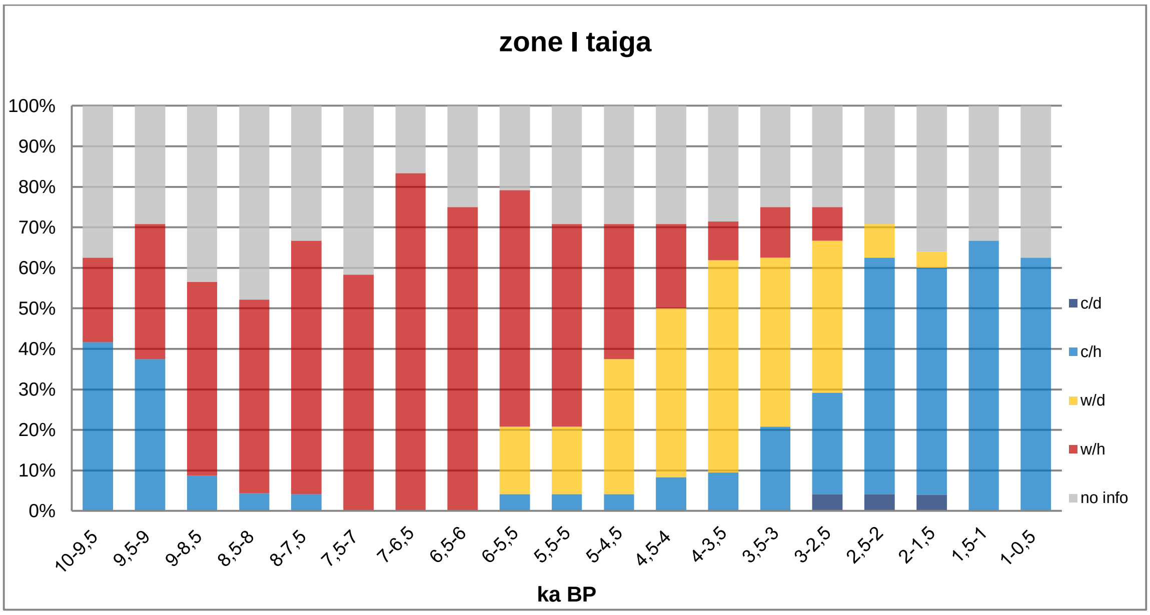
6.2.4 Subsumption of climate changes in Western Eurasia during the past 10,000 years

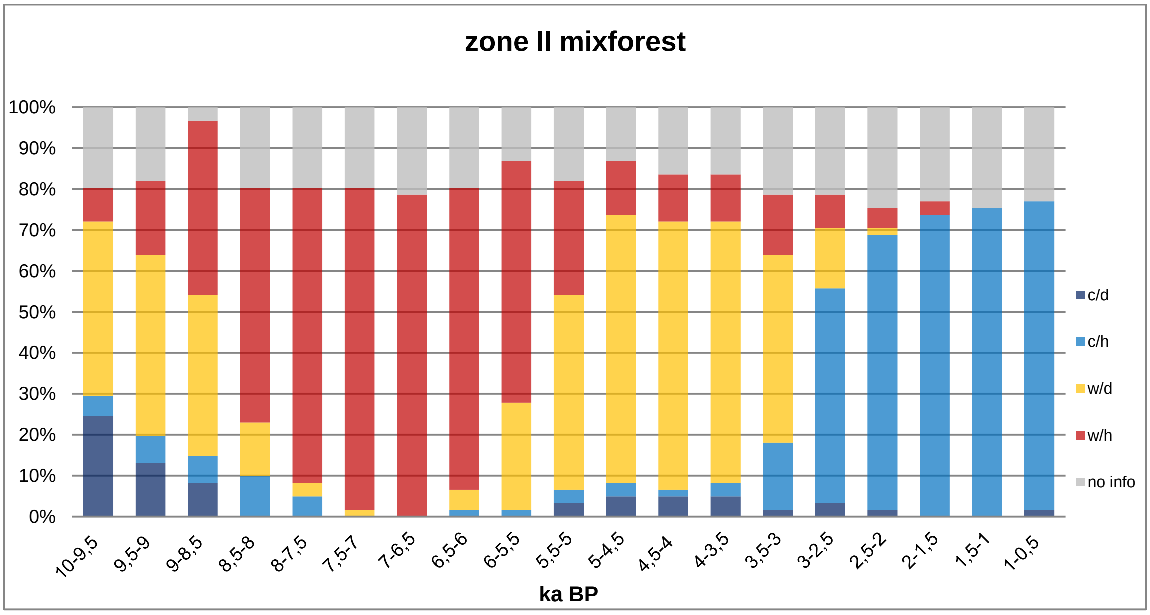
The review of literature on palaeoenvironmental investigations in Western Eurasia produces reliable results on the spatio-temporal differences in palaeoclimate development, including the most important stages of fluctuations and evolution. During the Holocene in Western Eurasia the development of vegetation cover took place as well as the evolution of soil cover in the course of palaeoclimatic fluctuations (Khotinski, 1982; Aleksandrovski, 1983, Borisov, 1975, Velichko, 2010). Based mainly on the results of ^{14}C-dating, in addition to the results of palynological, lithological and archaeological data studies, four global palaeoclimatic fluctuations in Western Eurasia were reconstructed for the Holocene period. In Figure 21(a-e) intercentennial palaeoclimatic fluctuations in Western Eurasia during the past 10,000 years are presented.

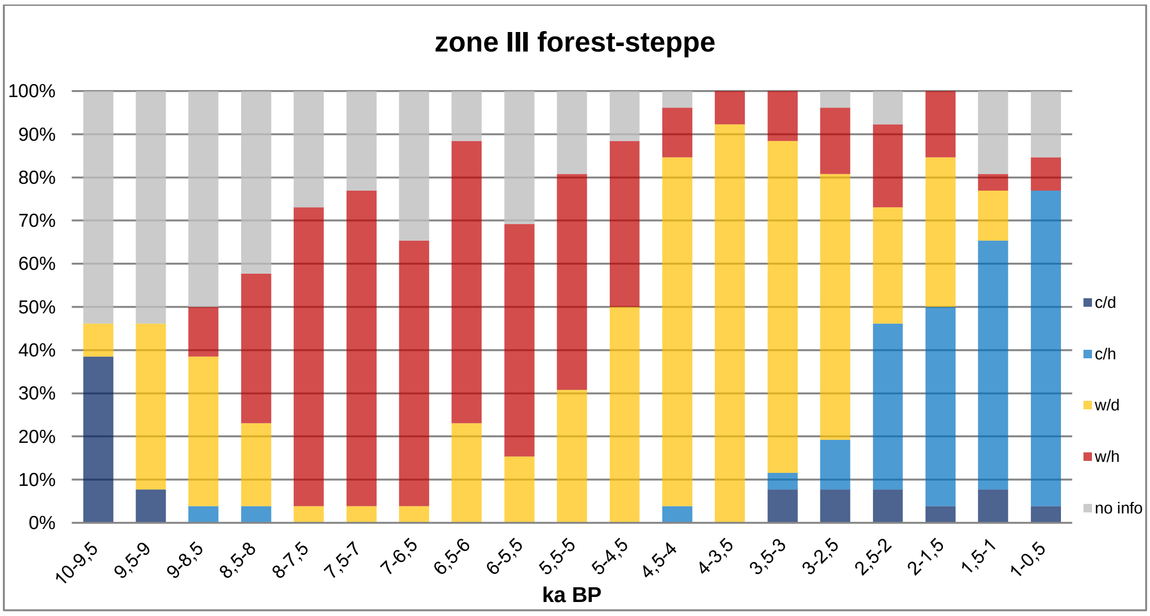
Relatively cold climate can be clearly observed in the early Holocene 10-8.2 ka BP. Since the beginning of the Boreal period (9 ka BP), climatic conditions slowly but steadily became warmer (Figure 21a-e). Warming supported the development of the vegetation cover, the changes in denudation-accumulative processes, and an intensification of weathering and soil forming processes. Climate changes strongly influenced vegetation cover, especially the development and species variation of the forest. The most northern part of Western Eurasia was occupied by tundra forest, indicated by a clear predominance of fir pollen in the early Holocene sediments. Dark coniferous fir forests dominated in the taiga zone. Pine and birch forests developed in the transition of the taiga to the mixed forest zone. Data about vegetation cover for the steppe zone are weak, though in the pollen diagrams from the sediments extracted in the steppe zone forest types are documented, which indicate the shift of the steppe zone northwardinto the territory of forest-steppe zone (Neustadt, 1957; Serebryannyi, 1971). The suppositions about the soil cover of early Holocene are hypothetical (Aleksandrovski, 2005) because of the poor conservation of relicts from this period due to the dominance of developed soil evolution (Aleksandrovski, 2002).

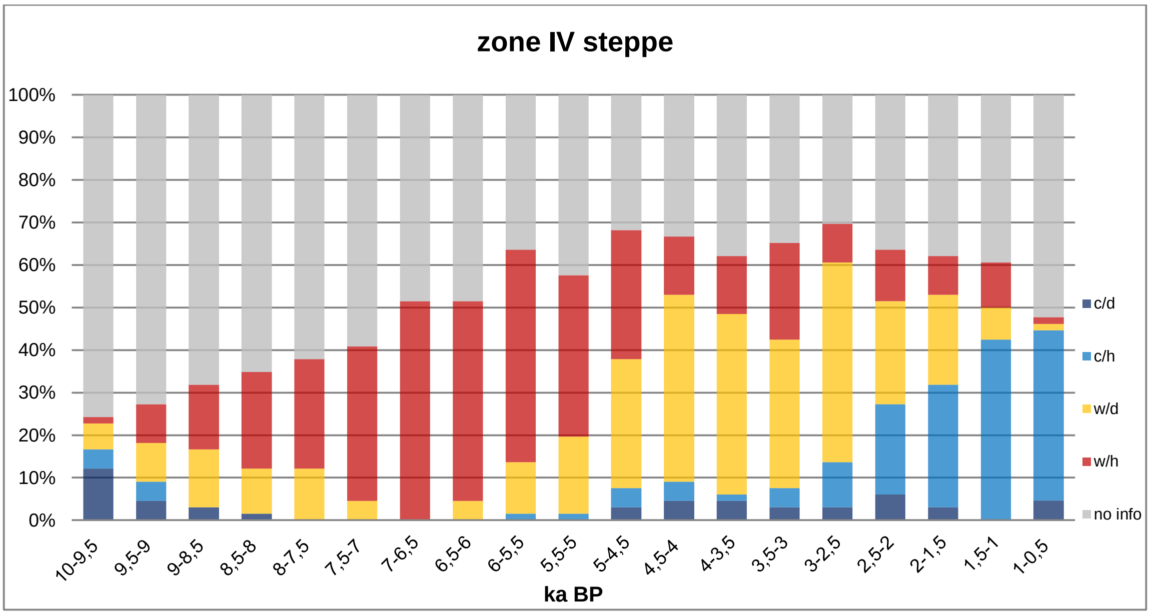
The middle Holocene is the time of “climatic optimum”, a period of favourable thermic conditions. The middle Holocene can be subdivided into two major periods: the period from 8.2-5 ka BP is characterized by favourable climatic conditions with “warm and humid” climate and lasted until approximately 3 ka BP. The peak of the most “warm and humid” period all over the zones dates to 7-6.5 ka BP. These climatic conditions favored the development of the vegetation cover. The tundra zone nearly disappeared on the continental part, preserved only north of the Kola Peninsula and on the shore of Baydaratskaya Bay (Markov, 1965). Dark coniferous fir taiga dominated in the taiga zone; *Picea, Pinus,* and *Betula* grew in the south of the tundra zone in the transition to the mixed forest zone. In the mixed forest zone thermophilic broad-leaved forests (pollen of *Quercus, Tilia* and *Ulmus)* became widespread. Pine forests developed in the river valleys of the forest-steppe and steppe zone corresponding to riverine forest, showing frequently local embeddings of *Quercus, Alnus, Tilia, Ulmus, Carpinus, Fogus* and *Carylus* (Neustadt, 1957). Palaeosoils developed during the middle Holocene differed from the soils developed under present day conditions: podzolic soils developed in the present day tundra zone whereas gray forest soils developed where today sod-podzol soils are the principal soil type. Concordantly, leached, and podzolized black soils appeared where today gray forest soils are developed (Aleksandrovski, 2005). During the middle Holocene in Western Eurasia almost stable landscape zonality was formed (with its maximum displacement to the north). Relatively "warm and humid" palaeoclimatic conditions changed into "warm and dry" conditions in the second half of the middle Holocene 5-3 ka BP. The beginning of the late Subboreal period (4-3.5 ka BP) is characterized as the most arid period during the Holocene in Western Eurasia and is known as "xerothermic phase".

"Cold and humid" climatic conditions onset in the late Holocene (3-0.5 ka BP) after a "xerothermic period"of 2000 years. The vegetation went through new drastic changes in the late Holocene. Dark coniferous forests expanded to the south, the southern boundaries of the tundra forests extended with a differentiation into: a) the northern taiga zone with fir and pine forests dominating, b) the middle taiga zone with broad-leaved forest dominating, c) the southern taiga zone, with mixed coniferous broad-leaved forests dominating. The boundariesbetween the mixed forest zone, the forest-steppe zone and the steppe zone remained more or less stable.During the late Holocene also west-east vegetation changes are observed. For example, pollen of grassy vegetation cover reaches 50% in the sediments originating from the western part of the studied territory, whereas in the east it reaches 82% from the total amount of the pollen (Neustadt, 1957). As the climate cooled, bogging intensified in the taiga, tundra-type pedogenesis in the taiga zone within the northern border of mixed forests advanced, parts of middle Holocene black soils evolved into gray forest soils, and parts of gray and dark gray forest soils evolved into sod-podzolic soils.

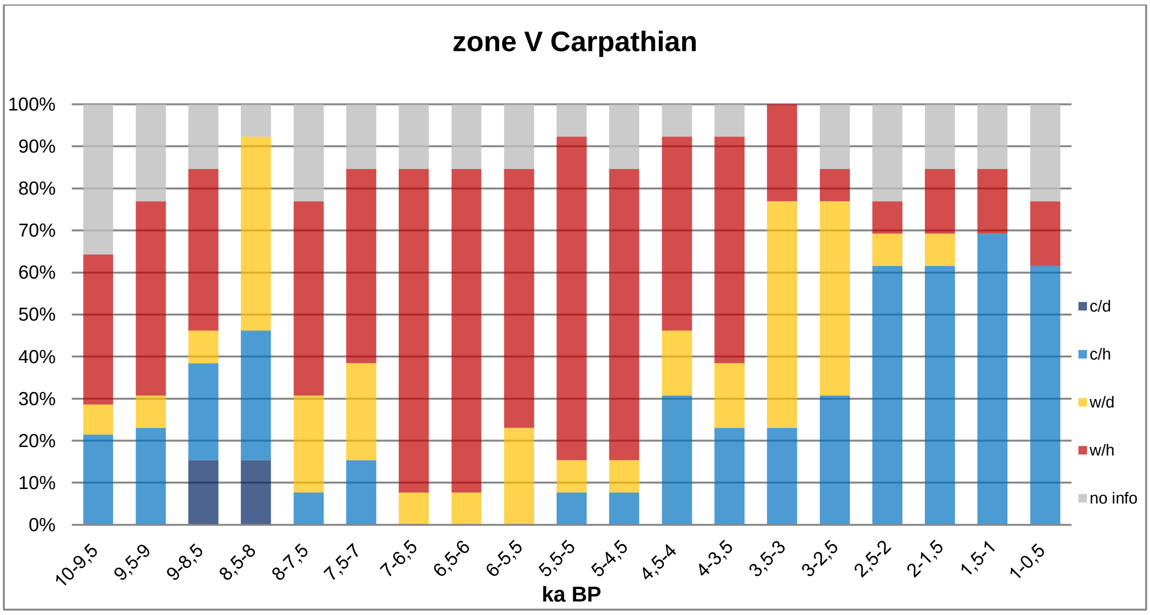

zone I taiga
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10-9,5
9,5-9
9-8,5
8,5-8
8-7,5
7,5-7
7-6,5
6,5-6
6-5,5
5,5-5
5-4,5
4,5-4
4-3,5
3,5-3
3-2,5
2,5-2
2-1,5
1,5-1
1-0,5
ka BP
c/d
c/h
w/d
w/h
no info
21(a)


zone II mixforest
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10-9,5
9,5-9
9-8,5
8,5-8
8-7,5
7,5-7
7-6,5
6,5-6
6-5,5
5,5-5
5-4,5
4,5-4
4-3,5
3,5-3
3-2,5
2,5-2
2-1,5
1,5-1
1-0,5
ka BP
c/d
c/h
w/d
w/h
no info
21(b)


zone III forest-steppe
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10-9,5
9,5-9
9-8,5
8,5-8
8-7,5
7,5-7
7-6,5
6,5-6
6-5,5
5,5-5
5-4,5
4,5-4
4-3,5
3,5-3
3-2,5
2,5-2
2-1,5
1,5-1
1-0,5
ka BP
c/d
c/h
w/d
w/h
no info
21(c)



21(d)



21(e)

Figure 21(a-e): Palaeoclimatic conditions in Western Eurasia during the Holocene in 500 years steps (- no data, -warm and humid, - warm and dry, - cold and humid, - cold and dry).

7 Conclusions

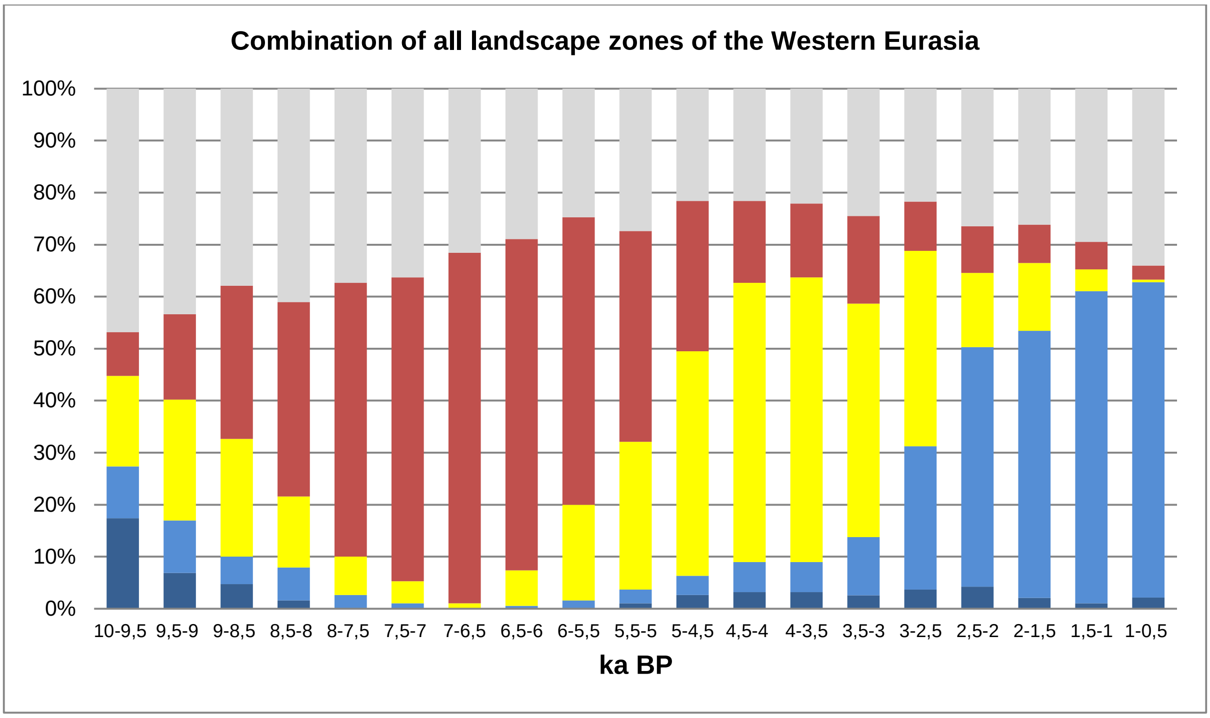
7.1 Conclusions on the methods

The systematic analysis of literature sources allows a spatio-temporal differentiated reconstruction of the Holocene palaeoenvironmental conditions in Western Eurasia. The review included 119 sources and provides a comparative insight into ecological development as well as spatio-temporally edited data about palaeoclimate and palaeolandscape. The main characteristic of the literature review is its retrospective character, allowing the creation of an objectified estimation based on multiple final reports from different 190 sites. A particular emphasis in the research was given to zone correlations and differentiation and to palaeoclimate and palaeolandscape analysis in 500 year intervals according to latitudinal zonality and to vertical zonality in the Carpathian Mountains. The approach of centenary reconstruction of palaeoclimate appeared to be the most reliable, avoiding pseudo-accuracy. However, the method has its advantages and disadvantages. One of the main advantages is the broad overview of all published investigations. The results of literature analysis and classification provide the theoretical and experimental foundation for scientific research, and also testify to the scientific feasibility of the work and its reliability. The disadvantage of this method is that the review and classifications made are a synthesis of discussion and analysis of the literature sources. It is impossible to ensure that the results of the source analyses are precise because they cannot be verified.

