Betula L. – Birch

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Present distributioh in the Western Carpathians

The Polish flora includes, depending on which taxonomy is accepted, either seven (Browicz 1979, Jentys-Szaferowa 1979) or six (Zając & Zając 2001) *Betula* species and subspecies. Among tree birches, *Betula pendula* Roth (= *B. verrucosa* Ehrh.) and *B. pubescens* Ehrh. subsp. *pubescens* are the most widespread taxa in Poland. The Carpathians and the Sudety Mountains are also inhabited by *Betula pubescens* Ehrh. subsp. *carpatica* (Waldst., Kit. ex Willd.). The highest altitude attained by this subspecies is 1740 m a.s.l in the High Tatras (Pawłowski 1956), while its lower limit of occurrence is at ca 1000 m a.s.l. on the Polish side and at ca 700 m a.s.l. on the Slovakian side (Browicz 1979).

The third tree species of birch, *Betula* × *oycoviensis* Besser is only found infrequently at sites on the Jura Krakowsko-Częstochowa Upland, the Sudety Mountains and the Świętokrzyskie Mountains.

In Poland, shrub birches are represented by two species: dwarf birch, *Betula nana* L., a glacial relict at present found at only three sites in Poland (in the Sudety Mountains and the lower Vistula river valley), and low birch, *B. humilis* Schrank, with its centre of distribution located in the Siberian Boreo-European Lowland and with its south-western limit of occurrence passing through Poland (Środoń 1979). The species grows mainly in communities of minerotrophic mires or carrs of the *Alnetea glutinosae* class.

Ecology

Betula pendula and *B. pubescens* subsp. *pubescens* are the species of widest distribution and greatest ecological importance over the territory of Poland. Both trees are widespread and show pioneer features due to their broad habitat tolerances. In natural vegetation, *Betula pendula* does not form monospecies stands or, in contrast to *B. pubescens*, its own plant communities. It is often found in forests, at initial stages of their development, in habitats of mixed coniferous forests and even of oak-hornbeam forests (Wojterski 1979). *Betula pendula* is known to prefer moderately humid mineral soils and is not found on lime rich rendzinas (it does not grow in the rocky Central Pieniny Mountains), while *B. pubescens* occupies mainly mesotrophic, humid organogenic soils and tolerates flooding relatively well (Zarzycki 1979). *Betula pubescens* subsp. *pubescens* occurs in communities of the *Alnetea glutinosa* class (*Betula pubescens-Thelypteris palustris* community). It forms the association of swamp birch-pine forest, *Vaccinio uliginosi-Betuletum pubescentis*, of the *Vaccinio-Piceetea* class, and occurs in acidophilous birch-oak forests of the *Quercetea robori-petraeae* class (Matuszkiewicz J.M. 2001). Tree birches are relatively frequent in the submontane belt, while at altitudes exceeding 500 m a.s.l. they do not play an important role in forests. However, *B. pubescens* subsp. *pubescens* is found in the lower montane belt of the Tatra Mountains, whilst sites with *B. pendula* are recorded not only in the lower, but even in the upper montane belt (Pawłowski 1956).

In pollen analysis, birch pollen is most useful in reconstructions of changes in vegetation, as its presence determines the stages of succession. However birch species also serve as climatic indicators. Pollen of *Betula nana*, occurrence of which enables the estimation of temperature of the coldest month as falling below 0°C, is particularly important (Kolstrup 1980, Tobolski 1991, Granoszewski 2003).

All birches are wind-pollinated and produce large amounts of light pollen that may be transported for great distances, even exceeding 120 km (Suszka 1993). The onset of the flowering period of birch depends strictly on air temperature within the preceding 40 days (Spieksma et al. 1995). Following Huntley and Birks, a value of 10% recorded for *Betula* in pollen spectra is the minimum amount indicating occurrence of birch in local communities, while frequency exceeding 25% suggest the local presence of forests with high proportions of birch (Huntley & Birks 1983). Amounts of *Betula* pollen exceeding 50% confirm the dominance of birch forests in the local landscape.

Expansion during the Late Glacial

Numerous macrofossil remains recorded for *Betula nana* indicate that the species has inhabited the

Carpathians and their environs at least since the pleniglacial of the last glaciation (Vistulian). The oldest site with *B. nana*, located in Dobra, close to Limanowa, is dated to ca 32 550±450 BP (Środoń 1968). Younger sites include Brzeźnica, dated to 27 805±330 BP (Mamakowa & Starkel 1974), and Nowa Huta, a district of Kraków, dated between 27 745±300 and 18 400±250 BP (Mamakowa & Środoń 1977). Remains of *Betula nana*, dated to 25 580±2420 BP, were also described from sediments at Łążek near Zaklików (Mamakowa 1968), while sediments of the Smerek peat bog, in the Bieszczady Mountains, bear a record of younger floras with macrofossil remains of both *Betula nana* and tree birch, *B. pubescens* subsp. *pubescens* (Ralska-Jasiewiczowa 1980), dated to 16 925±325 BP by the radiocarbon method. Macrofossils of *B. nana* dated to the Oldest Dryas were also identified by Koperowa (1962) in the Orawa-Nowy Targ Basin.

Following Ralska-Jasiewiczowa et al. (2004a), in the area of the Carpathians the Late Glacial pollen of *Betula* did not attain high values before ca 12 000 BP. In the Older Dryas the area of the Western Carpathians was covered by 5–15% isopolls. The lowest amounts were observed in the Beskid Niski range, the Pogórze Dynowskie Foothills and in the Western Beskidy Mountains. Expansion of birch in the Alleröd, indicated by isopolls of ca 25% in the western part of the Carpathians, was limited in the mountains due to spreading of *Pinus* and *Larix* and later by the cooling of the Younger Dryas (Ralska-Jasiewiczowa et al. 2004a).

History of expansion in the Western Carpathians during the Holocene (Fig. 14)

Isopolls were plotted using the total values of *Betula* pollen, including amounts for both tree birches (*Betula* sectio *Albae*) and shrub birches (*B.* sectio *Nanae*). The Holocene pollen of the last-mentioned group was not of great importance in the area of Poland.

10 000 BP

Due to an improvement in climatic conditions at the beginning of Holocene, expansion of birch in Poland was intensified and proceeded in a southerly direction (Ralska-Jasiewiczowa et al. 2004a). Most Carpathian areas are covered by 10–20% isopolls. In the northern part of the Bieszczady Mountains, lower amounts (up to 5%) are recorded. In the area of the Beskid Śląski and Beskid Żywiecki ranges, the western part of the Orawa-Nowy Targ Basin and in the southern part of the Bieszczady Mountains values of *Betula* pollen do not attain 5%.

