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# THE DEVELOPMENT OF VEGETATION IN THE INLAND AREA OF CROATIA DURING THE POSTGLACIAL PERIOD

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A review of the development of the vegetation in the inland area of Croatia includes the period of the Postglacial, and is based on a synthesis of previous archaeobotanical research, including pollen analysis, and analysis of plant macro-fossils. Changes in vegetation through individual postglacial periods are shown, particular attention being devoted to anthropogenic impacts on the vegetation.

**Key words**: vegetation, anthropogenic impacts, Postglacial, inland area, Croatia

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Pregled razvoja vegetacije u kontinentalnom području Hrvatske obuhvaća razdoblje postglacijala, a temelji se na sintezi dosadašnjih arheobotaničkih istraživanja, koja uključuju polenske analize, te analize biljnih makrofosila. Prikazane su promjene vegetacije tijekom pojedinih razdoblja postglacijala, a posebna pozornost posvećena je atropogenom utjecaju na vegetaciju.

**Key words:** vegetacija, antropogeni faktor, postglacijal, kontinentalno područje, Hrvatska

## INTRODUCTION

The review of the development of vegetation in the inland area of Croatia during the postglacial period (since ca 10000 BP or 9000 BC, according to LANG, 1994) presented in this paper is based on a synthesis of previous archaeobotanical research and covers the result of palynological (cf. CULIBERG & ŠERCELJ, 1981, 1994; GARDNER, 1997; GIGOV & NIKOLIĆ, 1960; SRDOČ *et al.*, 1985; ŠERCELJ, 1971) and macrofossil analyses (ŠOŠTARIĆ, 2001, 2003) from 12 sites (Fig. 1, Tab. 1).

The inland part of Croatia is one of the centres of European *Fagus* and other broad-leaf woodlands, and therefore it is very important to summarize the vegeta-

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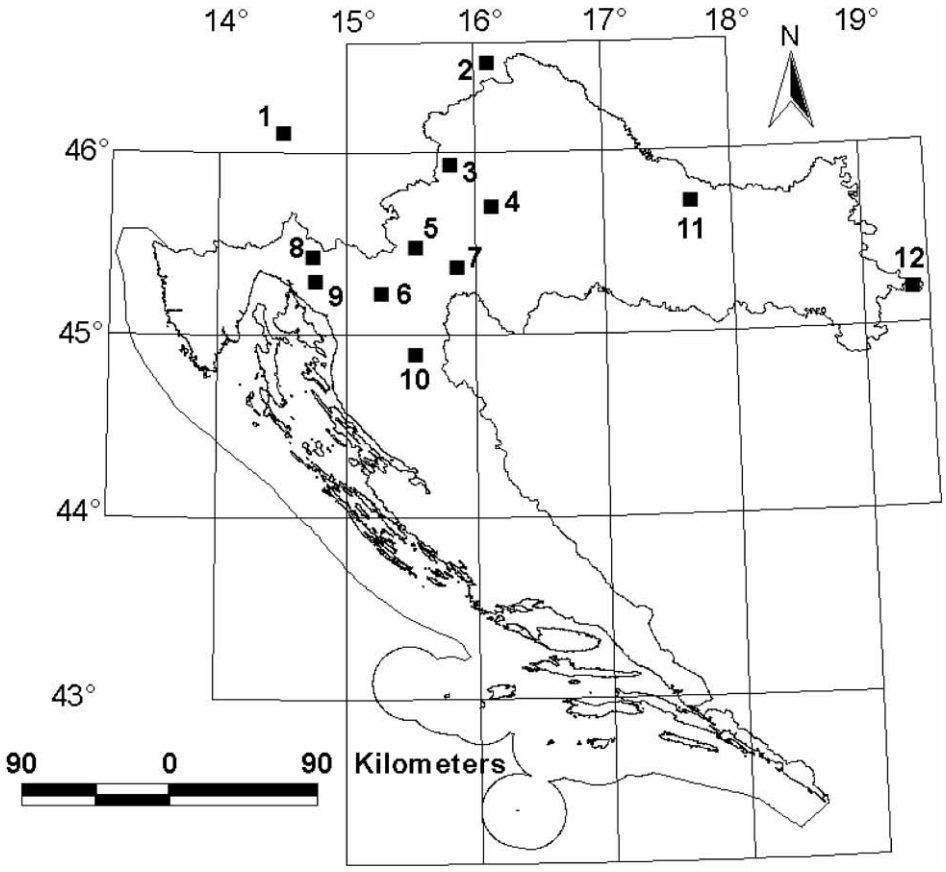


