Ulmus L. – Elm

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Present distribution in the Western Carpathians

At present, within the Polish part of the Carpathians, as well as in the entire country, three elm species are found: *Ulmus laevis*, *U. glabra* and *U. minor*. The most widespread taxon is *U. glabra*, observed across nearly the entire Polish Carpathians. *U. laevis* is recorded at numerous sites along the Dunajec and San rivers valleys and, like *U. minor*, growing additionally in the Wisłoka river valley (Zając & Zając 2001). This description shows that at present in the part of the Carpathians considered here the two last-mentioned species are associated mainly with valleys of large rivers, while *U. glabra* does not display such habitat selectivity. *Ulmus minor* and *U. laevis* may be components of riparian forests classified within the *Ficario-Ulmetum minoris* Knapp 1942 em J. Mat. 1976 association, flooded only episodically and characterized by moderately low groundwater levels, or of riparian poplar forests, *Populetum albae* Br.-Bl. 1931, located more to the north in the Carpathians. *Ulmus glabra* may be found within lime-sycamore forests, *Tilio platyphyllis-Acerion pseudoplatani* Klika 1955, overgrowing slopes (Matuszkiewicz W. 2005).

Ecology

The genus is known to prefer fertile and humid soils and is not found on those that are shallow or dry up rapidly, as well as avoiding permanently flooded, or very acidic or alkaline soils (Zachowicz et al. 2004).

Pollen values exceeding 2% suggest the local occurrence of elm in communities (Huntley & Birks 1983), while amounts exceeding 1% are likely to indicate dispersed trees (Zachowicz et al. 2004). Frequency exceeding 10% confirm the important role of the taxon in forest communities (Huntley & Birks 1983).

Expansion in Europe during the Late Glacial

The present day distribution ranges of the three European species of *Ulmus* found in the Polish part of the Western Carpathians, when considered together with data from European isopollen maps suggest that *Ulmus minor* migrated into the Carpathians from Southern Europe, *U. laevis* may have survived the Last Glaciation in Russia (possibly in the southern Ural Mountains; Tolonen 1980), while refugia of *U. glabra* were located in southern and south-western Europe, with a strong expansion in the British Isles in the early Holocene (Huntley & Birks 1983). The potential *Ulmus* refugium closest to the Western Carpathians was situated in the Gutaiului Mountains (Eastern Carpathians) where the sites of Steregoiu (Björkman et al. 2002, 2003) and Preluca Tiganului (Feurdean et al. 2007), have pollen records with high elm percentages dating to the Alleröd Interstadial and of a rapid expansion of the taxon in the Early Preboreal. However, *Ulmus* pollen grains were not observed in those parts of profiles correlated with the Younger Dryas. These facts suggest that in the Younger Dryas elm had retreated to lower montane locations, and its pollen dispersal was strongly restricted during this adverse period. A rapid improvement in climatic conditions at the beginning of the Holocene encouraged a rapid expansion of *Ulmus* and an increase in its pollen production. Thus at ca 9700 ^{14}C BP the taxon attained its maximum Holocene values exceeding 40% (Feurdean et al. 2007). The relatively early appearance of *U. glabra* in the Scandes Mountains in Sweden, dated to 8500 ^{14}C BP (Kullman 1998), suggests the occurrence of refugia of this species located further to the north. However, pollen of *U. glabra* is virtually indistinguishable (or very difficult to differentiate) from that of other elm species. However, much of the evidence used in attempting to locate Pleniglacial refugia is based on directions of migration during the early Holocene, with only sparse data from the Late Glacial.

History of expansion in the Western Carpathians during the Holocene (Fig. 24)

10 000–9500 BP

Pollen percentages recorded for this taxon at ca 10 000 BP, in the Tatra Mountains and the Orawa-Nowy Targ Basin, are already likely to indicate the occurrence of elm in the forests, together with other trees. However, in the Tatra Mountains values are highly variable, from 0.2% to over 5%, and this suggests that particular Tatra

valleys, located at lower altitudes, with their surroundings were the areas of the earliest occurrence of elm in the Holocene. Perhaps the taxon inhabited these regions also during the Late Glacial.

9500–9000 BP

Elm rapidly increased its area and attained values exceeding 10% in the western part of the Western Carpathians, particularly in the Beskid Makowski range, which indicates the abundant occurrence of *Ulmus* in that region. This observation was affected mainly by results from the site of Bogdanówka-Beło (site no. 277; Margielewski 2006). The pattern was also confirmed at sites in the Tatra Mountains, however likely to bear a record of pollen originating from long-distance transport. The Bieszczady Mountains included a centre of occurrence of the taxon located relatively close to the Polish part of the Western Carpathians.

9000–8500 BP

About 9000 BP, the genus was a very important component of the foothill zone and forests occupying stream valleys across the entire area of the Polish part of the Carpathians. The Beskid Makowski range and the Bieszczady Mountains (located beyond the Western Carpathians) were the regions characterized by the highest values of *Ulmus*.

8500–8000 BP

About 8500 BP, *Ulmus* expanded to the north from its centre, located in the Bieszczady Mountains, as well as spread within the Jasło-Sanok Depression. During this period over nearly the entire area of Polish Western Carpathians *Ulmus* was recorded in amounts exceeding 5%. The eastern part of the Beskid Niski range, where migration of elm appeared to be less intensive from the beginning of the Holocene, was as exception.

8000–7500 BP

Ulmus retreated from its centre of occurrence in the Jasło-Sanok Depression. Higher values observed for 8500 BP, as recorded in the diagram from Roztoki (121, 122; Harmata 1987), may have been influenced by local conditions (e.g. occurrence of elm trees close to the site). Elm also spread within the western part of the Beskid Niski range, as recorded at the site of Szymbark (126; Gil et al. 1974). From the Beskid Makowski range, *Ulmus* migrated to the east, to the Beskid Wyspowy range.

7500–7000 BP

Occurrence of elm in the Beskid Makowski range was limited. The only important centre of *Ulmus* occurrence, from which the taxon proceeded to expand, was the western part of the Beskid Niski range. However, the eastern part of this geographical unit was marked by regression of elm.

