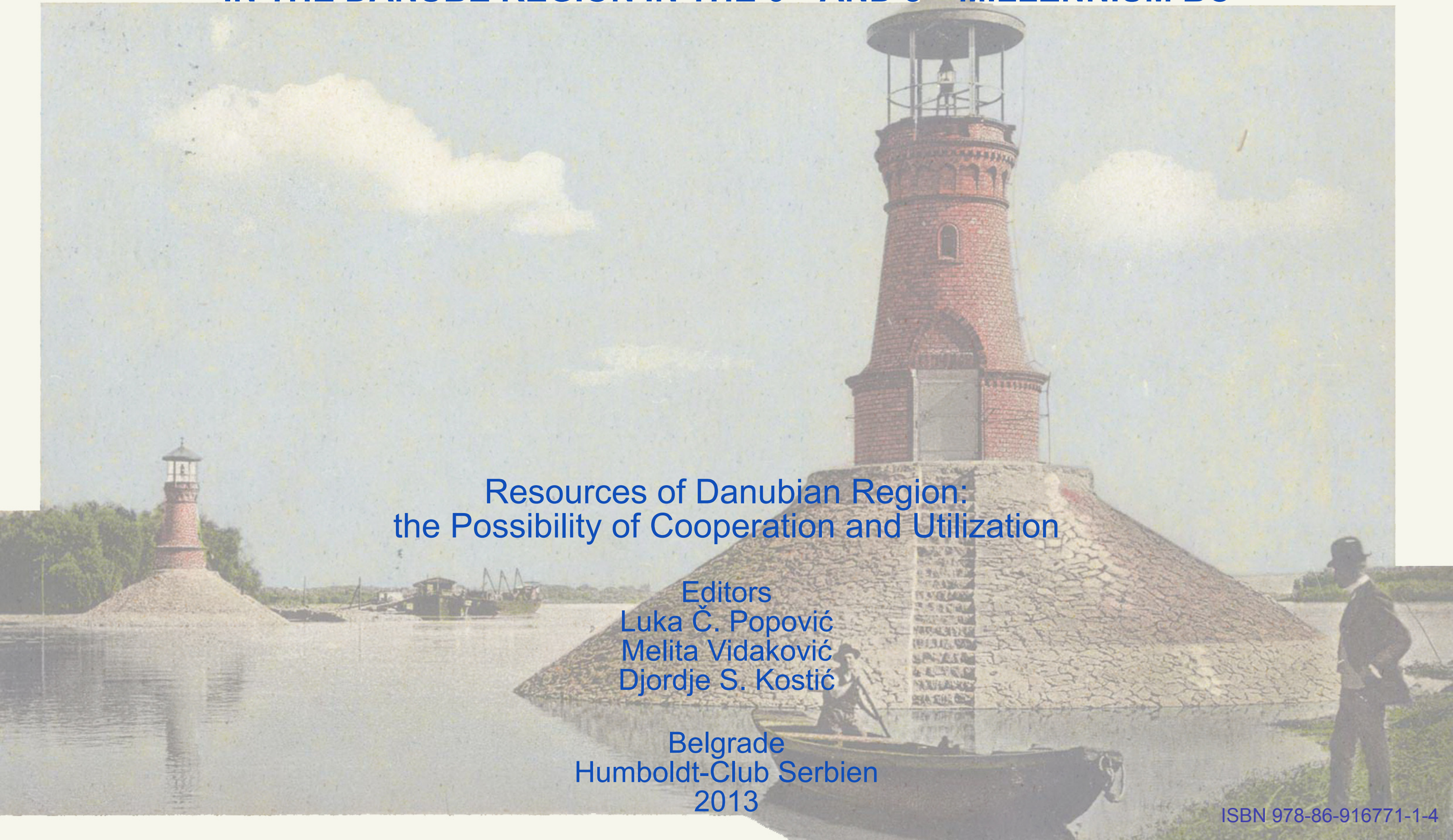
Miroslav Marić
Institute for Balkan Studies, Serbian Academy of Sciences and Arts, Belgrade
Serbia

THE VINČA CULTURE
CLIMATE AND ENVIRONMENT
IN THE DANUBE REGION IN THE 6TH AND 5TH MILLENNIUM BC



Resources of Danubian Region:
the Possibility of Cooperation and Utilization

Editors
Luka Č. Popović
Melita Vidaković
Djordje S. Kostić

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Abstract. The late Neolithic Vinča culture is the most prominent culture in the region of the Central Balkans. Covering a vast territory, its' settlements can be found in a variety of environments and climates. This paper focuses on a proposed environmental and climatic reconstruction based on animal and macrobotanical remains discovered on three Vinča culture sites within the Danube catchment around Belgrade.
Keywords: Central Balkans, Danube, Neolithic, Vinča culture, Environment and Climate reconstruction.

The late Neolithic in the Danube region of Serbia is marked by a culture best known for its eponymous site of Belo Brdo in a suburb of Belgrade called Vinča. Between 1908 and 1934, a series of excavation campaigns Dr. Miloje Vasić of the Belgrade University defined and shed light on the remains of a culture spanning almost the entire area of the central Balkans. The Vinča culture that dominated the region for almost a thousand years, between 5300 and 4400 cal. BC (Glaser 1996: 194-198) is found in the landscape around major rivers, like South and West Morava, Sava, Drina, Danube, Timiş and Tisza (Opačić 2005: 74). More than two hundred sites of the culture are found from eastern Croatia and Bosnia (Burić 2009, Čović 1961) in the west to Sofia plain in the east (Todorova 1990) and from Transylvania (Suciu 2009) and Banat (Lazarovici 1979) in Romania, to northern parts of FYR of Macedonia (Gimbutas 1974), Kosovo and Montenegro (Marković 1985) with the majority of culture found on the territory of Serbia. The focus of this paper is on 3 sites of the culture located on the banks of the Danube or in its immediate vicinity in order to try and recreate the environment and climate of the period in this area based on the discovered remains of wild animals and macrobotanical data.

Sites and research history

In order to start the reconstruction of the past environment, we need to set the locations of the sites to be presented in the paper (**Fig. 1**). Starting from the settlement not directly located on, or close to, the banks of Danube, the site of Ledine, is located in Žarkovo, a suburb of Belgrade. The settlement was located on a north-northwest oriented slope gradually descending towards the Makiš field and Sava River (**Fig. 2**), about 9 kilometres from its confluence with Danube. This kind of dominant position overlooking a river valley (in this case the Sava River) and surrounded by springs is a preferential type of location for Vinča culture settlements south of Danube and Sava rivers (e.g. Belovode, Supska, Gradac, Drenovac), i.e. in the hilly region of Serbia. The site was excavated to a limited extent on two occasions, the first time in 1948, and the last time in 1988. The excavations of 1948 established the existence of four settlement horizons within a 3 meter thick culture layer. The lower horizons were dated to Vinča A phase (horizon IV), with following horizons (III and II) belonging to Vinča B1-B2 phases and finally topped by a Vinča B2/C horizon (horizon I) (Garašanin M. & D. 1954: 107).

The second site, Opovo Bajbuk is located northwest of Belgrade, to the east of Opovo village in a valley close to the banks of Tamiš (Timiş) River. Even though not directly located on Danube banks, the site is located within its catchment on a hillock nestled within the inner side of an oxbow lake once belonging to either the Tamiš or Jer Rivers (Fig. 3, blue polygons). Several other Tamiš (Timiş) meanders can also be easily distinguished to the southwest of the site (Fig. 3, yellow polygons). It was excavated over several campaigns from 1983 to 1989 and multiple archaeological features were discovered. Unlike the other two sites analysed here, Opovo Bajbuk is not a multilayered site, but rather limited only to the later phases of Vinča culture, i.e. the Vinča B2/C and C period, or 4700 – 4500 cal. BC (Borojević 2006: 2).

The third site presented here is the eponymous site of Belo Brdo in Vinča. It is located on the right bank of Danube, at the confluence of Bolečica River (Fig. 4), 14 kilometres downstream of Belgrade. Although some authors declare it as a tell site mostly because of its 10 meter thick culture layer, it is still far from certain whether this is actually the case (Tasić & Marić 2010). Results of the earliest excavations (1908-1934) were published in the 1930's by Miloje Vasić in his four volume monograph entitled Prehistoric Vinča, but full archaeological recognition and fame were established after the second World War through works of Milutin Garašanin (1949, 1951, 1973), Borislav Jovanović (1961, 1984, 1996) and others. The site is best known as the archetype site for the chronology of the Vinča culture, owing to the occurrence of all phases (i.e. Vinča A – Vinča D) in the 8 meters of Vinča culture layers (Garašanin 1949).

Faunal data

Faunal data recovery is not a novelty on sites excavated in Serbia, but only recently (since the excavations of 1970's) have there been attempts to do it in a more systematic way. In this paper I present results obtained through analysis of faunal remains from all three sites, Opovo – Bajbuk, Žarkovo Ledine and Belo Brdo in Vinča.

Žarkovo – Ledine

Faunal remains from the 1949 excavation of the site were first published 43 years later (Schwartz 1992). The sample consisted of about 400, mostly fragmented bones, 297 identifiable by species, the rest only to element. **Table 1** is an overview of identified wild species which will be used in our reconstruction of the environment (domesticated species are excluded from the analysis on the basis of being held close to or within the settlement in anthropologically altered habitats). It is worth mentioning that the number of identifiable domestic animals remains outweighs the number of wild species by 2:1. Amongst the most numerous are the remains of domesticated cattle and pigs (Schwartz 1992: 132).

Opovo Bajbuk

The faunal data from Opovo Bajbuk site originates from an unpublished PhD thesis of Nerissa Russell (1993), who studied the faunal material during and after the excavations as a member of the excavation team. A significantly larger sample when compared to the Ledine and Belo Brdo bones consisting of over 43315 fragments of animal bone was analysed and is presented here (**Table 2**). Unlike Ledine and Vinča, Bajbuk differs in the fact that at least 62% of the identified fauna belongs to wild species, which is very unusual for late Vinča culture sites *en générale* (Tringham et al. 1985: 440). The actual percentage can be even higher as most of the cattle and pig bones could be, based on measurements attributed as wild specimens. Additionally, finds of mussel and snail shells, fish and bird bones indicate an intense hunting practice taking place around Bajbuk in late Vinča period.

