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SOME COMMENTS ON THE PALYNOSTRATIGRAPHY OF THE HOLOCENE IN POLAND, BASED ON ISOPOLLEN MAPS

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Abstract

The paper presents the division of Holocene into four palynostratigraphical units: early Holocene, middle Holocene, late Holocene – older part, and late Holocene – younger part. It stresses that the best defined border is that between the Late Glacial and early Holocene, and all other "borders" have the character of broad transitional zones. The attention is also paid to the complex of changes starting between 4000 and 3000 BP connected with the retreat of hazel and oak and expansion of hornbeam and beech with fir spreading in the south and spruce in the north-east of Poland. From *ca*. 6000 BP on the human activities cause increasing changes in vegetation that are difficult to be distinguished from those generated by natural factor.

Key words: palynostratigraphy, Holocene, climate changes, human impact, transitional zones

INTRODUCTION

Biostratigraphy, one of the basic methods for constructing the stratigraphic schemes, includes different specialistic methods, with palynostratigraphy, as an independent tool, being the most important among them. Palynostratigraphy is assisted by two other botanical methods: the analysis of macroscopic plant remains and investigations on the composition of peat deposits.

From the point of view of stratigraphy in a broader geographic sense than the regional stratigraphy, only very few borders proposed for the Holocene should be treated as synchronous ones. The firmest of them is the border between the glacial and interglacial, speaking more strictly – the late glacial/holocene border. This division line is nearly synchronous in central Poland with the results of investigations on the ice cores GRIP and GISP 2 from central Greenland. This has been demonstrated by the comparison of $\delta^{18}O$ from annually laminated sediments of Lake Gościąż at Gostynin Lake District with that coming from GRIP core (Goslar *et al.* 1995). Very detailed multi-proxy investigations on the sediments around this border from Lake Gościąż (Ralska-Jasiewiczowa *et al.* 2003) have shown several short-lasting accompanying climatic oscillations (like *ca*. 30 yrs rise of winter- and fall of summer precipitation preceding the main warming, and then the drier climate, first due to the fall of winter – and later also of summer precipitation *etc*.). The sediment section of *ca*. 350 years with the main border between the Late Glacial and Holocene occurring in the middle of this section was investigated in such a detailed way.

In the new monography on vegetation history of Poland based on the isopollen maps (Ralska-Jasiewiczowa *et al.* (eds) 2004) the chronological division into five main units referring roughly to the classical division into chronozones introduced by Mangerud *et al.* (1974) was applied. It is presented below in conventional radiocarbon years BP.

Late Glacial (14,000–10,000 BP). It includes the generally known climatic oscillations: still cool Oldest Dryas, the warming of Břlling, the poorly distinguishable oscillation of Older Dryas (cooler or drier climate?), the warming of Allerřd, the cooling of Younger Dryas.

Early Holocene(10,000–*ca*. 7500 BP). The time of climatic warming and of intensive plant migrations, includes Preboreal and Boreal chronozones together with the beginning of Atlantic chronozone when the migration processes were still strong.

Mid-Holocene (*ca*. 7500–5000 BP). It includes the remaining main part of Atlantic chronozone and at the same time the climatic optimum of the Holocene.

Late Holocene, older part (*ca*. 5000–2500 BP). It corresponds with the Subboreal chronozone and it can be divided into two phases not distinguished up till now.

Late Holocene, younger part (*ca*. 2500 BP till recent times). It is the period of increasing anthropopressure corresponding with the Subatlantic chronozone, characterized by cooling and humidification of climate, and many changes of vegetation connected in the first place with human activities.

The aim of such division was, first of all, an easy communication, and the borders between those units are often problematic and rather "belt-like" than "line-like".

EARLY HOLOCENE

The early birch-pine (*Betula-Pinus*) phase of Early Holocene distinguished as Preboreal chronozone, has already been penetrated by the first migrations of mesophilous