Such an outline of isopolls is likely to indicate that birch migrated to the Carpathians from the north.

9500–9000 BP

Apart from the westernmost part of the Orawa-Nowy Targ Basin and the southern areas of the Bieszczady Mountains, where percentage values of *Betula* pollen do not exceed 10%, most Carpathian ranges and foothills are covered by isopolls of 10–20%. At ca 9000 BP, birch attains its highest Holocene values in the Carpathians. Maximum amounts, exceeding 20%, are recorded in the western part of the Orawa-Nowy Targ Basin and in the Jasło-Sanok Depression. Practically the entire Carpathians are covered by 10–20% isopolls. Small areas in the Beskid Sądecki range and the north-western part of the Bieszczady Mountains, marked by frequency between 5 and 10%, are an exception.

8500–6500 BP

Values for *Betula* decrease as a result of the spread in the Carpathians of other trees and shrubs, such as *Ulmus*, *Picea*, and *Corylus*. Amounts exceeding 10% are observed exclusively in the eastern part of the Orawa-Nowy Targ Basin and in the western areas of the Beskid Sądecki range. In the eastern Carpathian regions (the Pogórze Dynowskie Foothills, the Jasło-Sanok Depression and the Bieszczady Mountains) proportions of *Betula* pollen decrease to 5%, and for ca 8000 BP – locally to even 2%. The 7500 and 7000 BP maps show the progressive decrease in the frequency of birch in forest communities of the Western Carpathians. Amounts exceeding 5% are recorded only for the Orawa-Nowy Targ Basin and the southern part of the Beskid Niski range. At ca 6500 BP, due to development of climax forest communities comprising trees of higher climatic requirements, values of *Betula* pollen attained only 2–5% practically over the entire study area. Such low amounts of birch pollen are likely to suggest long-distance transport and infrequent occurrence of *Betula* in the Carpathian flora (Ralska-Jasiewiczowa et al. 2004a).

6000–5500 BP

Isopollen maps plotted for this time period indicate a local expansion of birch in the Beskid Niski range, initially up to 10% and finally exceeding this value. A slight, local increase in the proportion of *Betula*, represented by isopollen values exceeding 5%, is recorded in the Orawa-Nowy Targ Basin.

5000–3500 BP

Most areas of the Western Carpathians are covered by isopolls showing similar values, between 2 and 5%. Higher amounts, exceeding 5%, are recorded exclusively for the Orawa-Nowy Targ Basin (peat bogs), while lower ones, below 2% – for the Jasło-Sanok Depression.

3000–2000 BP

Changes observed in isopollen maps suggest that *Betula* became a slightly more important element in the landscape. In the western areas of the Carpathians: Beskid Śląski, Beskid Żywiecki and Beskid Niski ranges, the Gorce Mountains and the Orawa-Nowy Targ Basin values for birch exceed 5%. For ca 2500 BP, a similar increase is recorded in the Beskid Makowski range, while according

to the time-slot of 2000 BP isopolls exceeding 5% cross the line of the Dunajec river in the east. Amounts exceeding 5% are observed also in the Bieszczady Mountains. The increase in *Betula* frequency is likely to be associated with the secondary succession of forest communities, proceeding in areas affected by anthropogenic changes.

1500–1000 BP

For ca 1500 BP, most Carpathian ranges are covered by 2–5% isopolls. The northern part of the Orawa-Nowy Targ Basin, the Beskid Makowski and Beskid Wyspowy ranges, the Gorce Mountains and the southern areas of the Bieszczady Mountains, all with *Betula* values exceeding 5%, are an exception. On the 1000 BP map, the range of the 5–10% isopoll is shifted more to the east, beyond the Dunajec river. Amounts below 2% are recorded locally in the Jasło-Sanok Depression.

500–0 BP

The boundary of isopolls indicating 5% and higher values is shifted to the east while the western ranges of the Carpathians are marked by amounts not exceeding 5% – as already observed for the 1500 and 1000 BP time-slots.

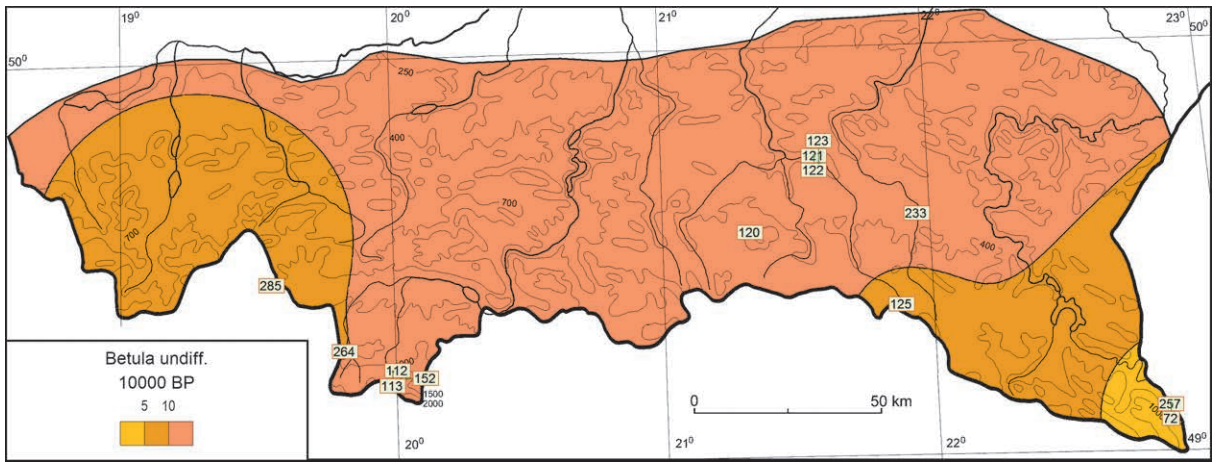
Presently, the western part of the Carpathians, including the Beskid Makowski range, is dominated by frequencies up to 5%, while the eastern areas, from the Beskid Wyspowy range, are typified by amounts exceeding 5%.