Vinča - Belo Brdo

The preliminary report on the faunal remains by Bökönyi (1992) does not go into detail about the percentages of discovered animal bones on the site, even though he had, at his disposal the bones discovered during the cutting of the entire depth of the profile performed between 1978 and 1981 in order to revise the sequence. Rather, Bökönyi insists that he is writing only a preliminary report on the finds, making generalized remarks on the species discovered. However, in conclusion, Bökönyi mentions the red deer as the most numerous find in the assemblage, followed by wild pig, roe deer and wild auroch bones. A more recent analysis by Vesna Dimitrijević (2006) focused in more detail on the faunal remains obtained over the newest excavation seasons (1998-2003 campaigns). A significantly larger sample was available from these excavations, amounting to about 21 000 fragments and complete animal bones, albeit from a single dwelling horizon.

Botanical data

Similar to recovery of faunal remains the collection of archaeobotanical data is also not a novelty in Serbian archaeology. Pollen analyses on the other hand were performed only on a handful of sites like Grivac, Divostin (Grüger and Beug 1988) or Gomolava (Bottema 1975) and in recent years Jaričište 1 (*unpublished*), but the technique has not yet become a standard practice. Macrobotanical analyses have been performed on more Vinča culture sites and in the recent years are becoming a regular practice in the field. There are two samples presented here, one from Opovo Bajbuk and the other from Belo Brdo in Vinča.

Opovo - Bajbuk

During the excavation of the site, field team collected soil samples which were later floated and analysed for plant remains. Alongside flotation, after the 1985 campaign systematic screening (with mash size 1 cm) was also employed in the field. Sieved and floated samples were later separated under several graduated geological sieves and studied with low power binocular microscopes (Borojević 2006: 13-14). It must be mentioned that, aside from charred plant seed remains, there were many charred wood remains as well which were also analysed making it possible to identify *Quercus* (oak) as the most numerous sample, followed by *Salicaceae* (willow/poplar) and *Cornus* (dogwood). In one sample there were fragments of *Ulmus/Ulmaceae* (Borojević 2006: 117).

Belo Brdo

The collection of macrobotanical samples on Belo Brdo site began during the latest excavation campaigns (1998-2012). Sampling strategy was slightly different from the one applied in Opovo, mostly due to the availability of water on site, which makes floating large quantities of samples very easy. The botanical data presented here (**Table 5**) is the first compiled publication of results obtained so far. Analyses were performed by Dragana Filipović, an archaeobotanist under initial guidance and supervision of Ksenija Borojević. During excavations in Belo Brdo many charred wood remains were recovered alongside other botanical samples. However, wood identification from Belo Brdo samples is in its initial stage, with just three species identified so far, maple (*Acer sp.*), ash (*Fraxinus excelsior L.*) and oak (*Quercus sp.*).

Habitat reconstruction

Having presented the available faunal and botanical data for the three sites being analysed here, we turn now to the possibilities of habitat reconstruction. Faunal and Botanical data will be first analysed separately, and then a composite overlay will be created.

Faunal data

Deer species

The most numerous of all wild species in the faunal records is the cervidae family, represented by three distinct species; red, roe and fallow deer. The red deer, largest of the three is usually associated with forests, both coniferous and deciduous with access to open terrain. They usually stay in woodlands during summer and prefer more open grassland in winter (Chen et al. 1998). Second in number to red deer, the roe deer's (*Capreolus capreolus*) habitat is mainly immature woodland or forest with plenty of undergrowth, dry reed beds, scrubs and similar places with adequate cover and rarely spread into farmland (Lyneborg 1977: 220-221). Fallow deer, the least present in samples from Vinča culture sites is, similar to red and roe deer, an animal of woodlands, mostly deciduous or mixed with some intermediate cover and access to grassy glades or fields (Lyneborg 1977: 219-220).

Wild pigs

Outside of the deer species, wild pig is the most numerous specimens in the faunal samples of the sites being analysed here. The natural habitat of the species is wooded terrain, particularly where forests border grasslands or arable soil. Wild pigs may also be found in steppe regions as long as there are rivers with sufficient stretches of undergrowth and marsh vegetation (Lyneborg 1977: 213).

Bos primigenius

The now extinct wild cattle of Europe, aurochs were amongst the largest species in the late Neolithic of the Balkans. A specialized grazer, the auroch required graminoids (grasses, sedges and such), which would indicate open, treeless areas (van Vuure 2005: 181). However there are suggestions that auroch habitats may have overlapped with that of the beaver (van Vuure 2005: 186), which would indicate river valleys with willow and alder trees and abundant sedges (*Carex sp*). Commonly associated with willows and alders are poplars and aspens (Janssen 1974).

Canids

The canids are represented by several different species, but most prominently the wolf and possibly jackal. Wolf habitat is a widely varied terrain, from woodlands to open countryside, but it is safe to assume that in the lowlands they would have preferred the cover of forests, marshlands and to a lesser degree steppe. The availability of prey in adequate numbers may have been more important than the actual nature of the terrain (Lyneborg 1977: 197). Covering vast territories that can exceed 50 kilometres per hunt make it difficult to identify an original habitat, additionally supported in migrations caused by the lack of prey in a region (Lyneborg 1977: 198).

Red fox

Another carnivore present in the faunal data, the red fox prefers woodland, but can be found in open country and close to human settlements. A diet of rodents and berries would place them towards the edges of forests, close to open grassland or even arable fields (Lyneborg 1977: 200).

Wild Cat

These wild species of cats are usually found in areas of continuous forests and scrubs, but can venture into open ground for hunting on prey. Being predominantly mountainous animals, it is very unusual that the wild cats were found on Opovo (Lyneborg 1977: 184-185).

Marten

This species is generally present in two varieties, pine and beech marten. Being found in the faunal data of Opovo, it would be safe to conclude that we are dealing with the second variety, i.e. the beech marten. The ideal habitat of this variety is the frequently cultivated and inhabited areas, but close to deciduous woodlands, as their main diet consists of small rodents like squirrels, birds and invertebrates (Lyneborg 1977: 187).

European polecat

Found mainly in thickets and woodland, European polecats can also be found in scrub and more open country with rocks, or in hedgerows around fields, which puts them relatively close to human settlements. Rabbits are their main diet would make their habitat overlap with that of the rabbits (Lyneborg 1977: 190-191).

Brown bear

A large omnivore, brown bear is associated with large, continuous blocks of conifer and deciduous forests, both in mountainous and flatter areas. Aside a diet of fruits, berries, insects and larger mammals, brown bears also consume fish which would make their habitat somewhat dependent on water bodies (Lyneborg 1977: 202-203).

Brown hare

Significant numbers of hare bones in the Opovo faunal assemblage fits well in the habitat of the Leporidae family. The ideal habitat for these animals is the flat and open country, farmlands, downs and heaths. They can also be found in open woodland, but not in large continuous blocks of forests (Lyneborg 1977: 141).

Rodents

The largest order of mammals with over 3000 species, rodents are distributed all over the world. They are highly adaptive to living in various, often arid environments and climates, with very varying habitats. Some, like hamsters (*Cricetus cricetus*), mice (*Murinae* family), mole rats (*Spalax sp.*) and ground-squirrels (*Citellus sp.*) are adapted to living in open, grassy environments, but can thrive in or near cultivated soil as well (Lyneborg 1977: 155-156, 148, 170). Others, like the water vole (*Arvicola terrestris*) prefer the proximity of water, building tunnels in river, stream, lake or marsh banks covered with dense vegetation and scattered trees (Lyneborg 1977: 162).

Beaver / Otter

Although not from the same family, beavers and otters share similar habitats. The typical habitat of the beavers (*rodents order*) is in lakes and rivers surrounded by deciduous forests and scrubs compounded of trees like ash, aspen, birch and willow, with plenty of undergrowth (Lyneborg 1977: 150-151). Carnivorous otters (*mustelidae order*) on the other hand do not construct their dwellings of fell timber, but still live in dens excavated very close to water, along streams, rivers and lakes, or in marshlands (Lyneborg 1977: 193-194).

Pond turtle

Pond turtle is usually found in all wetlands surrounded by wooded landscapes. Pond turtles prefer large bodies of slow moving fresh water with sandy areas for oviposition. They are considered semi-aquatic and can move away several hundred meters away from water (Ficetola & De Bernardi 2006)

Based on the preferences presented above we can structure faunal records in such a manner to indicate a strong presence of sylvan animals in all three assemblages with 13 different species associated with partial or permanent forest habitation (**Figure 5**). The second largest environment evidence, according to the faunal remains is the open steppe/grassland/arable soil, populated partially or permanently by 9 species. Six species found in faunal remains inhabit river banks and areas close to them, while 4 species prefer lakes/ponds/oxbow lakes. Marshland is the habitat of choice for 4 species, exactly the same as the scrub.

Botanical data

Unlike faunal data, botanical remains can provide a more detailed insight into the composition of biosphere in a region. A very useful feature of the botanical data is the possibility of reconstructing the so called *plant associations*, or *plant communities* (*phytocoenosis*) based on single plants or combinations of several plants. Plant communities represent plant species collections within a geographical unit that form a more or less uniform patch distinguishable from the neighbouring patches of different plant types (Gobat et al. 2004).