**Fig. 1.** Sites from which the archaeobotanical data used in the reconstruction of the development of the vegetation of the inland area of Croatia in the postglacial period were obtained (P –pollen analysis, MF – analysis of plant macro-fossils): 1. Podpeško jezero (Podpeško Lake), P (GARDNER, 1997); 2. Hajndl, MF (ŠOŠTARIĆ, 2003); 3. Dubravice, P (GIGOV & NIKOLIĆ, 1960); 4. Šćitarjevo, MF (ŠOŠTARIĆ, 2003); 5. Kamensko, MF (ŠOŠTARIĆ, 2003); 6. Skradnik, MF (ŠOŠTARIĆ, 2003); 7. Blatuša, P (GIGOV & NIKOLIĆ, 1960); 8. Trstenik, P (GIGOV & NIKOLIĆ, 1960; ŠERCELJ, 1971); 9. FUŽINE, P (GIGOV & NIKOLIĆ, 1960; ŠERCELJ, 1971); 10. Plitvička jezera (Lakes of Plitvice), P (CULIBERG & ŠERCELJ, 1981, 1994; SRDOČ *et al.*, 1985); 11. Nova Bukovica, MF (ŠOŠTARIĆ, 2001); Ilok, MF (ŠOŠTARIĆ, 2003).

tion history of this area. This paper presents the first summary for vegetation history of an important region of Europe from the viewpoint of ecology, plant geography and vegetation history. Some of the publications summarized here have only been published in Croatian or Slovenian or Serbian before, and therefore not available to a large readership. It is important to have a summary of the research done previously to find new theories about the state of the art, and these new theories provide the basis for further research and also for further research projects.

**Tab. 1.** Comparative review of the development of the vegetation of the sites analysed according to pollen analyses

| | **Trstenik** (GIGOV & NIKOLIĆ, 1960) 950 m a.s.l. | **Trstenik** (ŠERCELJ, 1971) | **Fužine** (GIGOV & NIKOLIĆ, 1960) 720 m a.s.l. | **Lakes of Plitvice** (CULIBERG & ŠERCELJ, 1981, 1994; SRDOČ *et al.* 1985) 650 m a.s.l. | **Blatuša** (GIGOV & NIKOLIĆ, 1960) 130 m a.s.l. | **Dubravice** (GIGOV & NIKOLIĆ, 1960) 183 m a.s.l. | **Podpeško Lake** (GARDNER, 1997) |
|---|---|---|---|---|---|---|---|
| SUBATLANTIC *Iron Age –Recent Period* ca 2500 BP – Rec. P., ca 800 BC – Rec. P. | *Fagus, Abies* (*Picea, Pinus*) | | (?) *Fagus, Abies* | *Abieti-Fagetum* | *Alnus, Quercus* (*Carpinus, Fagus, Ostrya*) | *Quercus* (*Abies, Alnus, Ostrya, Castanea*) | – strong anthropog. impact (500 AD); – +/– AP/NAP (1000 BC) |
| SUBBOREAL *Late Neolithic – Bronze Age* ca 5000 – 2500 BP, ca 3800 – 800 BC | *Fagus* (*Carpinus*) | (?) *Fagus, Quercus* et al. (*Cerealia*) | (?) *Abies, Pinus, Picea, Fagus* | *Abieti-Fagetum* (increasing frequency of *Abies*, 5000–6000 BP – Aeneolithic) | *Quercus* | *Quercus, Alnus* (*Fagus, Carpinus*) | – *Fagus, Abies, Corylus, Carpinus* (3000 BC); – *Fagus, Abies* |
| ATLANTIC *Neolithic* ca 8000 – 5000 BP, ca 7050 – 3800 BC | *Pinus* (*Picea, Fagus, Betula*) | (?) *Quercus* et al., *Corylus* (*Picea, Pinus*) | | *Abieti-Fagetum* | *Alnus, Quercus* (*Fagus, Carpinus*) | *Fagus, Carpinus* (*Abies, Alnus, Ostrya, Quercus, Castanea*) | – *Fagus* (*Quercus, Corylus*) (5500–4200 BC); – spread of *Corylus* (6000 BC) – *Quercus* et al. (7000 BC) |
| BOREAL ca 9000 – 8000 BP, ca 7850 – 7050 BC | | *Pinus, Quercus* et al. | | *Abieti-Fagetum* (end of Boreal) | *Quercus* (*Fagus, Carpinus*) | | *Pinus, Picea, Betula* (*Tilia, Quercus*) |
| PRAEBOREAL ca 10000 – 9000 BP | | | | | *Pinus* (*Fagus, Carpinus, Quercus, Corylus, Tilia*) | | *Pinus, Picea* |
| YOUNGER DRYAS ca 11000 – 10000 BP | | *Pinus, Betula* (*Quercus* et al.) *Artemisia, Poaceae* | | | | | |
| ALLERØD ca 12000 – 11000 BP | | *Pinus, Quercus* (+ *Tilia, Ulmus, Corylus, Fagus*) | | | | | |
| OLDER DRYAS ca 13000 – 12000 BP | | *Pinus, Picea* (*Ephedra, Juniperus*) *Artemisia, Poaceae* | | | | | |