7.2 Conclusions on theinterpretation

The reconstruction of the Holocene development of Western Eurasian palaeoenvironments based on literature review allows thereconstruction of four over-arching and 19 inner-centenary climatic changes.The pollen-based Axel Blytt (1876) and Rutger Sernander (1908) classification is well known and was originally developed for Scandinavia and includes five pollen-stratigraphical periods from the Preboreal to the Subatlantic period.N.A Khotinski (1982), L.A Alexandrovski (1983), E.A Spiridonova (1991) and V.V Velichko (2012) subgect differing Holocene climate classifications valid for the East-European plain (Figure 22). Summarizing classifications the Holocene consequence divide into four phases:

- 10 ka - 9 ka BP: Pereslaval cooling phase with cold temperatures and humidity fluctuations.
- 8 ka – 5 ka BP: Altithermum phase with warm and humid conditions.
- 5 ka – 2.5 ka BP: Xerothermic phase with warm and dry conditions.
- 2.5 ka – 0.5 ka BP: Neoglacial with cold and humid conditions.



Early Holocene	Middle Holocene	Late Holocene

Blytt-Sernander classification, modified by Khotinski, 1982:

Prebboreal period	Boreal period	Atlantic period	Subboreal period	Subatlantic period

Khotinski, 1977; Alexandrovski, 1983; Spiridonova, 1991; Velichko, 2012:

Pereslavl cooling	?	Climatic optimum	Xerothermic phase	Neoglacial

Figure 22: Classification palaeoclimatic conditions in western Eurasia of the Holocene period based on a literature review (- warm and humid, - warm and dry, - cold and humid, - cold and dry)

Including the findings of the literature review on the Holocene palaeoenvironmental development Western Eurasia into this revised Holocene stratigraphy the following phase can be characterized.

1. Early Holocene cooling known as Pereslavl phase occurred between 10,000 -9000 BP.

With fluctuations temperature, aridity and humidity begining in 9000 to 8200 BP. Palaeosoils developed in this period are not known. Maximum warming is dated to the offset of the early

Holocene 8500-8000 BP. It is determined that mean July temperatures were approximately 0.5°C higher than those of modern times (Velichko, 2012), mean January temperatures and annual precipitation were close to what is known from present day conditions.

2. Middle Holocene warming with increasing humidity around 8200-5000 BP is known as the Holocene optimum soilsdeveloped during this period are similar to the soils formed at presence, but are placed with an offset compared to the present soil zones. Three major phases of climatic fluctuations were reconstructed for the middle Holocene:

- The interval from 8000-5500 BP is characterized as the altithermum, the maximum warming is dated to 7000-6500 BP. Due to quantitative reconstructions based on stable isotope analysis and pollen transfer functions it is dated to 5500 years ago when the average July temperatures were still about 2.5°C higher today, while the average January temperatures were about -3°C colder than the present day ones; simultaneously annual precipitations exceeded amounts of modern annual precipitation by approximately 50 *mm* (Velichko, 2012)
- A cooling tendency is observed for the beginning of the Subboreal period (5000-4500 BP). Mean July temperatures were approximately -1°C lower than those of modern times, though mean January temperatures and precipitation were similar to the present ones.

3. Middle Holocene warming and aridization date to 5000-2500 BP has also known as "xerothermic phase". Maximum warm and dry periods correlate with the quantitative reconstruction of the maximum of Subboreal period 4000-3500 BP by A.A Velichko (2012). Mean July temperatures were approximately 1.5°C higher than those of the present day, with mean January and mean annual temperatures were approximately 2°C higher than those of present day climate. The amount of annual precipitation was approximately 25 *mm* higher than at present.

4. Late Holocene cooling and increasing humidity dateto 2500 BP and is also known as the Neoglacial period. It started during the Subatlantic period, when the cooling begins at about 2500 BP, all temperature indicies were close to present-day and the precipitations exceeded the modern on by 25 *mm* (Velichko, 2012). Soils developed nearly reached its present distribution, as determined not only by the pecularities of bioclimatic conditions but also by a feeble anthropogenic soil progradation during that time (Aleksandrovski, 2005).

In conclusion it may be said that the results described here made using proxy data and allow the spatio-temporally differentiated reconstruction of Holocene palaeoclimatic fluctuations in Western Eurasia. These findings have not only a theoretical but also a practical value. Centenary palaeoclimatic fluctuations provide an understanding of the problems of different spectrums the reconstruction shows several changes of palaeoclimate and palaeolandscape during the Holocene which could have influenced the settlement, culture, migrations and economy of ancient people. Altogether the results of our research correlate with generally accepted conceptions about the environment during the Holocene.

Literatur

1 Aleksandrovski, A.L., 1983. Soil evolution of the East European Plain in the Holocene. Science Moscow. 150 (in Russian)

2 Aleksandrovski, A.L., 1995b.Evolution of the soil covers of the Russian Plain during the Holocene. Soil Science, No.3, 290-297 (in Russian)

3 Aleksandrovski, A.L., Chichagova, O.A., Pustovaitov, K.E., Shishlina, N.I., 1997. Method and methodology of radiocarbon study of archaeological sites steppe regions of Russia. Steppe and Caucasus. Proceedings of the State Historical Museum. Moscow. 9-21 (in Russian)

4 Aleksandrovski, A.L., 2002. Development of soils in Eastern Europe during the Holocene. Moscow. 296

5 Aleksandrovski, A.L., Aleksandrovskaya, E.I., 2005. Soil evolution and geographical environment. Science Moscow. 223 (in Russian)

6 Aleshinskaya, A. S., Spiridonova, E., S 2000. Chronology of the Bronze age of the boreal zone of the European Russia. Archeological digest. Tver'. Vol. 1, No.4, 52-358 (in Russian)

7 Alisov, B.P., 1936. Geographical types of climates. Meteorology and Hydrology, No.6, 16-25 (in Russian)

8 Alisov, B.P., 1956. The climate of the USSR. Moscow University Publications. Moscow. 127 (in Russian)

9 Alifanov, V.M., Ivanov, I.V., 1984. History of the development of the USSR in the Holocene soils.All-Union Conference. Pushchino. 248 (in Russian)

10 Anichin, V.A., 1956. Geography Soviet Transcarpathia. Moscow. 295 (in Russian)

11 Artyushenko, A.T., 1970. Forest and steppe vegetation of Ukraine in the Quaternary.Naukova DumkaKiev.174 (in Russian)

12 Artyushenko, A.T., Arap, R.Ja., Bezus'ko, L.G., 1982. Vegetation history of the western regions of Ukraine in the Quaternary.Naukova Dumka Kiev.136 (in Russian)

13 Artyushenko, A.T., 1988. Climatic optima Late Glacial and Holocene plains of Ukraine.Palaeoclimate Holocene in the European part of the USSR. Moscow. 136-142 (in Russian)

14 Afanas'eva, T.F., Vasilenko, V.I., Tereshina, T.V., Sheremet, B.V., 1979. The soils of the USSR. Mysl' Moscow. 380 (in Russian)

15 Ahtyrtsev, B.P., Ahtyrtsev, A.B., 1984. The characterization of the Middle Holocene palaeo-soils in the basin of the Upper Don.The Bronze Age of the Eastern European steppe. Voronezh. No.5, 146-153 (in Russian)

16 Ahtyrtsev, B.P., Ahtyrtsev, A.B., Prjahin, A.D., 1997. Archaeology of the East European forest-steppe. Voronezh. No.10, 15-24 (in Russian)
17 Ahtyrtsev, B.P., Ahtyrtsev, A.B., Jablonskih, L.Ja., 2003. History of the formation and evolution of forest-steppe soils in the Holocene. Vestnik Voronezh State University.Geography and Ecology. Voronezh. No.3, 30-41 (in Russian)
18 Barynkin, P.P., Kozin, E.V., 1998. Climatic, cultural and demographic processes in the North Caspian in the Early and Middle Holocene.The problems of ancient history of North Prokaspii. Samara. 66-83 (in Russian)
19 Bezus'ko, L.G., Klimanov, V.A., Sheljag-Sosonko, Yu.P., 1988. Climatic conditions of the Ukraine in the Late Glacial and Holocene. Palaeoclimate Holocene European USSR. IGAN USSR Moscow. 125-135 (in Russian)
20 Bel'gard, A.L., Zonn, S.B., Krupenikov, A.I., Travleev, A.P., 1983. Influence of forest vegetation on the chernozem. Russian Chernozems 100 years after Dokuchaeva.Sciences Moscow. 117-126 (in Russian)
21 Berg, L.S., 1938. Foundations of Climatology. State educational and pedagogical publishing RSFSR People's Commissariat. Leningrad. 456 (in Russian)
22 Berg, L.S., 1947. Geographical zones in the USSR. OGIZ Moscow. 398 (in Russian)
23 Bondarchuk, V.G., 1946. Tektoorogenija. Kiev State University T.Shevchenko. Kiev. 262 (in Russian)
24 Borisov, A.A., 1948. Climates of USSR. Moscow. 255 (in Russian)
25 Borisov, A.A., 1975. Climates of USSR in the past, present and future. Leningrad University. Leningrad. 1-434 (in Russian)
26 Borisov, A.V., Demkina, T.S and Demkin,V.A., 2006a. The palaeosols and climate of Ergenies in Bronze Age, IV–II thous.B.C. 1st edition. Sciences Moscow. 210 (in Russian)
27 Borisova, O.K., 2009. Landscape and climatic changes in the middle latitudes of the Northern and Southern Hemispheres during the last 130,000 years. GEOS Moscow. 264 (in Russian)
28 Bolihovskaya, N.S., 1995. The evolution of the loess-soil formations in Northern Eurasia. Moscow State University. Moscow. 270 (in Russian)
29 Bostonalieva, Zh.K., 2008. Land use in the walnut-fruit forests for example forestry Arslanbob. Proceedings of Young Scientists. Bishkek. 370, 37-41(in Russian)
30 Broecker, W.S., Kulp, I.L., 1955. Lamont ^{14}C studies. Bull of the Geological Society of America. Vol. 66, No.12, 1739-1756

31 Budyko, M.I., 1980. Climate in the Past and Future. Climate's Handbook, Total Radiation, Part 1, Issues 1-34, 1964-1970. Leningrad. 352 (in Russian)

32 Varushenko, S.I., Varushenko, A.N., Klige, R.K., 1987. Changing the Caspian Sea and the drainage basins in palaeotime. Academy of Sciences of the USSR. Science Moscow. 239, +22 maps, +1 chart (in Russian)

33 Velichko, V.V., 1985. Empirical palaeoclimatology (principles and the degree of accuracy) Method of the reconstruction paleoclimates. Science Moscow. 7-20 (in Russian)

34 Velichko, V.V., Klimanov, V.A., 1990 Climatic conditions in the Northern Hemisphere 5-6 thousand years ago. Academy of Sciences of the USSR.Geographical Series, No.5, 38-52 (in Russian)

35 Velichko, V.V., 1991. Global climate change and the response of landscape environment. Academy of Sciences of the USSR. Geographical Series, No.5, 5-22 (in Russian)

36 Velichko, V.V., 2009. Palaeoclimates and palaeoenvironments of extra-tropical area of the Northern Hemisphere Late Pleistocene-Holocene. Atlas-monograph. GEOS Moscow. 120 +24 maps (in Russian)

37 Velichko, V.V., 2010. Climates and landscapes of Northern Eurasia under conditions of global warming. Retrospective analysis and scenarios. Atlas-monograph Evolution of landscapes and climates of Northern Eurasian. Late Pleistocene-Holocene elements of prognosis. GEOS Moscow. Vol. 3, 220 +16 p. il.

38 Vodyanitskii, Yu.N., Morgun, E.G., Rumyantseva, K.A., Obydenova, L.A., Chapygina, N.V., 2009. Geochemistry of magnetite and maghemite in soils in European Russia. Geochemistry International, Vol. 47, No.3, 297-310

39 Vorob’yova, O.V., 2012. Landscape zones Russian forest-steppe and steppe. Moscow.

40 Gerasimenko, N.P., 1997. Natural human environment in the south-east of Ukraine in the Late Glacial and Holocene (based on the polaeogeographical study of archaeological sites) Dontsk. Archaeological almanac, No.6, 3-64

41 Gerasimenko, N.P., 2004. Development of zonal ecosystems of Ukraine in the Quaternary. Synopsis. Kiev. 41 (in Russian)

42 Geyh, M.A., 2005. ^{14}C dating-still a challenge for users? Berlin-Stuttgart. 63-86

43 Goldberg, P., Macphail, R.I., 2006. Practical and Theoretical Geoarchaeology. Blackwell Publishing. Malden Oxford. 455

44 Grigor’ev, A.A., 1962. Brief geographical encyclopedia.SovietEncyclopediya. Moscow. Vol. 3, 580 (in Russian)

45 Grichuk, V.P., 1951. Historical stages of evolution of the vegetation cover South-East European part of the USSR during the Quaternary period. Proceedings of the Institute of Geography. Academy of Sciences of the USSR. No.50, 5-74

46 Davydova, M.I., Rakovskaya, Yo.M., Tushinski, G.K., 1989. Physical Geography of the USSR. Education Moscow. Vol. 1, 240 (in Russian)

47 Danukalova, G., Yakovlev, A., Alimbekova, L., Yakovleva, T., Morozova, E., Eremeev, A., Kosintsev, P., 2008. Biostratigraphy of the Upper Pleistocene (Upper Neopleistocene) - Holocene deposits of the Lemeza River valley of the Southern Urals region (Russia) Quaternary International, 190. 38-57

48 Danukalova, G., Yakovlev, A., Osipova, E., Alimvekova, L., Yakovleva, T., Kosintsev, P., 2011. Biostratigraphy of the Late Upper Pleistocene (Upper Neopleistocene) to Holocene deposits of the White River valley (Southern Urals, Russia) Quaternary International, 231. 28-43

49 Demkin, A.V., Lishakov, A.V., Kovalevskay, I.S., 1992. New aspects of the palaeo-soil study of archaeological monuments. RussianArchaeology. Moscow. No.4, 43-49 (in Russian)

50 Demkin, V.A., 1997. Paleopedology and archeology: Integration into the study of the history of nature and society. Pushchino. 213 (in Russian)

51 Demkin, V.A., Gugalinskaya, L.A., Alekseev, A.O., 2007. Palaeosoil as indicator evolution biosphere. Nature Moscow. 282 (in Russian)

52 Demkin, V.A., Borisov, A.V., Demkina, T.S., Khamutova, T.S., Zolotarev, B.N., Kashirskaya, N.N., Udal’tsov, S.N., El’tsov, M.B., 2010. Volga-Don steppes in ancient and medieval times. Pushchina. 120

53 Dergachev, V.A., 1986 Moldavia and the neighboring territories in the Bronze Age. Kishinev. 224 (in Russian)

54 Dergacheva, M.I., 1997. Archaeological soil science. 1st edition. Novosibirsk. 226 (in Russian)

55 Dobrovol’skogo, G.V., 1979. SoilUSSR. Mysl’ Moscow. 129 (in Russian)

56 Dokuchaev, V.V., 1879. Mapping Russian soils.Explanatory text to the soils map of the European Russia Chaslavskogo V. Ministry of State Property. (in Russian)

57 Dokuchaev, V.V., 1899. On the study of natural zones. Horizontal and vertical soils zones. (in Russian)

58 Dokuchaev, V.V., 1936. Russian chernozem. Selkhozgiz Moscow. 651(in Russian)

59 Dokuchaev, V.V., 1948. Study of natural zones. Geographgiz Moscow. 63 (in Russian)

60 Dolukhanov, P.M., Miklyaev, A.M., 1969. Paleogeography and absolute chronology of the monuments of the Neolithic and Bronze Age in the basin of the Western Dvina Holocene. Science Moscow. 120-128 (in Russian)

61 Dolukhanov,P.M., Pashkevich, G.A., 1977.Paleographical Boundaries, Upper Pleistocene-Holocene, and Development of Economic Types in South-east Europe.Paleoecology of ancient man. Science Moscow. 134-145

62 Dolukhanov, P.M., Subetto, D.A., Arslanov, Kh.A.,Davydova, N.N., Zaitseva, G.I., Kuznetsov, D.D., Ludikova, A.V., Sapelko, T.V., Savelieva, L.A., 2009. The Holocene History of the Baltic Sea, and the Ladoga Lake. The East European Plain on the Eve of Agriculture. 123-139

63 Evseeva, N.S., Zhilina, T.N., 2010. Palaeoenvironmental of the Late Pleistocene and Holocene. Tutorial Tomsk. 180

64 Elina, G.A., Arslanov, Kh.A., Klimanov, V.A., 1996. Stages of development of the Holocene vegetation in southern and eastern Karelia. Botanical Journal, Vol. 81, No.3, 1-17

65 Elina, G.A., 2010. Mire formation patterning and peat deposition in the Holocene in North-West Russia. Late Glacial and Holocene palaeovegetation and palaeogeography of Eastern Fennoscandia. The Finnish Environment, No.4, 227-300

66 Ephimenko, P.P., 1938. Primitive society. Essays on the History of Paleolithic period. State socioeconomic Publications. Leningrad. 658 (in Russian)

67 Zaharuk, Yu.N., Telegin, D.Ya., 1985. Culture Linear Pottery. Archaeology of the Ukrainian SSR. Nauka dumka Kiev. 126-133

68 Zemtsova, A.A., 2000. Swamp in Western Siberia-their role in the biosphere. Tomsk State University. Tomsk. No.2, 72 (in Russian)

69 Ivanov, I.V., Aleksandrovski, A.L., 1987. Methods of studying the evolution of soils. Pedology, No.1, 112-121 (in Russian)

70 Ivanov, I.V., 1992. Evolution of soil steppe zone in Holocene. Science Moscow. 144 (in Russian)

71 Ivanov, I.V., Velichko, A.A., Morozova, T.D., Demkin, V.A., Pesochina, L.S., 1994. The main features of the soil cover of Eastern Europe in the Atlantic period of the Holocene. Proceedings of the USSR Academy of Sciences, Vol. 337, No.5, 667-671

72 Ivanov, I.V., Vasil'ev, I.B., 1995. Man, Nature and soil Ryn-peskov Volga-Ural inter fluvial Holocene. Intellect Moscow. 264 (in Russian)

73 Ivanov, I.V., Demkin, V.A., 1999. Soils science and archaeology. Pedologycal, No.1, 106-113 (in Russian)

74 Ivanov I.V., 2010. Regional changes in environmental conditions of ancient societies in the steppes of Eurasia. Indo-European history in the light of new research. Moscow. 343-350

75 Inostrantsev, A.A., 1882. Prehistoric Human on the Ladoga Lake Shores.St. Petersburg. 291 (in Russian)

76 Kaiser, E., 2009. Die absolute Datierung der Katakombengrabkultur im Nördlichen Schwarzmeerraum Berlin. 59-70 (in Germany)

77 Kaiser, E., Schier, W., 2009. Mobilität, Migration und Innovation als archäologischer Forschungsgegenstand. In: Jahrbuch der historischen Forschung in der Bundesrepublik Deutschland. Berichtsjahr 2008. München. 17-30 (in Germany)

78 Karavaev, N.A., 1982. Waterlogging and soil evolution. Science Moscow. 296 (in Russian)

79 Karandeev, M.V., 1957. Geomorphology of the European part of the USSR. Moscow University Publications. Moscow. 314 (in Russian)

80 Kisilevski, S.V., 1974. Did you know? Gazetteer Leningrad region. Lenin Publications. Leningrad. 104-105 (in Russian)

81 Klimanov, V.A., 1976. On the history of restoration of the quantitative characteristics of past climate. Vesti Moscow University. Moscow. Geography, No.2, 92-98 (in Russian)

82 Klimanov, V.A., 1978. Palaeoclimatic conditions in the Russian plains Holocene climatic optimum. Academy of Sciences of the USSR. Vol. 242, No.4, 902-904 (in Russian)

83 Klimanov, V.A., 1985. Reconstruction of palaeotemperature and palaeoprecipitation based on spore-pollen data. Methods of the reconstruction palaeoclimate. Science Moscow. 38-48 (in Russian)