Starting from the identified charred wood samples and comparing them against a directory of identified habitats compiled by the *Institute of Botany of the Faculty of Biology, University of Belgrade* (Блаженчић et al. 2005) we see that the most common find is the charred remains of Oak (*Quercus*). One of several plant communities containing Quercus is the ***Quercus-Ulmus-Fraxinus riverside forests plant community***. A single sample of Ulmus sp. present in the Opovo sample supports this reconstruction (Блаженчић et al. 2005: 419). In this plant community the Poplar (*Populus alba/nigra*) is one of the dominant species alongside Ash (Fraxinus angustifolia/pallisae), Hornbeam (Carpinus betulus) and Alder (Alnus glutinosa). The habitat for this plant community is the alluvial plains more or less influenced by subterranean and flood waters. Other known plants in the community are Maple (*Acer campestre/negundo*), Ash (*Fraxinus excelsior/ornus/oxycarpa*), Wild cherry (*Prunus aviuum*), Lime (*Tilia cordata/tomentosa*), Elm (*Ulmus carpinifolia/effusa*), Willow (*Salix alba/caprea/fragilis*). The bush level is represented by many species, most notably Cornelian cherry (*Cornus mas*), Common dogwood (*Cornus sanguinea*), different Hawthorns (*Crataegus monogyna/nigra*), Common spindle (*Euonymus europaeus*), Alder buckthorn (*Frangula alnus*) and other. Certain plants of the community appear in the central parts of the alluvial plains on terrains barely above normal water table and are exposed to a significant influence of ground and subterranean water. On the other end of the community chain are those species that appear on the highest plateaus of Holocene clay and sand and represent a gradual transition towards climatogenetic forests. Flooding rarely occurs in these regions. This habitat occurs on the banks of lowland rivers and streams in moderate-continental and Pannonian-continental climate (Блаженчић et al. 2005: 419-421).

Away from the major rivers and lowland meanders and oxbow lakes Quercus species is the dominant species in the ***Thermophile deciduous forest community***. It is accompanied by Maple (*Acep sp.*), Chestnut (*Castanea Sativa*), Lilac (*Syringa vulgaris*), Hornbeam (*Carpinus sp.*), Cornelian Cherry (*Cornus Mas*), Juniper (*Juniperus communis*), Wild Apple/Pear (*Pirus sp.*), Poplars (*Populus sp.*), Prunus family (*Prunus sp.*) and many other. This community develops on flat or mildly sloped thermophilic terrain void of subterranean or free flowing water between 50 and 1400 meters ASL in continental, moderate-continental or sub-Mediterranean climates (Блаженчић et al. 2005: 475-485).

In combination with tree remains several unassigned plant and bush samples can identify another plant community, the ***Steppe oak forest***. This plant community reflects in the following species found both in Opovo and in Vinča: Oak (*Quercus sp.*) Cornelian Cherry (*Cornus mas*), Berries (*Rubus sp.*), Wild Strawberry (*Fragaria Vesca*), several types of Bedstraws (*Galium aparine/mollugo*), Gromwell (*Lithospermum officinale*), Campions (*Silene sp.*), Bindweeds (*Convolvulus sp.*). It is a light mono dominant or mixed forest with the highest floor dominated by different species of Oak (*Quercus cerris/frainetto/petraea/robur*). Steppe oak plant communities occur on flat or mildly slanted thermophilic terrain up to 400 meters ASL. They thrive on lime or loess soils, combined with brown soils, chernozems and loessoid chernozem in Pannonian-continental climate (Блаженчић et al. 2005: 517-519).

Brome grass (*Bromus L.*) together with Cleavers/Bedstraws (*Galium aparine/mollugo*), Reeds (*Phragmites communis*), Redshank (*Polygonum*), Clovers (*Trifolium repens*) is commonly found in Reed and other high helophyte species on the edges of water basins plant communities. This community represents tall closed grassy formations – reeds dominated by *Phragmites communis*. Such communities can be found on the muddy banks of ponds, canals and slow flowing rivers and streams in lowland terrain (Блаженчић et al. 2005: 93-95).

The pioneer and ephemeral vegetation of periodically flooded areas community can be identified by two plant species found in the botanical data recovered from Belo Brdo and one from Opovo. Those plant species are Figleaf Goosefoot (*Chenopodium ficifolium*) and Green foxtail (*Setaria viridis*). General characteristics of this community are small sward plants up to 40 cm in height which enjoy nitrophilic habitats on the banks of still-waters, ditches or oxbow lakes. The species of this community prefer periodically flooded muddy or sandy banks of ponds and puddles that dry out. Their preferable soil is wetland humus or dark clay soils, seldom on waterlogged chernozems or alluvial deposits (Блаженчић et al. 2005: 108-109).

Elder (*Sambucus nigra*), Danesblood (*Sambucus ebulus*), Bladder Cherry (*Physalis alkekengi*) and other plants of the Nightshade (*Solanaceae*) and Mallow (*Malvaceae*) family are a tell-tale indication of Willow – Alder - Birch river forest plant community. This community is defined by forests of thinned short and tall trees dominated in the lowlands by White willow, white, black or grey Poplar. On the lower floor typical species are represented by Maples, Hawthorns, Spindles, Ash and other. This community appears on the banks of lowland rivers on recent alluvial deposits, hydromorphic gleysols, pseudogleysols or alluvial semigleysols. The terrain is flooded for shorter or longer periods of time and contains high levels of sub-surface water. This *phytocoenosis* emerges in mildly continental, Pannonian continental and mountainous climates (Блаженчић et al. 2005: 405-408).

Vetches, combined with some Bromus, Medick (*Medicago sp.*), Buckthorns (*Rhamnus sp.*), Germanders (*Teucrium sp.*), Gromwells and Graminae and Poeaceae families can easily be identified in the perennial lime grass formations and basic steppe plant community. The general characteristics of this type of community are the low to mid height plants with rich green steppe like formations developed in karst or loess terrain. They can be found on dry and warm flat or mildly slant terrains. The geological base is loess, aeolian carbonate sands or limestone, whilst Soils are usually various chernozems, carbonate humus, seldom brown forest soils. These communities occur in areas of Pannonian continental, mildly-continental and transitory-continental climate (Блаженчић et al. 2005: 156-165).

Integrating faunal and botanical results with GIS modelling

Integrating the data presented so far, required a GIS aided modelling of the terrain performed on the 1:25 000 scale topographic maps printed by the Military Geographic Institute of Belgrade. Contour lines spaced at 2.5 meters, combined with SPOT heights present on the maps enabled the creation of three digital terrain models (DTM) covering an area of 14x19 kilometers around Opovo Bajbuk, 17x15 kilometers around Belo Brdo in Vinča and 9x14 kilometers around Žarkovo Ledine. A separate layer containing site locations was placed over the terrain model alongside a layer with orthogonal photographs of the area. Combining information from the topographic maps and orthogonal photography, a layer with past hydrological features was outlined including oxbow lakes, dried up meanders and streams in the examined regions. These preparations resulted in three separate digital terrain models that mimic the contours of the terrain from the late Neolithic period as much as it was possible.

Opovo Bajbuk

The DTM of the Opovo Bajbuk area shows that the elevations lie between 70 and 85 meters above sea level. In order to establish the surface water table during the late Neolithic the data from the two excavated archaeological sites of the Vinča culture found in the region, the early Vinča A-B1 Trnovača near Baranda (Jovanović 1965) and late Vinča B2/C-C Bajbuk (Tringham et al. 1985) were used. The site of Trnovača is located some 7 kilometers northwest of Bajbuk, near the village of Baranda. It lies on the left bank of Tamiš, on a degraded loess terrace. Even today, the site is surrounded by marshy terrain on three sides, turning into a river island during high water (**Figure 6**). Over the course of one campaign in the early 1960's, the boundaries of an early Vinča culture settlement of about 270x300 meters (Jovanović 1965: 19) in size were established. A stratigraphic sequence of approximately 1.5 meters was established during these excavations. In his description of the site extents Jovanović identifies the 76-75.50 meters ASL as the surface height values (Jovanović 1965: 19). Deducting the depth of the archaeological layers results in 74.50 - 74.00 meters as the mean value for surface water if not to influence the site. Further south on the Bajbuk site it is easy to notice that the current surface above the site is at around 75 meters ASL. From the report made by the excavation co-directors (Tringham et al. 1985: 425) it is clear that at the central part of the site, the end of archaeological layers is at 2.5 meters below the present day surface, so the boundary of geological layers is at 72.5m ASL which could also be the level of surface water in the area around the site. However, as the site is not located on an active part of the river, but rather within the extents of an oxbow lake, higher level of surface water could also be taken into account. Using these two simple calculations, a range between 72.5 and 74.5 meters ASL is obtained as the possible level of surface water in the region. Modeling the terrain with these settings confirms that both sites remained on dry land, away from water (**Figure 7**). However, comparing the digital simulation to the present day water table (conf. Borojević 2006: 109, Fig. 4.2b) the author is willing to accept 72.5m ASL as the most likely height of surface water around Tamiš river, with 72.5 - 73.5 meters ASL being the most likely surface water level in oxbow lakes around Opovo. Based on these assumptions, the superb choosing of the Bajbuk position becomes self evident (**Figure 8**). Surrounded on all sides except the east by water, the site is positioned on a bottleneck formed by the shape of the oxbow lake. To the Northwest of the settlement lies an elliptical terrace bounded on all sides by the waters of the same oxbow lake that envelopes the settlement, a perfect spot for agriculture. Chernozem soil covers the space between the northwest edge of the settlement and the bank of the oxbow lake as illustrated by brown colored polygon in **figure 9** (black arrow marks the position of the settlement). Combining these data with the faunal and botanical data presented earlier in the paper results in the paleoenvironment reconstruction as given in **figure 10**.