## RECONSTRUCTION OF VEGETATION CHANGES

The oldest layers on the basis of which it is possible to reconstruct the development of vegetation in the inland part of Croatia derive from the site called Trstenik in Gorski Kotar (950 m a.s.l.) and belong to the Late Glacial period (ca 13000–10000 BP, according to LANG, 1994) (cf. ŠERCELJ, 1971). In this oldest accessible layer the pine (*Pinus*) and spruce (*Picea*) predominate, with the presence of typical late-glacial elements (*Juniperus, Ephedra, Dryas octopetala*) and a high proportion of herbaceous plants (*Artemisia, Poaceae*). During the Late Glacial period and in the early parts of the Postglacial period the pine was dominant, and the proportion of accompanying elements varied. In the Allerød phase of the postglacial period (ca 12000–11000 BP) pollen curves of deciduous woody species appear that are usually a component part of mixed oak forests (*Quercus, Tilia, Ulmus*) and hazel (*Corylus*) and beech (*Fagus*) also appear. At the end of the Late Glacial period the proportions of birch (*Betula*) and of the deciduous trees already mentioned rose, and the shares of pine and spruce fell; this trend continued in the Preboreal (ca 10000–9000 BP) and in the Boreal (ca 9000–8000 BP). After that, probably in the Atlantic (ca 8000–5000 BP), the pine and birch forests retreated from the surrounding heights too, and the forest cover first of all was composed of a mixed oak forest, and then the share of hazels rose to about 40%. The spruce was still present, but with a share of no more than 10–20%. Then the phase of dominant beech started, probably in the Subboreal (ca 5000–2500 BP), which was also accompanied in an insignificant proportion by the fir, and, in a proportion that was usually significant, by mixed oak forest. In this phase of domination of the beech, the pollen of *Quercus ilex* and *Ostrya-Carpinus orientalis* occur in traces, and the share of grass, including the *Cerealia* type, rises considerably. This phenomenon and the rise in the proportion of herbaceous and cultivated plants is a direct indicator of human activity. Very probably then Bronze Age inhabitants were clearing the forest to obtain fertile fields and pastureland, on which, later, secondary spruce forests developed; these are dominant today, particularly on the northern slopes of the surrounding highlands.

The slightly earlier analysed pollen profile from Trstenik (cf. GIGOV & NIKOLIĆ, 1960) covers a much shorter period of time, but in this section it shows certain similarities with ŠERCELJ'S finds (1971). According to Gigov, in the Atlantic it was still the pine that was dominant (70–80%) with the presence of spruce, beech and birch. In the Subboreal it was the beech that was dominant, and after that, in the Subatlantic (ca 2500 BP – Recent Period) forests of beech and fir were dominant, with a smaller percentage of spruce and pine.

The site called Fužine (720 m a.s.l.), also in Gorski Kotar, did not prove to be so good for pollen profile sampling. The samples contain almost no pollen (cf. ŠERCELJ, 1971) or contain it only in a smaller part of the profile (cf. GIGOV & NIKOLIĆ, 1960). Still, Gigov manages to separate two forest phases. The first phase consisted of mixed deciduous and conifer forest of beech, fir, spruce and pine, which probably belonged to the Subboreal. The second phase consists of mixed forest of beech and fir, probably formed in the Subatlantic.

Pollen profiles from Plitvice Lakes (650 m a.s.l.) cover a period from the end of the Boreal, approximately 8000–7000 BP, until today (cf. CULIBERG & ŠERCELJ, 1981,

1994; SRDOČ *et al*., 1985). Analysis shows the presence of mixed forests of beech and fir only, and it can be said that today's type of climax vegetation *Abieti-Fagetum* developed in this area at the latest in the period of the late Boreal. In the period of approximately 5000–4000 BP the short-lasting domination of fir appeared, which fits in with the appearance of Aeneolithic settlements in the wider area, and perhaps this might reflect some anthropogenic influence.