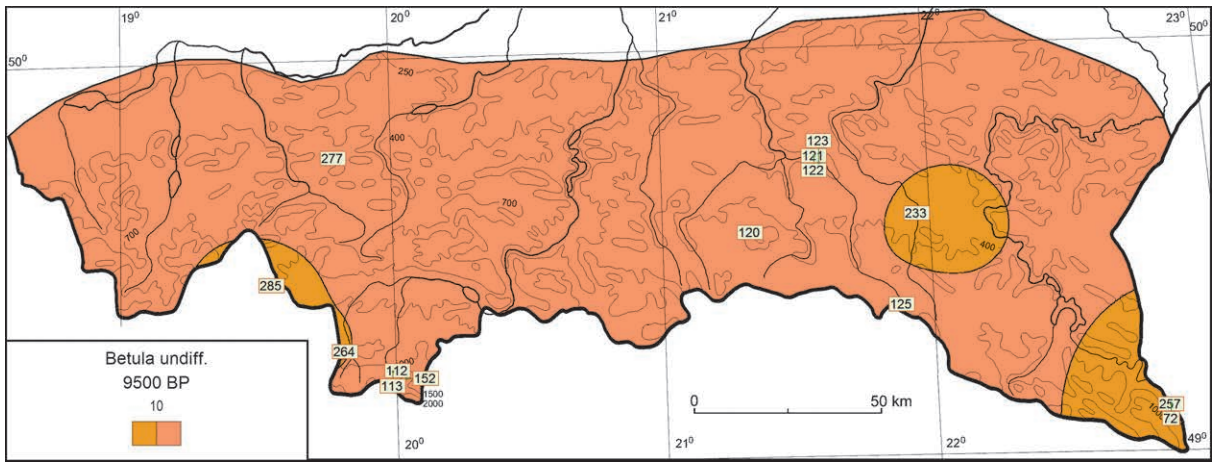
Conclusions

During the Last Glaciation, the Carpathians were inhabited by *Betula nana*, which is demonstrated by numerous macrofossil remains dated by the radiocarbon method. Most likely the Carpathians were also the Last Glacial refugium of tree birches.

At the beginning of the Holocene, expansion of tree birches into the areas of the Western Carpathians proceeded mainly from the north and they attained their maximum distribution ca 9000 BP. Between ca 5000 and 3500 BP, *Betula* pollen was recorded in its minimum values in the Carpathians and birch occurred infrequently in forest communities. The increase in amounts of *Betula*, initially only slight, however more intensive after 2500–2000 BP, is likely to indicate the importance of the taxon in secondary succession of forest communities in areas affected by human activity.

Fig. 14. *Betula*: dot and isopollen maps for 10 000–0 BP


Betula undiff.
10000 BP
5 10
0 50 km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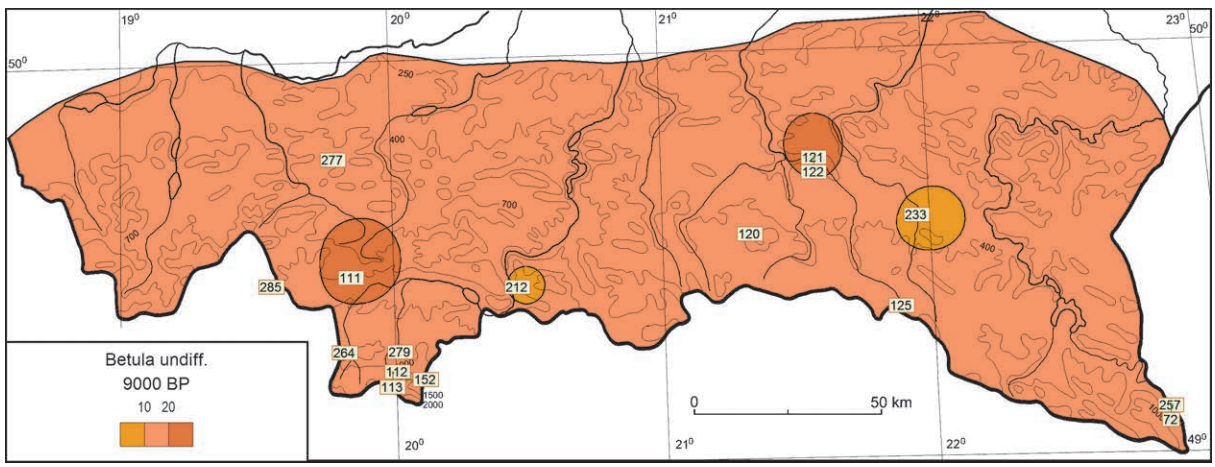
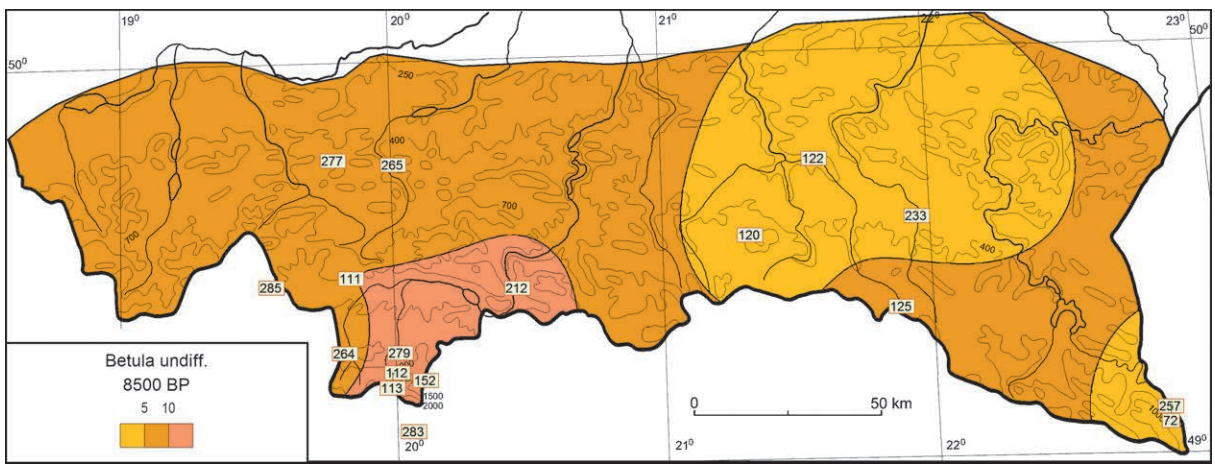
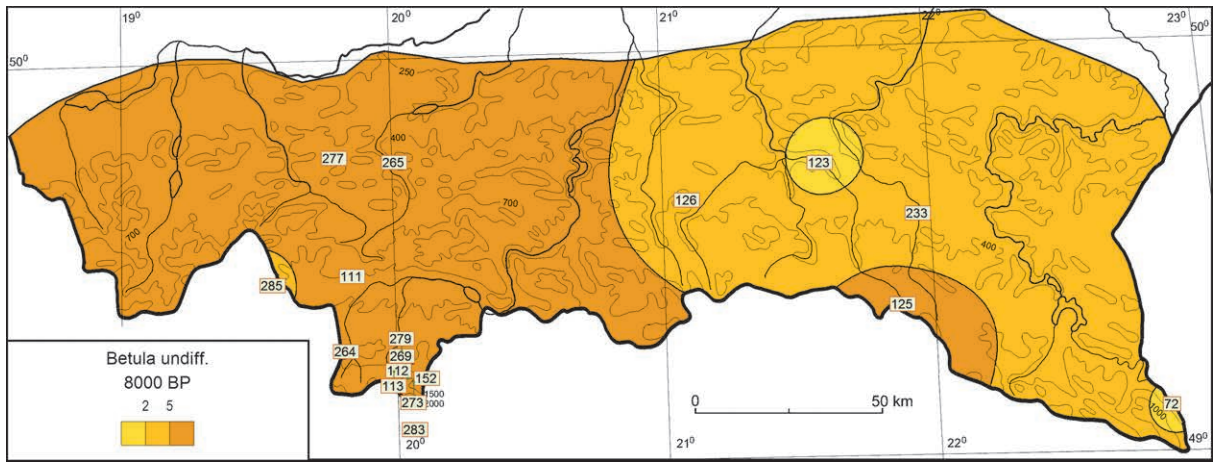
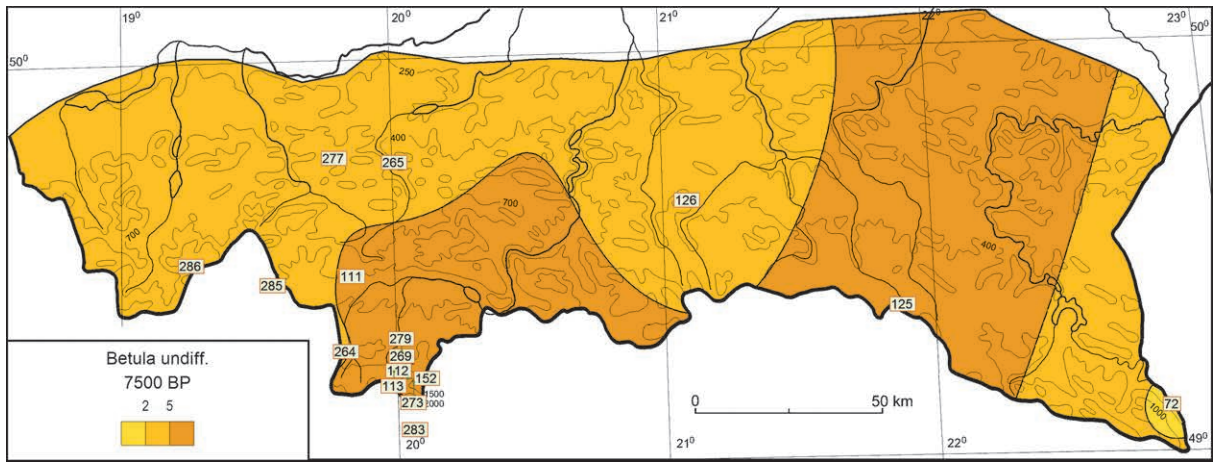
9500 BP
10
0 50 km