Belo Brdo

Unlike Opovo which is located in a predominantly flat terrain and surrounded by ponds, marshes and oxbow lakes, Belo Brdo is located on the banks of a major river (Danube) close to the confluence of a smaller stream (Bolečica). The site is located at the beginning of a slope rising gradually from the northeast towards the southwest (**Fig. 4**). Although Belo Brdo is reviewed as a tell site, geoelectrical tomography results obtained in the recent years have opened new grounds for interpretation on the matter (Tasić & Marić 2010). At this time we cannot be certain of the true extent of the site, as an unknown portion of it was eroded by Danube over the course of several thousand years. However, even today the remains of the settlement can be seen in the vertical profile of the terrace in the length of at least 200 meters. Owing to a century of archaeological research we can establish certain information regarding the original pre-settlement levels of natural soil. A cross-section plan of the 1908 excavations (Vasić 1910: 23, T. 7) clearly identifies the position of original humus at 8.6 meters below the present surface level. Several authors have, in the recent years, managed to reconstruct the original height of the terrain at the time of the beginning of the M. Vasić excavations in the central part of the site at around 86.80 meters ASL (Jovanović 1984, Marić 2012), enabling the placement of the original height of the prehistoric humus at 78.2m ASL. The publication containing the original research of Miloje Vasić (1932, 1936) shows that the deepest cut archaeological features were dug in as deep as 11.40 meters below the surface, which would be at 75.4 meters. Today, the confluence of Bolečica and Danube some 50 meters northeast of the site lies at 71.9 meters ASL. It would be safe to assume that we should look within this height range when considering the original level of surface water in the late Neolithic. Comparing these values (71.9-75.4m) with the ones obtained from similar calculations on Opovo Bajbuk and Trnovača sites (72.5-73.5m), the overlap is immediately evident, and we can postulate the value around 72.5 meters as the most likely value of surface water level in the late Neolithic. Basing the digital terrain model on this assumption, the model as shown in **figure 11** was constructed. The absence of larger permanent or semi-permanent bodies of still water makes up another significant difference between the environment of Belo Brdo and Opovo, which may slightly alter the positions of certain plant communities. The strong current of Danube would most likely inhibit the development of reed and other helophyte species on its banks, but these are to be expected on the banks and confluence of Bolečica, where it can still be found even today. Willow – Poplar forests would have been a more dominant plant society, possibly mixed with the pioneer and ephemeral vegetation on the banks of both Danube and Bolečica, as they are even today, especially around Bolečica. Moving away from Bolečica towards the site we would find the cleared out soil used as either pasture or arable land by the inhabitants of the settlement. The higher ground to the north and northwest of the site would have, most likely been occupied by predominantly oak forests, possibly in combination with lime, alder and other trees. On the opposite side of the Bolečica, away from the site, it is possible that the uncleared soil away from the Willow-Poplar forest may have been populated by *Quercus-Ulmus-Fraxinus* riverside forests, followed by more mixed oak forests further away from the waterline.

Žarkovo Ledine

The Ledine site is somewhat similar in location to the Belo Brdo site. It is quite possible that in the late Neolithic period the flow of Sava was much closer to the site as the traces of old meanders can be seen to the west of the site in the alluvial plain of Makiš (**Fig. 12**). It can be assumed that the 200x200 meters is the most probable extent of the settlement. Located between 100 and 110 meters ASL and with the thickness of archaeological layers being approximately 3.50 meters, the settlement is out of reach of ground waters of Sava, found at about 72-73 meters ASL. The same surface water table assumptions made for Opovo and Belo Brdo were also used in the modelling of terrain around Ledine (**Figure 13**). It is clear that at least a portion of the Makiš plain could have been either occasionally flooded or marshy very close to the site itself, which would have presented a perfect opportunity for hunting and fishing. Aside from the Reeds, this type of alluvial plain could have also been ideal for Willow-Alder-Birch River forests accompanied possibly by Poplars. The vicinity of water/marsh and the Žarkovo stream provided plenty of water for crop irrigation. East of the site, where the terrain rose further, the most likely vegetation communities would have been dominated by oak forests mixed with hornbeam, lime, beech and other trees. Even today, the eastern slope of the Banovo Brdo – Žarkovo – Cerak ridge on which the site is located is dominated by these types of trees as a part of the Košutnjak forest.

Concluding remarks

The reconstruction of paleoenvironment and climate is in its primary stages in Serbia, but some attempts can and must be made if we are to discover more of the past societies, their daily lives and practices. The abundance of animal bones on prehistoric sites can be a useful but not definite data in attempts to identify the climate and environments in which these animals lived and perished. Macrobotanical analysis, although only recently applied to a larger degree in archaeological research in Serbia is slowly but surely taking roots in current field practice as each excavation season passes.

Seeds, plant fragments, charred wood and even charred fruit obtained from such sampling have, in the recent years, contributed to a better understanding of the past plant species and their interaction and overlapping with manmade communities. However, more samples are needed from various periods of the Neolithic as well as from more sites to form a more detailed image of the past environment. Computer aided terrain modelling combined with faunal and macrobotanical sampling, geological and soil studies can additionally help with future reconstructions. Introducing newer and more precise technologies like pollen analysis would indeed result in much more detailed knowledge, especially when combined with $_{14}$C results or other methods of absolute dating that can provide chronological sequences in distinct regions. It is to be hoped that future research will enable the gathering of this data in larger quantities, especially in the light of slowly renewing international research cooperation being re-established between Serbian and EU based partners.

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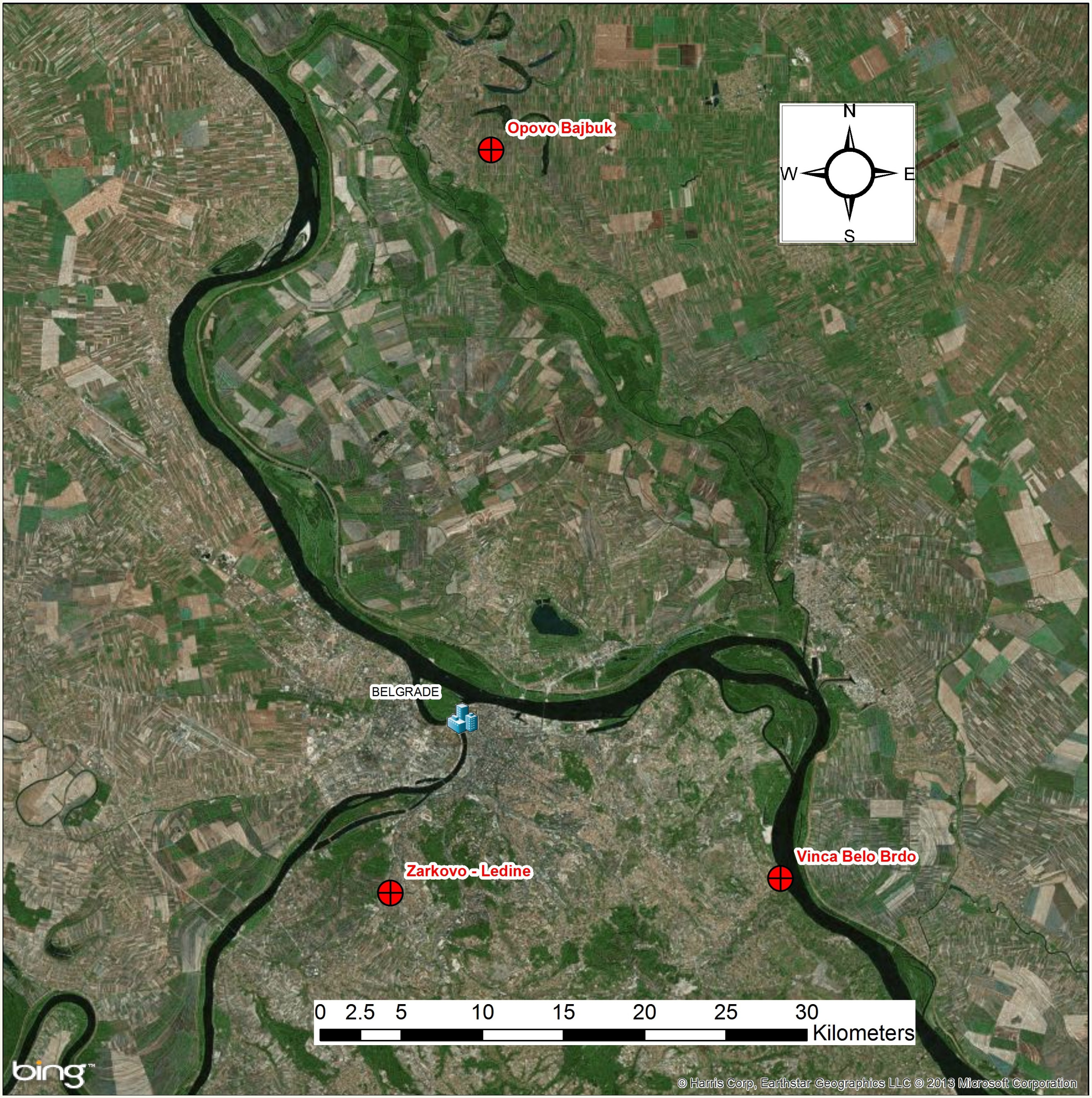
Opovo Bajbuk
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BELGRADE
Zarkovo - Ledine
Vinca Belo Brdo
0 2.5 5 10 15 20 25 30
Kilometers
bing
© Harris Corp, Earthstar Geographics LLC © 2013 Microsoft Corporation

Fig. 1.


N
W
E
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Zarkovo - Ledine
0
0.15
0.3
0.6
0.9
1.2
1.5
Kilometers
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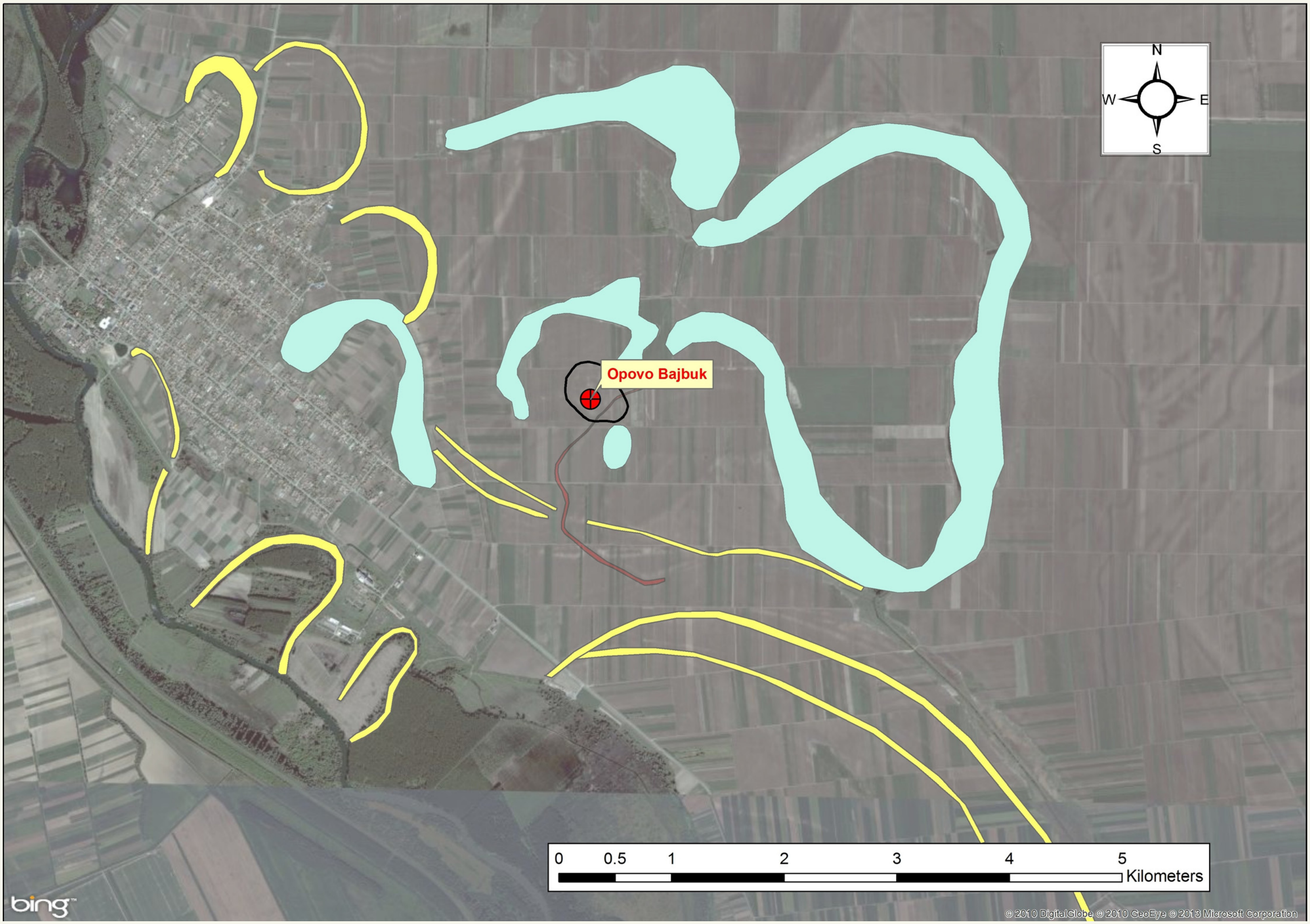
Fig. 2.