Somewhat more to the north and at a slightly lower altitude (130 m a.s.l.), between Topusko and Vrgin Most lies the village and peat of Blatuša. The pollen profile of this locality goes back to the period of the Preboreal (cf. GIGOV & NIKOLIĆ, 1960) in which the pine (*Pinus*) dominates, and, in conjunction with this tree, in shares of 10–20% come pollens from beech (*Fagus*), hornbeam (*Carpinus*), oak (*Quercus*) and birch (*Betula*), and in traces hazel (*Corylus*), lime (*Tilia*), alder (*Alnus*), chestnut (*Castanea*) and others. In the Boreal it was a mixed deciduous oak forest that predominated. Along with oak, which was present in proportions of from 20 to 40%, there were also beech (15–25%) and hornbeam (10–15%). The Atlantic was dominated by alder (*Alnus*) forest (35–45%) and oak (10–25%), with admixtures of beech and hornbeam. In the Subboreal it was once again oak that was dominant (35–40%) followed by alder, beech and hornbeam. The last, Subatlantic, phase started with the domination of oak by alder, with oak later on taking over the dominant role, while the other forest elements (*Carpinus*, *Fagus*, *Ostrya*) appeared in shares of about 10%. In the last three periods, from the Atlantic to the Subatlantic, this area had mixed deciduous forests of oak and alder, with admixtures of other forest elements, the only varying element being the quantitative proportions of these dominant species. Why there should be this oscillation it is hard to say. The percentage of herbaceous species is the same throughout the whole profile, a little greater in the last phase, so that there are no marked signs of anthropogenic impact. Irrespective of the varying of the proportions described, it may be concluded that the type of mixed deciduous forest with oak and alder prevailing was probably formed in the period of the Atlantic.

The peat in the village of Dubravice, north west Croatia (183 m a.s.l.) enabled the reconstruction of vegetation from the Atlantic up to the recent period (cf. GIGOV & NIKOLIĆ, 1960). In the Atlantic, this area was covered with mixed forests of beech and hornbeam. Beech dominated in the proportion of 40–65%, while hornbeam accounts for 15–25% of the forest cover. As for the other woody elements, there was the alder (*Alnus*, 10–15%) and in traces, the oak (*Quercus*), chestnut (*Castanea*), spruce (*Picea*), elm (*Ulmus*), pine (*Pinus*), willow (*Salix*), lime (*Tilia*), hazel (*Corylus*) and birch (*Betula*). An interesting presence is that of the fir (*Abies*, 5–10%) and black hornbeam (*Ostrya*). In the Subboreal there was a change in the forest cover, and beech and hornbeam, the proportions of which fell to no more than 10%, were replaced by mixed forest of oak (30–38%) and alder (27–35%). Fir totally vanished in this period, while spruce, willow, lime and holly (*Ilex*) pollen grains are present in traces. In the final phase, the Subatlantic, the oak became dominant (30–50), being accompanied by beech and alder (10–20%). Additional constituents of this forest, but in proportions of less than 10%, were hornbeam, hazel, fir, pine, chestnut, elm, spruce, willow, lime and holly. The proportion of the pollen of herbaceous plants in the first two phases is always less than the share of woody plants, which shows the

continuity of the forest cover. In the third, Subatlantic, period, in one phase it reached 65% after which it subsided again. As the determination of the pollen of the herbaceous plants has been done in too generalised a way, it is not possible to notice the fine distinctions that would indicate any anthropogenic influence with more precision. Apart from that, the dating was not performed very precisely, and so it is hard to estimate whether this change occurred in the Iron Age, the Antique/Roman or medieval period.

Since both sites in the interior of Croatia, Blatuša and Dubravice, are very interesting and significant for the reconstruction of the vegetation and yet have been treated in fairly general terms, the probably best known and most researched Slovene site has also been included in the synthesis – Ljubljansko barje, this time the most recent multi-disciplinary analysis of profiles from Podpeško jezero, with special reference to anthropogenic indicators (cf. GARDNER, 1997). In the context of pollen analyses and regional vegetation reconstructions through this long period of time, the distance of Ljubljansko barje from today's political borders with Croatia is quite negligible.

The profile of Podpeško jezero goes back to the later glacial period, characterised by the domination of pine (*Pinus)* and spruce (*Picea*). Around 8000 BC the expansion of the birch (*Betula*) began, and the lime appeared (*Tilia*) together with oak (*Quercus*). At the beginning of the Atlantic (around 7000 BC) the conifer forests were replaced by a mixed deciduous forest of oaks, limes and elms (*Ulmus*), with a smaller proportion of hazel (*Corylus*). After that, round about 6000 BC, came a short period of expansion of hazels, preceding a sudden expansion of beech (*Fagus*) around 5500 BC. Almost pure beech forests with a small percentage of oak and hazel dominated in the period between 5500 and 4200 BC, after which the proportion of fir (*Abies*) rose. After the domination of mixed forests of beech and fir, their values began to decline, in parallel with a growth in the proportion of hazel, and around 3000 BC the European hornbeam appeared (*Carpinus betulus*). In thus Subboreal phase there were mixed forests in which the beech dominated, with important percentages of hazel, hornbeam and fir, a mixture which is unique and without any modern analogies. In all these periods the pollen curve of woody plants dominates over that of herbaceous plants. At the end of the Subboreal, around 1000 BC, an interdependent cycle of rise and fall of the proportion of the pollen of woody and herbaceous species began, and from about 500 AD there was a lasting trend towards the reduction of the forest cover and a growth in the indicators of grassland and cultivated areas.