7000–6000 BP

Elm attained values of 5–10% across nearly the entire area of the Polish Carpathians. In the eastern part of the Beskid Niski range the taxon became more frequent, while in the western part of the mountains the centre of *Ulmus* occurrence gradually decreased its area in the south.

5500–5000 BP

At about 5500 BP, the centre of *Ulmus* occurrence, located in the western part of the Beskid Niski range, decreased its area in the south, and Regetovká (61) remained the only site with elm values exceeding 10% (Wacnik 1995). Populations in the Beskid Żywiecki range and in the western areas of the Beskid Wyspowy range were reduced as well.

5000–4000 BP

The beginning of the Subboreal period was marked by the retreat of *Ulmus* from most Polish and European areas. This event has been explained by the cooling of climate and by the spread of Dutch elm disease, facilitated by human pollarding practices (Moe & Rackham 1992). Regression of the taxon was also observed in the Polish part of the Carpathians, from the west and south-west directions and in the Jasło-Sanok Depression. In other areas of the Western Carpathians elm populations appeared to be stable, with frequencies oscillating between 5 and 10%.

4000–3000 BP

At ca 4000 BP, the decrease in *Ulmus* amounts below 5% was observed across nearly the entire area of the Polish Western Carpathians. Larger elm populations may have survived in valleys of the Eastern Tatras, the eastern part of the Beskid Sądecki range and in the Beskid Niski range.

3000–2000 BP

Proportions of elm continued to decrease in forest communities of the Beskid Żywiecki, Beskid Makowski and Beskid Wyspowy ranges. In these areas amounts of *Ulmus* fell below 2% already by ca 3500 BP, which indicates a scattered occurrence of the taxon. What is interesting is that the greatest development of elm population at this time was located in the Beskid Niski range (values of 5–10%), where the youngest occurrences of larger Holocene assemblages of *Ulmus* were found.

This period was marked by a continued regression of the genus towards the east. For the Beskid Żywiecki range, pollen frequency is too low to confirm whether or not elm was to be found *in situ*. At ca 2500 BP, the most important areas of *Ulmus* occurrence (amounts of 2–5%) included the eastern part of the Beskid Niski range, the western Beskid Niski range-southern Pogórze Ciężkowickie Foothills, the Eastern Tatras (where elm was present at lower altitudes or its pollen originated from long-distance transport), the eastern part of the Orawa-Nowy Targ Basin and the Bieszczady Mountains (beyond the Western Carpathians).

2000–1000 BP

At ca 2000 BP, areas of most abundant *Ulmus* occurrence were restricted to the Eastern Tatras (where long-distance transport of pollen was possible), the Orawa-Nowy Targ Basin, the Western Bieszczady Mountains and the eastern part of the Beskid Niski range. About 1500 BP a regression of elm took place in the Beskid Żywiecki range in a northerly direction. At certain sites in the western part of the Beskid Niski range and in the northern areas of the Jasło-Sanok Depression values for this taxon decreased below 1%, therefore its occurrence *in situ* cannot be confirmed.

1000–500 BP

Disappearance of elm from forest communities proceeded from both west and south, i.e. from the Beskid Niski range and the Jasło-Sanok Depression. The central part of the Polish Carpathians and the eastern part of the Beskid Niski range are the only areas in which pollen values indicate a scattered occurrence of *Ulmus*.

500–0 BP

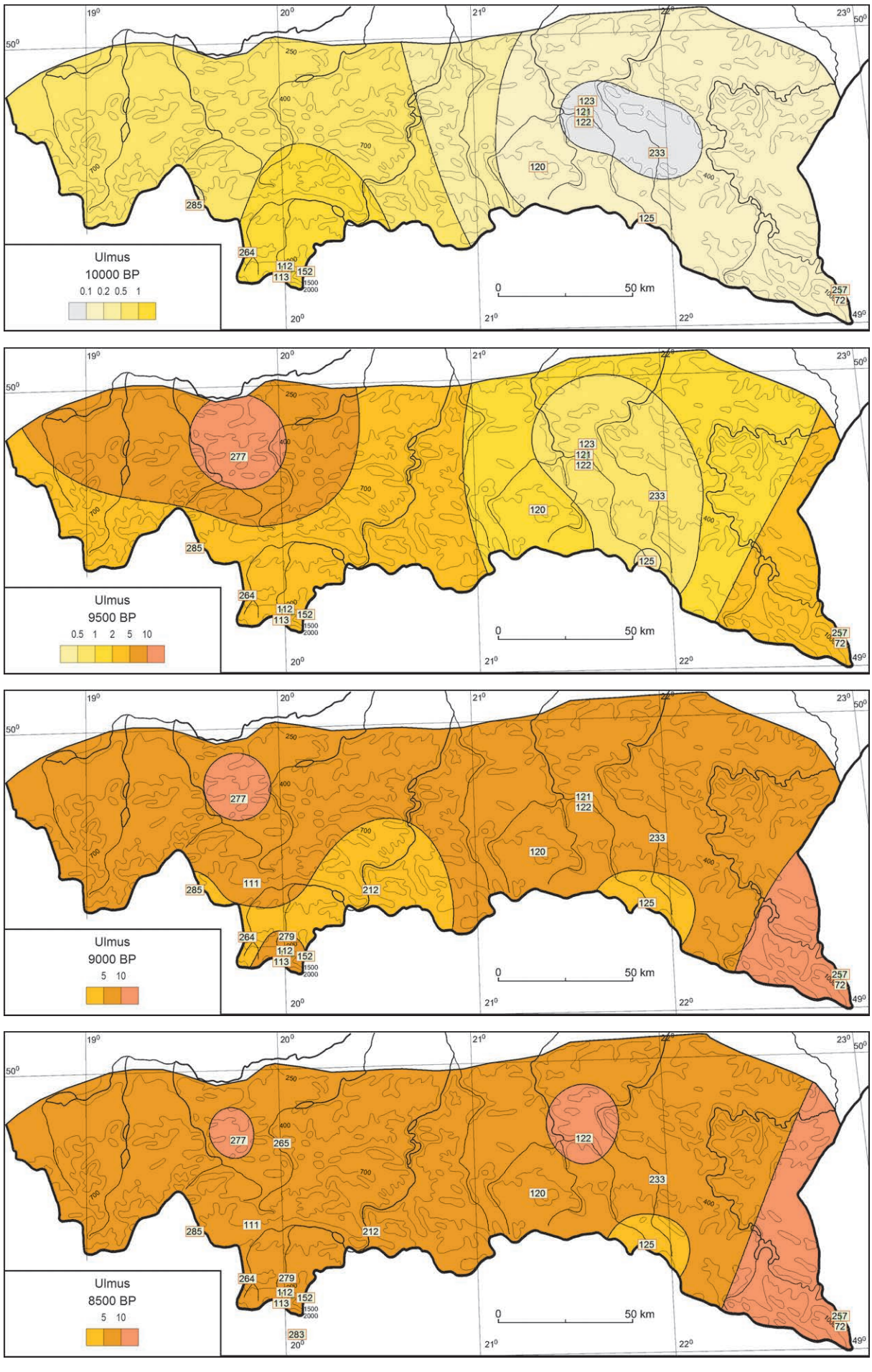
This period was marked by a clear trend towards disappearance of *Ulmus* from the Beskid Niski range and from farther north, which may have resulted from the expansion of the Vlach people, who migrated from the Balkans and cut down forests to obtain areas for pastures. In the western part of the Polish Carpathians, values for elm were unaffected by changes during the 500 and 0 BP time intervals. This fact may be explained by a lower intensity of settlement activity in this area.