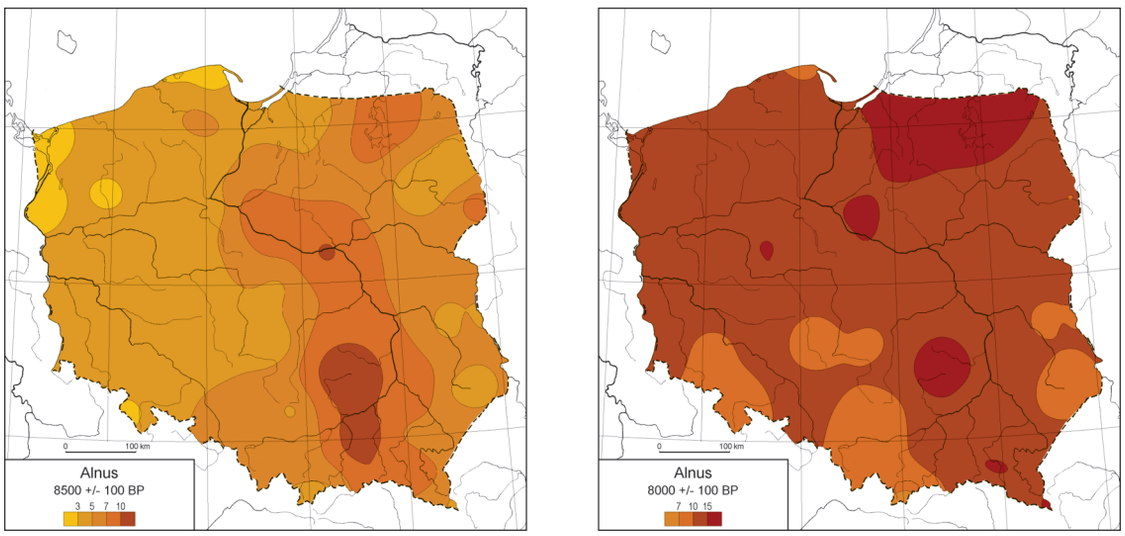

Fig. 1. Isopollen maps of alder (*Alnus*) for 8500 and 8000 BP, showing the rapidity of its expansion during that period on the territories of the whole country, what evidences probably the formation of numerous wet habitats due to the rises of water levels (according to Szczepanek *et al.* 2004).

trees and shrubs like elm (*Ulmus*) migrating from the south-east before 9500 BP, hazel (*Corylus*) coming mostly from the north-west (9500–9000 BP), and also probably oak (*Quercus*). Oak's migration routes were initially indistinct, and its main migration wave took place only between 8000 and 7500 BP. There are, however, oak trunks found, dated at older times (Lublinek, central Poland – 9200 BP, Goslar, Pazdur 1985, Smolice near Oświęcim – 8400 BP, Krąpiec 1992), evidencing earlier presence of oak in Poland.

Times after 9000 BP are characterized by continuous migrations of successive mesophilous genera of deciduous trees from the refuges located in different parts of Europe. It seems that the distance from the location of those refuges and the dissemination way were the most important factors responsible for the appearance order of particular trees on the territories of Poland. However, the data concerning the location of refuges are changeable and being complemented, especially during the last years due to the dynamically developing phylogenetic investigations on particular tree species. The new refugial areas are being found in this way, *e.g.* the Romanian Carpathians together with the Transylvania, Eastern Alps and even Belgium (Taberlet *et al.* 1998, Stewart, Lister 2001, Bordács *et al.* 2002, and others). In spite of the arbitrary acceptance of the upper border of Early Holocene at 7500 BP we should treat it rather as a broad transitional zone.

When speaking about the Early Holocene we should still draw some attention to the specific character of alder (*Alnus*) migration. It was proceeding gradually from the south along the Vistula valley since the beginning of Holocene, but between 8500 and 8000 BP it developed a huge expansion on the territories of nearly the whole country, except for some parts of the mountains (Fig. 1). Such a broad spread of wet woods suggests most probably the period of intensified rise of water levels. This phenomenon would be in accordance with the hypothesis of Starkel (1999) about the wide (global?) occurrence of a phase of humid climate connected with the extreme hydrological events just during that time.