84 Klimanov, V.A., 1996. The climate of the Northern Eurasia in the Late Glacial and Holocene. Moscow. 46 (in Russian)

85 Klimenko, V.V., Klimanov, V.A., Kozharinov, A.V., Fedorov, M.V., 1996. Global climate and the thousand-year Temperature trend in the Late Glaciations and Holocene. Methodology and Hydrology, No.7, 26-35 (in Russian)

86 Kozhaina, A.V., 1994. Dynamics of vegetation in Eastern Europe in the Late-Holocene. Synopsis. Moscow. 47 (in Russian)

87 Kozin, E.V., 2002. Neolithic Northern Caspian. Samara. 234 (in Russian)

88 Kozlovskaya, M.V., 1996. Environmental ancient tribes of the forest zone of Eastern Europe. Institute of Archaeology Russian Academy of Sciences. Moscow. 242 (in Russian)

89 Kozlovski, E.A., 2010. Russian Geological encyclopaedia. Moscow. Vol. 1, 664

90 Köppen, P., 1845. Über einige Landes-Verhältnisse der Vedent Zwischen dem Untern Dnjepr und dem asowschen Meer. Beitr. Kennt. Russ. Reich. Angrenz. Lander asiens. Bd.11. 3-47

91 Kottek, M., Grieser, J., Beck, C., Rudolf, B., Ribel, F., 2006. World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift, Vol. 15, No.3, 259-263

92 Krasnov, Yu.A., 1971. Early agriculture and livestock in the forest belt of Eastern Europe. In the II millennium BC the first half of I millennium AD. Science Moscow. 166 (in Russian)

93 Kremenetski, C.V., 1991 Palaeoecology of earliest agricultural tribes of the Russian plain. Science Moscow. 193 (in Russian)

94 Kremenetski, C.V., 1995. Holocene vegetation and climate history of south-western Ukraine. Review of Palaeobotany and Palynology, Vol. 85, 289-301

95 Kremenetski, C.V., McDonald, G.M., Galabala, R.O., Lavrov, A.S., Chichagova, O.A., Pustovaito, K.E., 1996. On the change in the northern border areas of some species of trees and shrubs in the Holocene. Botanical Journal, Vol. 81, No.4, 10–25 (in Russian)

96 Kremenetski, C.V., 1999. The natural environment of the Holocene on the Lower Don and Kalmykia. Steppe and Caucasus. Proceedings of the State Historical Museum. Moscow. 30-45

97 Krupenikov, I.A., 1982. Expensive nature of Moldova. Kishinev. 67-69

98 Krupski, N.A., 1979. Soil Atlas Ukraine SSR. Kiev. 269 (in Russian)

99 Kühl, N., Gebhardt, C., Litt, T., Hense, A., 2002. Probability Density Functions as Botanical-Climatological Transfer Functions for Climate Reconstruction Quaternary Research. 58(3) 381-392

100 Lavjorov, N.P., Medvedev, A.A., 2011. Space Research and Technology (Informatics) Science and technology in the industry. No.4, 6-25

101 Lebedeva, N.V., 2011. The shellfish in Holocene South-Minusinsk structural basin. Paleontology Synopsis. Tomsk. 154

102 Liverrovski, Yu.A., 1974. Soils USSR. Moscow. 462 (in Russian)

103 Logvinenko, N.V., 1974. Petrology of sedimentary rocks. Moscow. 416 (in Russian)

104 Markov, K.K., 1965. Major changes to the nature of the ground surface during the Holocene. Quaternary paleogeography. Moscow State University. Moscow. 5-18 (in Russian)

105 Markova, A.K., Kolfschotenvan, T., Bohncke, H., Kosintsev, P.A., Mol, J., Puzachenko, A.Yu., Simakova, A.N., Smirnov, N.G., Verporte, A., Golovachov, I.B., 2008. Evolution of European Ecosystems during Pleistocene Holocene Transition (24-8 ka BP). KMK Scientific Press. Moscow. 556 (in Russian)

106 Markov, G.E., 2009. Primitive society.Moscow State University, Faculty of History Publications. Moscow. 210

107 Martsinkevich, G.I., Klitsunova, N.K., 1989. The landscapes of Belarus. Minsk. 239 (in Russian)

108 Mahnach, N.A., 1971. The main stages of development of the flora and vegetation of Belarus in the Quaternary. Minsk. 212 (in Russian)

109 Mil'kov, F.N., Gvozdetski, N.A., 1986. The physical geography of the USSR.Overview. The European part of the USSR.Caucasus. Moscow. No.5, 376

110 Mil'kov, Ph.N., 1977. The landscapezone USSR. Mysl' Moscow. 296 (in Russian)

111 Mitchell, E.A., Charman, D.J., Warner, B.G., 2008. Testate amoebae analysis in ecological and paleoecological studies of wetlands: past, present and future. Biodiversity and Conservation, 17, 2115-2137

112 Motuzko, A.N., 2003. Basics palaeogeography. Belarusian State University. Minsk. 121 (in Russian)

113 Muratova, M.V., Suetova, I.A., 1983. Comparative analysis of environments of high and mid latitudes of the Northern Hemisphere during the climatic optimum Holocene. Vestnik of Moscow State University. Ser.5. Geography No.3, 38-46 (in Russian)

114 Neustadt, M.I., 1957. History of forests and paleogeography of the USSR in the Holocene.Academy of Sciences of the USSR. Moscow. 405 (in Russian)

115 Neustadt, M.I., Gudelis, V., 1961. Holocene Problems Institute of Geography Academy of Sciences of the USSR Institute of Geology and Geography Academy of Sciences of the Lithuanian SSR. Warsaw. 5-37

116 Neustadt, M.I., 1965. On methods of studying the Holocene deposits and used terminology. Palaeogeography and chronology of Upper Pleistocene and Holocene by the radiocarbon method. Science Moscow. 69 (in Russian)

117 Neustadt, M.I., 1969. Holocene.VIII Congress INQUA (International Union for Quaternary Research) Science Moscow. 97

118 Novenko, E.Yu., Volkova, E.M., Nosova, N.B., Zuganova, I.S., 2009. Late Glacial and Holocene landscape dynamics in the southern taiga zone of East European Plain according to pollen and macrofossil records from the Central Forest State Reserve (Valdai Hills, Russia) Quaternary International. 207 93–103

119 Novenko, E.Yu., 2011. Forest ecosystem dynamics of the south of Voldai Hills in the Late Pleistocene and Holocene.GEOS Moscow. 112 (in Russian)

120 Novoselova, N., 1989. Algae. Reference work. Naukova Dumka Kiev. 1-6 (in Russian)

121 Palamarchuk, M.M., 1992. Geography Ukraine. Prosveshchenie 159 (in Russian)
122 Parmuzin, Yu. P., 1985. Taiga USSR. Mysl' Moscow. 303 (in Russian)
123 Pashkevich, G.A., 1981.Vegetation dynamics of North-Western Black Sea during the Holocene and its changes under the influence of man. Anthropogenic factors in the history of modern ecosystems. Science Moscow. 74-86 (in Russian)
124 Pashkevich, G.A., 1989. Palaeobotanical research Trypillian materials interfluve Dnieper and Southern Bug. Prehistoric archeology. Naukova Dumka Kiev. 132-141 (in Russian)
125 Pashkevich, G.A., 1991. Palaeobotanical findings on the territory of Ukraine (Neolithic-Bronze) Kiev. 48 (in Russian)
126 Popova, A.S., 1970. Meshchera Lowlands. Moscow. 112 (in Russian)
127 Puzachenko, Yu.G., Mashkin, A.V., 1969. The information-analytical analysis of the medical and geographic research. Medical geography Moscow. No.3, 5-77
128 Pollen analysis 1950. Moscow. State publisher geol. of literature, 571 (in Russian)
129 Post von L., 1916. Einige südschwedischen Quellmoore. Bull. Geol. Inst. Univ. Upsala, 15, 219-278
130 Prohorov, A.M., 1969. Great Soviet encyclopaedia. Moscow. No.3, 632
131 Rakovskaya, E.M., Davydova, M.I., 2001.Physical Geography of Russia. Moscow. No.1, 288; No.2, 304 (in Russian)
132 Reimer, P.J., Baillie, M.G L., Bard, E., Bayliss, A., Beck, J.W., Bertrand, Ch.J H., Blackwell, P.G., Bick, C.E., Burr, G.S., Cutler, K.B., Doman, P.E., Edwards, R.L., Fairbanks, R.G., Friedrich, M., Guilderson, T.P., Hogg, A.G., Hughen, K.A., Kromer, B., McCormac. G., Manning, S., Ramsey, Ch.B., Reimer, R.W., Remmele, S., Southon J.R., Stuiver, M., Talamo, S., Taylor, F.W., Plicht von J., Weyhenmeyer, C.E., 2004. IntCal04 terrestrial radiocarbon age calibration, 0-26 cal kyr BP. Radiocarbon, Vol. 46, No.3, 1029-1058
133 Rihter, G.D., Mil'kov, F.N., 1956. Forest-steppe and steppe Russian plains. Academy of Sciences of the USSR. Moscow. 296
134 Romanovski, S.I., 1977. Sedimentological basis of lithology. Nedra Leningrad. 408 (in Russian)
135 Serebryanyi, L.R., 1971. Dynamics of distribution of some tree species in the north-west of the USSR in the post-glacial period. Palynology Holocene. Ed. M.I Neustadt. Academy of Sciences of the USSR. Moscow. 17-31 (in Russian)
136 Serebryannaya, T.A., 1982. The dynamics of the forest-steppe zone in the centre of the Russian Plain during the Holocene. Development of nature in the USSR in the Late Pleistocene and Holocene. Moscow. 179-186 (in Russian)

137 Serebryannaya, T.A., 1992. Dynamics borders of forest Central Holocene. Century dynamics biogeocenosis. Reading the memory of Academician Sukacheva N.V. Science Moscow. 54-71 (in Russian)

138 Smirnova, O.V., Turubanova, S.A., Bobrovski, M.V., Korotkov, V.N., Khanila, L.V., 2001. Reconstruction of the history of the forest zone of Eastern Europe and the problem of maintaining biological diversity.Vol. 121, No.2, 144-159 (in Russian)

139 Soil map of the World, FAO/UNESCO (Food and Agricultural of the United Nations Educational, Scientific and Cultural Organization) 1978 Paris

140 Sorrel, P., Popescu, Sp-M., Klotz, S., Suc, J-P., Oberhänsli, H., 2007. Climate variability in the Aral Sea basin (Central Asia) during the late Holocene based on vegetation changes Quaternary Research. No.67, 357-370

141 Stancikaite, M., Baltrünas, V., Sinkuünas, P., Kisieliene, D., Ostrauskas, T., 2006. Human response to the Holocene environmental changes in the Birzulis Lake region, NW Lithuania. Quaternary International. No.150, 113-129

142 Stenno, S.P., Tsiberkin, N.G., Sadovnikova, E.N., 2010. The interrelations of man and nature on the territory of Perm region in Last Pleistocene and in the first Half of Holocene system (100 000-5300 years ago) No.1 (12) - Scientific journal of the Perm University UDK 502.31(091) “6” (470.53/531)

143 Stuiver, M., Reimer, P.J., Bard, E., Beck, J.W., Burr, G.S., Hughen, K.A., Kromer, B., McCormac, G., Plicht van der J., Spurk, M., 1998. INTCAL98 Radiocarbon Age Calibration, 24 000-0 cal BP. Radiocarbon, 40(3) 1041-1083

144 Subetto, D.A., Sapelko, T.V., Kuznetsova, D.D., Ludikova, A.V., Dolikhanov, P.M., Zaitseva, G.I., 2007. The formation history of the drainage from the Ladoga Lake new palaeo-limnological data. Radiocarbon. St-Petersburg. 381-403

145 Sukachev, V.N., 1926. Swamps their education development and properties. Leningrad Forestry Institute. Leningrad. 162 (in Russian)

146 Spiridonova, E.A., 1990. The evolution landscapes in the Holocene steppe zone. Academy of Sciences of the USSR, No.6 (in Russian)

147 Spiridonova, E.A., 1991. The evolution of vegetation Don Basin in the Upper Pleistocene-Holocene. Science Moscow. 221 (in Russian)

148 Spiridonova, E.A., 1991. Changing the natural conditions of the Holocene in the Don Basin Mosolovskoe settlement Bronze Age in the system monuments in the steppe and forest. Voronezh. 53-55 (in Russian)

149 Tolpa, S., 1927. Pollen analysis of peat bogs in Janow on Roztoczu. Kosmos (in Polish)

150 Philippenko, D.P., 2012. The fauna and ecology of estuarine shellfish waters south-eastern part of the Baltic Sea. Kaliningrad.1-24

151 Physical Geographical World Atlas, USSR 1964

152 Khakhlova, O.S., Zazovskaya, E.P., Chichagova, O.A., Yablonsky, L.T., 2010. Radoicarbon Dating of Different Materials from kurgans of the Early Nomands of the Southern CIS-Urals.Ser.3. Geography. Mai-Jiun 82-94

153 Hermann Parzinger 2006. DIE FRÜHEN VÖLKER EURASIENS. Von Neolithikum bis zum Mittelalter München. 1045 (in Germany)

154 Khotinski, N.A., 1977. The Holocene of the Northern Eurasia.Science Moscow. 200

155 Khotinski, N.A., 1978.Palaeogeographic foundations dating and periodization Neolithic forest zone of the European part of the USSR. Brief reports of the Archaeological Institute, 153, 7-14 (in Russian)

156 Khotinski, N.A., 1982. Holocene chronological sections: discussion problems paleo-geography of the Holocene. Development of nature in the USSR in the late Pleistocene and Holocene. Moscow. 142-147 (in Russian)

157 Khotinski, N.A., 1991. Climate and man in Holocene of the arid and humid zones of Northern Eurasia. Aral crisis. Moscow. 48-66

158 Shamyakin, I.P., 1988. Encyclopedic directory. Belorussian Soviet Encyclopedic them P. Brovka Minsk.408 (in Russian)

159 Shnitnikova, A.V., 1957. General variability humidity in the Northern Hemisphere continents. West Geography of the Society a new series. Leningrad. Vol. 16, 337 (in Russian)

160 Chendev, Yu.G., 2005. Natural and anthropogenic evolution of forest-steppe soils in the Central Russian Upland Holocene. Moscow State University. Moscow. 303 (in Russian)

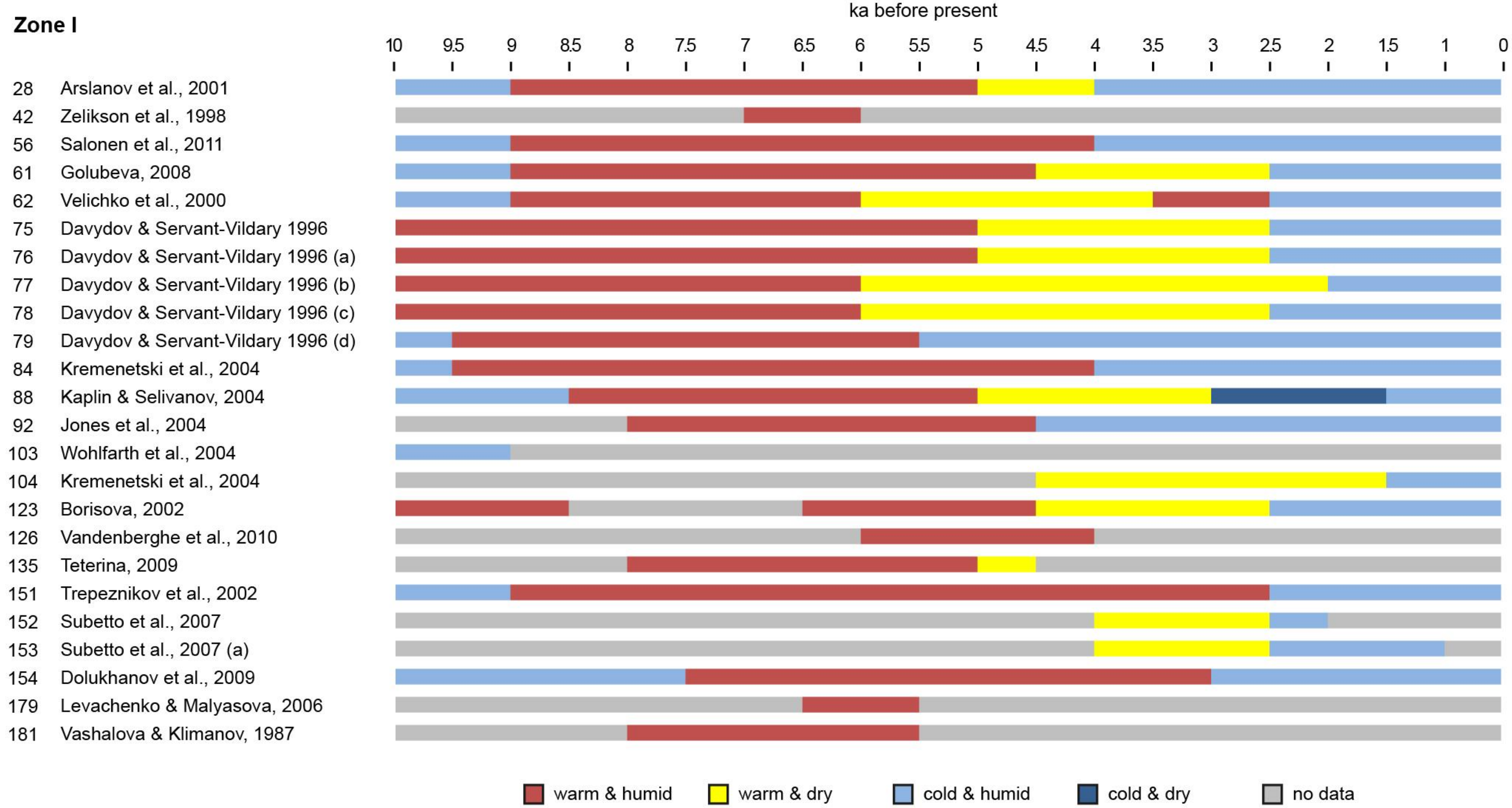
161 Josias Braun-Blanquet., 1928. Pflanzensoziologie J. Springer. 330