Conclusions

Considering the rapid appearance of elm in the Beskid Makowski range, at the site of Bogdanówka-Beło (277; Margielewski 2006), it cannot be excluded that the taxon may have survived the latest Pleistocene cooling, i.e. the Younger Dryas, in this part of the Carpathians. Although low frequencies of *Ulmus*, recorded in the area for this period, may be explained by long-distance transport, it seems more likely that the trees actually decreased their pollen production under conditions of very low temperatures. This hypothesis is supported by the fact that in the Gutaiului Mountains in Romania, where the potential Late Glacial refugia of the taxon were documented (Feurdean et al. 2007), *Ulmus* values recorded for the Younger Dryas were not higher than ones observed in the Beskid Makowski range (Margielewski 2006). In the Holocene, forests containing this taxon developed simultaneously in both areas (Early Preboreal). Isopollen maps plotted for this period show the Beskid Makowski range as an enclave of elm in the Western Carpathians. According to these results, the Preboreal populations of *Ulmus* in the Bieszczady Mountains are likely to originate from the refugium of the Gutaiului Mountains, however it cannot be excluded that the Bieszczady populations survived the Late Glacial *in situ*. An important methodical issue in interpretations of the potential occurrence of North Carpathian *Ulmus* refugia is the lack of geological deposits containing a record of Vistulian interstadials, which might have provided an unequivocal answer to the question whether elm survived in this area.

The first noticeable decrease in the proportion of elm in the Holocene occurred ca 8500 BP in the Bieszczady Mountains, while the next one was at ca 7500 BP in the Beskid Makowski range. However, these were only local events within the Polish Carpathians. Disappearance of elm from the entire area of the Polish Western Carpathians began between 6000 and 5500 BP, which is consistent with conclusions based on isopollen maps plotted for the area of Poland (Zachowicz et al. 2004). The process, initially recorded in the western part of the Polish Western Carpathians and gradually proceeding to the east, probably reflects the direction of spread of Dutch elm disease. At ca 4000 BP, the rate of decrease in elm frequency was intensified, possibly as a result of stronger human pressure. Another reason for the disappearance of the taxon from most habitats in the study region was the expansion of spruce, preventing the regeneration of elm stands at numerous sites.

Fig. 24. *Ulmus* L.: dot and isopollen maps for 10 000–0 BP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10000 BP
0.1 0.2 0.5 1
Ulmus
9500 BP
0.5 1 2 5 10
Ulmus
9000 BP
5 10
Ulmus
8500 BP
5 10
0
50 km
19°
20°
21°
22°
23°
50°
49°
250
400
700
1000
1500
2000
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121
122
233
120
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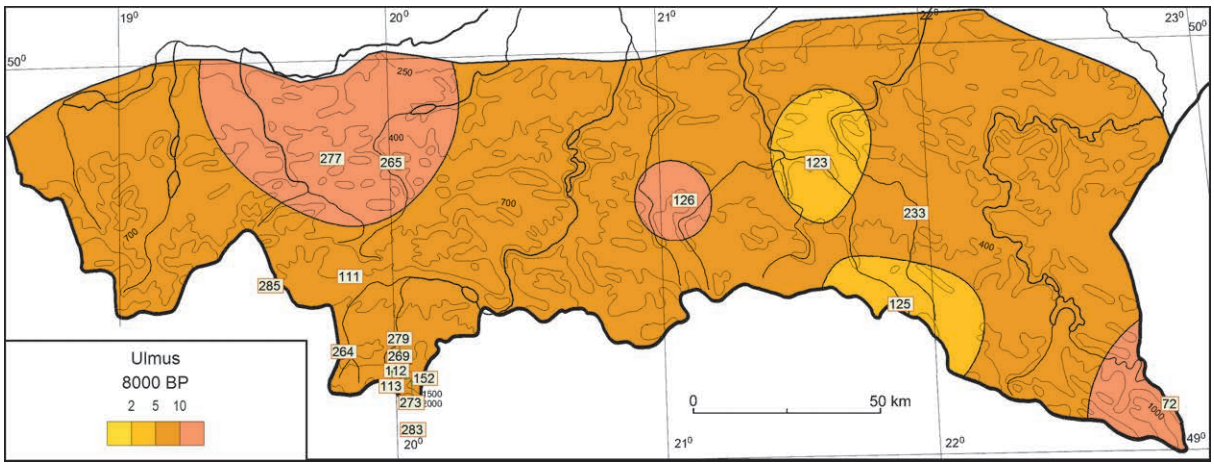
113
152
257
72
277
111
212
279
265
283