Betula undiff.
9000 BP
10 20
0 50 km


Betula undiff.
8500 BP
5 10
0 50 km


Betula undiff.
8000 BP
2 5
0 50 km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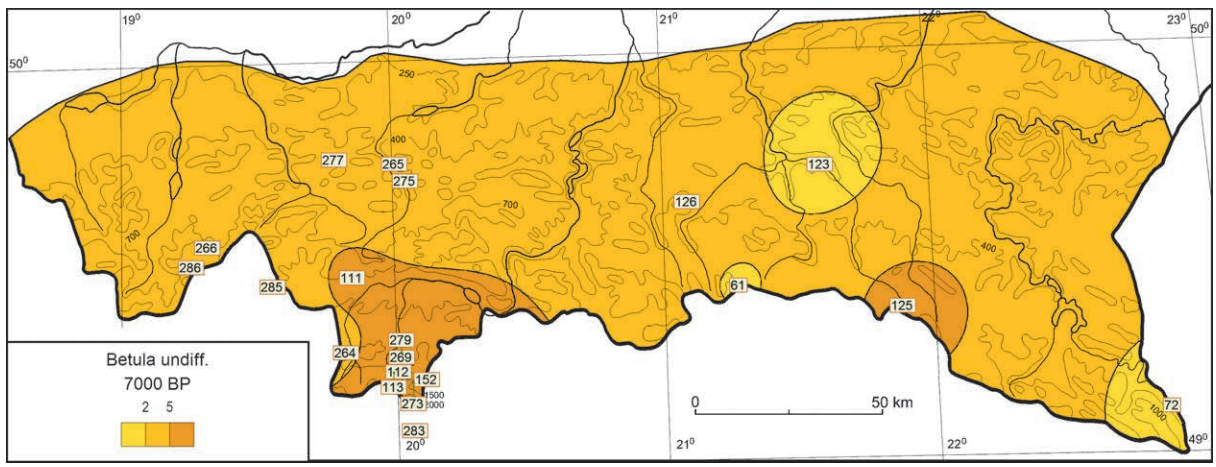
7500 BP
2 5