Since there are no signs of geomorphologic or suchlike influences, GARDNER, (1997) is of the opinion that the change in the vegetation in this region around 4000 BC is of an anthropogenic character, because it overlaps with the appearance of the first agricultural/pastoral communities that were engaged in animal husbandry and the cultivation of cereals. This first anthropogenic impact was not strong enough to result in a loss of the forest cover, but did bring about changes in the composition of the forests, enabling the development of species that needed more light for growth (for example *Quercus*, *Carpinus*) and could not cope with the competition of species (such as *Fagus* and *Abies*) that are much less dependent on quantities of light. This shows the basic difference between the European areas south and north of the

Alps. Anthropogenic impacts of the Neolithic communities north of the Alps is reflected more or less clearly in the pollen curves, showing a gradual depletion of the forest cover and the cultivation of grains, and impeding and changing the dynamics of the spread of woody species from the south European refugia. In the refugium area south of the Alps, the early anthropogenic impact was absorbed and was reflected in the change of the forest composition, but not in the loss of the forest covering.

A comparative review of the development of vegetation in the analysed sites in the continental or inland area of Croatia reveals a great diversity and richness of taxa, which is to be expected, considering that it is a refugium area that is at issue. This diversity hinders any general reconstruction, because no more or less united sequence in the development of the vegetation exists, as it does in the coastal area of Croatia (cf. ŠOŠTARIĆ, 2003). Nevertheless, it is visible that during the late glacial period in this area the pine and spruce were present, as well as typical post-glacial species (*Juniperus, Ephedra, Dryas octopetala*) as well as steppe elements (*Artemisia, Poaceae*) in a high percentage. They obviously remained in the higher mountain areas, and arrived along the water courses to the lower areas, so that elements of them are recorded in the first postglacial phases. In the lower and more protected areas, as early as the ice age there were confined smaller areas of mixed deciduous oak forests characteristic of this refugium area, the composition of which was dominated by the oak (*Quercus*) accompanied by the linden (*Tilia*), elm (*Ulmus*) and hazel (*Corylus*). As the glacial cold gave way, so the range of these mixed forests gradually expanded, which came particularly to the fore in the period of the Atlantic, thanks to the improvement in the climate. The beech (*Fagus*) was also present in the area in the late glacial period, but did not have any greater importance until about the end of the Atlantic and the beginning of the Subboreal, when its sudden spread occurred. In this period the climate deteriorated, with lower temperatures and more precipitation, which suited the spread of the beech at the expense of oak forests. Apart from that, the beech is among that group of trees that require very little light for development in the juvenile phase and can exist with no more than 2% of daylight, in contradiction to the taxa of the mixed oak forest, which need much more daylight for successful development (GARDNER, 1997; LANG, 1994). The expansion of the beech was accompanied, slightly belatedly, by the expansion of the fir (*Abies*), which can also successfully develop at low levels of daylight. This resulted in the formation of mixed forests of beech and fir (*Abieti-Fagetum*). Mixed deciduous oak forests were still present, existing parallel to the beech forests, and were particularly dominant in the lower areas, also constituting an admixture to the beech forests. At the end of the Subboreal and the beginning of the Subatlantic, the hornbeam (*Carpinus*) figured increasingly as a component part of the deciduous forests.

During all the post-glacial periods up to the Subatlantic, the share taken by the pollens of woody species dominated over the pollens of herbaceous plants, which means that the inland area of Croatia was continuously covered by forest, and that up to the Subatlantic there was no natural or anthropogenic devastation to result in the loss of forest cover. Since Croatia is part of the South European refugium in which, in a small area, a large number of different species and communities were

compressed, the competition for suitable space was much greater than in the area to the north of the Alps, and every ecological niche and shade of microclimatic condition was exploited to the maximum. Hence the great diversity in the pollen profiles of similar, indeed of the same, localities. A certain reserve has to be made about the area of Eastern Croatia, a fertile flatland area very suitable for arable farming and inhabited from the early prehistoric periods, where much more powerful anthropogenic impacts on vegetation might be expected; however, to date no pollen analyses have been carried out, an omission which certainly needs to be rectified.