N
W
E
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Opovo Bajbuk
0
0.5
1
2
3
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Kilometers
bing
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Fig. 3.


N
W
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Vinca Belo Brdo
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Kilometers
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Fig. 4.

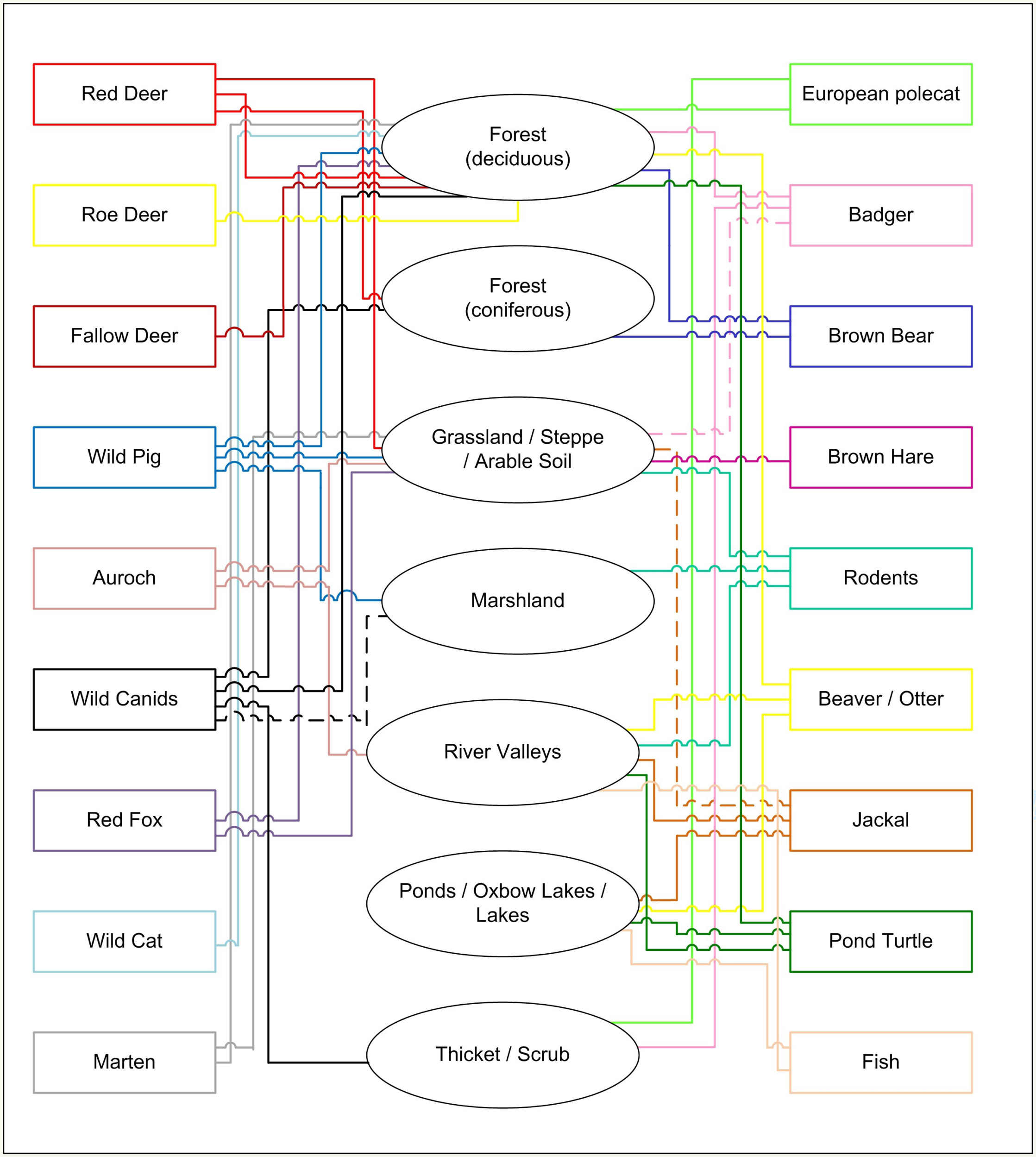
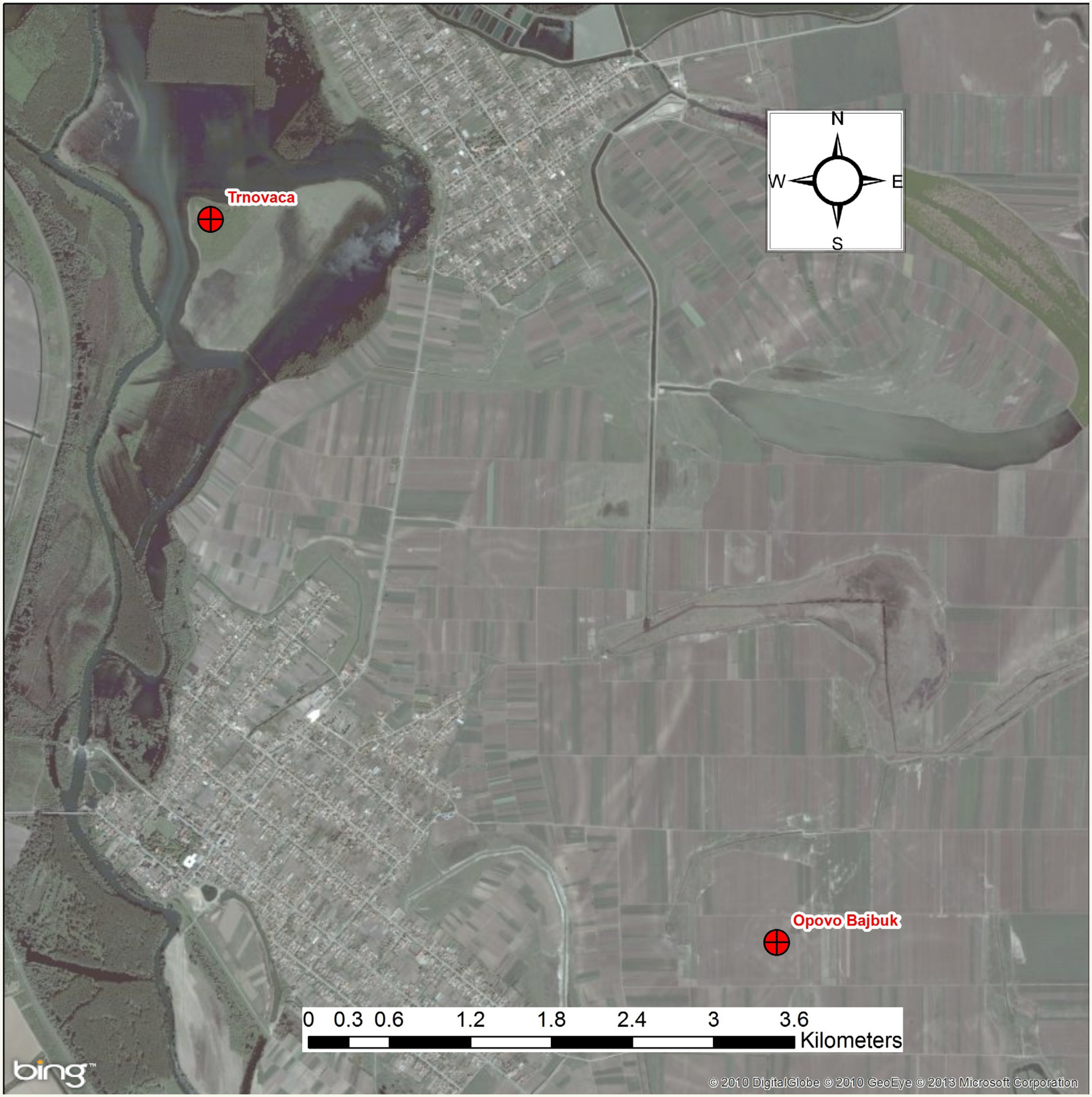

Red Deer
Roe Deer
Fallow Deer
Wild Pig
Auroch
Wild Canids
Red Fox
Wild Cat
Marten
Forest
(deciduous)
Forest
(coniferous)
Grassland / Steppe
/ Arable Soil
Marshland
River Valleys
Ponds / Oxbow Lakes /
Lakes
Thicket / Scrub
European polecat
Badger
Brown Bear
Brown Hare
Rodents
Beaver / Otter
Jackal
Pond Turtle
Fish

Fig. 5.


