

The "Waly" reserve was originally grazed, and new gaps in the sward were continuously formed by grazing animals. When the reserve was set aside in 1954, grazing was prohibited, but this regulation was not efficiently enforced, especially in the SEE part of the reserve which is surrounded by arable fields. Consequently, there was a marked invasion of shrubs in the NWW part of the reserve adjoining the forest, but the vegetation in the SEE corner still remains more open, with *Carlina onopordifolia* seedlings appearing in the gaps and encroaching on the neighbouring fields which have since been abandoned. This very clearly indicates that *Inuletum ensifoliae* is a seral plant community which can be maintained (with all its interesting components) only through continuous disturbance (e.g. grazing). The "Waly" reserve is the locus classicus of the hybrid *Carlina* x *szaferei* (= *C. acaulis* x *C. onopordifolia*). On the arable fields near the "Waly" reserve many rare thermophilous and calciphilous segetal weeds once occurred, forming the community *Caucalido-Scandicetum* (with *Adonis aestivalis*, *Anagallis foemina*, *Caucalis platycarpos*, *Conringia orientalis*, *Fumaria vaillantii*, etc.) (KORNAS 1950). Most of them have recently become very scarce or even extinct because of modernization of the agricultural practices.

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## Palaeoenvironmental changes in the Polish Carpathians (S. Poland) during the last 12'000 years

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#### INTRODUCTION

The Polish Carpathians include the northern part of the West Carpathians and a small northwestern part of the East Carpathians. For the purpose of palaeo-ecological synthesis within IGCP Project No. 158 (RALSKA-JASIEWICZOWA and LATALOWA 1992), the area has been subdivided into five type regions (Fig. 1). Type regions P-a and P-b, in the West Carpathians, include the Polish part of the Tatra Mts. (2500 m a.s.l.), the Western Beskidy Mts. (1725 m a.s.l.) and the intervening Orawa-Nowy Targ Basin (650-700 m a.s.l.). The region P-c, Low Beskidy, lies between 500-800 m with occasional elevations up to 997 m a.s.l. Region P-d comprises the Jaslo-Sanok Depression and Forelands with elevations in the range of 230-600 m a.s.l. Regions P-c and P-d together form a lower-lying corridor between the western and eastern ranges of the Carpathians, directly exposed to the climatic influences of the Hungarian Plain. The Bieszczady Mts. in the East Carpathians, which rise from 420 to 1350 m a.s.l., form type region P-e.

Although geologically similar, formed chiefly of flysch, there are major differences in geomorphology, hydrology, climate and vegetation between the eastern and western parts of the Polish Carpathians. Thus, the climate of the

Bieszczady Mts. is more continental and the mountain slopes drier than in the western regions. In terms of vegetation, spruce is a more minor and beech a more important component of forests in the east than in the west. The conclusions on environmental changes in the Polish Carpathians presented here are based on data from six reference and eight additional sites (Fig. 1). They represent all type regions except for the Beskidy Mts. (P-b). Sites are located at 600-650 m a.s.l. in P-a (Nowy Targ Basin), 470-680 m a.s.l. in P-c, 230-300 m a.s.l. in P-d, and 600-700 m a.s.l. in P-e region. The sites are all mires. In the Jasło-Sanok region, however, the development of mires was preceded by a late-glacial phase of lacustrine conditions (WOJCIK 1987). The main changes in regional vegetation, human impact, mire development, hydrology and climate are presented schematically for each region and correlated in the event stratigraphy table (Fig. 2).

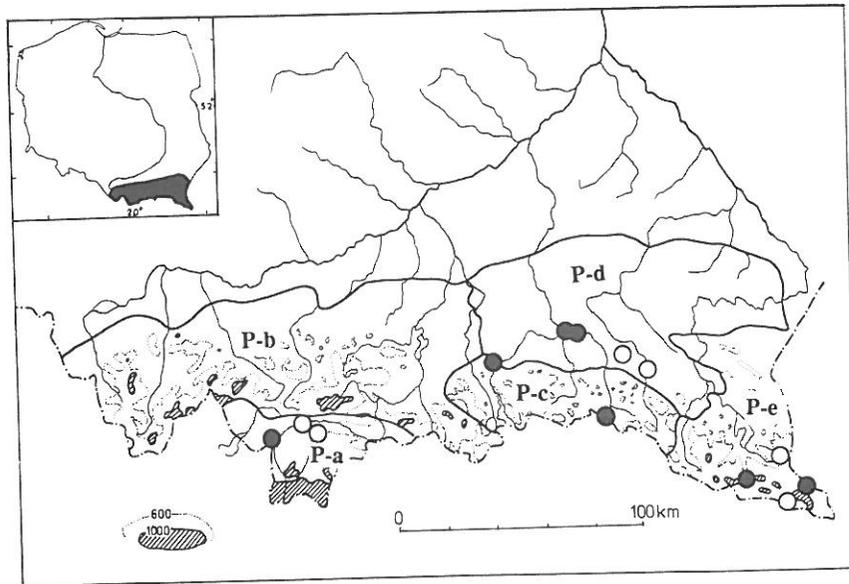


Fig. 1. The subdivision of the Polish Carpathians into palaeoecological type regions. P-a, P-b, P-c, P-d, P-e, see p. 109.  
● - reference sites for IGCP-158 Project, ○ - additional sites.