MID-HOLOCENE

Mid-Holocene, corresponding with the main, younger part of Atlantic chronozone and the holocene climatic optimum should be, according to the classic opinion, characterized by the stability of forest communities ("climax forests"). Such statement is not, however, quite correct. The mature forest communities were still submitted to gradual changes connected to a high extent with the processes of soil maturing and leaching (Birks 1986) and they were slowly changing their composition. For instance, the contribution of oaks was gradually increasing during the whole time of Mid-Holocene, up to the maximum occurring already during the Late Holocene (4500–4000 BP). The contribution of elms was maximal around 6500 BP and from 6000 BP on it started to decrease, just at the time when limes (*Tilia*) and ash (*Fraxinus*) reached their highest contributions. Hazel culminated twice – during the Early Holocene (around 8000 BP) and again, by the end of Mid- and during the older part of Late Holocene (Ralska-Jasiewiczowa *et al.* (eds) 2004). The second rise of hazel contribution and also other periodical changes, like short-lasting falls of elm, rises of birch or aspen (*Populus tremula*), could be connected during the Mid-Holocene with the appearances and activities first of nomadic groups of Mesolithic people, and from 6500–6000 BP on, also with the settling of Neolithic populations, changing the natural environment locally, but with increasing extent. The upper border of Mid-Holocene has to be indicated in the pollen diagrams by a rapid fall of elm pollen which, however, not always is well marked or synchronous; for instance in the Bieszczady Mountains it occurs only around 4400–4200 BP (Ralska-Jasiewiczowa 1980), and in some lowland sites as early as *ca*. 6000–5700 BP (Latałowa 1992). So again, we can speak only about a transitional zone, and besides, the foundation of such an important border on an event treated generally today as a pathogenic phenomenon, and concerning one tree-genus only, seems unsatisfactory.