162 Yakovlev, S.A., 1914 Soils and subsoils on the Armavir-Tuapse railroad. St. Petersburg. 419 (in Russian)

163 Wilber, K., 2006. A Brief History of Every thing Shambala Publications, USA Boston. 476

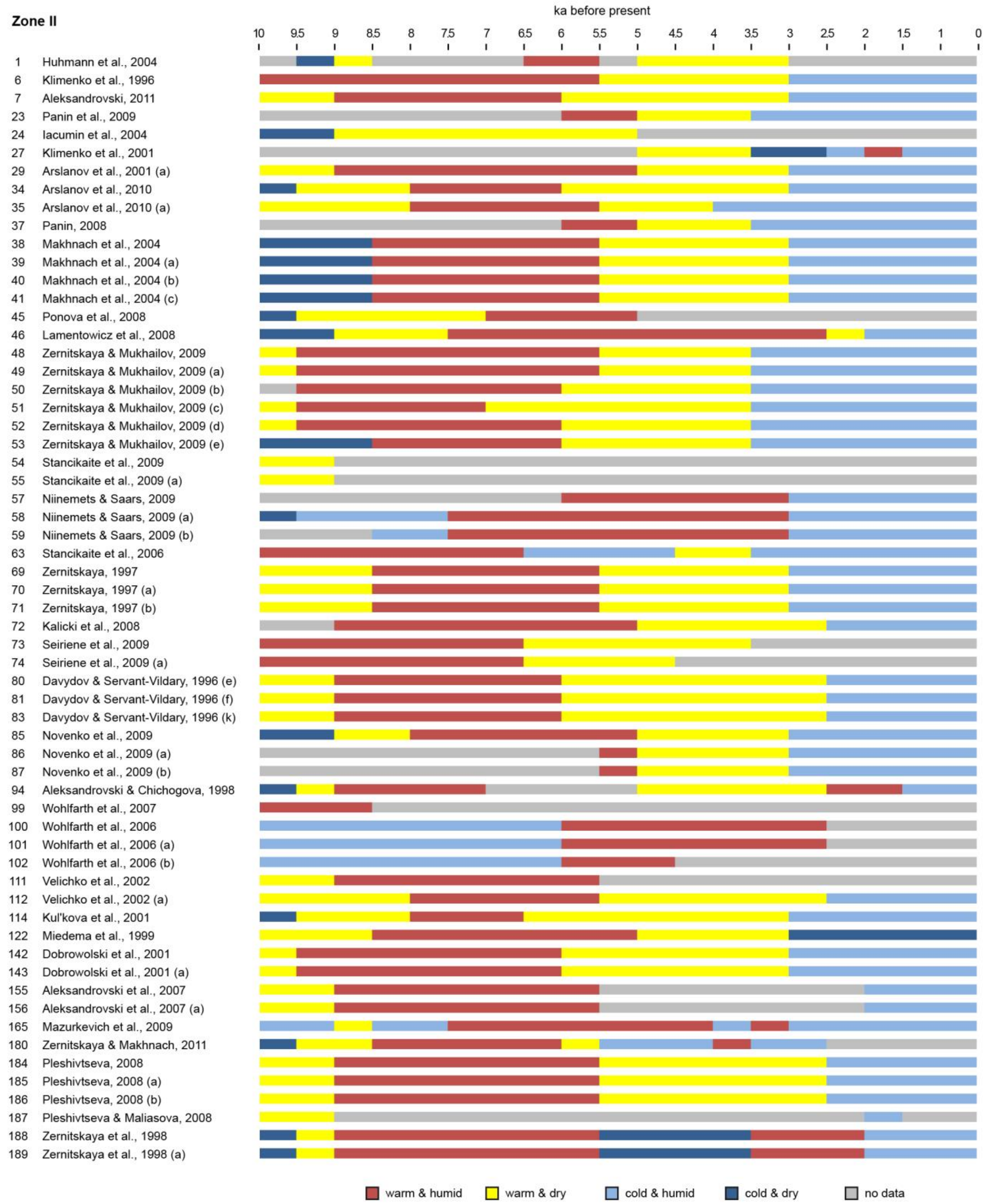
Appendix

Zone I - Taiga



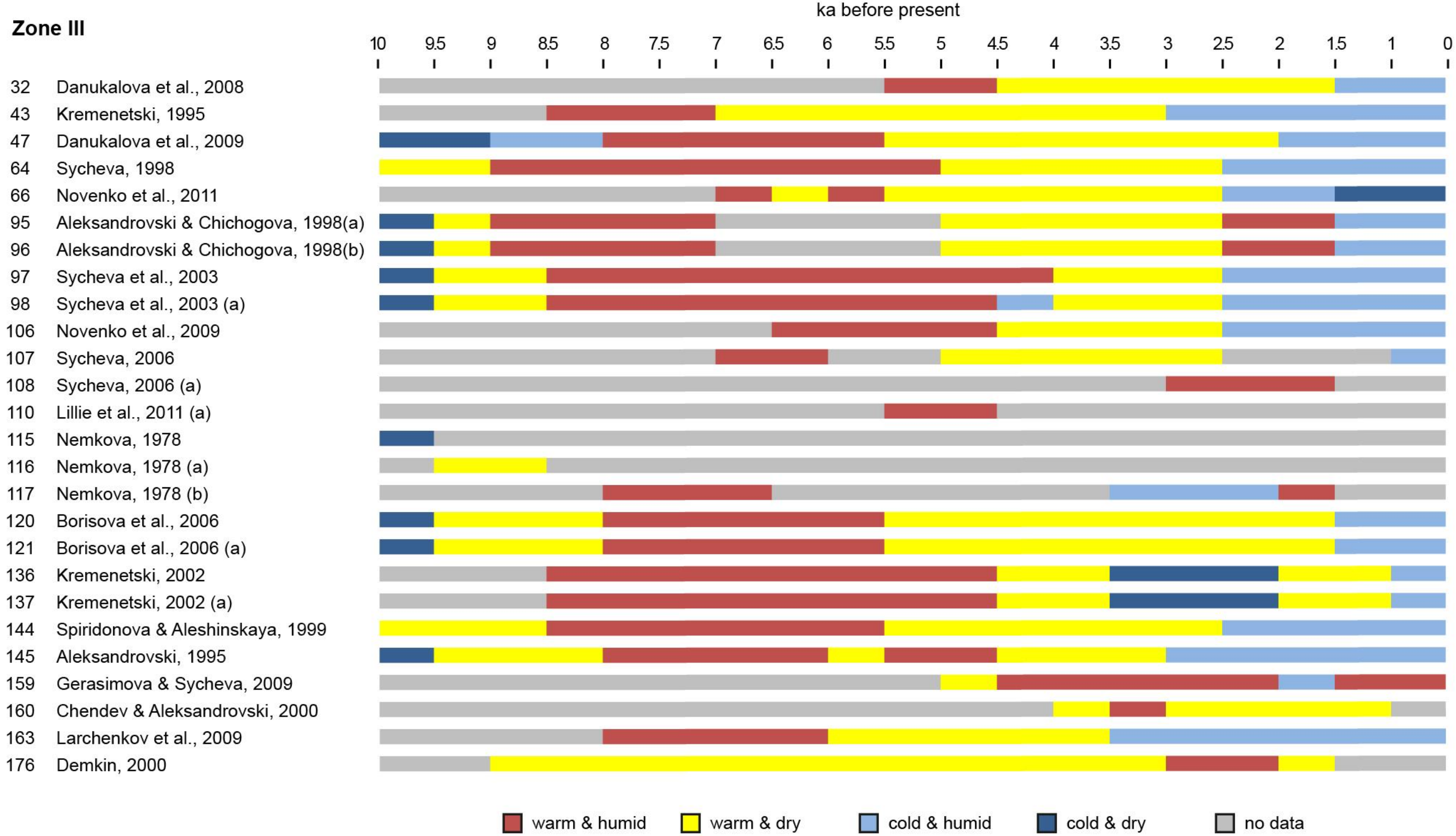
4(a)

Zone II – Mixed forest



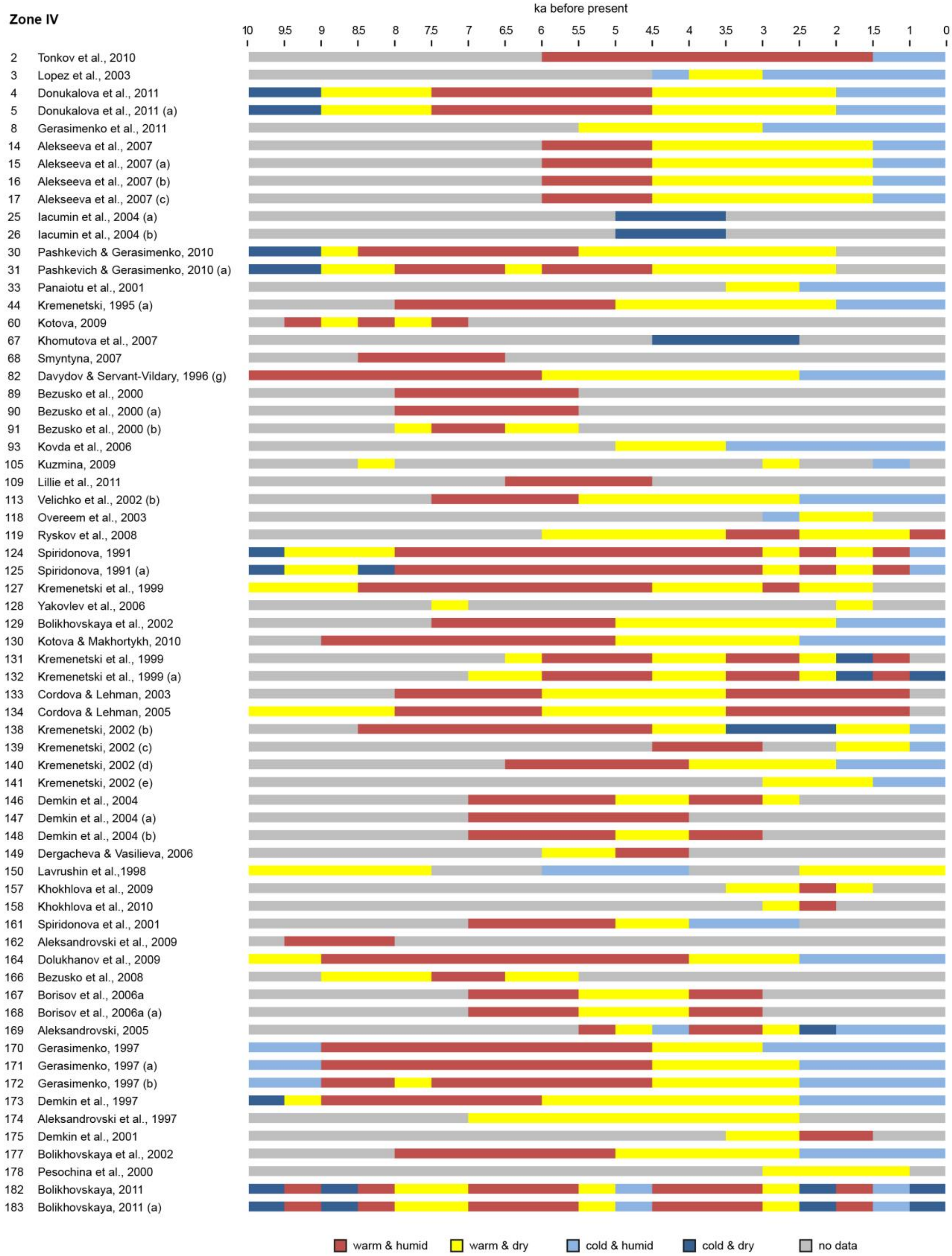
4(b)

Zone III – Forest-steppe



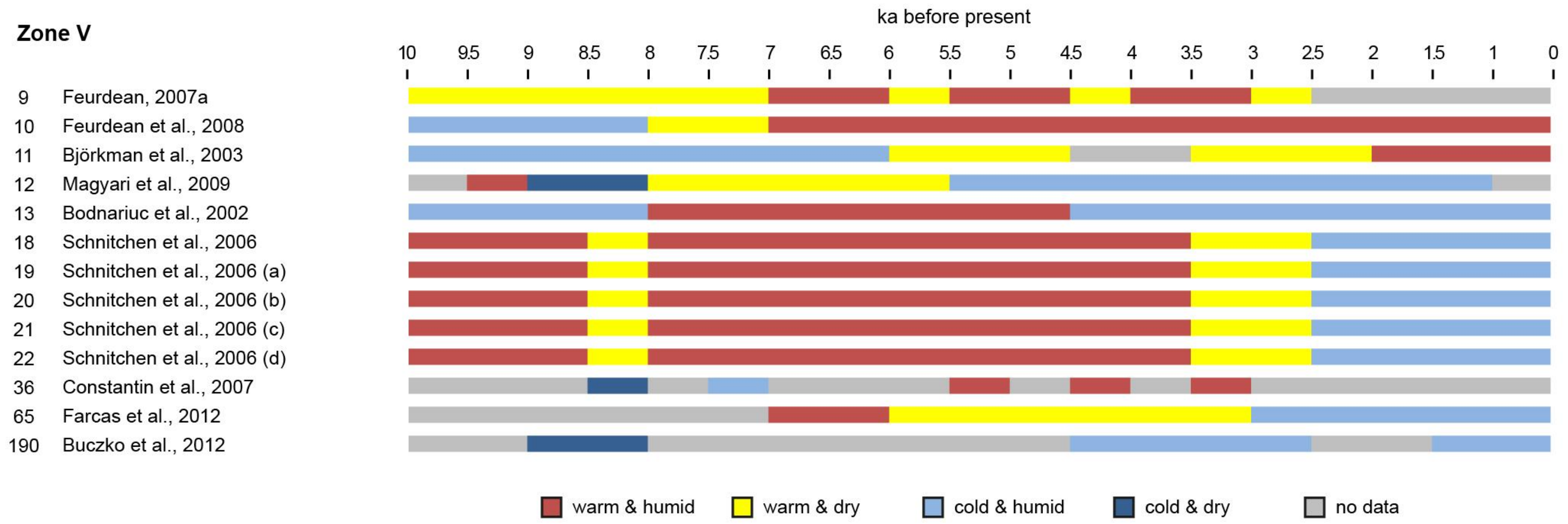
4(c)

Zone IV - Steppe



4(d)

Zone V – Carpathian Mountains



4(e)

Table 4(a-e): Palaeoclimatic conditions during the Holocene 10 ka BP into five zones (I – the taiga zone, II - mixed forest, III - forest-steppe, IV - steppe and V - Carpathian Mountains) in the Western Eurasia with sites. The figure shows the sites number (1-190) and publications. Paleoclimatic conditions are divided into five categories: warm & humid (red), warm & dry (yellow), cold & humid (blue), cold & dry (dark blue) and no data (gray).

No	Reference	File Name	Site Name	Country	Coord Y	Coord X	Absolute Dating	Dating Technique	Dated Material	Direct	No direct	Sediment age min	Sediment age max	Palaeonv. Archive	Palaeoenv- Proxy
							select one:	select one:						**select one:**	**select one:**
					Northing	Easting	Yes / No	conv. 14-C / AMS / TL / OSL / IRSL / 210-Pb / Dendro	charcoal / carbonates / bones / leaves / wood / peat / soil			Min. kyrs	Max. kyrs	written archive, lake, fluvial, colluvial, dune deposits, soils, stalagmites	Pollen, Microfossils, Carbonates, Grain Size Analysis, Sed.chemistry, Clay Minerals, Oxygen-Isotopes
1	M. Huhmann, K.V. Kremenetski, A. Hiller, H. Brückner, 2004. Late quaternary landscape evolution of the upper Dnister valley, western Ukraine. Palaeogeography, Palaeoclimatology, Palaeoecology, 209/1-4, p.51-71.	01- Huhmann_etal-2004	Mykolajiv	Ukraine	49°31'	23°59'	Y	AMS cal.14C	wood, carbonates, peat	wood, carbonates, peat		40 ka	0.9 ka	fluvial deposits	pollen, radiocarbon data
2	Sp. Tonkov., H.J. Beug, E. Bozilova, M. Filipova-Marinova, H. Jungner, 2010. Palaeoecological studies at the Kaliakra area, northeastern Bulgarian Black Sea coast: 6000 years of natural and anthropogenic change. Veget Hist Archaeobot	02-Tonkov_etal-2010	lake Bolota	Bulgaria	43°23'14.52"	28°28'16.70"	Y	cal.14C	several materials from the core(grain)	grain		6 ka	0 ka	lake deposits	pollen, macrofossil plant, radiocarbon data
3	Pilar Lopez ., Jose Antonio Lopez-Saez., Eugeny Nikolaevich Chernykh ., Pavel Tarasov Late Holocene vegetation history and human activity shown by pollen analysis of Novienki peat bog (Kargaly region, Orenburg Oblast, Russia) Veget Hist Archaeobot (2003) 12:75–82	03- Lopez_etal-2003	Kargaly	Russia	51°56'	55°10'	Y	cal.14C	peat	peat		4.6 ka	0.9 ka	soils	pollen, radiocarbon data
4	G.Danukalova., A. Yakovlev., E. Osipova., L.Alimvekova., T. Yakovleva., P. Kosintsev Biostratigraphy of the Late Upper Pleistocene (Upper Neopleistocene) to Holocene deposits of the Belaya River valley (Sourthern Urals, Russia) Quaternary International 231(2011) p.28-43	04-Donukalova_etal-2011	Kutanovo	Russia	52°58'54.83"	57°02'17.3"	Y	uncal.14C	soil, bone, molluscs	molluscs	soil, bone	30 ka	1.6 ka	fluvial deposits	pollen, molluscs, radiocarbon data, small mammals, large mammals, amphibians and reptiles
5	G.Danukalova., A. Yakovlev., E. Osipova., L.Alimvekova., T. Yakovleva., P. Kosintsev Biostratigraphy of the Late Upper Pleistocene (Upper Neopleistocene) to Holocene deposits of the Belaya River valley (Sourthern Urals, Russia) Quaternary International 231(2011) p.28-43	04(a)-Donukalova_etal-2011	Nizhnebikkuzino	Russia	52°57'	556°29'22"	Y	uncal.14C	soil, bone, molluscs	molluscs	soil, bone	30 ka	1.6 ka	fluvial deposits	pollen, molluscs, radiocarbon data, small mammals, large mammals, amphibians and reptiles
6	V.V. Klimenko, V.A. Klimanov, A.V. Kozharinov, M.V. Fedorov Global climate and the thousand-year Temperature trend in the Late Glatiation and Holocene Meterologiia i Gidrologiia 7(1996) p.26-35	05- Klimenko_etal-1996	Polovetsko-Kupanskoe	Russia	56°17'	41°17'	Y	cal.14C	organic material	organic material		11 ka	0 ka	peat bogs	pollen, oxygen-isotopes, radiocarbon data, curves palaeotemperature
7	A. L. Alexandrovskiy Soil Evolution on the Low Terraces of Lake Nero *ISSN 1064_2293, Eurasian Soil Science, 2011, Vol. 44, No. 10, pp. 1055–1067.*	06-Aleksandrovski-2011	Pesochnoe 1	Russia	57°05'	39°22'	Y	cal.14C	soil	soil		14 ka	0 ka	lake deposits	radiocarbon data
8	N. Gerasimenko, D. Subetto, V. Bakhmutov, L. Dubis, M. Gladyrevska New data on the Middle and Late Holocene environmental changes from the Saki Lake, Griemea (Ukraine) INQUA 501 Seventh Plenary Meeting and Field Trip, Odessa (ukrane) 2011 p.92-94	07-Gerasimenko_etal-2011	lake Saki	Ukraine	45°07'	33°33'	Y	AMS cal.14C	clay	clay		5.5 ka	0 ka	lake deposits	pollen, morphological, radiocarbon data
9	A. Feurdean Younger Dryas to mid-Holocene environmental history of the lowlands of NW Transylvania, Romania.Quaternary Research 68: 2007(a) p.364–378	08-Feurdean-2007a	Turbuta	Romania	47°15'441"	23°18'715"	Y	AMS cal.14C	wood, soil, clay, molluscs	wood	soil,clay,molluscs	13 ka	3 ka	soils	pollen, geochemical, radiocarbon data
10	Angelica Feurdean, Stefan Klotz, Volker Mosbrugger, Barbara Wohlfarth Pollen-based quantitative reconstructions of Holocene climate variability in NW Romania Palaeogeography, Palaeoclimatology, Palaeoecology 260 (2008) p.494–504	09-Feurdean_etal-2008	Preluca Tiganului	Romania	47°48'83"	23°31"91"	Y	AMS cal.14C	peat, charcoal, wood, bark	peat, charcoal, wood, bark		12 ka	0 ka	lake daposits	pollen, macrofossils plant, curves palaeotemperature, annual precipitation, radiocarbon data
11	Leif Björkman, Angelica Feurdean, Barbara Wohlfarth Late-Glacial and Holocene forest dynamics at Steregoiu in the Gutaiului Mountains, Northwest Romania Review of Palaeobotany and Palynology 124 (2003) p.79-111	10-Björkman_etal-2003	Steregoiu	Romania	47°48'48"	23°32'41"	Y	AMS cal.14C	mosses, bark, twig, needles, charcoal, wood, leaf fragments	mosses, wood	bark, twig, charcoalwood,	15 ka	0 ka	lake deposits	pollen, radiocarbon data
12	E.K. Magyari., K. Buczko´, G. Jakab, M. Braun, Z. Pa´l & D. Kara´tson, 2009a. Palaeolimnology of the last crater lake in the Eastern Carpathian Mountains – a multiproxy study of Holocene hydrological changes. Hydrobiologia 631:29–63	11-Magyari_etal-2009	lake Saint Ana	Romania	46°07'35"	25°53'15"	Y	AMS cal.14C	seed, leaf	seed, leaf		9 ka	0.7 ka	lake deposits	pollen, macrofossil plant, diatom, geochemical, radiocarbon data
13	A. Bodnariuc., A. Bouchette, J. J. Dedoubat, T. Otto, M.Fountugne & G. Jalut, 2002. Holocene history of the Apuseni Mountains, central Romania.vegetational Quaternary Science Reviews 21: p.1465–1488.	12- Bodnariuc_etal-2002	Ic Ponor I	Romania	46°37'46"	22°48'24"	Y	cal.14C	peat, plant macro-remains,	peat, plant macro-remains,		11 ka	0 ka	peat bogs	pollen, lithological, radiocarbon data
14	T. Alekseeva., A. Alekseev., B.A. Maher., V. Demkin Late Holocene climate reconstructions for the Russian steppe, based on mineralogical and magnetic properties of buried palaeosols. Palaeogeography, Palaeoclimatology, Palaeoecology 249 (2007) p.103–127	13-Alekseeva_etal-2007	Abganerova	Russia	48°06'	43°59'	Y	uncal.14C	soil, calcareouse, silty clay loam	soil, calcareouse, silty clay loam		5 ka	0.6 ka	soils	X-ray, radiocarbon data, Mossbauer analysis
15	T. Alekseeva., A. Alekseev., B.A. Maher., V. Demkin Late Holocene climate reconstructions for the Russian steppe, based on mineralogical and magnetic properties of buried palaeosols. Palaeogeography, Palaeoclimatology, Palaeoecology 249 (2007) p.103–127	13(a)- Alekseeva_etal-2007	Peregruznoe	Russia	48°45'	43°36'	Y	uncal.14C	soil, calcareouse, silty clay loam	soil, calcareouse, silty clay loam		5 ka	0.6 ka	soils	X-ray, radiocarbon data, Mossbauer analysis
16	T. Alekseeva., A. Alekseev., B.A. Maher., V. Demkin Late Holocene climate reconstructions for the Russian steppe, based on mineralogical and magnetic properties of buried palaeosols. Palaeogeography, Palaeoclimatology, Palaeoecology 249 (2007) p.103–127	13(b)-Alekseeva_etal-2007	Kalmykia	Russia	45°37'	44°25'	Y	uncal.14C	soil, calcareouse, silty clay loam	soil, calcareouse, silty clay loam		5 ka	0.6 ka	soils	X-ray, radiocarbon data, Mossbauer analysis
17	T. Alekseeva., A. Alekseev., B.A. Maher., V. Demkin Late Holocene climate reconstructions for the Russian steppe, based on mineralogical and magnetic properties of buried palaeosols. Palaeogeography, Palaeoclimatology, Palaeoecology 249 (2007) p.103–127	13(c)- Alekseeva_etal-2007	Malyaevka	Russia	48°42'	45°28'	Y	uncal.14C	soil, calcareouse, silty clay loam	soil, calcareouse, silty clay loam		5 ka	0.6 ka	soils	X-ray, radiocarbon data, Mossbauer analysis