0 50 km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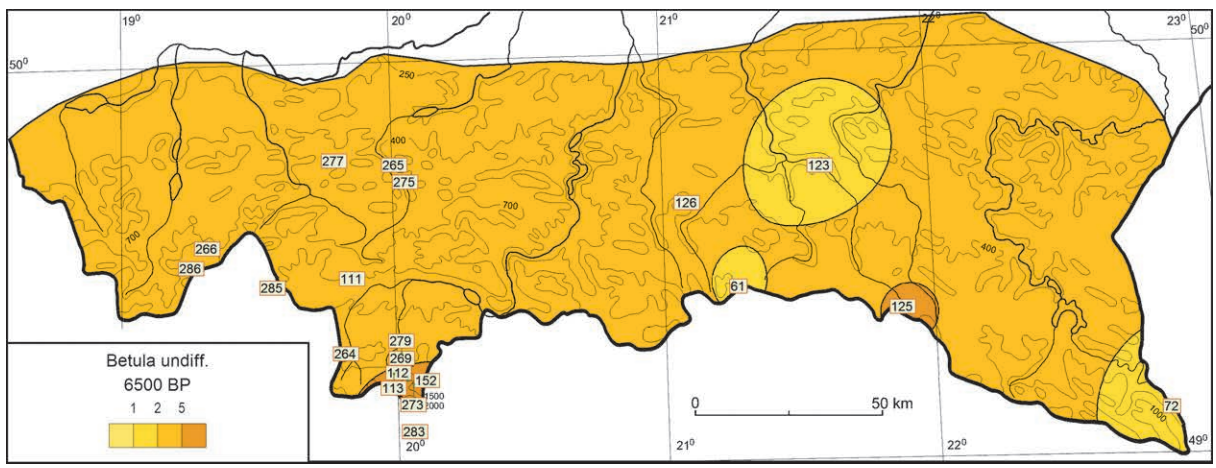
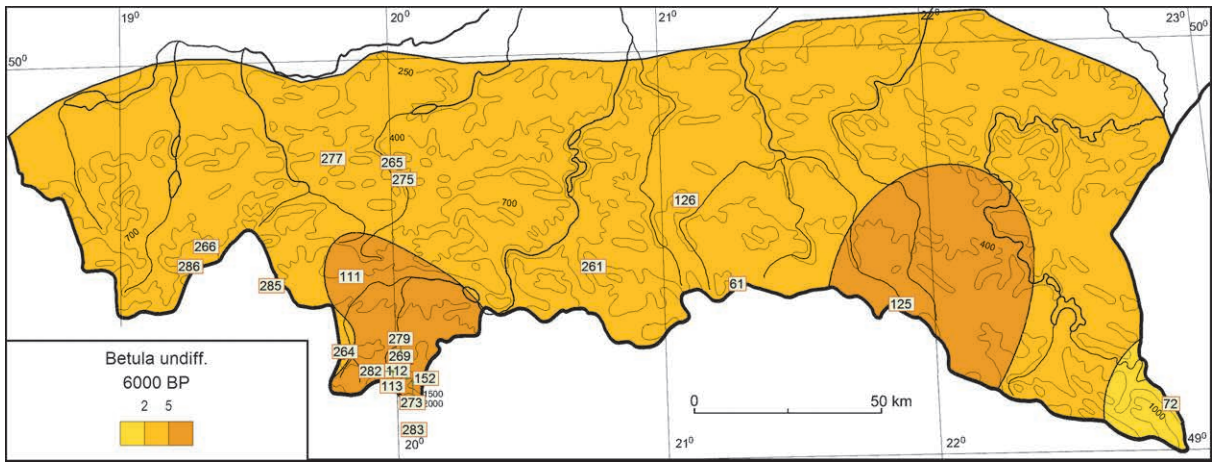
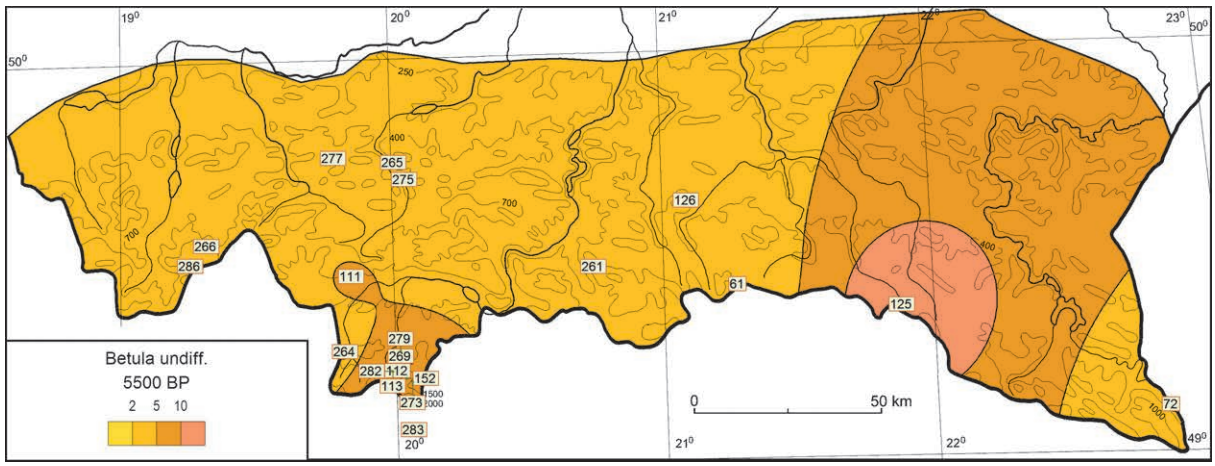
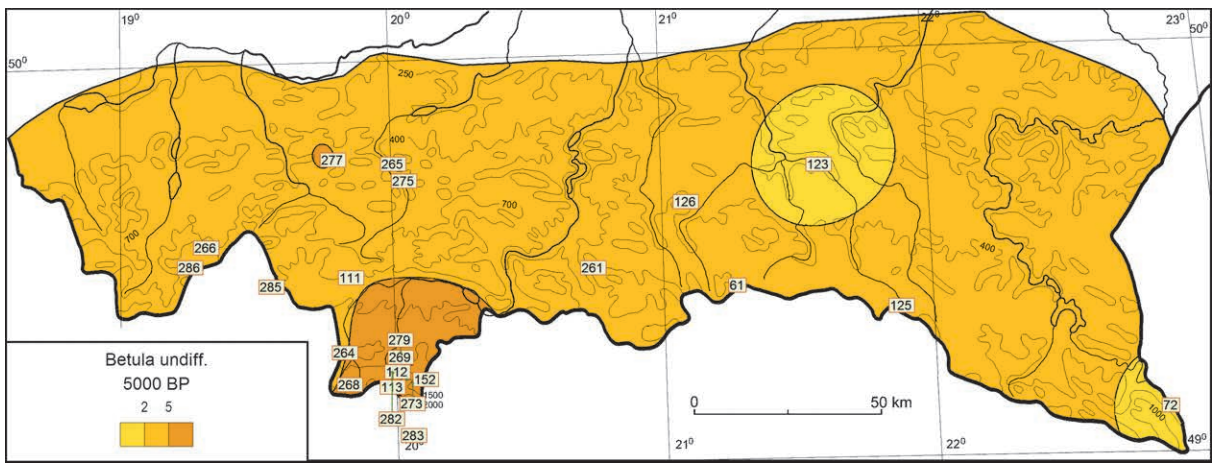
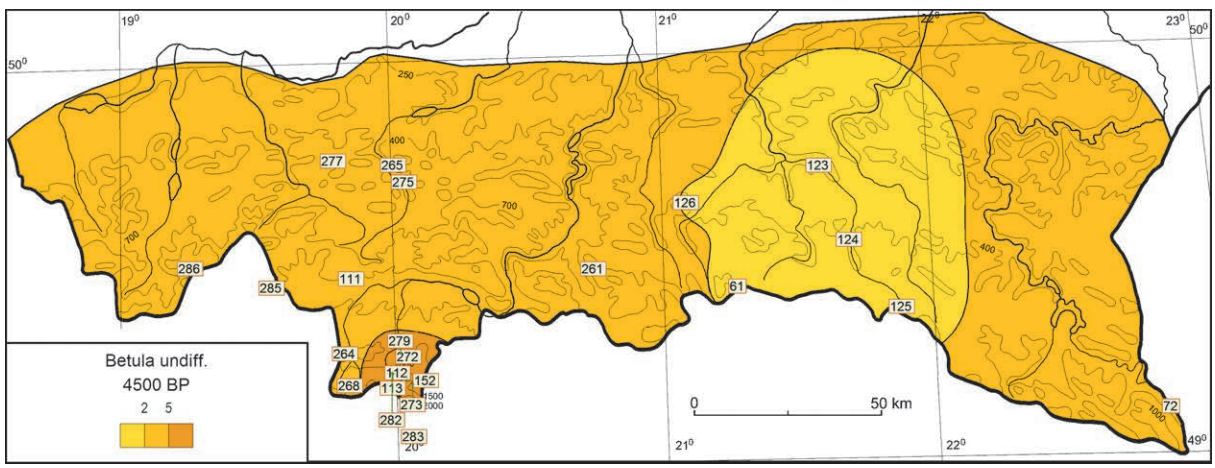
7000 BP
2 5
0 50 km