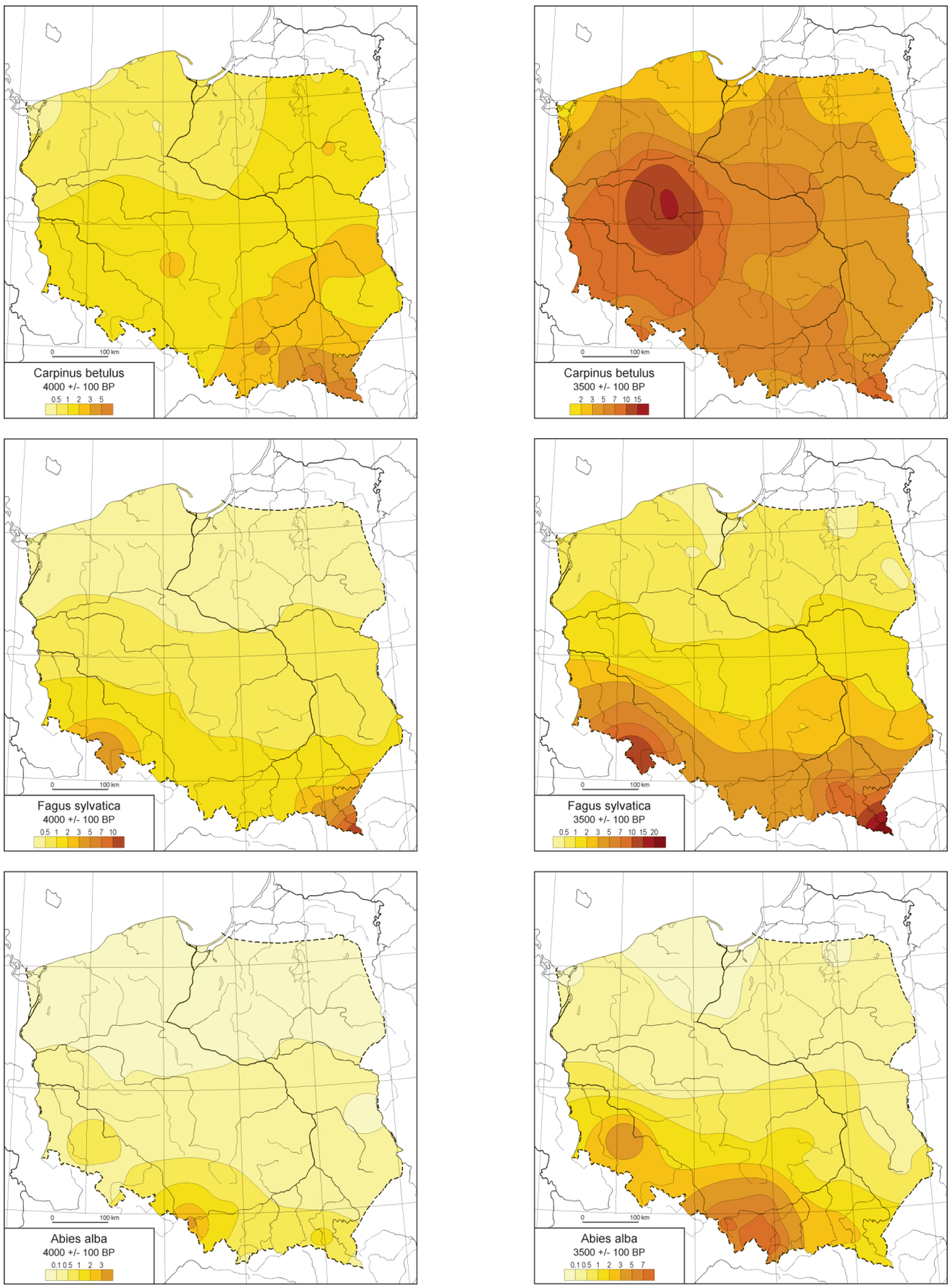

Fig. 2. Isopollen maps of hornbeam (*Carpinus*), beech (*Fagus*), and fir (*Abies*) for 4000 and 3500 BP, showing the way of expansion of these trees during the presented time (according to Ralska-Jasiewiczowa *et al.* (eds) 2004, Latałowa *et al.* 2004a, Obidowicz *et al.*, 2004).

LATE HOLOCENE, OLDER PART

The older part of Late Holocene, corresponding with the Subboreal chronozone is the time of deep changes of vegetation, and once more renewed tree migrations. It contains a very distinct, complex border, not exposed by palynologists too far up till now, dividing the older part of Late Holocene into two important phases:

Phase *ca*. 5000–(4000) 3700 BP is characterized by the maximal holocene spread of oaks and more or less indicated expansion of hazel. It is possible that the half-shrubby communities with dominant oak and hazel extended on the post-farming grounds devastated by the Neolithic populations during their activities. Their ecological stability might have been rather weak. Both oaks and hazel were favoured by man during the deforestation processes due to their utility values. The oak-hazel communities were rather connected with the lowland-upland regions; in the mountains oak grows only in the foothill zone.

Phase *ca*. (4000) 3700–2500 BP is differentiated by a rapid reduction of hazel, slower decrease of oak contribution, and coincidently proceeding expansions of hornbeam (*Carpinus betulus*) and beech (*Fagus sylvatica*), both coming from the south-east, but beech migrating also from the south-west via the Sudetes. Hornbeam extended on the lowlands toward the north-west, and beech settled mostly in the mountains, on the foothills and uplands (Fig. 2). Some humidification and cooling of climate is being postulated at that time however, these would not be the climatic change stimulating the expansion of hornbeam, which is a moderately continental tree. Beech, a species with more atlantic demands, will be spreading in the peri-Baltic areas of Poland distinctly later (3000– 2000 BP). So, the reasons of synchronous expansions of hornbeam and beech from the south-east to Poland are not clear enough. Still, at a similar time as beech and hornbeam expansions (4000–3500 BP) also the fir (*Abies alba*) began to migrate from the south-west to the mountain areas of the Carpathians and Sudetes (Fig. 2), and in the north-east of Poland a new centre of spruce (*Picea abies*) occurrence started to form. This coincidence of beech, fir and spruce movements would suggest some more general climatic changes taking place during the period in question.

It is also symptomatic that the very distinct border horizon synchronous with the lower border of the discussed phase and indicated in this case by the intensive reduction of hazel and rapid increase of beech contribution, but with the minute values of hornbeam, can be traced in the pollen profiles from the annually laminated sediments of volcanic lakes located in the Eifel region in the north-west Germany (Fig. 3) (Kubitz 2000, Brauer *et al.* 2000 and others), and also in other localities from north Germany and from Denmark (Ralska-Jasiewiczowa *et al.* 2003 and references cited there).

For the processes of hornbeam spread in Poland the possibility of occupation of post-farming lands, which in the older phase of Late Holocene were periodically overgrown by pioneer woods and subsequently by oak-hazel communi-