The pollen of cereals (*Cerealia*), a direct indicator of anthropogenic activity, is rarely recorded in the pollen profiles. ŠERCELJ (1971) recorded it in the probably Subboreal layer of the Trstenik site, which might go back to the Early Neolithic. As GARDNER (1997) indicated with respect to the example of Podpeško Lake, anthropogenic influences on vegetation do not have to be directly visible in indicator species. At the end of the Subboreal and the beginning of the Subatlantic, which corresponds approximately to the Bronze and Iron ages, species that require more light and usually are found in the composition of mixed deciduous oak forests occur in the pollen profiles with increasing frequency. This is particularly visible at Blatuša and Dubravice (GIGOV & NIKOLIĆ, 1960), in which beech actually does not dominate in a single one of the postglacial phases. The pollen of beech, oak, alder, hornbeam and other taxa are always present, the proportions only varying. This can with difficulty be ascribed only to climatic oscillations, rather anthropogenic impact must be assumed as well. Livestock foraging in the woods is particularly fond of beech, particularly the young shoots, and this kind of continuous exploitation of the beech forest will hinder its ability to regenerate. This was exploited by the faster growing species that need more light for growth, and in this phase mixed oak forests once again took over the dominant position, and the hornbeam, which stands pasturing well and quickly forms cover, appears in greater numbers. The fir is also very sensitive to grazing, particularly since it cannot regenerate the lower parts of the tree, and so its presence was reduced (cf. GARDNER, 1997; LANG, 1994). Arable areas, however small they were, also opened up space for faster-growing deciduous species. The results of analysis of plant macrofossils tend to confirm this statement. The Bronze Age site of Nova Bukovica by Slatina (cf. ŠOŠTARIĆ, 2001) shows that the prehistoric inhabitants were engaged in animal husbandry and arable farming and that in the forests the oak was present in large populations, because its mast was probably used to feed swine. A prehistoric site in Kamensko of the early Iron Age (cf. ŠOŠTARIĆ, 2003) also shows that the inhabitants of the time were into animal husbandry and arable farming, particularly the cultivation of cereals. It is very likely that they sent the animals to forage in the woods and then cleared areas in the forest for the cultivation of grains and legumes; however, this was an impact that did not have a lasting effect and/or did not cover areas big enough to have a major deleterious influence on the forest cover. Particularly illustrative is the site called Hajndl, Early Iron Age (cf. ŠOŠTARIĆ, 2003), which not only shows that the inhabitants of this prehistoric settlement kept animals and cultivated crops, but also reflects their impact on the environment. This refers primarily to the

elements of grassland vegetation of the present day class *Molinio-Arrhenatheretea*, and elements of bush and forest edge vegetation in the framework of the present day class *Querco-Fagetea*. Weed species found show that they probably cultivated winter and summer sown crops, and a relatively large number of species found that today belong to the category of ruderal vegetation show that this was a quite permanent settlement, and that there was hence a fairly long-term effect on the environment. The ancient period sites of Ščitarjevo and Ilok (cf. ŠOŠTARIĆ, 2003) reflect the richness of the agricultural activity, which refers not only to the cultivation of cereals and legumes, but to the long-term cultivation of fruit, which implies a permanent settlement and a developed infrastructure. This undoubtedly resulted in quite a large-scale devastation of the environment, and, as in the coastal area, the vanishing of quite large areas of forest, particularly in the lowland regions.

It can be concluded that the anthropogenic impact on forest vegetation in the inland part of Croatia started as early as the Neolithic, but that it did not essentially jeopardise it in this early phase. It did not result in the loss of the forest cover, as it did in parts of Central Europe, but certainly in the change of its composition. The separation of winter and summer sowings, the development of grassland for grazing, and the arable-fallow system for cultivation of the soil (cf. BEHRE, 1988; BEHRE & JACOMET, 1991) started perhaps in the Bronze Age, and at the latest in the Iron Age, making the anthropogenic impact on the environment all the greater. In this phase the forest cover still dominated. Probably the arable and grassland plots were quite small and for the fodder for the livestock, the pasturing in the forest was important. Thus the anthropogenic impact is still reflected in the oscillations in the composition of the forests, but in the rise in the proportion of herbaceous plants as well. The ancient Roman period brought a much more advanced agriculture and undoubtedly greater anthropogenic influence, which entails a sensible reduction in the forest cover.

Particularly interesting are finds of chestnut (*Castanea*) pollen in the layers of the Atlantic or Neolithic phase from Dubravica (GIGOV & NIKOLIĆ, 1960). It is generally held that the chestnut and the walnut (*Juglans*) were brought into the area, and further off into North West Europe, by the Romans, and the pollen curve for them usually occurs in the ancient Roman period. In the coastal period, this really is the case. Results of pollen analysis (cf. e.g. JAHNS & BOGAARD, 1998) and of analyses of plant macrofossils (cf. e.g. ŠOŠTARIĆ & KÜSTER, 2001) show that chestnut and walnut were brought to the coastal area by the Greeks and Romans, who cultivated them, the species later spreading to appropriate natural habitats. As for the inland part of Croatia and Slovenia, ŠERCELJ (1971) thinks that the chestnut was present here earlier, but, since it is not an essential component of the climax forests, appeared only occasionally. It got the chance for development only with the anthropogenic opening of the compact complex of the natural forests, which happened to a great extent in the Antique/Roman period. Thus the formation and spread of specific communities of oak and chestnut were accelerated by the parallel processes of the cultivation of the chestnut and the devastation of the natural forests.