Ulmus
8000 BP
2 5 10
277
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123
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111
125
279
264
269
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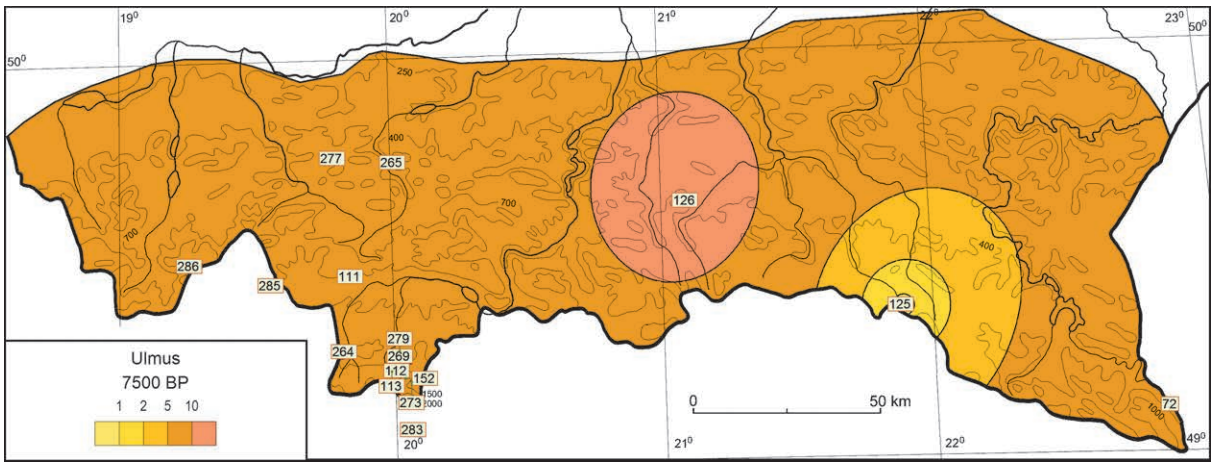
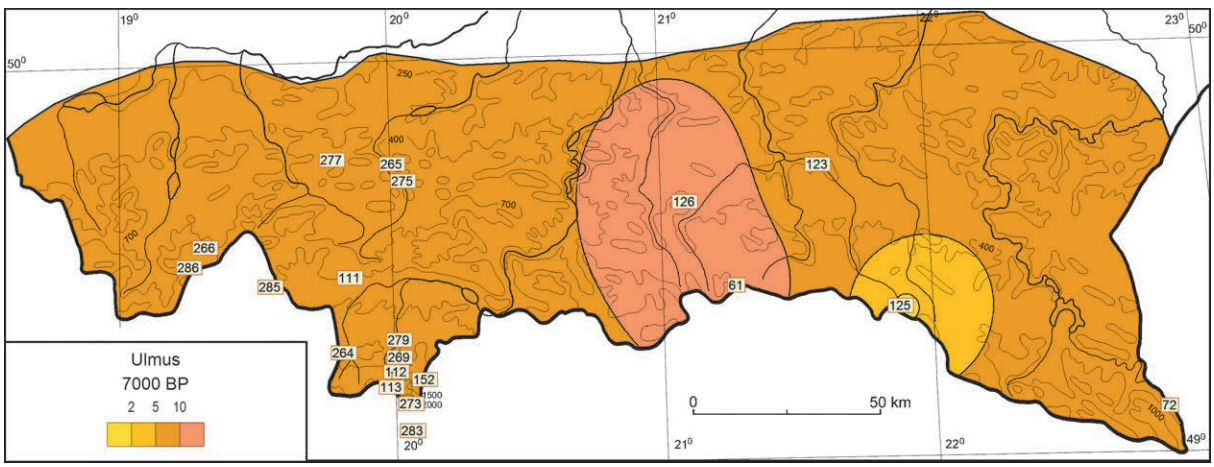
152
113
273
283
72
0
50 km


Ulmus
7500 BP
1 2 5 10
277
265
126
286
285
111
125
279
264
269
112
152
113
273
283
72
0
50 km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7000 BP
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277
265
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152
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273
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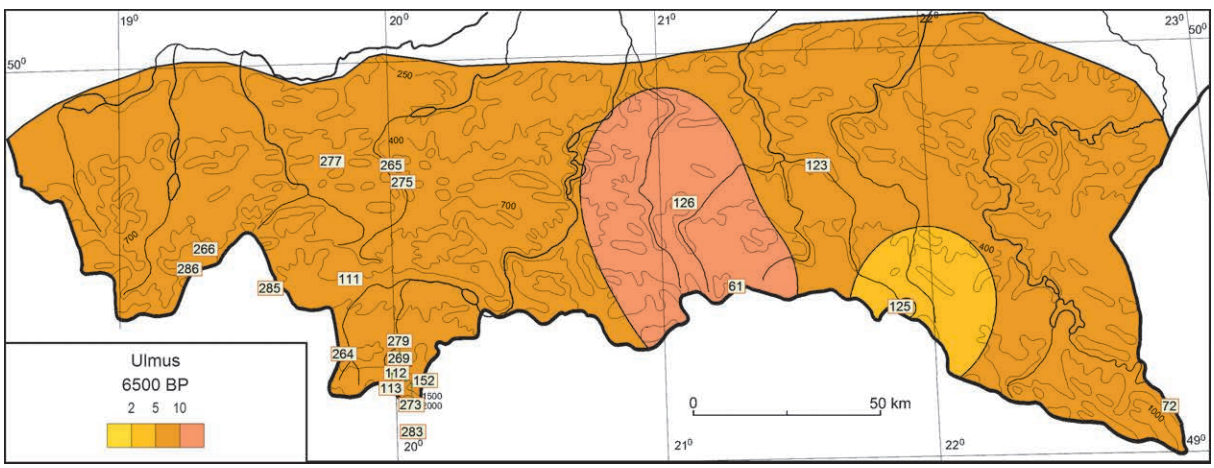
72
0
50 km