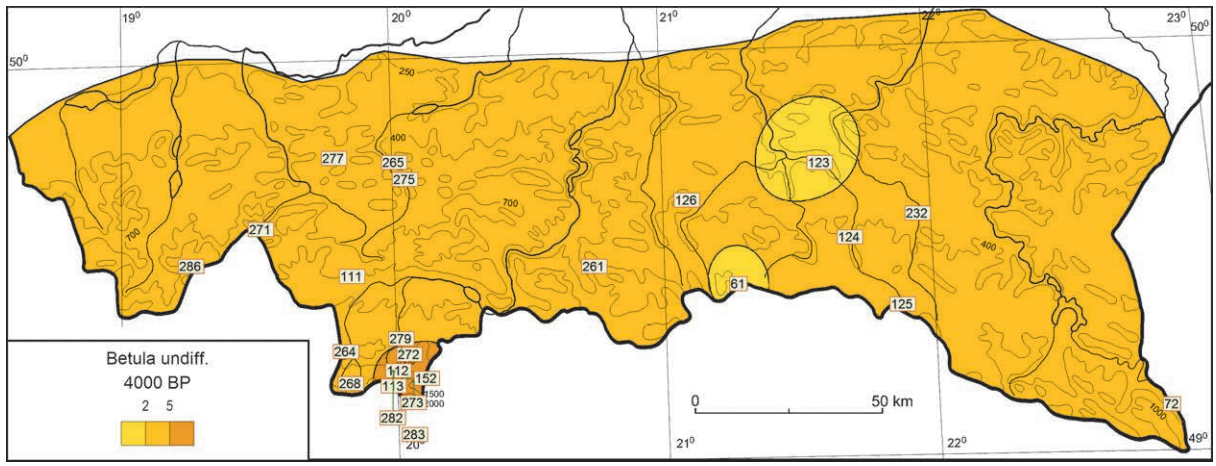

Betula undiff.
6500 BP
1 2 5
0 50 km

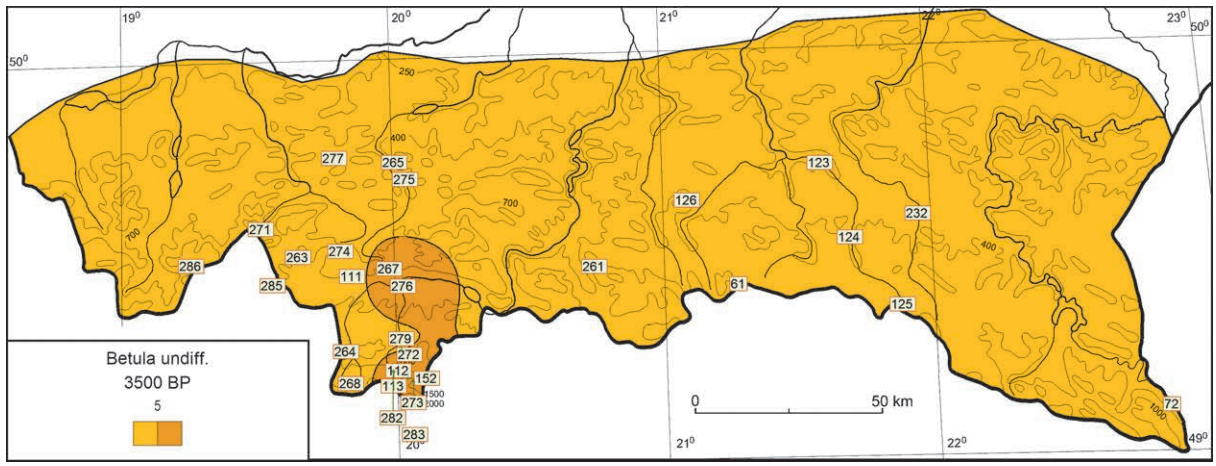

Betula undiff.
6000 BP
2 5
0 50 km

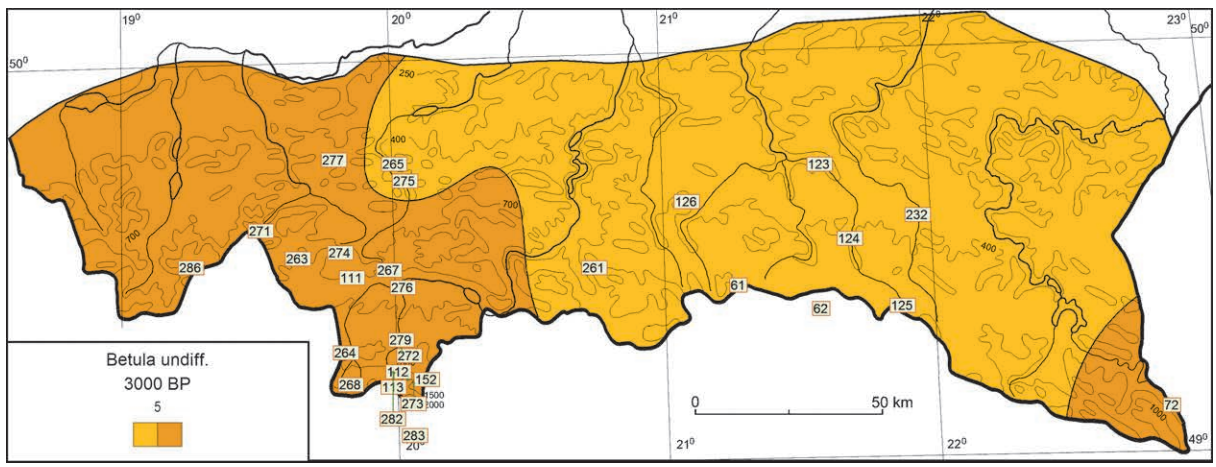

Betula undiff.
5500 BP
2 5 10
0 50 km

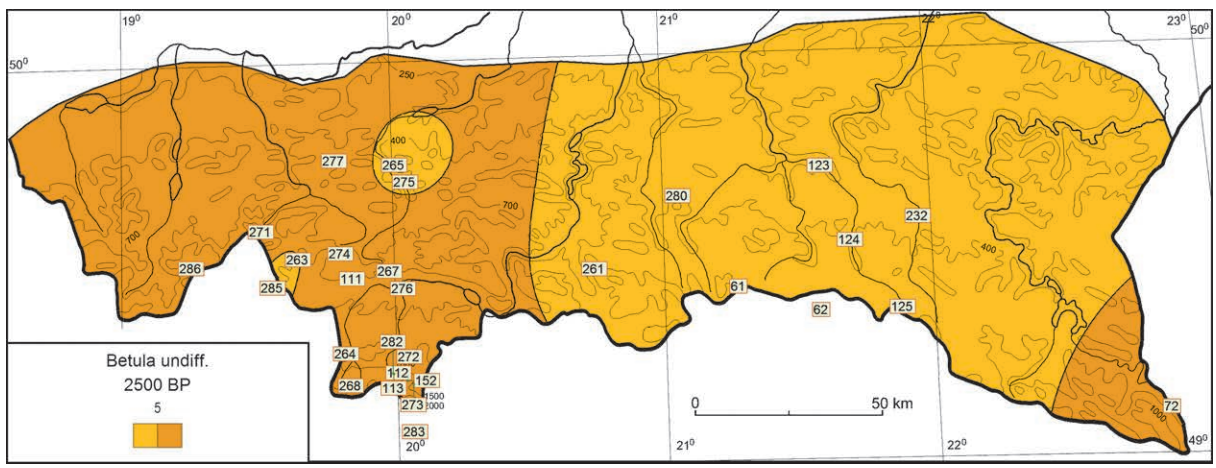

Betula undiff.
5000 BP
2 5
0 50 km