## REGIONAL VEGETATION

The main components of the late-glacial forests in the Polish Carpathians were mostly conifers - *Pinus sylvestris* (*Pinus mugo* included?), *Pinus cembra*, *Larix* and *Picea*. *Betula* played a significant role only in the Jasło-Sanok Depression (HARMATA 1987), *Pinus cembra* and *Larix* were more important components of the forests in the Eastern Carpathians (RALSKA-JASIEWICZOWA 1980). Remnants of conifer forests survived the Younger Dryas, up to at least 650-700 m a.s.l. Their decline occurred around 9'600 B.P. in the east, but only around 8'900 B.P. further west.

The formation of Holocene woodlands in different parts of the Carpathians was closely connected with time and the migration routes of particular trees. It generally progressed earlier in the eastern areas, e.g. the expansion of *Ulmus* has been recorded around 9'300 B.P. in the Bieszczady Mts. but only around 8'800 B.P. in the Nowy Targ Basin (OBIDOWICZ 1989, 1992). *Corylus* and *Tilia* appear to have migrated into the Carpathians along the Carpathian Low (regions P-c and P-d) shortly after 9'000 B.P. and subsequently spread both east- and westwards (RALSKA-JASIEWICZOWA 1983). The mid-Holocene woodlands of low and middle altitudes were generally dominated by *Ulmus* and *Corylus*.

The forest communities remained relatively stable during the middle Holocene, specifically from c. 8'700 till 4'500 B.P. in the east, and from 8'000 till 4'900 B.P. in the west, with a locally increasing role of *Picea* in the younger part of this time span.

The period between c. 4'900-3'600 B.P. witnessed a fundamental transformation of the Carpathian forests. *Ulmus* and *Corylus* receded nearly synchronously in all regions (except that *Corylus* is still abundant in P-a). *Picea* became dominant in the western and central Carpathians (P-a, P-c and P-d), remaining so for c. 1'000-1'300 years. The decline of *Ulmus* and *Corylus* in the eastern ranges was followed by the immediate expansion of *Carpinus* and *Fagus*. These species appear to have immigrated from the east and spread westward between c. 4'400 B.P. (P-e) to 3'600 B.P. (P-a). In contrast, *Abies*

Fig. 2 (p. 112-113). The Polish Carpathians - event stratigraphy table.  
1 - first arrival, 2 - expansion, 3 - maximum values. B.P. - before present.  
A - *Abies*, Al - *Alnus*, B - *Betula*, Bn - *Betula nana*, Ca - *Carpinus*, Co - *Corylus*, F - *Fagus*, Fx - *Fraxinus*, H - *Hippophae*, J - *Juniperus*, L - *Larix*, Pc - *Pinus cembra*, Pi - *Picea*, Ps - *Pinus sylvestris*, Q - *Quercus*, T - *Tilia*, U - *Ulmus*.



migrated into the mountains from the west and spread initially in lower elevations. It appeared at c. 3'900 B.P. in P-d, 3'600 B.P. in P-a, 3'200 B.P. in P-c, and 2'700 B.P. in P-e regions (RALSKA-JASIEWICZOWA 1983).

The modern forest zones in the Polish Carpathians were gradually formed between c. 4'300-2'500 B.P. In the Bieszczady Mts. *Carpinus* and *Fagus* forests were established around 4'300 B.P. but the expansion of *Abies* was considerably delayed. In the Jaslo-Sanok Depression, vegetation similar to the present developed around 4'000 B.P., and in the Nowy Targ Basin around 3'600 B.P. The recession of the atlantic forests in the Low Beskidy was delayed until around 3'300 B.P. because of the exposure of this region to the climatic influences from the south (SZCZEPANEK 1987, 1989).

## HUMAN IMPACT

The earliest evidence of human settlements in the pollen records from the Carpathians comes from the Jaslo-Sanok Depression (P-d). It is dated at around 5'000 B.P. (HARMATA 1987), and may reflect the penetrations of the Neolithic Funnel Beaker Culture (VALDE-NOWAK 1991). In the Bieszczady region (P-e), traces of human presence appear around 4'400-4'300 B.P. It is most likely that these records were connected with the Neolithic Tribes of the Corded Ware Culture based on pastoral economy.

Tribes of the Late Bronze and Early Iron Lusatian Culture spread into the Polish Carpathians between 3'200-3'000 B.P. These people were also largely dependent on animal husbandry. Their impact on the mixed deciduous forests of the lowest forest zone is distinctly visible in the pollen records.

The period of Roman influence, after 2'000 B.P., is marked by a further intensification of human impact (TUNIA 1991). Numerous north-south trade routes were opened up through the Carpathians and permanent settlements built along them. The inhabitants of these settlements practiced both agriculture and animal husbandry.

Large-scale forest destruction with the development of secondary forests and permanently-grazed meadows occurred during the Early Medieval and Medieval colonization of the Carpathians after 1'000 B.P. The establishment of a system of castles and fortified settlements during this period had the greatest impact on the forelands of the eastern ranges.

Evidence of human impact in the Low Beskidy (P-c) is limited and confined to the relatively recent past. This may reflect an unfavourable selection for the documentation of anthropogenic changes.

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