Ulmus
6500 BP
2 5 10
277
265
275
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286
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61
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264
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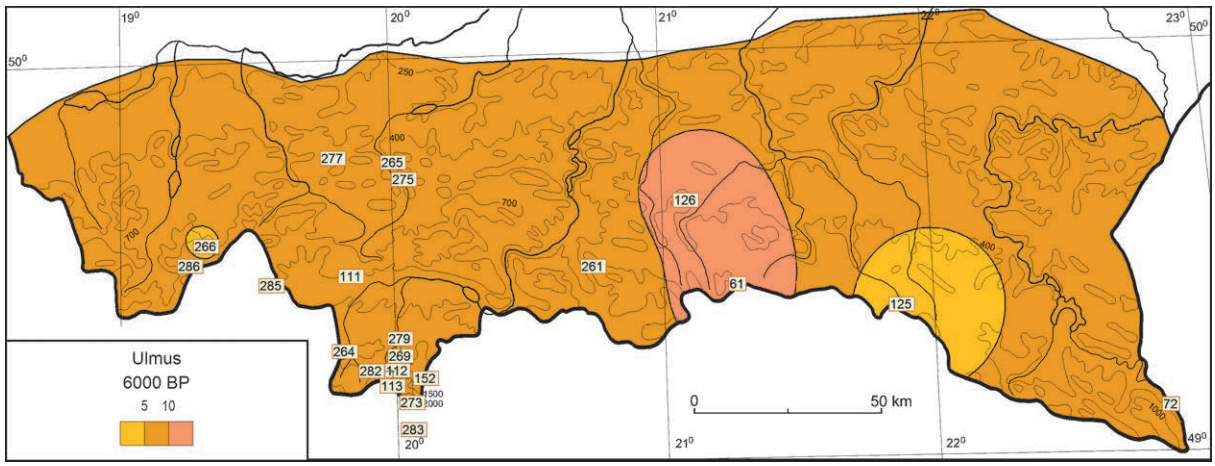
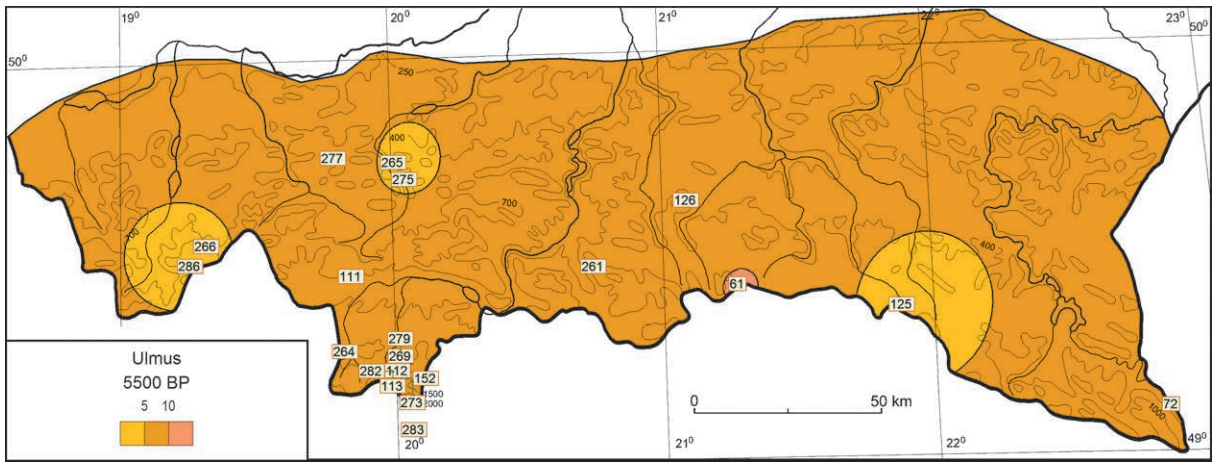
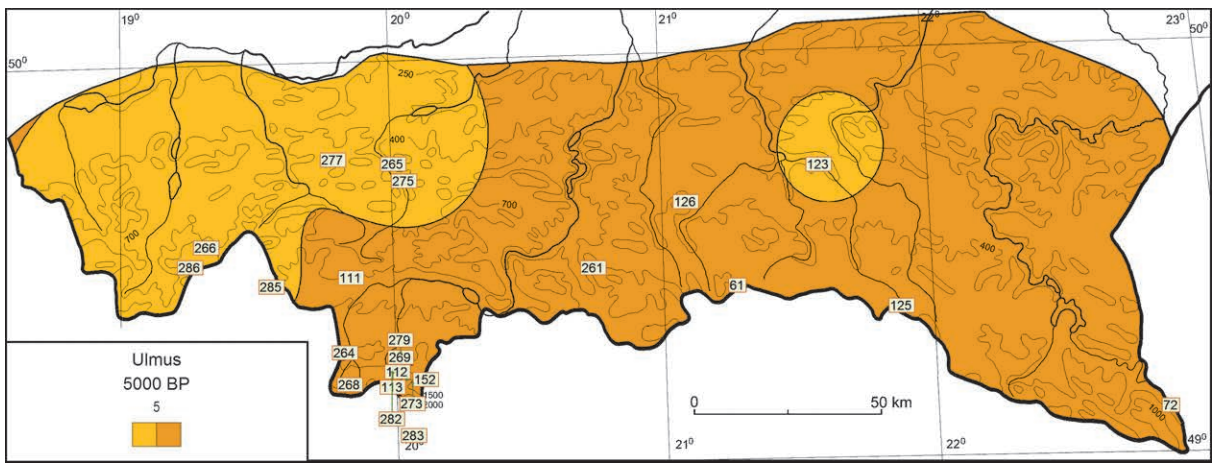
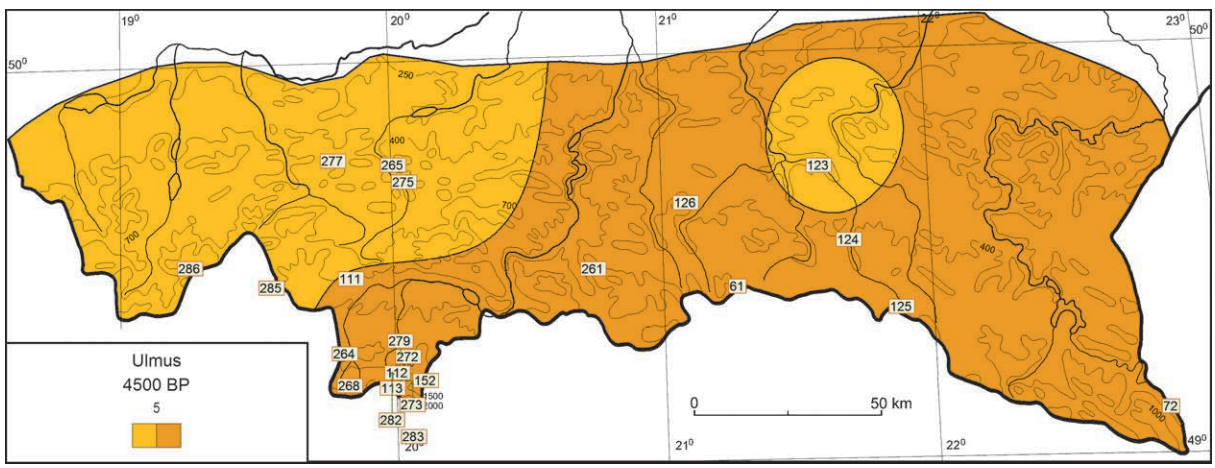
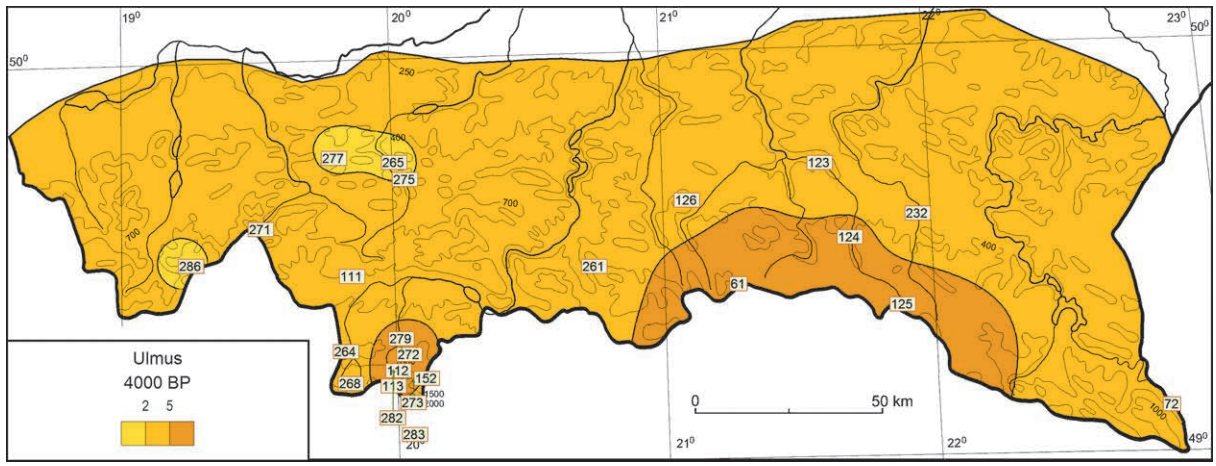
152
113
273
283
72
0
50 km