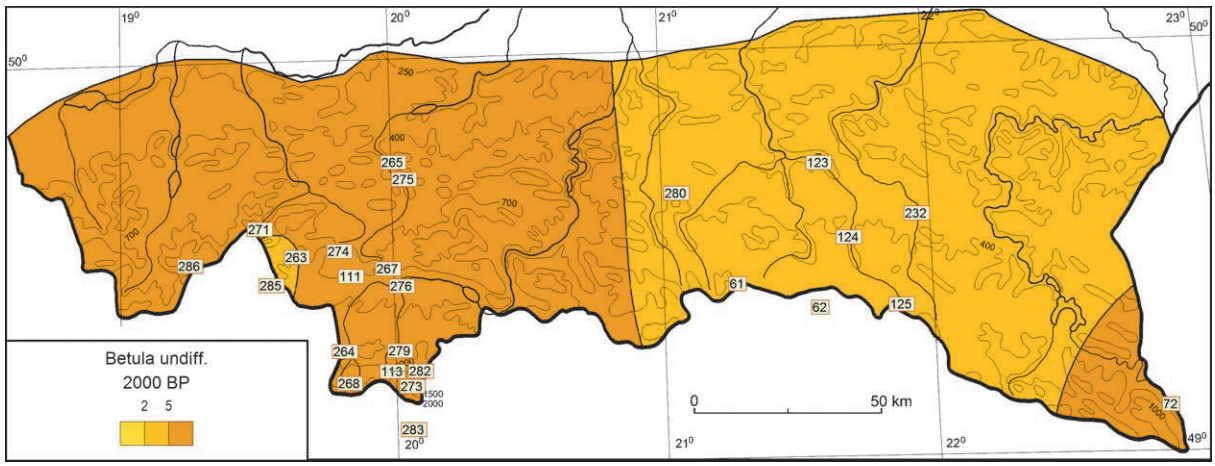

Betula undiff.
4500 BP
2 5
0 50 km

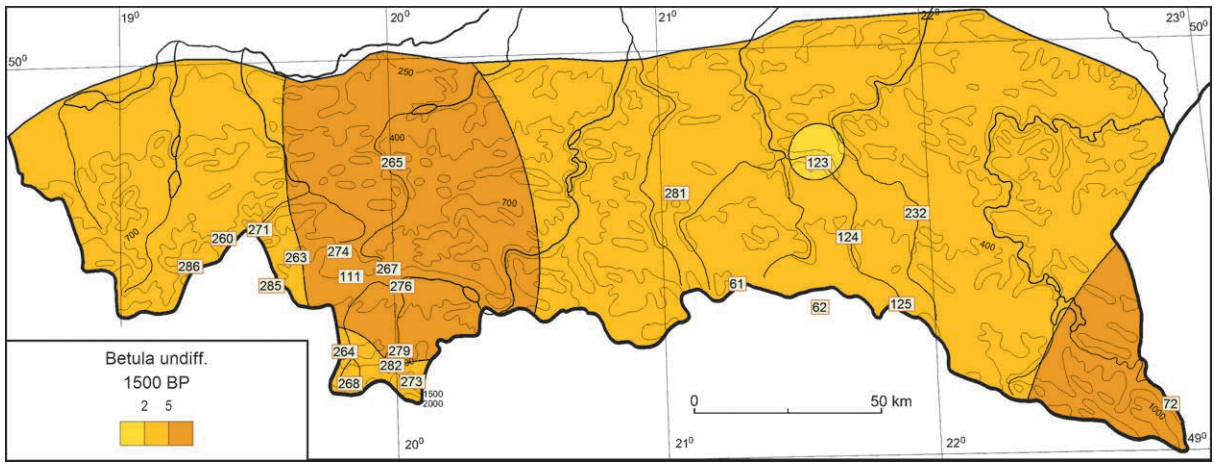

Betula undiff.
4000 BP
2 5
0 50 km

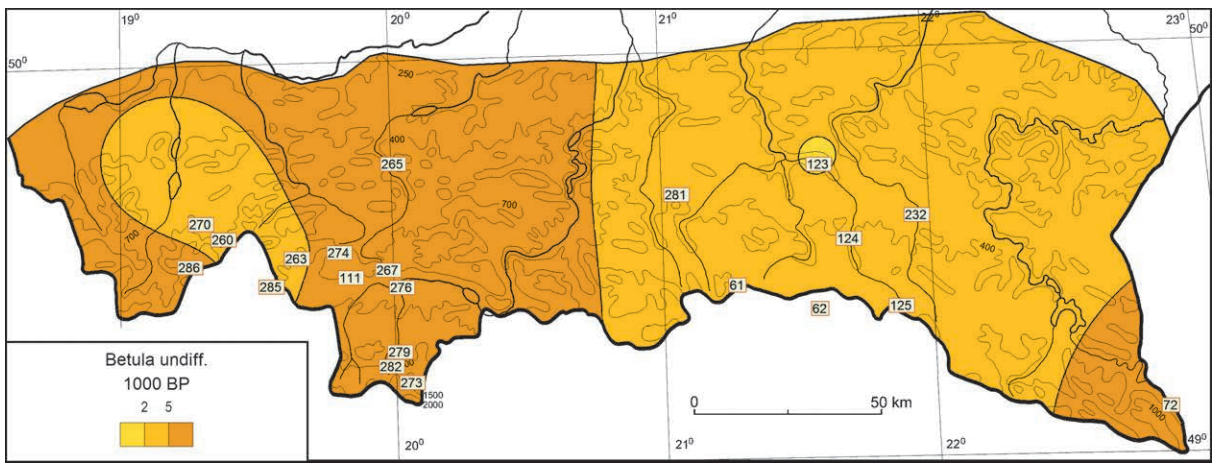

Betula undiff.
3500 BP
5
0 50 km


Betula undiff.
3000 BP
5
0 50 km


Betula undiff.
2500 BP
5
0 50 km


Betula undiff.
2000 BP
2 5
0 50 km