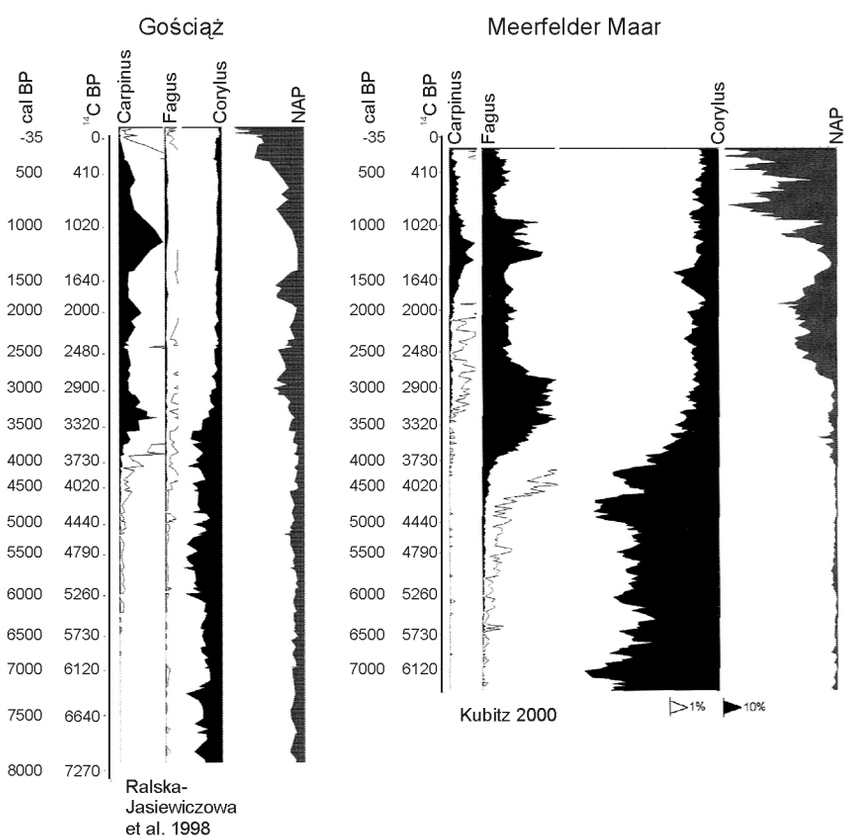

Fig. 3. The comparison of selected pollen curves from two diagrams representing annually laminated sediments from NW Germany and central Poland, showing the synchroneity (at *ca*. 3700 BP) of beech (*Fagus*) rise at Meerfelder Maar with hornbeam (*Carpinus*) rise at Lake Gościąż, and coincident declines of hazel (*Corylus*) curves in both diagrams.

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ties, was of great importance. Also in later times hornbeam used similar possibilities to expand on grounds abandoned by settlers of younger cultural groups.

LATE HOLOCENE, YOUNGER PART WITH INCREASING ANTHROPOPRESSURE

The younger part of Late Holocene corresponds with the Subatlantic chronozone characterized by cooler and more humid climate. However again the demarcation of its lower border is generally based on the arbitrary chronologic criteria alongside with not always distinct enough climatic criteria (*e.g.* records of water level rises, Ralska-Jasiewiczowa, Starkel 1988, Ralska-Jasiewiczowa *et al.* 1998), and also with anthropogenic events resulting to some extent from the climate changes (Ralska-Jasiewiczowa *et al.* 2003). The changes of vegetation were in that time very distinctly connected with the settlement processes: *e.g.* such composed factors as the invasions of Scythians and the coincident rises of ground water levels resulted in the decline of the Lusatian culture, which was the most wide-spread culture in Poland, characterized by the high density of population (Godłowski, Kozłowski 1979). Those processes are reflected in pollen diagrams as the regeneration of forest vegetation, first of pioneer woods and next of deciduous forests with dominant hornbeam. Around 2000–1800 BP the new settlement wave connected with the Roman Period caused again the deforestation processes and development of anthropogenic vegetation.

At *ca*. 1500–1400 BP the new regeneration of deciduous forests and temporary retreat of pine expanding under the influence of human activities have been distinctly indicated, also on the isopollen maps (Fig. 4) (Ralska-Jasiewiczowa *et al.* 2003, (eds) 2004). These phenomena resulted from the ethnic movements of the Migration Period. However already since around 1000 BP an advancing spread of human economy start to transform the natural environment in a process persistent and developing till nowadays. It generates an ostensible picture resembling the approaching end of holocene interglacial cycle: the disappearance of the deciduous forests, and first the mass spread of pine followed by the total deforestation of the whole country, and the occupation of its territory by open vegetation (Fig. 4).

After Makohonienko (2004), W. Matuszkiewicz (1990) estimates roughly the contribution of oak-hornbeam with lime forests to the potential natural plant communities of Poland at 41.6%, when J.M. Matuszkiewicz (2002) shows that these types of forest communities cover at present no more than 0.2% of the country area. The results of synanthropization of the natural environment lead in this way to its total devastation.