Since in this context the very interesting sites of Blatuša and Dubravice (GIGOV & NIKOLIĆ, 1960) have been analysed in very general terms and without any direct

dating of the individual layers, a review certainly ought to be made. A multidisciplinary approach to the analysis of these sites (cf. e.g. GARDNER, 1997) would provide new, more precise, data about the development of the vegetation of the area and its dependence on anthropogenic impact.

## CONCLUSION

A comparative review of the development of the vegetation of the sites analysed in the continental area of Croatia (Tab. 2) reveals the great diversity and richness of the taxa, which can be expected since this is a refugium area. It is clear that in the

**Tab. 2.** Summary of the development of the vegetation of the inland area of Croatia during the postglacial period (AP – arboreal pollen, NAP – non-arboreal pollen; lower areas – ca 100 – 300–600 m a.s.l., higher areas – ca 300–600 – 1200–1300 m a.s.l., depend on geographical position, altitude, inclination and aspect of area). In this review the system of chronostratigraphical ages of Late Glacial and Holocene (according to LANG 1994) is applied. The system is based on simplified combination of old climestratigraphical names of ages (like Boreal, Atlantic et al.) and time scale based on absolute dating techniques (BP – conventional radiocarbon ages /years before present/ and dendrochronologicaly calibrated ages /years before Christ/). Even this system is adjusted above all to the North Europe, it is used in this review as a simple and approximate time orientation. In this article special attention is given to the anthropogenic impact on the vegetation, therefore in time scale also historical ages (like Neolithic, Bronze Age et al.) are included and approximately placed in suitable Ages.

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|---|---|---|---|
| **SUBATLANTIC**<br>**(Iron Age – Recent Period)**<br>ca 2500 BP – Rec. P.,<br>ca 800 BC – Rec. P. | ***Quercus*** etc.<br>and<br>+ ***Carpinus***<br>(lower areas) | +/– AP/NAP | ***Fagus***<br>***Abies***<br>(higher areas) |
| **SUBBOREAL**<br>**(Late Neolithic – Bronze Age)**<br>ca 5000 – 2500 BP,<br>ca 3800 – 800 BC | | anthropogenic impact<br>AP | ***Fagus***<br>(***Abies***) |
| **ATLANTIC**<br>**(Neolithic)**<br>ca 8000 – 5000 BP,<br>ca 7050 – 3800 BC | | (anthropogenic impact)<br>***Quercus* + *Tilia*, *Ulmus*, *Corylus***<br>AP | (***Fagus***) |
| **BOREAL**<br>ca 9000 – 8000 BP,<br>ca 7850 – 7050 BC | | AP | |
| **PRAEBOREAL**<br>ca 10000 – 9000 BP | | AP | |
| **LATE GLACIAL**<br>ca 13000 – 10000 BP | | (***Quercus* + *Tilia*, *Ulmus*, *Corylus***)<br>***Pinus, Picea;***<br>***Juniperus, Ephedra, Dryas octopetala***<br>***Artemisia, Poaceae*** | (***Fagus***) |

later glacial period, this area contained the pine (*Pinus*) and spruce (*Picea*) and typical representatives of the postglacial era (*Juniperus, Ephedra, Dryas octopetala*) as well as steppe elements (*Artemisia, Poaceae*) in a high proportion. They clearly stayed on in the higher mountain areas, and arrived along the water courses in the lower areas, elements thus being recorded in the first postglacial phases. In the lower and more protected areas, during the glacial period itself, there were confined smaller areas of mixed deciduous oak forests, characteristic of this refugium area, the composition of which was dominated by oak (*Quercus*), which was accompanied by linden (*Tilia*), elm (*Ulmus*) and hazel (*Corylus*). As the glacial cold relented, the range of these mixed forests gradually expanded, which was particularly prominent in the period of the Atlantic, thanks to the improvement in the climate. The beech (*Fagus*) was also present in the area in the later glacial phase, but did not have any great importance until about the end of the Atlantic and the beginning of the Subboreal, when it started suddenly to spread. The spread of the beech was accompanied, with a small degree of delay, by that of the fir (*Abies*), which resulted in the formation of mixed beech and fir forests (*Abieti-Fagetum*). Mixed deciduous oak forests were still present, existing in parallel with the beech woods and dominant particularly in lower areas, or constituting admixtures to the beech forests. At the end of the Subboreal and beginning of the Subatlantic, the hornbeam (*Carpinus*) appears with increasing frequency as a component part of the mixed deciduous forests.