Trnovaca
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S
Opovo Bajbuk
0 0.3 0.6 1.2 1.8 2.4 3 3.6
Kilometers
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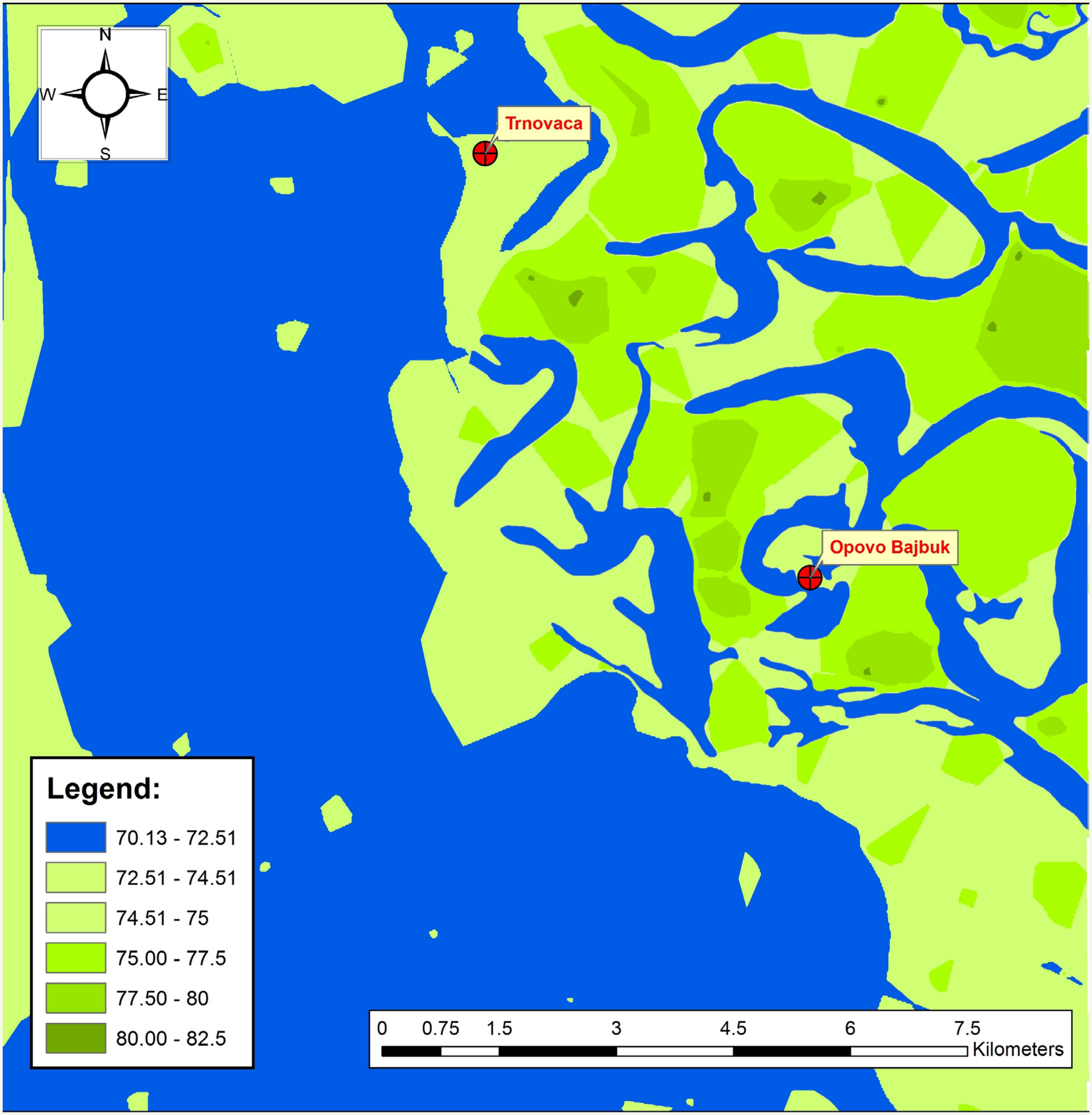
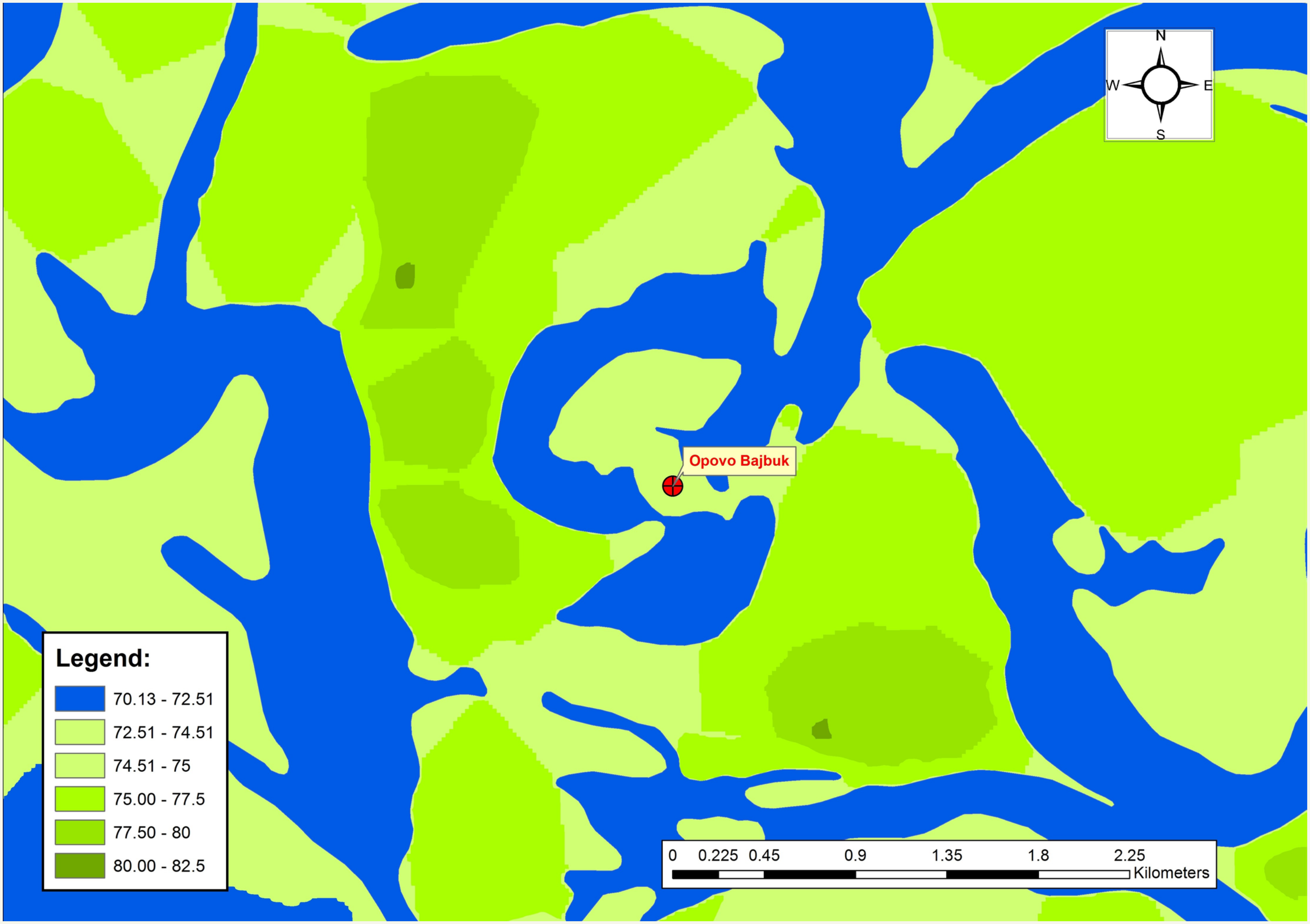
© 2010 DigitalGlobe © 2010 GeoEye © 2013 Microsoft Corporation

Fig. 6.



Dunărea

Fig. 7.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Opovo Bajbuk
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72.51 - 74.51
74.51 - 75
75.00 - 77.5
77.50 - 80
80.00 - 82.5
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1.35
1.8
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Kilometers

Fig. 8.