To sum up the above remarks we should state that those stratigraphic borders we can distinguish in the Holocene using the palynological methods have mostly the character of broad transitional zones. Some of the traditionally accepted borders are often difficult to observe. The most distinct and recognized in a broadest geographical range is the border between the Late Glacial and the Holocene. In central Europe well indicated are the complex changes connected with the reduction of hazel, hazel/oak communities, and migrations of hornbeam, beech, partly also fir and in the north-east the late spread of spruce. The beginning of those changes occurs between 4000 and 3000 BP (most often around 3700 BP), just in the middle of traditionally distinguished Subboreal chronozone (5000–2500 BP, Mangerud *et al.* 1974). These are, however, the phenomena of regional character in its broad sense. Besides, from *ca*. 6000 BP on, it becomes more and more difficult to separate the vegetational changes caused by human activities in their different aspects, from changes caused by natural factors.

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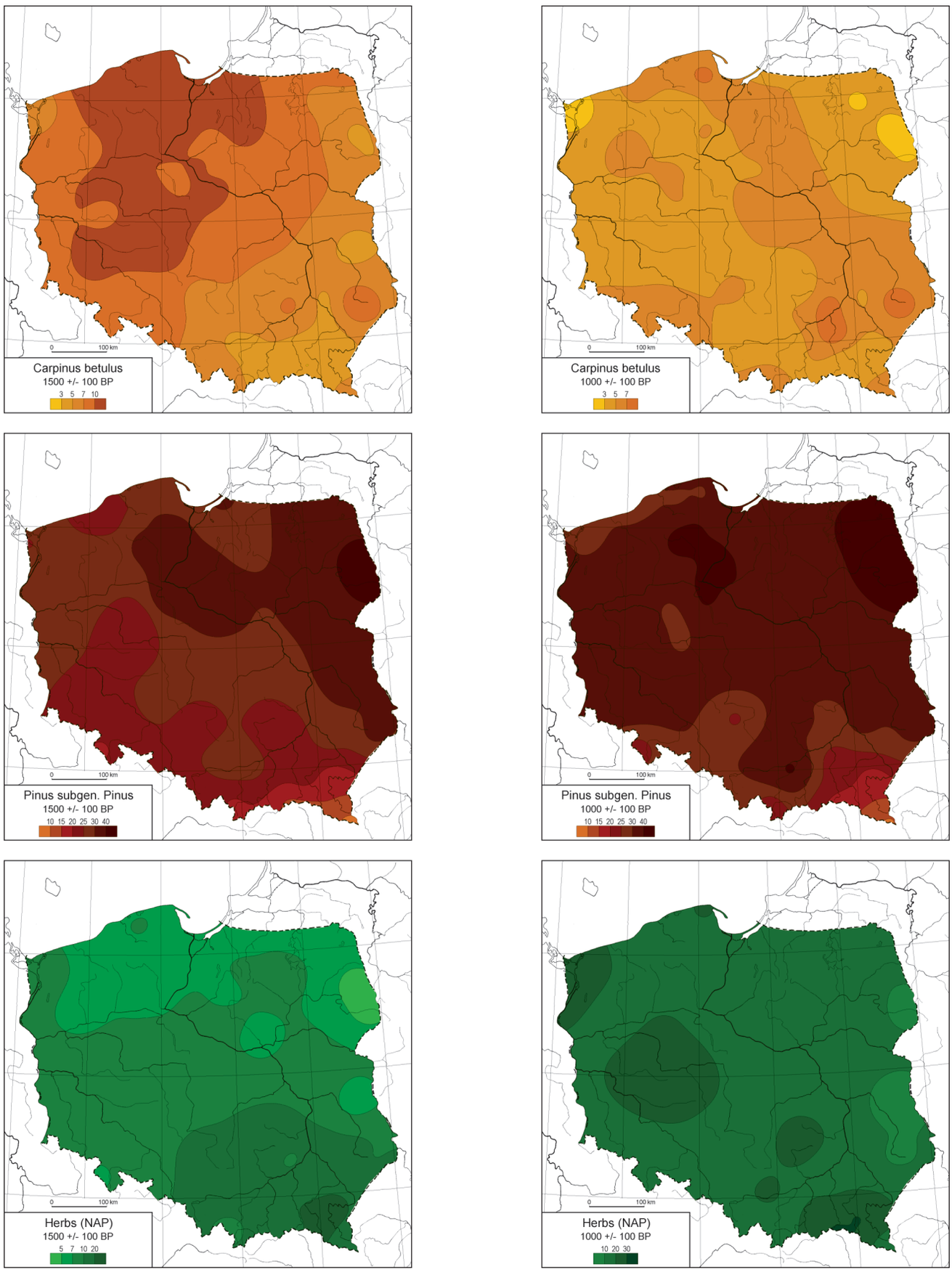
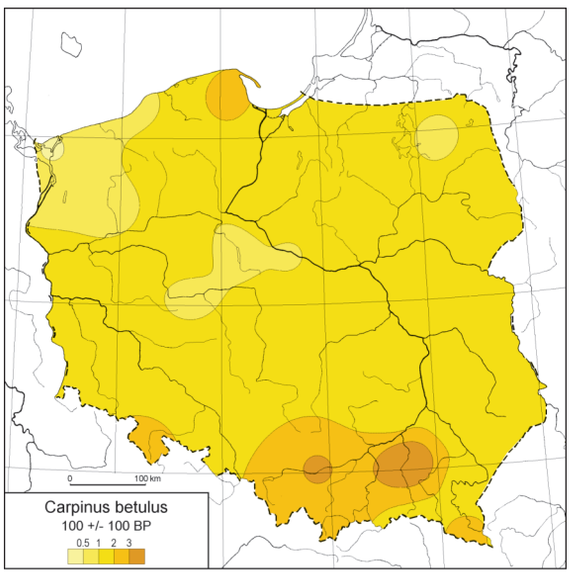
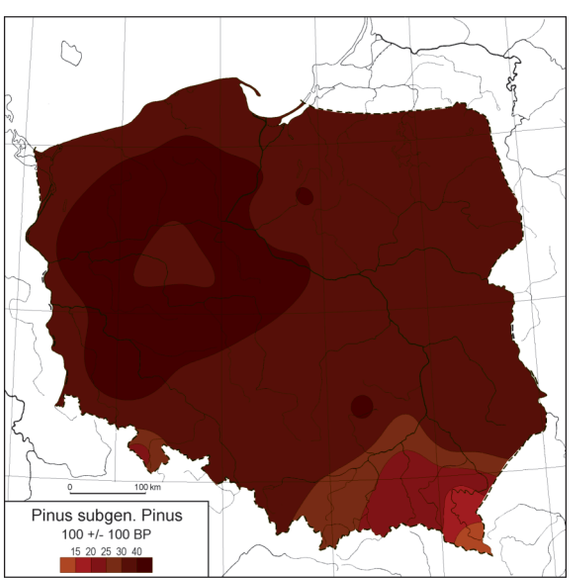