18	C. Schnitchen D. J. Charman E. MagyariM. Braun I. Grigorszky B. To´thme´re´szM. Moln_ar Zs. Sz_anto Reconstructing hydrological variability from testateamoebae analysis in Carpathian peatland J Paleolimnol (2006) 36:1–17	14-Schnitchen_etal-2006	Kismohos	Hungary	48°20'	20°26'	Y	cal.14C	bulk peat	bulk peat		10 ka	0 ka	peat bogs	radiocarbon data, testate amoebae
19	C. Schnitchen D. J. Charman E. MagyariM. Braun I. Grigorszky B. To´thme´re´szM. Moln_ar Zs. Sz_anto Reconstructing hydrological variability from testateamoebae analysis in Carpathian peatland J Paleolimnol (2006) 36:1–17	14(a)-Schnitchen_etal-2006	Sirok	Hungary	47°56'	20°11'	Y	cal.14C	bulk peat	bulk peat		10 ka	0 ka	peat bogs	radiocarbon data, testate amoebae
20	C. Schnitchen D. J. Charman E. MagyariM. Braun I. Grigorszky B. To´thme´re´szM. Moln_ar Zs. Sz_anto Reconstructing hydrological variability from testateamoebae analysis in Carpathian peatland J Paleolimnol (2006) 36:1–17	14(b)-Schnitchen_etal-2006	Nuires-tö	Hungary	48°11'	22°30'	Y	cal.14C	bulk peat	bulk peat		10 ka	0 ka	peat bogs	radiocarbon data, testate amoebae
21	C. Schnitchen D. J. Charman E. MagyariM. Braun I. Grigorszky B. To´thme´re´szM. Moln_ar Zs. Sz_anto Reconstructing hydrological variability from testateamoebae analysis in Carpathian peatland J Paleolimnol (2006) 36:1–17	14(c)-Schnitchen_etal-2006	Lucs	Romania	46°18'	25°44'	Y	cal.14C	bulk peat	bulk peat		10 ka	0 ka	peat bogs	radiocarbon data, testate amoebae
22	C. Schnitchen D. J. Charman E. MagyariM. Braun I. Grigorszky B. To´thme´re´szM. Moln_ar Zs. Sz_anto Reconstructing hydrological variability from testateamoebae analysis in Carpathian peatland J Paleolimnol (2006) 36:1–17	14(d)-Schnitchen_etal-2006	Fenyves-tetö	Romania	47°40'	24°02'	Y	cal.14C	bulk peat	bulk peat		10 ka	0 ka	peat bogs	radiocarbon data, testate amoebae
23	A.V. Panin , J.N. Fuzeina, V.R. Belyaev Long-term development of Holocene and Pleistocene gullies in the Protva River basin,Central Russia Geomorphology 108 (2009) p.71–91	15- Panin_etal-2009	Borovsk District	Russia	55°12'	36°22'	Y	cal.14C	charcoal, wood, bulk, peat, soil	charcoal,	wood, bulk, peat	6 ka	0 ka	soils	lithological, radiocarbon data
24	P. Iacumin,V. Nikolaev, M. Ramigni, A. Longinelli Oxygen isotope analyses of mammal bone remains from Holocene sites in European Russia: palaeoclimatic implications Global and Planetary Change 40 (2004) p.169–176	16- Iacumin_etal-2004	Zamiost'e	Russia	56°40'	38°20'	N	cultural age	human bone	human bone		10.5 ka	5 ka	soils	oxygen-isotopes
25	P. Iacumin,V. Nikolaev, M. Ramigni, A. Longinelli Oxygen isotope analyses of mammal bone remains from Holocene sites in European Russia: palaeoclimatic implications Global and Planetary Change 40 (2004) p.169–176	16(a)- Iacumin_etal-2004	Mandjikiny	Russia	45°43'0"	42°54'0"	N	cultural age	human bone	human bone		5 ka	0 ka	soils	oxygen-isotopes
26	P. Iacumin,V. Nikolaev, M. Ramigni, A. Longinelli Oxygen isotope analyses of mammal bone remains from Holocene sites in European Russia: palaeoclimatic implications Global and Planetary Change 40 (2004) p.169–176	16(b)-Iacumin_etal-2004	Novorossiisk	Russia	45°43'0"	42°54'0"	N	cultural age	human bone	human bone		6 ka	1.7 ka	lake deposits	oxygen-isotopes
27	V. V. Klimenko, V. A. Klimanov, A. A. Sirin, and A. M. Sleptsov Climate Changes in Western European Russia in the Late Holocene *Doklady Earth Sciences, Vol. 377, No. 2, 2001, p.190–194*	17-Klimenko_etal-2001	Usvyatskii Mokh bog	Russia	56°	32°	Y	cal.14C	peat	peat		5 ka	0 ka	peat bogs	cuvers temperatures, annual precipitation, radiocarbon data
28	Kh.A Arslanov., L.A Savelieva., V.A Klimanov., S.B Chernov., f:e Maksimov:, T.V Tertychnaya., D.A Subbetto New data on chronology of landscape-paleoclimatic stages in Nort-Western Russia during the Late Glacial and Holocene Radiocarbon, Vol 43, Nr2B, 2001, p.581-594	18- Arslanov_etal-2001	lake Lembolovskoye	Russia	60°21'45"	30°18'80"	Y	cal. 14C	peat, gyttja	peat, gyttja		9.8 ka	1.2 ka	lake deposits	pollen, radiocarbon data
29	Kh.A Arslanov., L.A Savelieva., V.A Klimanov., S.B Chernov., f:e Maksimov:, T.V Tertychnaya., D.A Subbetto New data on chronology of landscape-paleoclimatic stages in Nort-Western Russia during the Late Glacial and Holocene Radiocarbon, Vol 43, Nr2B, 2001, p.581-594	18(a)-Arslanov_etal-2001	bog Mshinskoye	Russia	59°52'00"	29°55'00"	Y	cal.14C	peat, sand, clay, layers	peat, sand, clay, layers		9.7 ka	0 ka	lake deposits	pollen, radiocarbon data
30	G.A. Pashkevich, N.P.Gerasimenko The Holocene Vegetation, Climate and Early Human Subsistence in the Uktaine. The East European Plain on the Eva of Agriculture 2010 p.45-51	19-Pashkevich & Gerasimenko-2010	Rogalik 12	Ukraine	48°35'	39°41'	Y	uncal.14C	soil	soil		10 ka	2 ka	peat bogs	pollen, macrofossils plant, radiocarbon data
31	G.A. Pashkevich, N.P.Gerasimenko The Holocene Vegetation, Climate and Early Human Subsistence in the Uktaine. The East European Plain on the Eva of Agriculture 2010 p.45-51	19(a)-Pashkevich & Gerasimenko-2010	lake Glubokoye	Ukraine	48°57'40"	37°48'50"	Y	uncal.14C	soil	soil		10 ka	2 ka	soils	pollen, macrofossils plant, radiocarbon data
32	G. Danukalova, A.Yakovlev, L. Alimbekova, T.Yakovleva,E. Morozova, A. Eremeev, P. Kosintsev Biostratigraphy of the Upper Pleistocene (Upper Neopleistocene)–Holocene deposits of the Lemeza River valley of the Southern Urals region (Russia) Quaternary International 190 (2008) 38–57	20-Danukalova_etal-2008	cave Karst	Russia	54°33'	57°16'	Y	uncal.14C	mollusca, bone, wood	wood	molluscs, bone	50 ka	0.2 ka	fluvial deposits	pollen, molluscs, radiocarbon data, small mammals, large mammals, amphibians and reptiles
33	C.G. Panaiotu, E.C. Panaiotu, A.Grama & C. Necula Paleoclimatic Record from a Loess-Paleosol Profile in Southeastern Romania *Phys. Chem. Earth (A),* Vol. 26, No. 1 I-12, 2001p. 893-898	21-Panaiotu_etal-2001	lake Mostigtea	Romania	44°09'	26°49'	N					8 ka	0 ka	soils	IRM , ARM, RMP
34	Kh.A. Arslanov, P.M. Dolukhanov, L.A. Savelieva, E.N. Dzinorudze, G.F. Kuzmin, V.P. Denisenkov The Holocene Environments in North-Western and Central Russia The East European Plain on the Eva of Agriculture 2010 p.109-121	22- Arslanov_etal-2010	bog Prigorodnoe	Russia	54°47'	32°03'	Y	cal.14C	peat	peat		13 ka	0 ka	peat bogs	pollen, diatom, radiocarbon data
35	Kh.A. Arslanov, P.M. Dolukhanov, L.A. Savelieva, E.N. Dzinorudze, G.F. Kuzmin, V.P. Denisenkov The Holocene Environments in North-Western and Central Russia The East European Plain on the Eva of Agriculture 2010 p.109-121	22(a)-Arslanov_etal-2010	lake Zhizhitsa	Russia	56°21'	30°31'	Y	cal.14C	peat	peat		13 ka	0 ka	lake deposits	pollen, diatom, radiocarbon data
36	Silviu Constantin, Ana-Voica Bojar, Stein-Erik Lauritzen, Joyce Lundberg Holocene and Late Pleistocene climate in the sub-Mediterraneancontinental environment: A speleothem record from Poleva Cave (Southern Carpathians, Romania) Palaeogeography, Palaeoclimatology, Palaeoecology 243 (2007) 322–338	23-Constantin_etal-2007	cave Poleva	Romania	44°44'	21°45'	Y	uncal.14C				42 ka	2.3 ka	cave deposits	oxygen-istopes, U-series dates
37	A.V. Panin Chronology of Erosion in the Center of the Eastern European Plain over the Last 5000 Years *Doklady Earth Sciences, 2008, Vol. 423, No. 8, p.1324–1328*	24- Panin-2008	Satino	Russia	55°12.8'	36°22.0'	Y	cal.14C	soil, charcoal, wood	soil, charcoal, wood		6 ka	0.5 ka	fluvial deposits	radiocarbon data

38	N. Makhnach, V. Zernitskaja, I. Kolosov, G. Simakova Stable oxygen and carbon isotopes in Late Glacial–Holocene freshwater carbonates from Belarus and their palaeoclimatic implications Palaeogeography, Palaeoclimatology, Palaeoecology 209 (2004) p.73– 101	25-Makhnach_etal-2004	lake Teklits	Belarus	54°56'	28°30'	Y	cal.14C	gyttja, sand, marl	gyttja, sand, marl		11.9 ka	0 ka	lake deposits	pollen, geochemical,oxygen-isotopes, X-ray, radiocarbon data
39	N. Makhnach, V. Zernitskaja, I. Kolosov, G. Simakova Stable oxygen and carbon isotopes in Late Glacial–Holocene freshwater carbonates from Belarus and their palaeoclimatic implications Palaeogeography, Palaeoclimatology, Palaeoecology 209 (2004) p.73– 101	25(a)- Makhnach_etal-2004	lake Okono	Belarus	54°50'	28°32'	Y	cal.14C	gyttja, sand, marl	gyttja, sand, marl		12.8 ka	0 ka	lake deposits	pollen, geochemical, oxygen-isotopes, X-ray, radiocarbon data
40	N. Makhnach, V. Zernitskaja, I. Kolosov, G. Simakova Stable oxygen and carbon isotopes in Late Glacial–Holocene freshwater carbonates from Belarus and their palaeoclimatic implications Palaeogeography, Palaeoclimatology, Palaeoecology 209 (2004) p.73–101	25(b)- Makhnach_etal-2004	lake Lozoviki	Belarus	55°16'	28°07'	Y	cal.14C	gyttja, sand, marl, peat	gyttja, sand, marl, peat		11.9 ka	0 ka	lake deposits	pollen, geochemical, oxygen-isotopes, X-ray, radiocarbon data
41	N. Makhnach, V. Zernitskaja, I. Kolosov, G. Simakova Stable oxygen and carbon isotopes in Late Glacial–Holocene freshwater carbonates from Belarus and their palaeoclimatic implications Palaeogeography, Palaeoclimatology, Palaeoecology 209 (2004) p.73–101	25(c)-Makhnach_etal-2004	Ptich	Belarus	53°48'	27°25'	Y	cal.14C	laom, tufa, peat	laom, tufa, peat		12.8 ka	0 ka	soils	pollen, geochemical, oxygen-isotopes, X-ray, radiocarbon data
42	E.M. Zelikson, O.K. Borisova, C.V. Kremenetsky, A.A. Velichko Phytomass and carbon storage during the Eemian optimum, late Weichselian maximum and Holocene optimum in Eastern Europe Global and Planetary Change 16–17 _1998 p.181–195	26-Zelikson_etal-1998	Russian Plain	Russia	65°	55°	Y	cal.14C				6 ka	5.5 ka	soils	pollen, radiocarbon data
43	C.V.Kremenetskii Holocene vegetation and climate histiry of southwestwrn Ukraine. Review of Palaeobotany and Palynology 85 (1995) p.289-301	27-Kremenetskii-1995	swamp Dovjok	Ukraine	48°45'	28°15'	Y	uncal.14C	humic acids, peat,	humic acids, peat,		8 ka	0.8 ka	peat bogs	pollen, radiocarbon data
44	C.V.Kremenetski Holocene vegetation and climate histiry of southwestwrn Ukraine. Review of Palaeobotany and Palynology 85 (1995) p.289-301	27(a)-Kremenetskii-1995	swamp Kardashiniski	Ukraine	46°31'	32°37'	Y	uncal.14C	humic acids, peat,	humic acids, peat,		8 ka	0.8 ka	peat bogs	pollen, radiocarbon data
45	N.K Ponova., T.G Antipina., N.E Zeretskaya New data on polinology, geochronology and stratigraphy of the lake and marsh sediments in the Middle Urals "polinology: stratigraphy and geoecology" Volume II.2008 p.188-194	28-Ponova_etal-2008	Kalatinsk	Russia	57°21'	60°08'	Y	uncal.14C	peat, sapropel	peat, sapropel		10 ka	5 ka	peat bogs	pollen, radiocarbon data
46	Mariusz Lamentowicz, Milena Obremska, Edward A.D. Mitchell Autogenic succession, land-use change, and climatic influences on the Holocene development of a kettle-hole mire in Northern Poland Review of Palaeobotany and Palynology 151 (2008) 21–40	29- Lamentowicz_etal-2008	Tuchola Pinewoods	Poland	53°34'30"	17°54'05"	Y	AMS cal.14C	pine bark	pine bark		9.4 ka	0.5 ka	peat bogs	pollen, macrofossils plant and amoebae, radiocarbon data
47	G. Danukalova., A. Yakovlev., P. Kosintcev., A. Agadjanian., L. Alimbekova., A. Eremeev, E.. Morozova Quaternary fauna and flora of the Southern Urals region (Bashkortostan Republic) Quaternary International 201 (2009) 13–24	30-Danukalova_etal-2009	Karmaskaly (Chatra creek)	Russia	54°22'	56°10'	Y	uncal.14C	bones, molluscs, wood	bones, molluscs, wood		13 ka	0 ka	soils	radiocarbon data, small mammals, molluscs
48	V. Zernitskaya & N. Mikhailov Evidence of early farming in the Holocene pollen spectra of Belarus Quaternary International 203 (2009) 91–104	31-Zernitskaya & Mukhailov-2009	Lake Bobrovichsko	Belarus	52°37'49"	25°46'55"	Y	uncal.14C	gyttja, peat	gyttja, peat		13.7 ka	0 ka	lake deposits	pollen, radiocarbon data
49	V. Zernitskaya & N. Mikhailov Evidence of early farming in the Holocene pollen spectra of Belarus Quaternary International 203 (2009) 91–104	31(a)- Zernitskaya & Mukhailov-2009	Ivanicovka	Belarus	52°16'	26°02'	Y	uncal.14C	peat	peat		13.7 ka	0 ka	peat bogs	pollen, radiocarbon data
50	V. Zernitskaya & N. Mikhailov Evidence of early farming in the Holocene pollen spectra of Belarus Quaternary International 203 (2009) 91–104	31(b)-Zernitskaya & Mukhailov-2009	Neropla	Belarus	54°01'17"	29°44'28"	Y	uncal.14C	gytja, peat, wood	gytja, peat, wood		13.7 ka	0 ka	lake deposits	pollen, radiocarbon data
51	V. Zernitskaya & N. Mikhailov Evidence of early farming in the Holocene pollen spectra of Belarus Quaternary International 203 (2009) 91–104	31(c)-Zernitskaya & Mukhailov-2009	Mezhuzhol	Belarus	56°02'	28°10'	Y	uncal.14C	gyttja, sand, mollusk	gyttja, sand		13.7 ka	0 ka	lake deposits	pollen, radiocarbon data
52	V. Zernitskaya, N. Mikhailov Evidence of early farming in the Holocene pollen spectra of Belarus Quaternary International 203 (2009) 91–104	31(d)-Zernitskaya & Mukhailov-2009	Lozoviki	Belarus	55°33'	27°52'	Y	uncal.14C	gyttja, peat, wood, sand	gyttja,peat, wood, sand		13.7 ka	0 ka	lake deposits	pollen, radiocarbon data
53	V. Zernitskaya & N. Mikhailov Evidence of early farming in the Holocene pollen spectra of Belarus Quaternary International 203 (2009) 91–104	31(e)- Zernitskaya & Mukhailov-2009	Osveya	Belarus	56°02'	28°10'	Y	uncal.14C	gyttja, peat, wood, sand	gyttja,peat, wood, sand		13.7 ka	0 ka	peat bogs	pollen, radiocarbon data
54	M. Stanc˘ikait, D. Kisielien, D. Moeb, G. Vaikutien Lateglacial and early Holocene environmental changes in northeastern Lithuania Quaternary International 207 (2009) 80–92	32-Stancikaite_etal-2009	Petrasiunai	Lithuania	55°50'52"	25°42'10"	Y	AMS cal.14C	gyttjav, peat, macrofossil	gyttjav, peat,macr ofossil		13.1 ka	9.4 ka	lake deposits	pollen, macrofossils plant, diatom, lithological, radiocarbon data
55	M. Stanc˘ikait, D. Kisielien, D. Moeb, G. Vaikutien Lateglacial and early Holocene environmental changes in northeastern Lithuania Quaternary International 207 (2009) 80–92	32(a)-Stancikaite_etal-2009	Juodonys	Lithuania	55°44'22"	25°26'15"	Y	AMS cal.14C	gyttjav, peat, macrofossil	gyttjav, peat,macr ofossil		13.1 ka	9.4 ka	peat bogs	pollen, macrofossils plant, diatom, lithological, radiocarbon data
56	J. Sakari Salonen, Heikki Seppä, Minna Väliranta, Vivienne J. Jones, Angela Self, Maija Heikkilä, Seija Kultti, Handong Yang The Holocene thermal maximum and late-Holocene cooling in the tundra of NE European Russia Quaternary Research 75 (2011) 501-511	33- Salonen_etal-2011	Lake Kharinei	Russia	67°22′	62°45′	Y	AMS cal.14C, 210Pb	bulk sediment, macrofossil	Bulk sediment, macrofossi l		14 ka	0 ka	lake deposits	pollen, macrofossils plant, radiocarbon data
57	E. Niinemets & L. Saarse Holocene vegetation and land-use dynamics of south-eastern Estonia Quaternary International 207 (2009) 104–116	34-Niinemets & Saars-2009	Plaani	Estonia	57°40'30"	27°04'30"	Y	AMS cal.14C, 210Pb	gyttja	gyttja		6 ka	0 ka	lake deposits	pollen, radiocarbon data
58	E. Niinemets & L. Saarse Holocene vegetation and land-use dynamics of south-eastern Estonia Quaternary International 207 (2009) 104–116	34(a)-Niinemets & Saars-2009	Verijärv	Estonia	57°48'30"	27°03'30"	Y	AMS cal.14C, 210Pb	gyttja, wood, bark, fish scales	wood	gyttja, bark,fis hscales	10.5 ka	0 ka	lake deposits	pollen, radiocarbon data
59	E. Niinemets & L. Saarse Holocene vegetation and land-use dynamics of south-eastern Estonia Quaternary International 207 (2009) 104–116	34(b)-Niinemets & Saars-2009	Lasva	Estonia	57°51'30"	27°10'30"	Y	AMS cal.14C, 210Pb	gyttja, wood, macroremains	wood	gyttja, macror emains	8.4 ka	0 ka	lake deposits	pollen, radiocarbon data
60	N. Kotova The Neolithization of Northern Black Sea area in the context of climate changes Documenta Praehistorica XXXVI (2009) p.159-174	35-Kotova-2009	Rakushechnyi Yar	Russia	47°31'40"	40°36'50"	Y	cal.14C	pots-snuff, bone, stone	pots-snuff	bone, stone	7.5 ka	5.5 ka	soils	pallen, radiocarbon data
61	Yu.V Golubeva Holocene climate and vegetation of Komi republic Institute of Geology ,Komi Science Centreural Bronch of RAS Litospherab,2008, N 2, p. 124-132	36-Golubeva-2008	lake Sindor	Russia	62°43'37"	51°53'08"	Y	cal.14C	peat, sand, loam, sandy loam	peat,sand, loam, sandy loam		10.3 ka	0 ka	lake deposits	pollen, radiocarbon data, curves palaeotemperature