During all the postglacial periods up to the Subatlantic, pollens of woody species are dominant over pollens from herbaceous plants, which means that the continental area of Croatia was continuously covered with forests, and that until the Subatlantic there were no major areas of natural or anthropogenic devastation to result in the loss of the forest cover.

Anthropogenic impacts on the forest vegetation in the continental part of Croatia started as early as the Neolithic, but did not constitute an essential threat to it at this time. It did not result in loss of the forest cover, as it did in some parts of Central Europe, rather in a change in the composition. The separation of winter sown and summer sown crops, the development of grassland for animal grazing, and the arable-fallow system of tillage started perhaps in the Bronze Age, at the latest in the Iron Age, making the anthropogenic impact on the environment greater. In this phase, the forest cover was still dominant. Probably the arable and grass plots were still quite small, and foraging in the forests was still important for the livestock. Thus the anthropogenic impact continued to be expressed in oscillations in the composition of the forest, as well as in the rise in the proportion of herbaceous plants. The Antique/Roman period brought with it a much more advanced agriculture, and without doubt much greater anthropogenic impacts, which necessarily imply a sensible reduction in the area of the forest cover.

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## SAŽETAK

### Razvoj vegetacije u kontinentalnom području Hrvatske tijekom postglacijala

R. Šoštarić

Komparativni pregled razvoja vegetacije analiziranih lokaliteta u kontinentalnom području Hrvatske (tab. 2) odaje veliku šarolikost i bogatstvo svojti, što je za očekivati, s obzirom da se radi o refugijalnom području. Vidljivo je da su tijekom kasnog glacijala na ovom području bili prisutni bor (*Pinus*) i smreka (*Picea*), te tipični postglacijalni predstavnici (*Juniperus, Ephedra, Dryas octopetala*), kao i stepski elementi (*Artemisia, Poaceae*) u visokom postotku. Oni su se očito zadržavali u višim

gorskim predjelima, te vodenim tokovima pristizali u niže predjele, tako da su njihovi elementi zabilježeni i u prvim postglacijalnim fazama. U nižim i zaštićenijim predjelima već su tijekom glacijala bile stisnute manje površine miješanih listopadnih hrastovih šuma karakterističnih za ovo refugijalno područje, u čijem sastavu je prevladavao hrast (*Quercus*), a pratili su ga lipa (*Tilia*), brijest (*Ulmus*) i lijeska (*Corylus*). Kako su glacijalne hladnoće popuštale, tako se postepeno širio i areal ovih miješanih šuma, što je naročito došlo do izražaja u razdoblju atlantika, zahvaljujući poboljšanju klime. Bukva (*Fagus*) je također bila prisutna na ovom području u kasnoglacijalnoj fazi, ali nije imala veću važnost sve do otprilike kraja atlantske i početka subboralne faze, kada je počelo njeno naglo širenje. Širenje bukve pratilo je, s malim zakašnjenjem, širenje jele (*Abies*), što je rezultiralo formiranjem miješanih šuma bukve i jele (*Abieti-Fagetum*). Miješane listopadne hrastove šume i dalje su bile prisutne, egzistirajući paralelno uz bukove šume i dominirajući naročito u nižim predjelima ili čineći primjesu bukovim šumama. Krajem subboreala i početkom subatlantika sve se češće javlja grab (*Carpinus*) kao sastavni dio miješanih listopadnih šuma.

Tijekom svih postglacijalnih razdoblja do subatlantika, udio polena drvenastih vrsta dominira u odnosu na udio polena zeljastih biljaka, što znači da je kontinentalno područje Hrvatske kontinuirano bilo pokriveno šumom i da do subatlantika nije bilo većih prirodnih ili antropogenih devastacija koje bi rezultirale gubitkom šumskog pokrova.

Antropogeni utjecaj na šumsku vegetaciju u kontinentalnom dijelu Hrvatske započeo je još u neolitiku, ali je u toj ranoj fazi nije bitno ugrožavao. Nije rezultirao gubitkom šumskog pokrivača, kao u srednjoj Europi, već promjenom njegovog sastava. Odvajanje zimskih i ljetnih usjeva, razvoj travnjaka za ispašu stoke, te »arable-fallow« sustav obrađivanja zemlje započeo je možda u brončanom, najkasnije u željeznom dobu, čime je i antropogeni utjecaj na okoliš bio veći. U toj fazi još uvijek dominira šumski pokrivač. Vjerojatno su ratarske i travnjačke parcele relativno male i još uvijek je za prehranu stoke važna ispaša u šumi. Stoga se antropogeni utjecaj i dalje odražava u kolebanjima u sastavu šume, ali i u rastu udjela zeljastih biljaka. Antičko razdoblje donosi puno naprednije poljodjelstvo i nesumnjivo veći antropogeni utjecaj, koji podrazumijeva i osjetno smanjenje šumskog pokrivača.