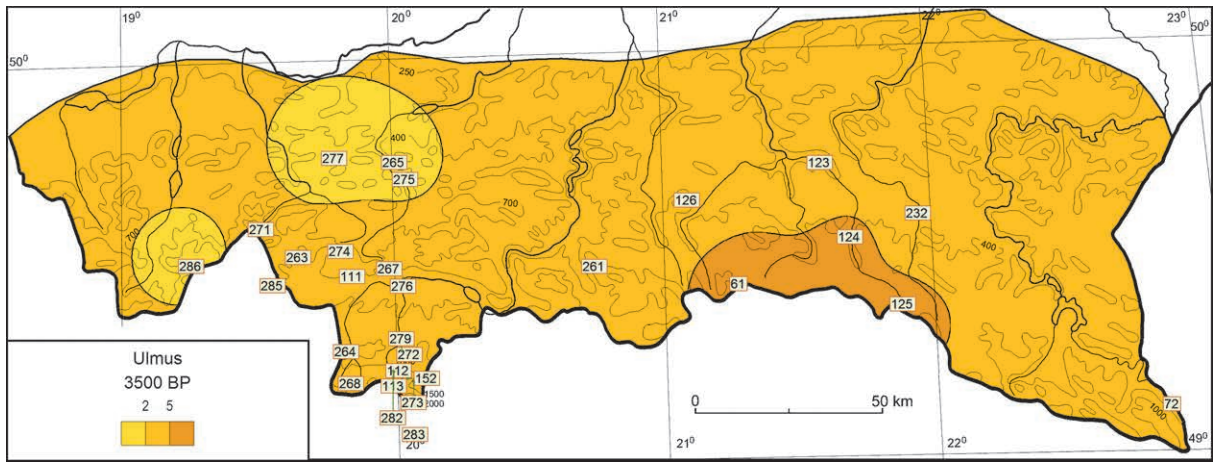

Ulmus
6000 BP
5 10
0 50 km

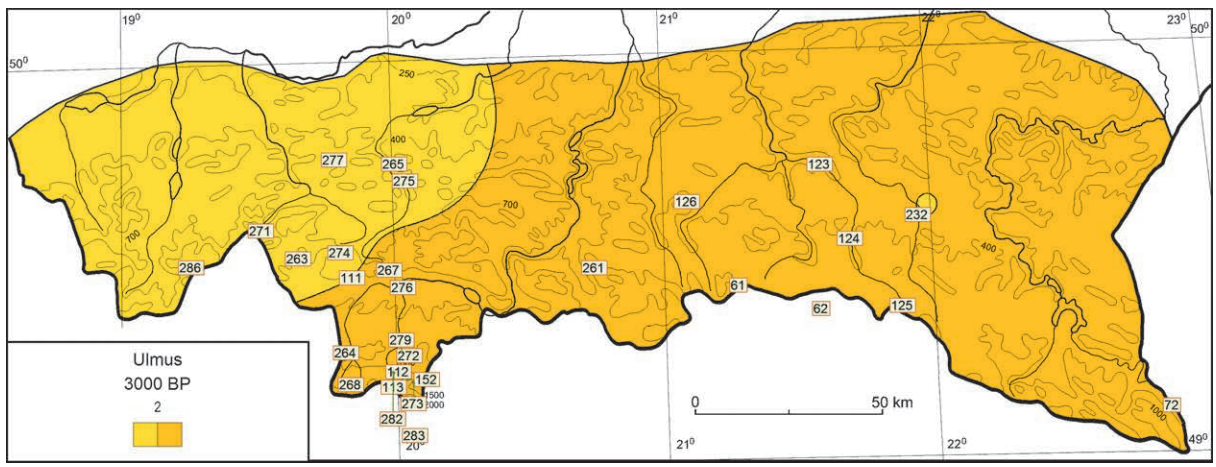

Ulmus
5500 BP
5 10
0 50 km

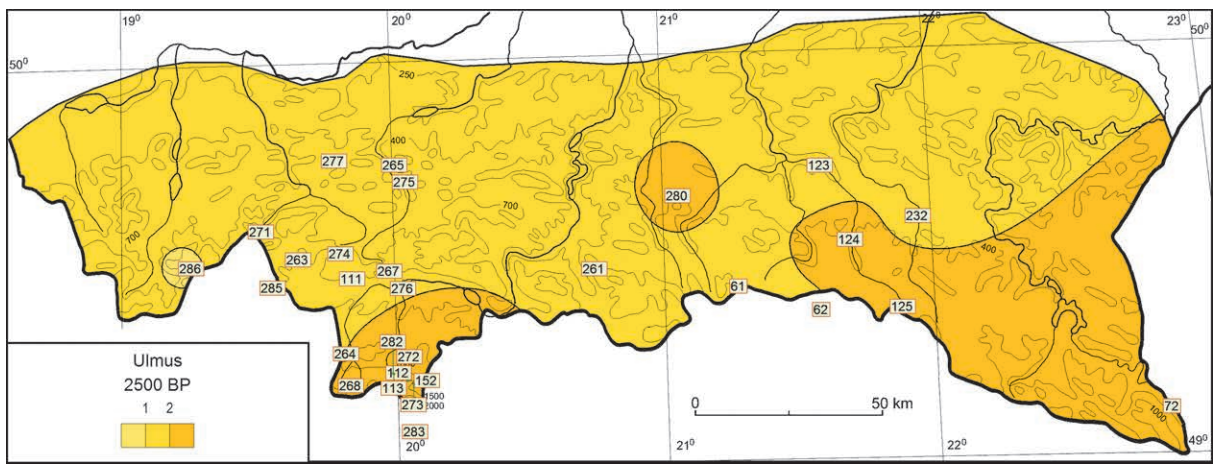

Ulmus
5000 BP
5
0 50 km

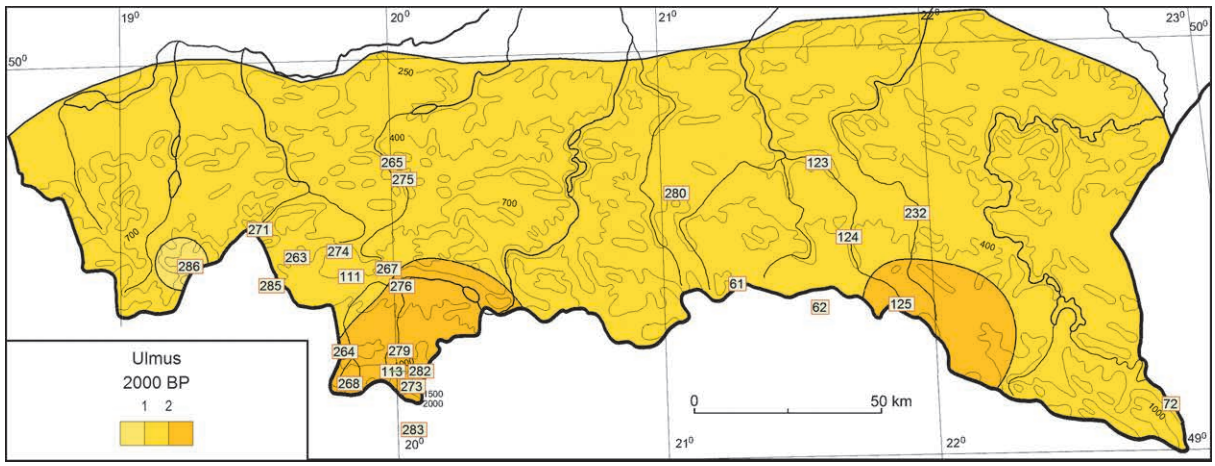

Ulmus
4500 BP
5