62	A.A.Velichko., K.V.Kremenetskii., Inegendank., Imingram.,O.K.Borisova.,YU.N.Gribchenko.,E.M.Zelikson.,V.A.Klimanov .,E.Yu.Novenko.,L.G.Pirumova.,V.V.Pisareva.,L.V.Razumovskii.,S.N.Ti mireva Late Quanternery Paleogeogrephy of the North-East of Europe Besed (on the Complex Study of the Galich lake Sediments) A seria of geography 3.2001.p.42-54	37-Velichko_etal-2000	lake Galich	Russia	58°24'	42°17'	Y	uncal.14C	peat, wood	peat		10 ka	0 ka	lake deposits	pollen, diatom, geochemical, radiocarbon data, annual precipitation
63	Migle Stancikaite, Valentinas Baltrūnas, Petras Sinkuūnas, Dalia Kisieliene, Tomas Ostrauskas Human response to the Holocene environmental changes in the Birzulis Lake region, NW Lithuania Quaternary International 150 (2006) p.113–129	38-Stancikaite_etal-2006	lake Bitzulis	Lithuania	55°47'	22°26'	Y	AMS cal.14C	peat, macrofossil, gyttja	gyttja, macrofossi l. peat		8.1 ka	0 ka	lake deposits	pollen, radiocarbon data
64	S.A.Sycheva Centuries-Old Rhythm of Soil and Relief Forming on Middle-Russian Upland in Holocene Series of geographic 3 2002 .87-97	39-Sycheva-1998	Shumskaia	Russia	51°41'	37°52'	Y	uncal.14C	soil	soil		10 ka	0 ka	fluvial deoisits	morphological, radiocarbon data
65	Sorina Farcas, Ioan Tantau, Marcel Mîndrescu, Bogdan Hurdu Holocene vegetation history in the Maramures¸ Mountains (Northern Romanian Carpathians) Quaternary International XXX (2012) p.1-13	40-Farcas_etal-2012	Taul MareeBardau	Romania	47°50'	24°36'	Y	AMS cal.14C	peat	peat		7 ka	0 ka	peat bogs	pollen, radiocarbon data
66	E.Yu Novenko., E.M Volkova., I.S Zyuganova Dynamics of vegetation and climate of the upper basin of the Don in the Holocene "Problema sovremennoi polinologii Tom-II" p.162-166	41- Novenko_etal-2011	swamp Bolsheberezo vskoe	Russia	53°39'41''	38°35'03''	Y	uncal.14C	charcoal, peat	charcoal, peat		7 ka	o ka	peat bogs	pollen, radiocarbon data
67	T.E. Khomutova, T.S. Demkina, A.V. Borisov, N.N. Kashirskaya, M.V. Yeltsov, V.A. Demkin An assessment of changes in properties of steppe kurgan paleosoils in relation to prevailing climates over recent millennia Quaternary Research 67 (2007) p.328–336	42-Khomutova_etal-2007	Avilov	Russia	50°12'	45°06'	N					4 ka	0 ka	soils	morphological
68	O.V. Smyntyna Late Mesolithic of the Ukrainian part of the Lower Danube region: New perspectives of human adaptation and interpretation of natural environments Quaternary International 167–168 (2007) p.114–120	43- Smyntyna-2007	Mirnoye	Ukraine	46°28'09''	30°22'21''	Y	cal.14C	bone	bone		8 ka	7 ka	fluvial deposits	morphological
69	V.P. Zernitskaya. The evolution of lakes in the Poles'ye in the late and holocene. Quaternary Internazional, Vols 41/42, 1997.p.153-160	44- Zernitskaya-1997	lake Novoselki	Belarus	53°54'	30°20'	Y	uncal.14C	peat, gress	peat		12 ka	0 ka	lake deposits	pollen, radiocarbon data
70	V.P. Zernitskaya. The evolution of lakes in the Poles'ye in the late and holocene. Quaternary Internazional, Vols 41/42, 1997.p.153-160	44(a)- Zernitskaya-1997	lake Peschanoe	Belarus	51°58'59''	25°29'	Y	uncal.14C	peat, gress	peat		12 ka	0 ka	lake deposits	pollen, radiocarbon data
71	V.P. Zernitskaya. The evolution of lakes in the Poles'ye in the late and holocene. Quaternary Internazional, Vols 41/42,1997.p.153-160	44(b)-Zernitskaya-1997	lake Selyakhi	Belarus	51°36'03''	23°36'58''	Y	uncal.14C	peat, gress	peat		12 ka	0 ka	lake deposits	pollen, radiocarbon data
72	Tomasz Kalicki, Siarhey Sauchyk, Gilberto Calderoni, Galina Simakova Climatic versus human impact on the Holocene sedimentation in river valleys of different order: Examples from the upper Dnieper basin, Belarus Quaternary International 189 (2008) p.91–105	45-Kalicki_etal-2008	lake Neroplia	Belarus	53°1'16''	29°44'43''	Y	uncal.14C	peat, soil, fossil ice, sand	peat, soil, fossil ice, sand		10 ka	0 ka	fluvial deposits	pollen, lithological, geochemical, radiocarbon data
73	V. Sˇeiriene, M. Kabailiene, J. Kasperovicˇiene, J. Ma_zeikas, R. Petrosˇius, R. Pasˇkauskas Reconstruction of postglacial palaeoenvironmental changes ineastern Lithuania: Evidence from lacustrine sediment data Quaternary International 207 (2009) p.58–68	46- Seiriene_etal-2009	lake Varenis	Lithuania	54°17'	24°33'	Y	cal.14C	gyttja, clay, molluscs	gyttja, clay, molluscs		13.2 ka	3.8 ka	lake deposits	pollen, diatom, radiocarbon data
74	V. Sˇeiriene, M. Kabailiene, J. Kasperovicˇiene, J. Ma_zeikas, R. Petrosˇius, R. Pasˇkauskas Reconstruction of postglacial palaeoenvironmental changes ineastern Lithuania: Evidence from lacustrine sediment data Quaternary International 207 (2009) p.58–68	46(a)-Seiriene_etal-2009	lake Baltys	Lithuania	55°35'	25°31'	Y	cal.14C	gyttja, clay, peat, molluscs	gyttja, clay, peat, molluscs		11.2 ka	4.4 ka	lake deposits	pollen, diatom, radiocarbon data
75	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47-Davydov & Servant-Vildary-1996	lake Imandra	Russia	67°30'	33°00'	Y	cal. 14C	gyttia, diatomite, peat, plant wood	gyttia, diatomite, peat, plant wood		10 ka	0 ka	lake deposits	pollen, diatom, lithological, radiocarbon data
76	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(a)- Davydov & Servant-Vildary-1996	lake Kovdor	Russia	66°30'	33°00'	Y	cal.14C	gyttia,diatomit e, peat, plant remains, wood	gyttia,diato mite,peat, plantremai ns, wood		10 ka	0 ka	lake deposits	pollen, diatom, lithological, radiocarbon data
77	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(b)-Davydov & Servant-Vildary-1996	lake Mitrophan	Russia	67°50'	59°	Y	cal.14C	peat, molluscs, clay, sand	peat, molluscs, clay, sand		10 ka	0 ka	lake deposits	pollen, diatom, lithological, radiocarbon data
78	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(c)-Davydov & Servant-Vildary-1996	lake Vishnewskoy e	Russia	60°30'	29°30'	Y	cal.14C	mud, clay	mud, clay		10 ka	0 ka	lake deposits	pollen, diatom, lithological, radiocarbon data
79	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(d)-Davydov & Servant-Vildary-1996	lake Ilmen	Russia	59°15'	33°06'	Y	cal.14C	mud, clay	mud, clay		9 ka		lake deposits	pollen, diatom, lithological, radiocarbon data
80	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(e)-Davydov & Servant-Vildary-1996	lake Volday	Russia	58°00'	33°16'	Y	cal.14C	sand, gyttia, sapropel	sand, gyttia, sapropel		9 ka	3 ka	lake deposits	pollen, diatom, lithological, radiocarbon data
81	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(f)- Davydov & Servant-Vildary-1996	lake Naroch	Belarus	54°53'03'	26°47'06''	Y	cal.14C	sand, sapropel	sand, sapropel		10 ka	0 ka	lake deposits	pollen, diatom, lithological, radiocarbon data
82	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(g)-Davydov & Servant-Vildary-1996	lake Nero	Russia	50°08'	39°28'	Y	cal.14C	boulders, sand, clay, sapropel,	boulders, sand, clay, sapropel,		10 ka	0 ka	lake deposits	pollen, diatom, lithological, radiocarbon data

83	N.Davydova & S. Servant-Vildary. Late pleiatocene and holocene histiry of the lakes in the Kola Peninsula, Karelia and the North-Western part of the East Europen Plain. Quaternary Science reviews. Vol.15, 1996.p.997-1012	47(k)-Davydov & Servant-Vildary-1996	lake Oltush	Russia	51°55'	24°03'	Y	cal.14C	sand, guttia, peat, lacustrine lime	sand,guttia peat, lacustrine lime		10 ka	3 ka	lake deposits	pollen, diatom, lithological, radiocarbon data
84	Konstantin V. Kremenetski, Glen M. MacDonald, Bruce R. Gervais, Olga K. Borisova, Jeffrey A. Snyder Holocene vegetation history and climate change on the northern Kola Peninsula, Russia: a case study from a small tundra lake. Quaternary International 122 (2004) p.57–68	48-Kremenetski_etal-2004	lake KP3	Russia	69°04'19''	36°00'40''	Y	AMS cal.14C	moss, wood, humic acids, decal. sediments	wood,humi c acids, decal. sediments		10.8 ka	0.7 ka	lake deposits	pollen, macrofossils plant, radiocarbon data
85	E.Yu. Novenko, E.M. Volkova, N.B. Nosova, I.S. Zuganova Late Glacial and Holocene landscape dynamics in the southern taiga zone of East European Plain according to pollen and macrofossil records from the CentralForest State Reserve (Valdai Hills, Russia) Quaternary International 207 (2009) p.93–103	49-Novenko_etal-2009	Staroselsky Moch	Russia	56°35'	32°55'	Y	cal.14C	peat, gyttja, wood, clay	peat	gyttja, wood, clay	9.7 ka	1.5 ka	peat bogs	pollen, macrofossils plant, radiocarbon data
86	E.Yu. Novenko, E.M. Volkova, N.B. Nosova, I.S. Zuganova Late Glacial and Holocene landscape dynamics in the southern taiga zone of East European Plain according to pollen and macrofossil records from the CentralForest State Reserve (Valdai Hills, Russia) Quaternary International 207 (2009) p.93–103	49(a)-Novenko_etal-2009	Forest Mire 1	Russia	56°32'	32°52'	Y	cal.14C	peat, gyttja, wood, clay	peat, gyttja	wood, clay	5.5 ka	0 ka	peat bogs	pollen, macrofossils plant, radiocarbon data
87	E.Yu. Novenko, E.M. Volkova, N.B. Nosova, I.S. Zuganova Late Glacial and Holocene landscape dynamics in the southern taiga zone of East European Plain according to pollen and macrofossil records from the CentralForest State Reserve (Valdai Hills, Russia) Quaternary International 207 (2009) 93–103	49(b)-Novenko_etal-2009	Forest Mire 2	Russia	56°37'	32°57'	Y	cal.14C	peat, gyttja, wood, clay	peat, gyttja	wood, clay	5.5 ka	0.3 ka	peat bogs	pollen, macrofossils plant, radiocarbon data
88	Pavel A. Kaplin, Andrei O. Selivanov Lateglacial and Holocene sea level changes in semi-enclosed seas of North Eurasia: examples from the contrasting Black and White Seas Palaeogeography, Palaeoclimatology, Palaeoecology 209 (2004) p.19–36	50-Kaplin & Selivanov-2004	river Onega	Russia	63°54'09''	38°05'36''	Y	cal.14C	sand, loam, gyttja, peat			10 ka	0.7 ka	coastal deposits	radiocarbon data
89	L.G. Bezusko, N.S. Kotova, N.N. Kovalyuh The population of the Neolithic-Early Neolithic Western Azov and the Environment Antiquities of steppe black sea regoin and Crimea volume VIII 2000 p.89-108	51-Bezusko_etal-2000	Semenovka	Ukraine	46°53'	35°24'	Y	cal.14C	bones, wood	bones, wood		8 ka	6 ka	fluvial deposits	pollen, radiocarbon data
90	L.G. Bezusko, N.S. Kotova, N.N. Kovalyuh The population of the Neolithic-Early Neolithic Western Azov and the Environment Antiquities of steppe black sea regoin and Crimea volume VIII 2000 p.89-108	51(a)-Bezusko_etal-2000	Kamennaia Mogila	Ukraine	46°56'59''	35°28'10''	Y	cal.14C	soil, bones, wood, sand	soil, bones, wood	sand	8 ka	6 ka	fluvial deposits	pollen, radiocarbon data
91	L.G. Bezusko, N.S. Kotova, N.N. Kovalyuh The population of the Neolithic-Early Neolithic Western Azov and the Environment Antiquities of steppe black sea regoin and Crimea volume VIII 2000 p.89-108	51(b)-Bezusko_etal-2000	Chapaevka	Ukraine	47°10'08''	35°31'33''	Y	cal.14C	soil, bones, wood, sand	soil, bones, wood		8 ka	6 ka	fluvial deposits	pollen, radiocarbon data
92	Vivienne J. Jones, Melanie J. Leng, Nadia Solovieva, Hilary J. Sloane, Tarasov P Holocene climate of the Kola Peninsula; evidence from the oxygen isotope record of diatom silica Quaternary Science Reviews 23 (2004) p. 833–839	52-Jones_etal-2004	lake Chuna	Russia	67°57'	32°29'	Y	cal.14C	carbonates, clay	carbonate		9 ka	0 ka	lake deposits	pollen, oxygen-isotope, diatom, radiocarbon data , X-ray
93	Irina Kovda, Claudia I. Mora, Larry P. Wilding Stable isotope compositions of pedogenic carbonates and soil organic matter in a temperate climate Vertisol with gilgai, southern Russia Geoderma 136 (2006) p.423–435	53-Kovda_etal-2006	Vertisols	Russia	44°38'17''	42°15'04''	Y	cal.14C	soil, carbonate	soil, carbonate		5 ka	0 ka	soils	stable-isotops, radiocarbon data
94	A.L. Alexandrovski, O.A. Chichagova Radiocarbon age of Holocene paleosols of the East European forest–steppe zone Catena 34 _1998. p.197–207	54-Aleksandrovski & Chichogova-1998	Novosvobodn aya	Russia	56°08'00''	47°15'00''	Y	cal.14C	soil	soil		10 ka	0 ka	soils	morfological, radiocarbon data
95	A.L. Alexandrovski, O.A. Chichagova Radiocarbon age of Holocene paleosols of the East European forest–steppe zone Catena 34 _1998. p.197–207	54(a)-Aleksandrovski & Chichogova-1998	Trayanov	Ukraine	48°17'	25°56'	Y	cal.14C	soil	soil		10 ka	0 ka	soils	morfological, radiocarbon data
96	A.L. Alexandrovski, O.A. Chichagova Radiocarbon age of Holocene paleosols of the East European forest–steppe zone Catena 34 _1998. p.197–207	54(b)-Aleksandrovski & Chichogova-1998	Zhurishki	Russia	53°41'42''	38°43'23''	Y	cal.14C	soil	soil		10 ka	0 ka	soils	morfological, radiocarbon data
97	Svetlana Sycheva, Maya Glasko, Olga Chichagova Holocene rhythms of soil formation and sedimentation in the Central Russian Upland Quaternary International 106–107 (2003) p.203–213	55-Sycheva_etal-2003	Poseym'e	Russia	51°40'	36°40'	Y	cal.14C	humic acids	humic acids		11 ka	0 ka	soils	radiocarbon data
98	Svetlana Sycheva, Maya Glasko, Olga Chichagova Holocene rhythms of soil formation and sedimentation in the Central Russian Upland Quaternary International 106–107 (2003) p.203-213	55(a)-Sycheva_etal-2003	Kulikova Pole	Russia	53°10'	39°10'	Y	cal.14C	humic acids, charcoal	humic acids, charcoal		11 ka	0 ka	soils	radiocarbon data
99	Barbara Wohlfarth, Terri Lacourse, Ole Bennike, Dmitry Subetto, Pavel Tarasov, Igor Demidov, Ludmila Filimonova, Tatyana Sapelko Climatic and environmental changes in north-western Russia between 15,000 and 8000 cal yr BP: a review Quaternary Science Reviews 26 (2007) p.1871–1883	56-Wohlfarth_etal-2007	lake Terebenskoye	Russia	58°08'	32°59'	Y	AMS cal.14C	wood	wood		13.7 ka	8.6 ka	lake deposits	pollen, macrofossils plant, lithological, geochemical, radiocarbon data
100	Barbara Wohlfarth., Pavel Tarasov., Ole Bennike., Terri Lacourse., Dmitry Subetto., Peter Torssander., Fedor Romanenko Late glacial and Holocene palaeoenvironmental changes in the Rostov-Yaroslavl' area, West Central Russia Journal of Paleolimnology (2006) 35:543–569	57-Wohlfarth_etal-2006	lake Nero	Russia	57°10'25''	39°25'36''	Y	AMS cal.14C	bark, wood, gyttja, sand, clay	bark, wood	gyttja, sand, clay	14.8 ka	0 ka	lake deposits	pollen, macrofossils plant, lithological, geochemical, radiocarbon data
101	Barbara Wohlfarth., Pavel Tarasov., Ole Bennike., Terri Lacourse., Dmitry Subetto., Peter Torssander., Fedor Romanenko Late glacial and Holocene palaeoenvironmental changes in the Rostov-Yaroslavl' area, West Central Russia Journal of Paleolimnology (2006) 35:543–569	57(a)-Wohlfarth_etal-2006	lake Chashnitsy	Russia	56°56'29''	39°22'55''	Y	AMS cal.14C	bark, wood, gyttja, sand, clay	wood	bark, gyttja, sand, clay	11 ka	0 ka	lake deposits	pollen, macrofossils plant, lithological, geochemical, radiocarbon data
102	Barbara Wohlfarth., Pavel Tarasov., Ole Bennike., Terri Lacourse., Dmitry Subetto., Peter Torssander., Fedor Romanenko Late glacial and Holocene palaeoenvironmental changes in the Rostov-Yaroslavl' area, West Central Russia Journal of Paleolimnology (2006) 35:543–569	57(b)-Wohlfarth_etal-2006	lake Zaozer'e	Russia	56°49'41''	39°21'20''	Y	AMS cal.14C	bark, wood, gyttja, sand, charcoal	wood, charcoal	bark, gyttja, sand	11.6 ka	5 ka	lake deposits	pollen, macrofossils plant, lithological, geochemical, radiocarbon data