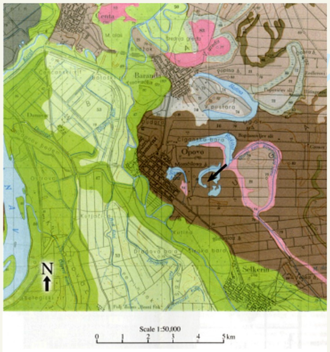
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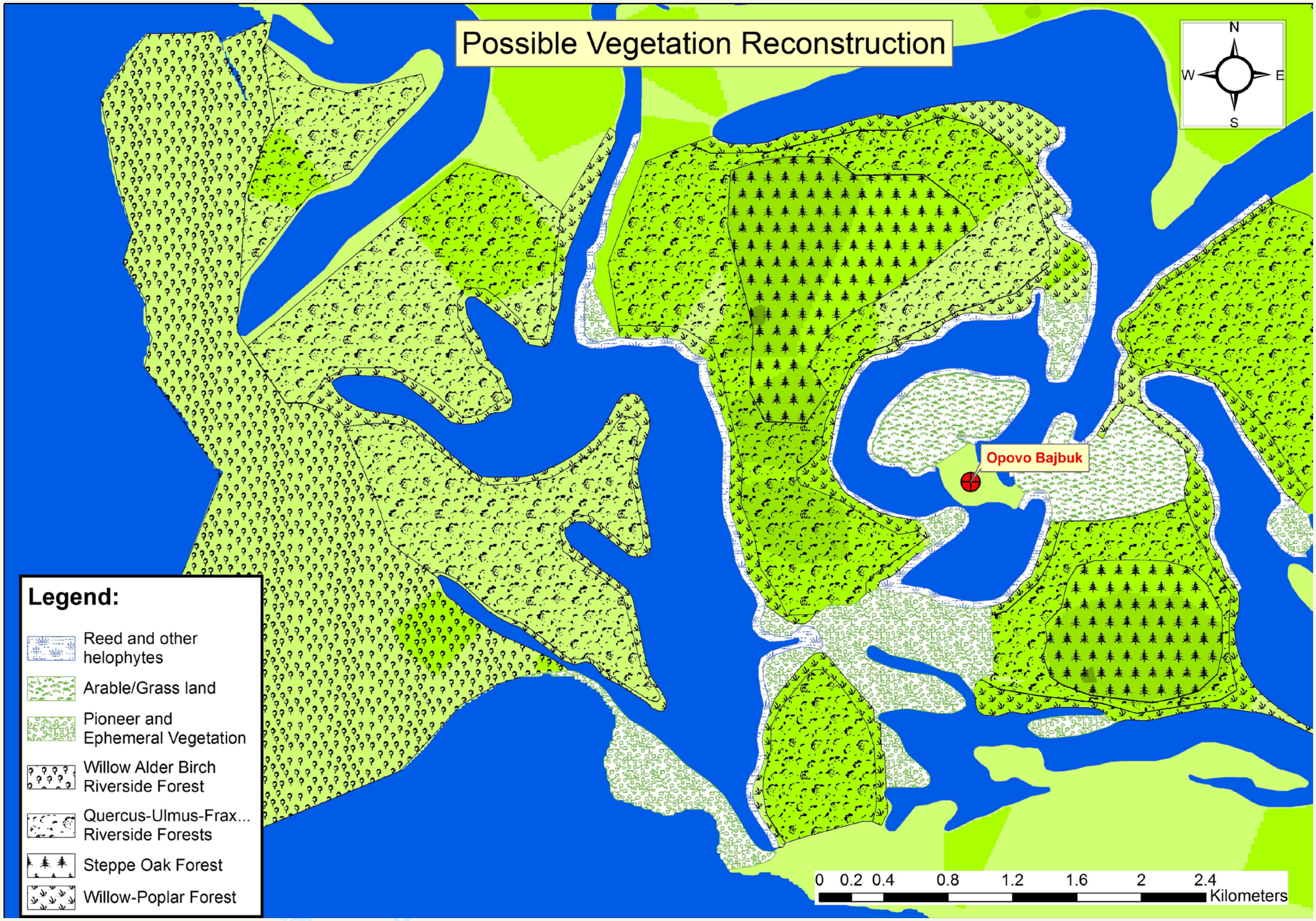
Fig. 9.


Possible Vegetation Reconstruction
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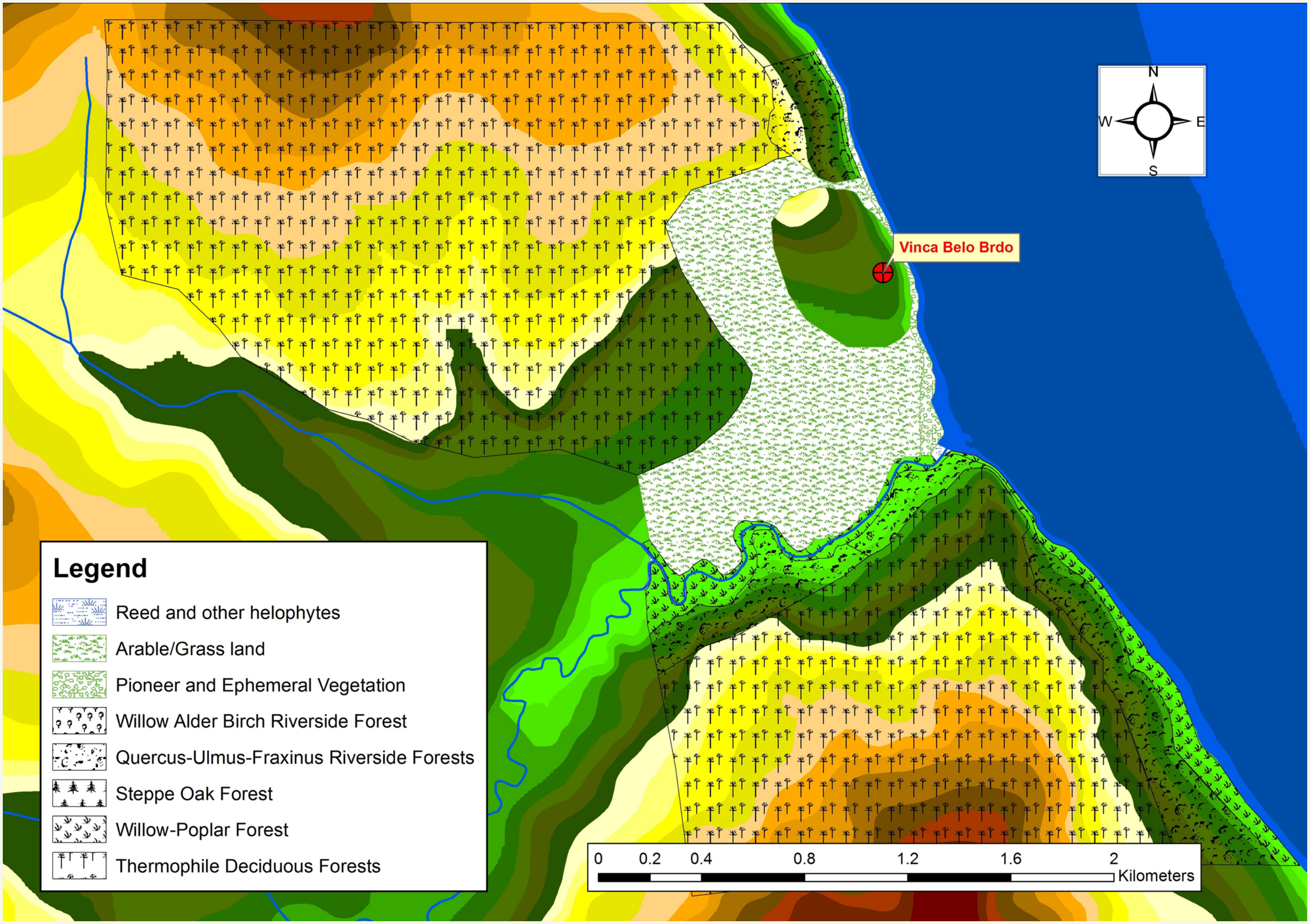
S
Opovo Bajbuk
Legend:
Reed and other helophytes
Arable/Grass land
Pioneer and Ephemeral Vegetation
Willow Alder Birch Riverside Forest
Quercus-Ulmus-Frax... Riverside Forests
Steppe Oak Forest
Willow-Poplar Forest
0 0.2 0.4 0.8 1.2 1.6 2 2.4
Kilometers

Fig. 10.


Vinca Belo Brdo
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Legend
Reed and other helophytes
Arable/Grass land
Pioneer and Ephemeral Vegetation
Willow Alder Birch Riverside Forest
Quercus-Ulmus-Fraxinus Riverside Forests
Steppe Oak Forest
Willow-Poplar Forest
Thermophile Deciduous Forests
0 0.2 0.4 0.8 1.2 1.6 2
Kilometers

Fig. 11.