Betula undiff.
1500 BP
2 5
0 50 km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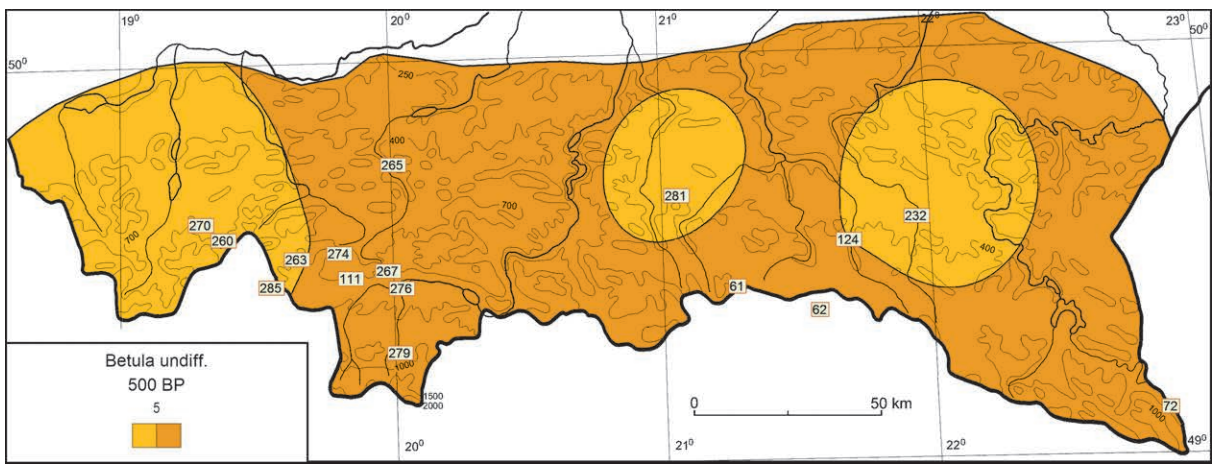
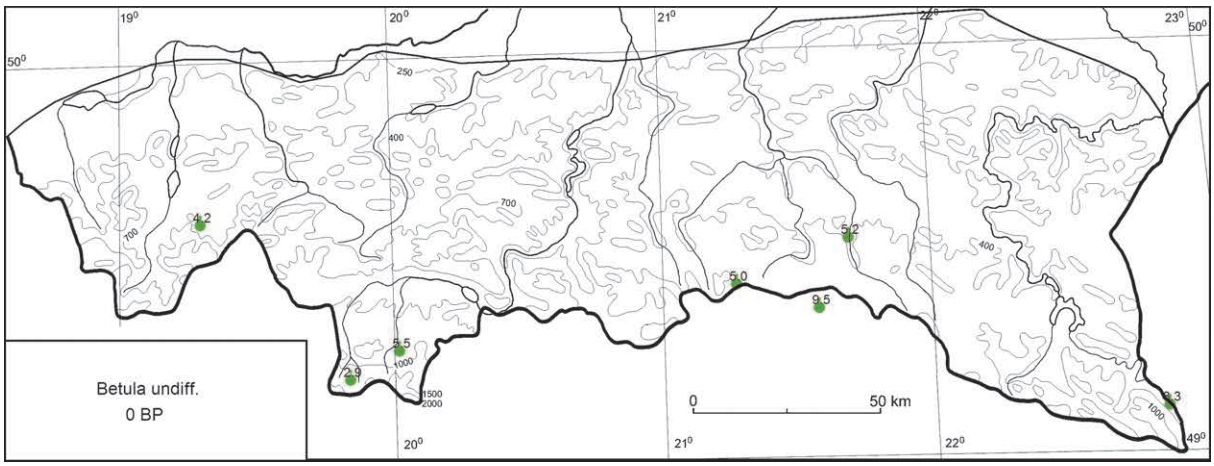
1000 BP
2 5
0 50 km


Betula undiff.
500 BP
5
0 50 km


19°
20°
21°
22°
23°
50°
49°
250
400
700
1000
1500
2000
4.2
5.5
2.9
5.2
5.0
9.5
9.3
Betula undiff.
0 BP
0
50 km