103	B. Wohlfarth., L. Schwark., Ol.Bennike., L. Filimonova., P. Tarasov., L. Bjorkmanj., L. Brunnberg., I. Demidov., G.Possnert Unstable early-Holocene climatic and environmental conditionsin northwestern Russia derived from a multidisciplinary Study of a lake-sediment sequence from Pichozero, southeastern Russian Karelia The Holocene 14,5 (2004) p.732-746	58-Wohlfarth_etal-2004	lake Pichozero	Russia	61°47'	37°25'	Y	AMS cal.14C	wood, gyttja	wood	gyttja	12.9 ka	9.5 ka	lake deposits	pollen, macrofossils plant, lithological, radiocarbon data
104	C.V. Kremenetski, T. Boettger, G.M. MacDonald, T. Vaschalova, L. Sulerzhitsky, A. Hiller Medieval climate warming and aridity as indicated by multiproxy evidence from the Kola Peninsula, Russia Palaeogeography, Palaeoclimatology, Palaeoecology 209 (2004) p.113–125	59-Kremenetski_etal-2004	Khibiny Mts	Russia	68°01'	34°32'	Y	uncal.14C	wood, charcoals, humic acids, soil	wood, charcoals, humic acids	soil	4.2 ka	0 ka	soils	oxygen-isotopes, radiocarbon data
105	E.A. Kuzmina Late Pleistocene and Holocene small mammal faunas from the South Trans-Urals Quaternary International 201 (2009) .25–30	60-Kuzmina-2009	Syrtinsky	Russia	53°23'	59°2'	Y	uncal.14C	wood, bones	bone		24 ka	1 ka	caves	lithological, small mammal, radiocarbon data
106	E. Yu. Novenko, M.P. Glasko, O.V. Burova Landscape-and-climate dynamics and land use in Late Holocene forest-steppe ecotone of East European Plain (upper Don River Basin case study) Quaternary International 203 (2009) p.113–119	61-Novenko_etal-2009	Kulikovo Battle Field	Russia	53.65°	38.79°	Y	uncal.14C	wood, humic acids,charcoal, mollusks, sand	wood, humic acids,	charcoal, mollusks, sand	6.6 ka	0 ka	soils	pollen, lithological, curves palaeotemperature, annual precipitation, radiocarbon data
107	S.A. Sycheva Long-term pedolithogenic rhythms in the Holocene Quaternary International 152–153 (2006) p.181–191	62-Sycheva-2006	Tuskar	Russia	50°54'	37°	Y	uncal.14C	soil, sand, carbonates	soil, sand, carbonate		7 ka	0 ka	soils	geochemical, radiocarbon data
108	S.A. Sycheva Long-term pedolithogenic rhythms in the Holocene Quaternary International 152–153 (2006) p.181–191	62(a)-Sycheva-2006	Volonchikhino	Russia	52°	39°	Y	cal.14C	soil, iron	soil, Iron		3 ka	1 ka	soils	geochemical, radiocarbon data
109	Malcolm Lillie, Chelsea Budd, Inna Potekhina Stable isotope analysis of prehistoric populations from the cemeteries of the Middle and Lower Dnieper Basin, Ukraine Journal of Archaeological Science 38. 2011 p.57-68	63-Lillie_etal-2011	Vsilyevka	Ukraine	48°15'	33°46'	Y	uncal.14C	bone	bone		10.4 ka	4.5 ka	soils	oxygen-isotopes, radiocarbon data
110	Malcolm Lillie, Chelsea Budd, Inna Potekhina Stable isotope analysis of prehistoric populations from the cemeteries of the Middle and Lower Dnieper Basin, Ukraine Journal of Archaeological Science 38. 2011 p.57-68	63(a)-Lillie_etal-2011	Molukhov Bugor	Ukraine	49°08'	32°28'	Y	uncal.14C	bone	bone		5.5 ka	3.6 ka	soils	carbon-isotopes, nitrogen-isotopes, radiocarbon data
111	A.A. Velichko, N. Catto, A.N. Drenova, V.A. Klimanov, K.V. Kremenetski, V.P. Nechaev Climate changes in East Europe and Siberia at the Late glacial–holocene transition Quaternary International 91 (2002) p.75–99	64-Velichko_etal-2002	Ponizovye	Russia	55°	31°	Y	uncal.14C	soil, wood	soil, wood		10.5 ka	5 ka	soils	pollen, radiocarbon data, curves palaeotemperature, annual precipitation
112	A.A. Velichko, N. Catto, A.N. Drenova, V.A. Klimanov, K.V. Kremenetski, V.P. Nechaev Climate changes in East Europe and Siberia at the Late glacial–holocene transition Quaternary International 91 (2002) p.75–99	64(a)-Velichko_etal-2002	Melekhovo	Russia	57°	39°	Y	uncal.14C	soil, wood	soil, wood		12 ka	0 ka	soils	pollen, radiocarbon data, curves palaeotemperature, annual precipitation
113	A.A. Velichko, N. Catto, A.N. Drenova, V.A. Klimanov, K.V. Kremenetski, V.P. Nechaev Climate changes in East Europe and Siberia at the Late glacial–holocene transition Quaternary International 91 (2002) p.75–99	64(b)-Velichko_etal-2002	Buzuluksky Bor	Russia	53°	51°	Y	uncal.14C	soil, wood	soil, wood		7 ka	0 ka	soils	pollen, radiocarbon data, curves palaeotemperature, annual precipitation
114	M. A. Kul'kova, A. N. Mazurkevich and P. M. Dolukhanov Chronology and palaeoclimate of Prehistoric sites in western Dvina-Lovat. Area of north-western Russiageochronometria Vol. 20, 2001.p.87-94 Journal on Methods and Applications of Absolute Chronology	65-Kul'kova_etal-2001	Usvyaty	Russia	55°44'55''	30°45'20''	Y	uncal.14C	wood, gyttja and peat	wood, gyttja and peat		12 ka	0 ka	lake deposits	pollen, radiocarbon data, geochemical
115	V.K Nemkova., 1978. Stratigraphy of the late glacial and post-glacial deposits of the Fore-Urals. The Late Pleistocene and Holocene History of the Southern Urals and Fore-Urals. BFAN USSR Press, Ufa, p.4–45	66-Nemkova-1978	Yukalikul	Russia	55°30'	54°42'	Y	uncal.14C	peat, wood	wood	peat	10.7 ka	8.7 ka	fluvial deposits	pollen, macrofossils plant, radiocarbon data
116	V.K Nemkova., 1978. Stratigraphy of the late glacial and post-glacial deposits of the Fore-Urals. The Late Pleistocene and Holocene History of the Southern Urals and Fore-Urals. BFAN USSR Press, Ufa, p.4–45	66(a)- Nemkova-1978	Tally-Kullevo	Russia	54°25'	54°22'	Y	uncal.14C	peat, clay	peat, clay		8.7 ka	8 ka	fluvial deposits	pollen, macrofossils plant, radiocarbon data
117	V.K Nemkova., 1978. Stratigraphy of the late glacial and post-glacial deposits of the Fore-Urals. The Late Pleistocene and Holocene History of the Southern Urals and Fore-Urals. BFAN USSR Press, Ufa, p.4–45	66(b)- Nemkova-1978	Ishkarova	Russia	55°28'37''	54°31'35''	Y	uncal.14C	peat	peat		7.5 ka	6.5 ka	fluvial deposits	pollen, macrofossils plant, radiocarbon data
118	I. Overeem, S.B. Kroonenberg, A. Veldkamp, K. Groenesteijn, G.V. Rusakov, A.A. Svitoch Small-scale stratigraphy in a large ramp delta: recent and Holocene sedimentation in the Volga delta, Caspian Sea Sedimentary Geology 159 (2003) p.133–157	67-Overeem_etal-2003	Astrakhan	Russia	46°22'	48°04'	Y	uncal.14C	wood, soil, clay, sand, molluscs	wood	soil,clay, sand, molluscs	6.6 ka	0 ka	coastal deposits	morphological, radiocarbon data
119	Ya.G. Ryskov, V.A. Demkin, S.A. Oleynik, E.A. Ryskova Dynamics of pedogenic carbonate for the last 5000 years and its role as a buffer reservoir for atmospheric carbon dioxide in soils of Russia Global and Planetary Change 61 (2008) p.63–69	68-Ryskov_etal-2008	Pokrovka	Russia	48°	54°45'	N		soil, carbonates	soil	carbonates	5.6 ka	0 ka	soils	carbon-isotopes
120	O.Borisova, Al. Sidorchuk, A. Panin Palaeohydrology of the Seim River basin, Mid-Russian Upland, based on palaeochannel morphology and palynological data Catena 66 (2006) p.53-73	69-Borisova_etal-2006	L'gov	Russia	51°39'	35°14'	Y	uncal.14C	wood, peat, clay, sand	wood, peat, clay, sand		14 ka	0 ka	fluvial deposits	pollen, morphological, radiocarbon data
121	O.Borisova, A.Sidorchuk, A.Panin Palaeohydrology of the Seim River basin, Mid-Russian Upland, based on palaeochannel morphology and palynological data Catena 66 (2006) p.53-73	69(a)-Borisova_etal-2006	Svopa	Russia	51°44'	34°57'	Y	uncal.14C	wood, peat, clay, sand	wood, peat, clay, sand		14 ka	0 ka	fluvial deposits	pollen, morphological, radiocarbon data
122	R. Miedema, I.N. Koulechova, M.I. Gerasimova Soil formation in Greyzems in Moscow district: micromorphology, chemistry, clay mineralogy and particle size distribution 1999	70-Miedema_etal-1999	Pushchino	Russia	54°49'59''	37°37'	Y	uncal.14C	soil	soil		11.8 ka	0 ka	soils	geochemical, X-ray, radiocarbon data
123	O.K.Borisova The Holocene and vegetation of the Nortern Russian Plain (The Vychegda river basin) Beijing 2002 p.478-486	71-Borisova-2002	Baika-2	Russia	61°16'	46°44'	Y	uncal.14C	peat, clay, sandy	peat, clay, sandy		9 ka	0 ka	fluvial deposits	pollen, macrofossils plant, radiocarbon data
124	E.A. Spiridonova Evolution of vegetetion Don basin in the upper Plaistocene-Holocene. Akademy og Sciences of the USSR „Nauka" M.1991 p.150-216	72-Spiridonova-1991	Razdorskoe	Russia	47°33'31''	40°40'16''	Y	uncal.14C	wood	wood		10 ka	0 ka	soils	pollen, radiocarbon data

125	E.A. Spiridonova Evolution of vegetetion Don basin in the upper Plaistocene-Holocene. Akademy og Sciences of the USSR „Nauka“ M.1991 p.150-216	72(a)-Spiridonova-1991	Samsonovskoe	Russia	47°40'22''	40°45'47''	Y	uncal.14C	wood	wood		10 ka	0 ka	soils	pollen, radiocarbon data
126	J. Vandenberghe, R. Gracheva, A. Sorokin Postglacial floodplain development and Mesolithic–Neolithic occupation in the Russian forest zone Proceedings of the Geologists' Association 121 (2010) p.229–237	73-Vandenberghe_etal-2010	Mimino-2	Russia	57°56'24''	45°53'16''	Y	AMS cal.14C	wood, peat, soils, clay, sand	humicacid, charcoal, wood		10.2 ka	0.6 ka	fluvial deposits	pollen, macrofossils plant, radiocarbon data
127	C. V. Kremenetski, T. BoK ttger, F. W. Junge, A. G. Tarasov Late- and postglacial environment of the Buzuluk area, middle Volga region, Russia Quaternary Science Reviews 18 (1999) p.1185-1203	74-Kremenetski_etal-1999	Pobochnoye	Russia	53°01'30''	51°50'30''	Y	uncal.14C	peat, gyttja	peat, gyttja		13 ka	0 ka	soils	pollen, stable-isotopes, radiocarbon data, X-ray, malluscs
128	A. Yakovlev, G. Danukalova, Pavel Kosintcev, Liliana Alimbekova, Evgenija Morozova Biostratigraphy of the Late Palaeolithic site of ''Bajslan-Tash cave'' (the Southern Urals) Quaternary International 149 (2006) p.115–121	75-Yakovlev_etal-2006	cave Bajslan-Tash	Russia	52°15'	56°37'5''	Y	uncal.14C	wood coal, bones	wood coal, bones		13.5 ka	1.6 ka	fluvial deposits	pollen, molluscs, small mammals, large mammals, radiocarbon data
129	N.S Bolikhovskaya., M.D Kaitamba., A.V Porotov., O.B Parunin On the paleogeography of the Holocene of the Taman' peninsula Black Sea coasts: metodological aspects of palynological analysis and palaeoenvironmental reconstructions "Metodicheskie aspekty palinologii" M-2002 p.23-26	76-Bolikhovskaya_etal-2002	Kiziltashkii limana	Russia	45°07'	37°03'	Y	cal.14C	molluscs	molluscs		7 ka	0 ka	fluvial deposits	pollen, malluscs, radiocarbon data
130	N. Kotova & S. Makhortykh Human adaptation to past climate changes in the northern Pontic steppe Quaternary International 220 (2010) 88-94	77-Kotova & Makhortykh-2010	Razdolnoe	Ukraine	45°17'	33°47'	N	cultural age	bone	bone		8 ka	0 ka	soils	pollen, small mammals
131	C.V. Kremenetski., O.A. Chichagova., N.I. Shishlina Palaeoecological evidence for Holocene vegetation, climate and land-use change in the Low Don and Kalmuk area, southern Russia. Veget Hist Archaedot (1999) 8:233-246	78-Kremenetski_etal-1999	mire Lipigi	Russia	49°33'	43°26'	Y	uncal.14C	peat, wood	peat, wood		6 ka	1.5 ka	fluvial deposits	pollen, macrofossils, radiocarbon data
132	C.V. Kremenetski., O.A. Chichagova., N.I. Shishlina Palaeoecological evidence for Holocene vegetation, climate and land-use change in the Low Don and Kalmuk area, southern Russia. Veget Hist Archaedot (1999) 8:233-246	78(a)-Kremenetski_etal-1999	mire Kharabuluk	Russia	47°46'	44°26'	Y	uncal.14C	peat	peat		7.5 ka	0 ka	lake deposits	pollen, macrofossils, radiocarbon data
133	C.E. Cordova & P.H. Lehman Archaeopalynology of synanthropic vegetation in the *chora* of Chersonesos, Crimea, Ukraine Journal of Archaeological Science 30 (2003) p.1483–1501	79-Cordova & Lehman-2003	Chersonesos	Ukraine	44°33'47''	33°24'42''	Y	cal.14C	soil	soil		7.5 ka	0 ka	soils	pollen
134	C.E. Cordova & P.H. Lehman Holocene environmental change in southwestern Crimea, Ukraine. The Holocene 15,2 (2005) p.263-277	80-Cordova & Lehman-2005	Sevastopol	Ukraine	44°36'	33°30'	Y	AMS cal.14C	charcoal,humic acids, ash	charcoal, humic acids, ash		11 ka	0 ka	soils	pollen, radiocarbon data
135	A.Teterina Rodents of the North Urals in the Late Pleistocene and Holocene Quaternary International 201 (2009) p.31–36	81-Teterina-2009	Studenaya, Medvezhiya	Russia	62°10'	58°15'	Y	uncal.14C	wood	wood		34 ka	0 ka	cave deposits	small mammals, radiocarbon data
136	C.V Kremenetski Steppe and forest steppe belt of Eurasia: Holocene environmental history," in Prehistoric Steppe Adaptation and the Horse, edited by Marsha Levine, Colin Renfrew, and Katie Boyle. 2002 p.11-27. Cambridge: McDonald Institute.	82-Kremenetski-2002	Dovjok	Ukraine	48°14' 21''	28°31'34''	Y	uncal.14C	soil, wood	soil, wood		10 ka	0 ka	peat bogs	pollen, radiocarbon data
137	C.V Kremenetski Steppe and forest steppe belt of Eurasia: Holocene environmental history," in Prehistoric Steppe Adaptation and the Horse, edited by Marsha Levine, Colin Renfrew, and Katie Boyle, 2002 p.11-27. Cambridge: McDonald Institute.	82(a)-Kremenetski-2002	Orgeev	Moldova	47°22'59''	28°49'23''	Y	uncal.14C	soil, wood	soil, wood		10 ka	0 ka	soils	pollen, radiocarbon data
138	C.V Kremenetski Steppe and forest steppe belt of Eurasia: Holocene environmental history," in Prehistoric Steppe Adaptation and the Horse, edited by Marsha Levine, Colin Renfrew, and Katie Boyle, 2002 p.11-27. Cambridge: McDonald Institute.	82(b)-Kremenetski-2002	Saki	Ukraine	45°07'17''	33°32'13''	Y	uncal.14C	soil, wood	soil, wood		10 ka	0 ka	soils	pollen, radiocarbon data
139	C.V Kremenetski Steppe and forest steppe belt of Eurasia: Holocene environmental history," in Prehistoric Steppe Adaptation and the Horse, edited by Marsha Levine, Colin Renfrew, and Katie Boyle, 2002 p.11-27. Cambridge: McDonald Institute.	82(c)-Kremenetski-2002	Rogalik	Russia	48°55'	40°03'	Y	uncal.14C	soil, wood	soil, wood		10 ka	0 ka	soils	pollen, radiocarbon data
140	C.V Kremenetski Steppe and forest steppe belt of Eurasia: Holocene environmental history," in Prehistoric Steppe Adaptation and the Horse, edited by Marsha Levine, Colin Renfrew, and Katie Boyle, 2002 p.11-27. Cambridge: McDonald Institute.	82(d)-Kremenetski-2002	Razdorskoe	Russia	47°32'	40°38'	Y	uncal.14C	soil, wood	soil, wood		10 ka	0 ka	soils	pollen, radiocarbon data
141	C.V Kremenetski Steppe and forest steppe belt of Eurasia: Holocene environmental history," in Prehistoric Steppe Adaptation and the Horse, edited by Marsha Levine, Colin Renfrew, and Katie Boyle, 2002 p.11-27. Cambridge: McDonald Institute.	82(e)-Kremenetski-2002	Lipigi	Russia	49°30'	43°26'	Y	uncal.14C	soil, wood	soil, wood		10 ka	0 ka	soils	pollen, radiocarbon data
142	R. Dobrowolski, K. Bafaga, A. Bogucki, S. Fedorowicz, J. Melke, A. Pazdur, S. Zubovie Chronostratigraphy oft he Okunin and Czerepacha lake-mire geosystems (Volhynia polesiye, NW Ukraine) during the Late Glacial and Holocene Geochronometria Vol. 20, p.107-115, 2001 . Journal on Methods and Applications of Absolute Chronology	83-Dobrowolski_etal-2001	Okunin	Ukraine	51°12'	24°18'	Y	uncal.14C	peat	peat		12.3 ka	0 ka	fluvial deposits	pollen, radiocarbon data
143	R. Dobrowolski, K. Bafaga, A. Bogucki, S. Fedorowicz, J. Melke, A. Pazdur, S. Zubovie Chronostratigraphy oft he Okunin and Czerepacha lake-mire geosystems (Volhynia polesiye, NW Ukraine) during the Late Glacial and Holocene Geochronometria Vol. 20, p.107-115, 2001 . Journal on Methods and Applications of Absolute Chronology	83(a)-Dobrowolski_etal-2001	Czerepacha	Ukraine	51°04'	24°30''	Y	uncal.14C	peat	peat		12.3 ka	0 ka	fluvial deposits	pollen, radiocarbon data
144	E.A. Spiridonova, A.S. Aleshinskaya Devision into periods of the Neolithic-The Eniolithic of Europen Russia according to the Polinological Data. Rassiiskaia Arheologiia 1991(1) p.23-33	84-Spiridonova & Aleshinskaya-1999	Lebezhinka	Russia	54°41'15''	47°52'11''	Y	uncal.14C	soil	soil		10 ka	0 ka	soils	pollen, radiocarbon data
145	A.L. Aleksandrovskiy Evolution of the soil of the Russian Plain in the Holocene. Pedology 1995.3. p. 290-297	85-Aleksandrovski-1995	Khotina	Ukraine	48°30'55''	26°29'40''	Y	uncal.14C	soil	soil		10 ka	0 ka	soils	morphological, radiocarbon data