Fig. 4. Isopollen maps of hornbeam (*Carpinus*), pine (*Pinus*) and sum of herbs for 1500, 1000 and 100 BP, illustrating the regeneration of deciduous forest during the Migration Period, the following expansion of pine, and progressing anthropogenic deforestation towards recent times (according to Ralska-Jasiewiczowa *et al.* (eds) 2004, Latałowa *et al.* 2004b, Harmata *et al.* 2004).





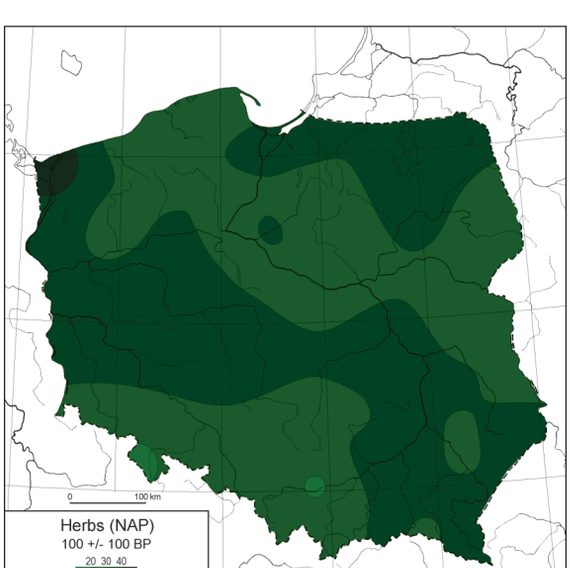


Fig. 4. continued

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