0 50 km

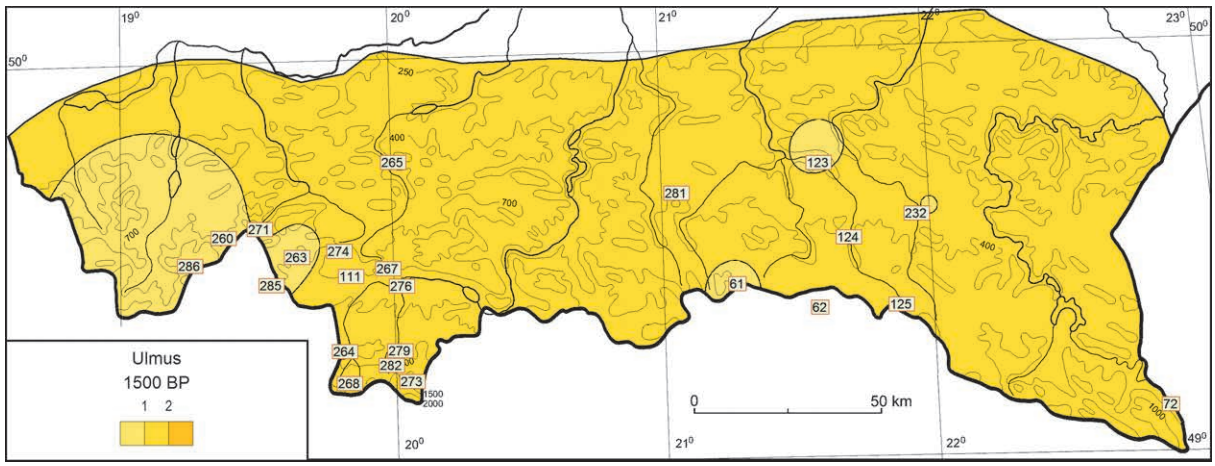

Ulmus
4000 BP
2 5
0
50 km

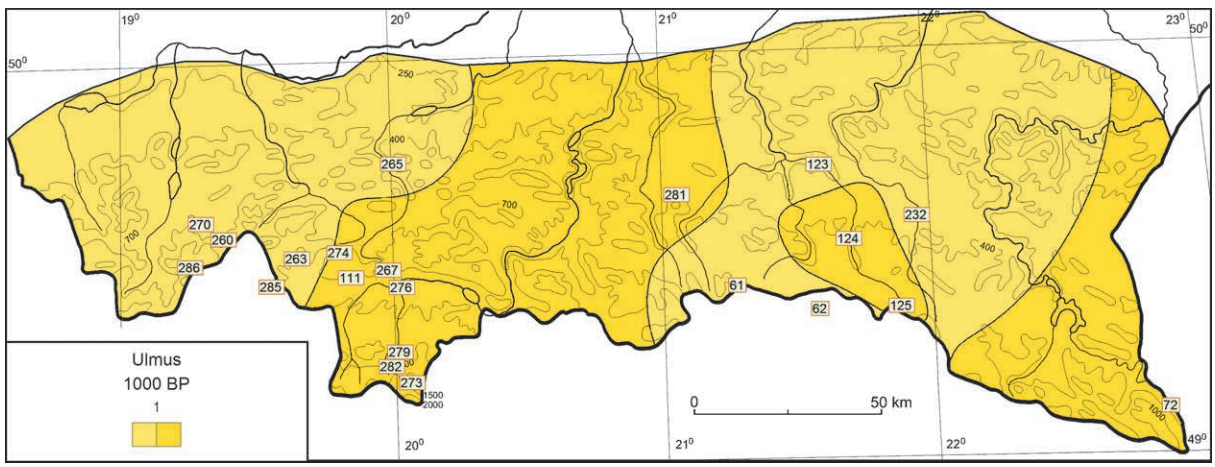

Ulmus
3500 BP
2 5
0
50 km

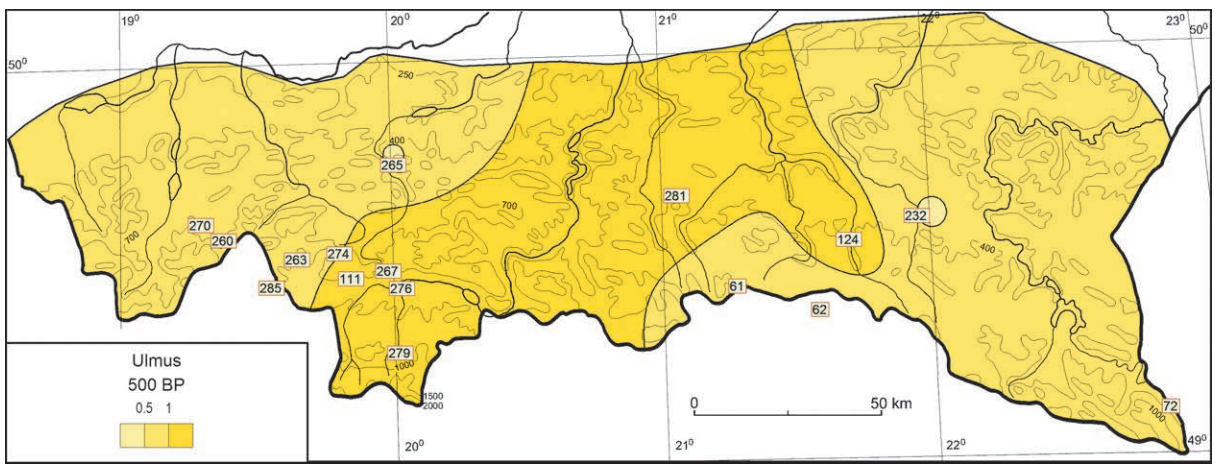

Ulmus
3000 BP
2
0
50 km

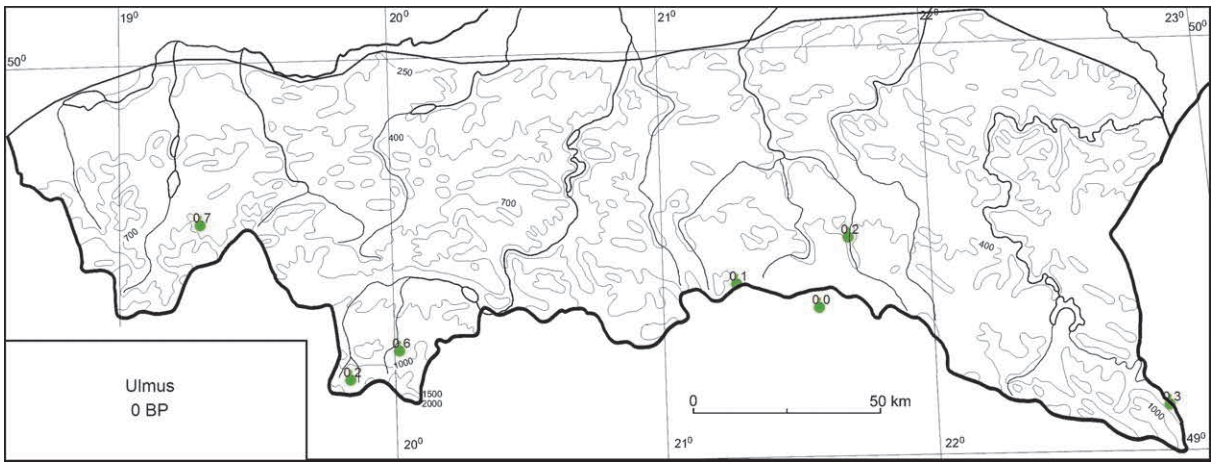

Ulmus
2500 BP
1 2
0
50 km


Ulmus
2000 BP
1 2
0 50 km


Ulmus
1500 BP
1 2
0 50 km


Ulmus
1000 BP
1
0 50 km


Ulmus
500 BP
0.5 1
0 50 km


19°
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0.6
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0.1
0.0
0.3
Ulmus
0 BP
0
50 km