146	V.A. Demkin, A.V. Borisov, T.S. Demkina, U.I. Solovieva, M.V. Eltsov, N.I. Kashirskaia (Pushino-na-Oke) The dynamics of the natural condition of the Lower Volga region in the Late Chalcolithic and Bronze. Archaeology of Natural Sciences p.452-460	86-Demkin_etal-2004	Avilivskii	Russia	49°13.083'	43°54.133'	Y	uncal.14C	soil	soil		6 ka	3 ka	soils	morphological, radiocarbon data
147	V.A. Demkin, A.V. Borisov, T.S. Demkina, U.I. Solovieva, M.V. Eltsov, N.I. Kashirskaia (Pushino-na-Oke) The dynamics of the natural condition of the Lower Volga region in the Late Chalcolithic and Bronze. Archaeology of Natural Sciences p.452-460	86(a)-Demkin_etal-2004	Abganerova	Russia	47°58'	43°38'	Y	uncal.14C	soil	soil		6 ka	3 ka	soils	morphological, radiocarbon data
148	V.A. Demkin, A.V. Borisov, T.S. Demkina, U.I. Solovieva, M.V. Eltsov, N.I. Kashirskaia (Pushino-na-Oke) The dynamics of the natural condition of the Lower Volga region in the Late Chalcolithic and Bronze. Archaeology of Natural Sciences p.452-460	86(b)-Demkin_etal-2004	Mu-Sharet	Russia	46°15'	44°20'	Y	uncal.14C	soil	soil		6 ka	3 ka	soils	morphological, radiocarbon data
149	M.I. Dergacheva, D.I. Vasilieva (Novosibirs, Samara)Poleosoils, cultural horizons, and environmental conditions of their formation in the Bronze Age in the steppe zone Samra Zavolzhja Archaeology of Natural Sciences 2006 p.464-476	87-Dergacheva & Vasilieva-2006	Spiridonovka	Russia	52°36'	51°42'	Y	uncal.14C	soil	soil		6 ka	4 ka	soils	morphological, radiocarbon data
150	A. Lavrushin, E.A. Spiridonov, L.D. Sulerzhitsky Geological-poleological events north of the arid zone in the last 10 000BP. Samara-1998. 40-65	88-Lavrushin_etal-1998	Kair-Shak III	Russia	46°17'	48°3'	Y	uncal.14C	soil, send, wood	soil, sand	wood	10 ka	0 ka	lake deposits	pollen, radiocarbon data
151	Yu.A.Trapeznikov., I.I.Borzenkova., O.M.Vinigradova St-Petersburg's Climate:Past, Present A seria of geography 1.2003 p.101-105	89-Trepeznikov_etal-2002	lake Nizhnee Suzdalskoe	Russia	60°	30°10'	Y	uncal.14C	wood, soil	wood		10 ka	0 ka	lake deposits	pollen, radiocarbon data
152	Subetto D.A., Sapelko T.V., Kuznetsova D.D., Ludikova A.V., Dolikhanov P.M., Zaitseva G.I. The formatsion history of the drainage from the Ladoga lake new paleolimnological data. Radiocarbon St-Petersburg 2007 p.381-403	90-Subetto_etal-2007	lake Makarovskoe	Russia	60°43'5''	29°08'8'	Y	cal.14C	gyttia	gyttia		4 ka	2 ka	lake deposits	pollen, diatom, radiocarbon data
153	Subetto D.A., Sapelko T.V., Kuznetsova D.D., Ludikova A.V., Dolikhanov P.M., Zaitseva G.I. The formatsion history of the drainage from the Ladoga lake new paleolimnological data. Radiocarbon St-Petersburg 2007 p381-403	90(a)-Subetto_etal-2007	lake Uzlovoe	Russia	61°05'6''	29°44'8''	Y	cal.14C	gyttia	gyttia		4 ka	1 ka	lake deposits	pollen, diatom, radiocarbon data
154	P.M. Dolukhanov, D.A. Subetto, Kh.A. Aeslanov, D.A., N.N. Davydova, G.I. Zaitseva, E.N. Djinoridze, D.D. Kuznetsov, A.V. Ludikova, T.V. Sapelko,and L.A. Savelieva The Holocene History of the Baltic Sea, and the Ladoga Lake The East European Plain on the Eve of Agriculture 2009. p. 123-139	91-Dolukhanov_etal-2009	Nevsky Pyatachok	Russia	59°50'37''	30°58'12''	Y	uncal.14C	wood, gyttia, peat	wood, gyttia, peat		11.6 ka	0 ka	lake deposits	pollen, diatom, radiocarbon data
155	Aleksandrovski A.L., Kovalyukh N.N., Skripkin V.V. Stages of the Holocene evolutsion of soils and landscapes in Moscow. Radiocarbon St-Petersburg 2007 p.404-410	92-Aleksandrovski_etal-2007	Shipilova-1	Russia	55°37'54''	37°42'40''	Y	uncal.14C	soil	soil		10 ka	1 ka	fluvial deoisits	morphological, radiocarbon data
156	Aleksandrovski A.L., Kovalyukh N.N., Skripkin V.V. Stages of the Holocene evolutsion of soils and landscapes in Moscow. Radiocarbon St-Petersburg 2007 p.404-410	92(a)-Aleksandrovski_etal-2007	Borisovo-1	Russia	55°37'51'	37°41'46''	Y	uncal.14C	soil	soil		10 ka	1 ka	fluvial deoisits	morphological, radiocarbon data
157	O.S. Khakhlova, E.P. Zazovskaya, O.A Chichagova., L.T. Yablonsky Radoicarbon Dating of Different Materials from kurgans of the Early Nomands of the Southern CIS-Urals. A series of geographic 3. Mai-Jiun 2010 p.82-94	93-Khokhlova_etal-2009	Filippovka-1	Russia	51°26'09''	54°14'07''	Y	AMS cal.14C	bone, wood, chercoal, collagen	bone, wood, chercoal, collagen		3.5 ka	1.5 ka	soils	radiocarbon data
158	O.S. Khokhlova, A.A. Goleva The paleo-soils of the dorrow tomb of the early Iron age of Akob II in the Akbuluk district of Orenburg region. Vestnik OGU 12(118)/december' 2010	94-Khokhlova_etal-2010	Akoba II	Russia	51°00'	55°37'20''	Y	cal.14C	soil, carbonates	soil, carbonate s		3.5 ka	1.5 ka	soils	morphological, radiocarbon data
159	O.A. Gerasimova, S.A. Sycheva Landscapes and soils of the central steppe of East European Plain of the 4-5'th centuries AD A series of geographic 3 Mai-Jiun 2010 p.69-80	95-Gerasimova & Sycheva-2009	Zamiatino-7	Russia	52°17'	38°56'	N					4.6 ka	0 ka	soils	morphological
160	Yu.G. Chendev, A.L. Aleksandrovski Soila and Environment in the Voronezh river basin in the Half of the holocene Pedology.2002 4. p.389-397	96-Chendev & Aleksandrovskiy-2000	Starojivotinoe	Russia	51°53'20''	39°10'10''	N					4 ka	1.5 ka	soils	morphological
161	I.A Spiridonova, A.S Aleshin, S.N Korenevskii, V.L Rostunov Comparative analysis of the natural environment the lifetime of the Maikop culture of the Central Fore-Caucasus (Stavropol region, North Ossetia-Alania) materials for the study of historical and cultural heritage of the North Caucasus. Issue 2 Archaeology, Anthropology, poleoclimate Moscow, 2001 p.144-162	97- Spiridonova_etal-2001	Galyugai-1-2	Russia	43°41'43.6''	44°55'57.83''	Y	uncal.14C	soil, carbonates, wood	soil, carbonate s, wood		7 ka	2.5 ka	soils	pollen, radiocarbon data
162	A.I. Aleksandrovski, T.D. Belanovskaya, P.M. Dolukhanov, V.Ya. Kiyashko, K.V. Kremenetsky, N.V. Lavrentiev, A.M. Shukurov, A.V.Tsybriy, V.V. Tsybriy, N.N. Kovalyuk, V.V. Skripkin and G.I. Zaitseva The Lower Don Neolithic The East European Plain on the Eve of Agriculture 2009. p.89-99	98-Aleksandrovski_etal-2009	Razdorskoye-2	Russia	47°32'27''	40°38'51''	Y	AMS cal.14C	bones, soil, charcoal	soil		9 ka	8 ka	soils	pollen, radiocarbon data
163	E.P. Larchenkov, S.V. Kadurin, P.M. Dolukhanov Late Quaternery Environments of Northern Black Sea Area. The East European Plain on the Eve of Agriculture 2009. p.35-45	99-Larchenkov_etal-2009	Selishe	Ukraine	49°	28°25'59''	Y	AMS cal.14C	bone	bone		7.7 ka	0 ka	soils	pollen, lithological, radiocarbon data
164	D.M.Dolukhanov, A.L. Chepalyga and N.V. Lavrentyev Late Quaterary Environments of the North Caspion Lowland. The East European Plain on the Eve of Agriculture 2009. p.65-70	100-Dolukhanov_etal-2009	Solenoye Zaimishche	Russia	47°55'22''	46°08'13''	Y	uncal.14C	soil	soil		10 ka	0 ka	lake deposits	pollen, oxygen-isotopes, radiocarbon data
165	A.Mazurkevich, P.Dolukhanov, A.Shukurov, and G.Zaitseva Late Stone-Early Bronze Sites Ahe in the Western Dvina-Lovat Area. The East European Plain on the Eve of Agriculture 2009. p. 145-153	101-Mazurkevich_etal-2009	Serteya-1,2	Russia	55°40'44''	31°29'21''	Y	AMS cal.14C	wood, soil	wood, soil		10 ka	4 ka	lake deposits	pollen, diatom, radiocarbon data
166	A.G. Bezusko, L.G. Bezusko, S.G. Mosyakin, Yu.V. Grechishkina Archaeological and palynological studies in the Ukraine (Eniolit/Neolithic and Medieval): Current Status and Prospects. Modern mikropaleontological: paleobiological and geological aspects. p.388-391	102-Bezusko_etal-2008	Kamennaia Magila	Ukraine	46°58''	35°25''	Y	uncal.14C	wood	wood		8.6 ka	5 ka	soils	pollen, radiocarbon data

167	A.V Borisov, T.S Demkina, V.A Demkin The paleosols and climate of Ergenies in Bronze epoch, IV-II thous. B.C. 1stedition. Nauka, in Russian. 2006a	103-Borisov_etal-2006a	Aksai-1	Russia	47°58'	43°58'	N		soil	soil		6 ka	3 ka	soils	pollen, morphological
168	A.V Borisov, T.S Demkina, V.A Demkin The paleosols and climate of Ergenies in Bronze epoch, IV-II thous. B.C. 1stedition. Nauka, in Russian. 2006a	103(a)-Borisov_etal-2006a	Zunda-Tolga-1	Russia	46°02'	44°22'	N		soil	soil		6 ka	3 ka	soils	pollen, morphological
169	A.L Aleksandrovski History of soil and climate in Southern Russia in the Holocene. Gorodskie chtenia-II Moscow 2005p.79-87	104Aleksandrovski-2005	Zolotirovka-1	Russia	45°07'	43°09'	Y	cal.14C	soil, carbonates	soil, carbonate		6 ka	0 ka	soils	morphological, radiocarbon data
170	N.P. Gerasimenko Natural human environment in the south-east of Ukraine in the Late Glacial and Holocene (based on the poleogeographical study of archaeological sites) Archaeological almanakh 6, Collection of articles. Donetsk.1997. p.3-64	105-Gerasimenko-1997	Rogalik grupp, Peredelsk	Ukraine	48°44'10''	39°14'36''	Y	uncal.14C	soil, wood,	soil, wood		15 ka	0 ka	soils	pollen, morphologocal, radiocarbon data
171	N.P. Gerasimenko Natural human environment in the south-east of Ukraine in the Late Glacial and Holocene (based on the poleogeographical study of archaeological sites) Archaeological almanakh 6, Collection of articles. Donetsk.1997. p.3-64	105(a)-Gerasimenko-1997	Builovatoe	Ukraine	47°03'	37°18'	Y	uncal.14C	soil, wood,	soil, wood		15 ka	0 ka	soils	pollen, morphologocal, radiocarbon data
172	N.P. Gerasimenko Natural human environment in the south-east of Ukraine in the Late Glacial and Holocene (based on the poleogeographical study of archaeological sites) Archaeological almanakh 6, Collection of articles. Donetsk.1997. p.3-64	105(b)-Gerasimenko-1997	Ambrosievka	Ukraine	47°48'09''	38°28'46''	Y	uncal.14C	soil, wood,	soil, wood		15 ka	0 ka	soils	pollen, morphologocal, radiocarbon data
173	V.A.Demkin., Ya.G.Ryskov., T.S.Demkina Buried Soils in the Sands of the Ural Steppe Region as the Indicators of Paleoenvironmental Conditions during the Holocene Pedolody 11 1997 p.1293-1305	106-Demkin_etal-1997	Izobilnoe; Pokrovka (Ietsk)	Russia	51°10'	54°59'	N		soil, carbonates, sand	soil, carbonate s, sand		12 ka	0 ka	soils	oxygen-isotopes, morphological
174	A.L.Aleksandrovskii, A.A. Gol'eva, V.S. Gunova Reconstruction of Paleolandscape Conditions of the Early Scythian Soila in Stavropol' Region Pedolody 5. 1997 p.533-542	107-Aleksandrovski_etal-1997	Tersko-Kumskoi lowland	Russia	44°53'	45°	Y	cal.14C	microsample, wood, bones	microsamp le, wood, bones		7 ka	2 ka	soils	pollen, morphological, radiocarbon data
175	V.A. Demkin, T.V. Alekseeva, T.S. Demkina, O.A. Alekseev Paleopedological Study of a Mysterious Monument of Ancient History in the Don River Scroll Pedolody 5. 2001 p.533-543	108-Demkin_etal-2001	Trehostrovska ia (Donskaia griada)	Russia	49°05'35''	43°55'21''	Y	uncal.14C	charcoal, soil	charcoal, soil		3.2 ka	1.5 ka	soils	morphological, radiocarbon data
176	V.A.Demkin Paleosol Studies of Archeological Monuments in the Sok River Valley (Samara Region) Pedolody 1. 2000 p.38-49	109-Demkin-2000	Chekalino-IV	Russia	53°19'13''	48°26'41''	N		soil, carboneres	soil, carbonate		9 ka	1 ka	fluvial deposits	morphological
177	N.S.Bolikhovskaya, Yu.V. Gorlov, M.D. Kaitamba, C.Müller, A.V. Porotov, O.B. Patunin, Fouache The Taman Peninsula Landscape and Climate Chenges in the Course of the regent 6000 Years Northern Black Sea and the Bosporus 2002 p.257-271	110-Bolikhovskaya_etal-2002	Kubani (Taman Peninsula)	Russia	45°20'21''	37°24'11'	Y	cal.14C	peat	peat		7.5 ka	0.8 ka	peat bogs	pollen, lithological, morphological, radiocarbon data
178	I.S. Pesochina, A.A. Gol'eva, S.V. Zaitsev Variabilility of Soils and Environmental Condition in the Northeastern Azov Region in the Middle Sarmation Epoch Pedolody 6. 2000 p.683-691	111-Pesochina_etal-2000	Shaumian-96 (Chaltyr)	Russia	47°17'00''	39°30'00''	N					2.5 ka	1.3 ka	soils	morphological
179	D.V. Levachenko,E.S.Malyasova Holocene climatic Optimum in Pechora Delta A series of geographic 4.2007 p.125-132	112-Levachenko & Malyasova-2006	Yushino	Russia	68°08'	54°12'	Y	uncal.14C	wood, peat	wood, peat		6.5 ka	5.5 ka	peat bogs	pollen, radiocarbon data
180	V.P Zernitskaya & N.A Makhnach The dynamics of natural environments in the Late Glacial and Holocene Belarusians from data on the siege of the lake Sergeyevsky "Problema sovremennoi polinologii Tom-II" p.100-104	113-Zernitskaya & Makhnach-2011	Sergeyevskoe	Belarus	53°30'40''	27°45'40''	Y	cal.14C	wood, carbonates	wood, carbonate		15 ka	2.8 ka	lake deposits	pollen, oxygen-isotopes, lithological, geochemical, radiocarbon data
181	T.V. Vashalova & V. A. Klimanov Quantitative paleoclimate reconstruction in Hibinah as analogs of a climate of the future. Vestnik Moscow University Ser:5 Geografiia 1(1987)	114-Vashalova & Klimanov-1987	Hibin	Russia	67°44'	33°43'	Y	uncal.14C	peat, wood, sand	peat, wood, sand		8 ka	5.5 ka	lake deposits	pollen, radiocarbon data
182	N.S Bolikhovskaya Features of the vegetation and climate in arid regions of European Russia in the Holocene "Problema sovremennoi polinologii Tom-II" p.43-47	115-Bolikhovskaya-2011	Solenoye Zaimishche	Russia	47°54'	46°10'	Y	AMS cal.14C	soil, wood	soil, wood		11.5 ka	0 ka	lake deposits	pollen, radiocarbon data
183	N.S Bolikhovskaya Features of the vegetation and climate in arid regions of European Russia in the Holocene "Problema sovremennoi polinologii Tom-II" p.43-47	115(a)-Bolikhovskaya-2011	delta Volgi	Russia	45°43'	47°55'	Y	AMS cal.14C	soil, wood	soil, wood		11.5 ka	0 ka	lake deposits	pollen, radiocarbon data
184	E.S Pleshivtseva New sections of the Pskov region of Holocene palynological characterization "polinology: stratigraphy and geoecology" Volume II.2008 p.198-203	116-Pleshivtseva-2008	Tushinskii moh	Russia	59°06'10''	30°59'09''	Y	uncal.14C	peat, gyttia, sand, clay,	peat, gyttia, sand, clay,		14 ka	0 ka	bog-fluvial deposits	pollen, radiocarbon data
185	E.S Pleshivtseva New sections of the Pskov region of Holocene palynological characterization "polinology: stratigraphy and geoecology" Volume II.2008 p.198-203	116(a)- Pleshivtseva-2008	Kripetskoe	Russia	57°57'18''	28°34'48''	Y	uncal.14C	peat, gyttia, sand, clay,	peat, gyttia, sand, clay,		14 ka	0 ka	bog-fluvial deposits	pollen, radiocarbon data
186	E.S Pleshivtseva New sections of the Pskov region of Holocene palynological characterization "polinology: stratigraphy and geoecology" Volume II.2008 p.198-203	116(b)- Pleshivtseva-2008	Galskii moh	Russia	56°24'47''	30°49'05''	Y	uncal.14C	peat, gyttia, sand, clay,	peat, gyttia, sand, clay,		14 ka	0 ka	bog-fluvial deposits	pollen, radiocarbon data
187	E.S Pleshivtseva ., E.S Maliasova New sections of the Novgorod region of Holocene palynological characterization "polinology: stratigraphy and geoecology" Volume II.2008 p.204-208	117- Pleshivtseva & Maliasova-2008	swamp Olgina (Voldai)	Russia	57°59'	33°17'	Y	uncal.14C	peat	peat		12 ka	0 ka	fluvial deposits	pollen, radiocarbon data
188	V.P Zernitskaya., E.A Krutous., V.A Klimanov Study of peatlands to climate recovery features of the development of Belarusian Polesie Minsk 1998 p.68-74	118-Zernitskaya_etal-1998	Novoselki	Belarus	53°00'45''	26°53'19''	Y	uncal.14C				12 ka	0 ka	peat deposits	pollen, curves palaeotemperature, annual precipitation
189	V.P Zernitskaya., E.A Krutous., V.A Klimanov Study of peatlands to climate recovery features of the development of Belarusian Polesie Minsk 1998 p.68-74	118(a)-Zernitskaya_etal-1998	Zditova	Belarus	52°25'60''	25°16'00''	Y	uncal.14C				12 ka	0 ka	peat deposits	pollen, curves palaeotemperature, annual precipitation
190	Krisztina Buczkó, Enikö Katalin Magyari, Mihály Braun, Miklós Bálint Diatom-inferred lateglacial and Holocene climatic variability in the South Carpathian Mountains (Romania) Quaternary International xxx (2012) p.1-13	119-Buczko_etal-2012	lake Brazi	Romania	45°23'47''	22°54'06''	Y	AMS cal.14C	siliceous algae	siliceous algae		13.6 ka	0 ka	lake deposits	diatom, lithological, radiocarbon data

Table 6: Literature reference database (list of references with location data, absolute dating, age min, age max, archives and proxy

Statutory Declaration

I declare that my PhD tesis: “Late Quaternary Climate Change in Western Eurasia. A spatio-temporal review of climate proxies” was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.
Any thoughts from others or literal quotations are clearly marked.

Berlin, 23 February 2015 ______________________