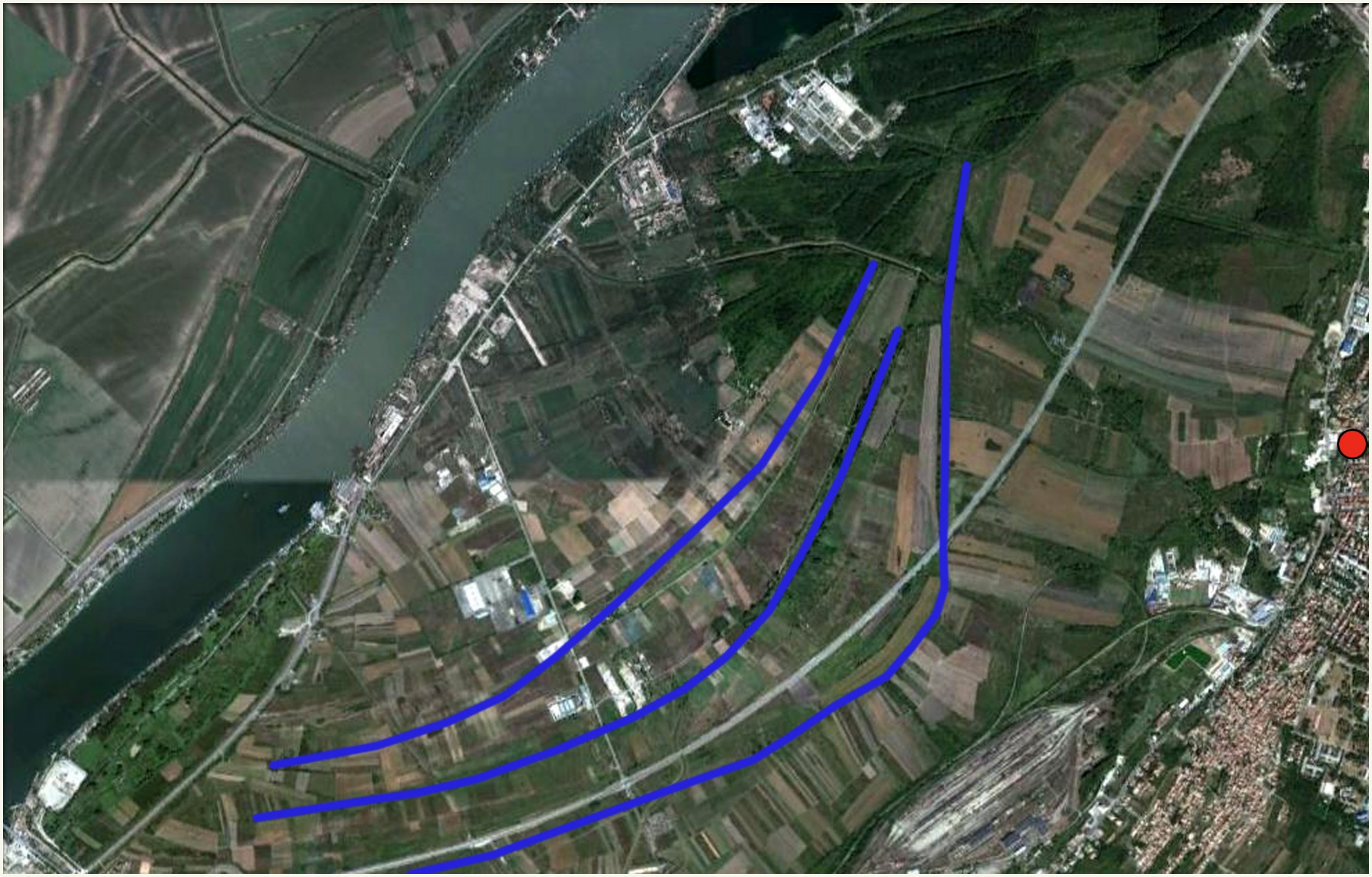
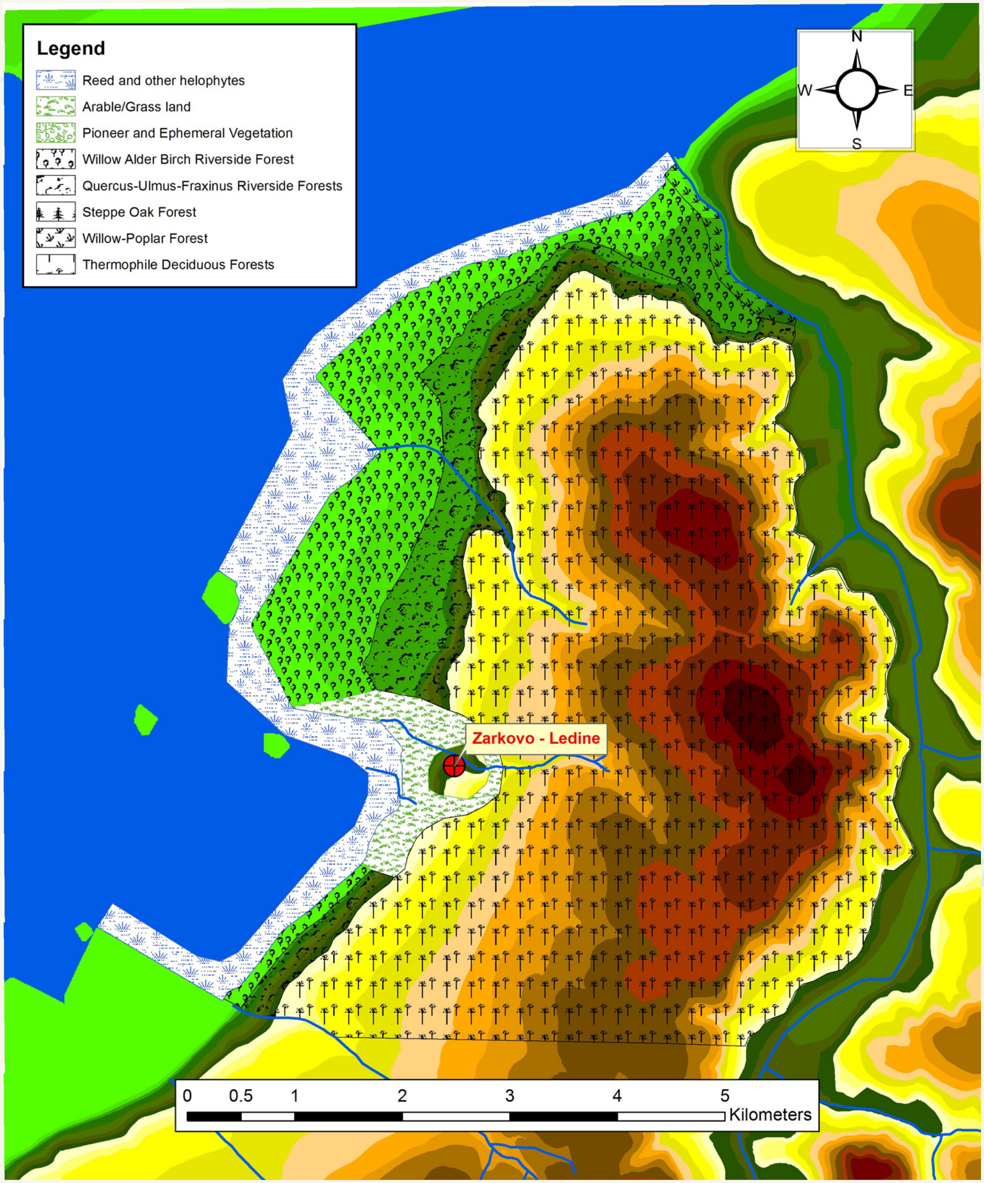


Fig. 12.


Legend
Reed and other helophytes
Arable/Grass land
Pioneer and Ephemeral Vegetation
Willow Alder Birch Riverside Forest
Quercus-Ulmus-Fraxinus Riverside Forests
Steppe Oak Forest
Willow-Poplar Forest
Thermophile Deciduous Forests
N
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Zarkovo - Ledine
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Kilometers

Fig. 13.

Table 1.

Species	Frequency
Red Deer *Cervus Elaphus L.*	75
Roe Deer *Capreolus Capreolus L.*	11
Auroch *Bos Primigenius Boj.*	1
Beaver *Castor Fiber L.*	2
Hare *Lepus Europeaus L.*	1

Table 2.

Species	Freq.	Species	Freq.	Species	Freq.	Species	Freq.
Auroch *Bos primigenius*	163	**European water vole** *Arvicola terrestris*	2	**European mole** *Talpa Europaea*	1	**Amphibian**	1
Roe Deer *Capreolus Capreolus L.*	1335	**Beaver** *Castor Fiber L.*	11	**European hamster** *Cricetus cricetus*	69	**Frog**	1
Red Deer *Cervus Elaphus L.*	4625	**Otter** *Lutra Lutra*	25	**European groundsquirrel** *Spermophilus citellus*	8		
Fallow Deer *Dama Dama*	4	**Hare** *Lepus Capensis L.*	73	**Marten** *Martes martes/foina*	7	**Carp** *Cyprinidae (carpio)*	38
Wild Pig *Sus Scrofa L.*	2249	**Hedgehog** *Erinaceus europaeus*	1(?)	**European Polecat** *Mustela putorius*	2	**Northern pike** *Esox lucius*	7
Canids *Medium Canid*	12	**Lesser mole rat** *Spalax leucodon*	5	**Brown Bear** *Ursus Arctos L.*	6	**Mussel shells**	2762
Grey Wolf *Canis Lupus*	12	**Birds** *Avis sp.*	101	**Rodents** *Rodentia*	35	**Snails**	446
Fox *Vulpes Vulpes L.*	17	**Pond Turtle** Emys orbicularis L.	123	**Wild Cat** *Felis Silvestris*	9	**Fish** Pisces sp.	1501

Table 3.

Species	**Frequency**	**Species**	**Frequency**
Beaver *Castor Fiber*	6	**Wild Pig** *Sus Scrofa*	140
Hare *Lepus Europaeus*	47	**Red Deer** *Cervus Elaphus*	564
European polecat *Mustela Putorius*	3	**Roe Deer** Capreolus Capreolus	155
European badger *Meles Meles*	2	**Fallow Deer** *Dama Dama*	5
Otter *Lutra Lutra*	3	**Auroch** *Bos Primigenius*	8
Fox *Vulpes Vulpes*	22	**Brown Bear** *Ursus Arctos*	2
Wolf *Canis Lupus*	1		

Table 4.

TAXA			
Grasses *Poaceae*	**Vetch** *Vicia L.*	**Cornelian Cherry** *Cornus Mas L.*	**Bedstraw** *Galium aparine L.*
Elder *Sambucus Nigra L.*	**Danesblood** *Sambucus ebulus L.*	**Wild Grape** *Vitis vinifera L. ssp. sylvestris*	
Wild Strawberry *Fragaria vesca L.*	**Water Chestnut** *Trapa Natans L.*	**White Gromwell** *Lithospermum officinale L.*	
Rye Grass *Lolium L.*	**Nightshade fam.** *Solanaceae*	**Knotweed** *Polygonum L.*	
Goosefoot *Chenopodium L.*	**Blackberry** *Rubus L.*	**Brome Grass** *Bromus L.*	

TAXA					
Apple/Pear *Pyrus sp.*	**Bedstraw** *Galium aparine*	**Nightshades** *Solanaceae*	**Berries** *Rubus sp.*	**Wild buckwheat** *Polygonum convolvulus*	**Germanders** *Teucrium* sp.
Cornelian Cherry *Cornus mas L.*	**Hedge Bedstraw** *Galium* cf. *mollugo*	**Vetch** *Vicia* sp.	**Danesblood** *Sambucus ebulus*	**The Redshank** *Polygonum* cf. *persicaria*	**Spurge Flax** *Thymelaea passerina*
Oak *Quercus sp.*	**Cleavers** *Galium* sp.	**Carrot/Parsley sp.** *Apiaceae*	**Elder** *Sambucus nigra*	**Pale Persicaria** *Polygonum lapathifolium*	**Figleaf Goosefoot (C3.5)** *Chenopodium ficifolium*
Blackthorn *Prunus cf. spinosa*	**Common Gromwell** *Lithospermum officinale*	**Crucifers** *Cruciferae*	**Wild Grape** *Vitis vinifera L. ssp. sylvestris*	**Knotweed** *Polygonum* sp.	**Bindweed** *Convolvulus sp.*
Water chestnut *Trapa natans L.*	**Medick** *Medicago* sp.	**True Grass** *Graminae*	**Common reed** *Phragmites communis*	**Buckthorns** *Rhamnus* sp.	**Cockspur** *Echinochloa crus-galli*
Bladder cherry *Physalis alkekengi*	**Grass** *Phalaris* sp.	**Mallows** *Malvaceae*	**Oat** *Avena sp.*	**Fiddle dock** *Rumex* cf. *pulcher*	**Campion** *Silene* sp.
Blackberry *Rubus fruticosus*	**Common Knotgrass** *Polygonum aviculare*	**Clover** *Trifolium* sp.	**Rye brome** *Bromus secalinus*	**Green foxtail** *Setaria viridis*	**Field Gromwell** *Buglossoides arvensis*

Table 5.