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The Góry Świętokrzyskie Mountains (Central Poland)

Edward BRÓŻ

1. INTRODUCTION

The Gory Swietokrzyskie Mountains are typically low and located north of the huge Carpathian Mountain range. Their area and limits are determined in different ways, depending on the accepted criterion (Fig. 1). The Gory Swie-

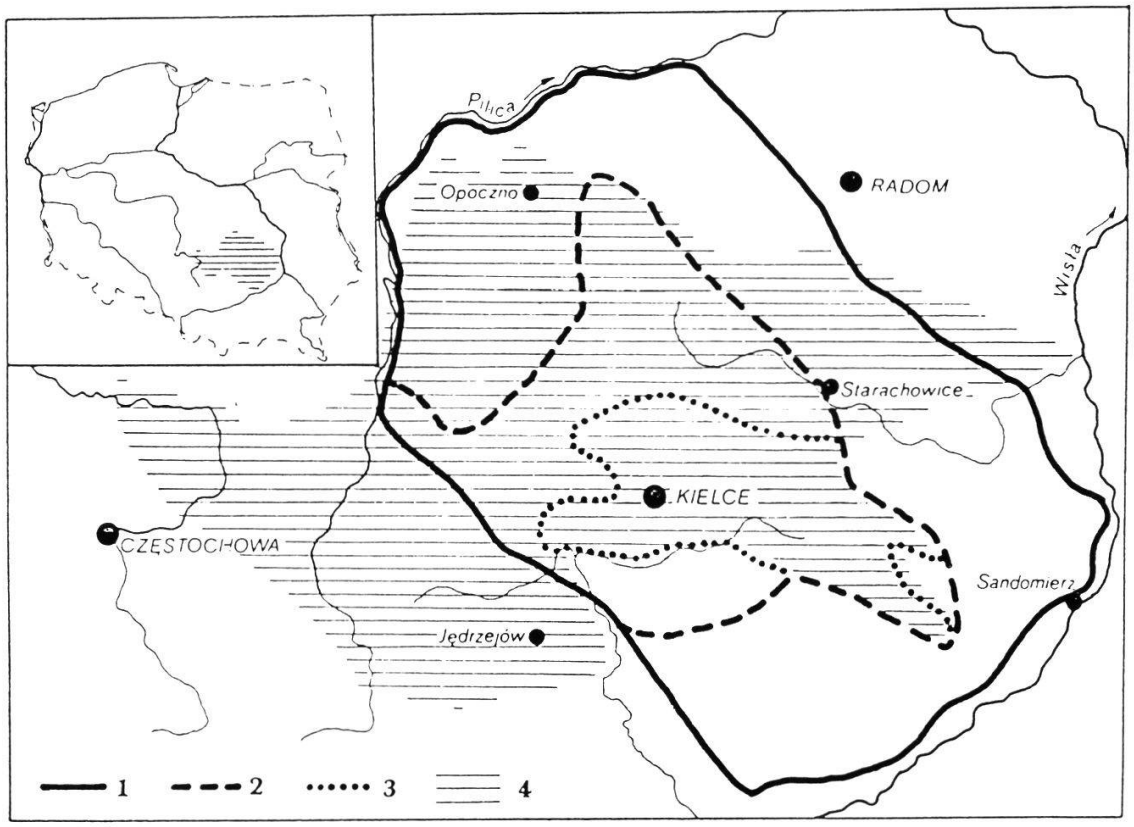

Fig. 1. Location and limits of the Swietokrzyski region according to the following criteria: 1 - tectonic-structural (CZARNOCKI 1930), 2 - geomorphological (WROBLEWSKI 1977), 3 - geographical (KONDRACKI 1981), 4 - geobotanical (SZAFER and PAWLOWSKI 1972).

tokrzyskie Mts. were raised for the first time (as the so called "Sandomirydy") on the turn of the Cambrian and Ordovician Period as a result of Precaledonian orogenic movements. The final formation of the orogen occurred, howev-

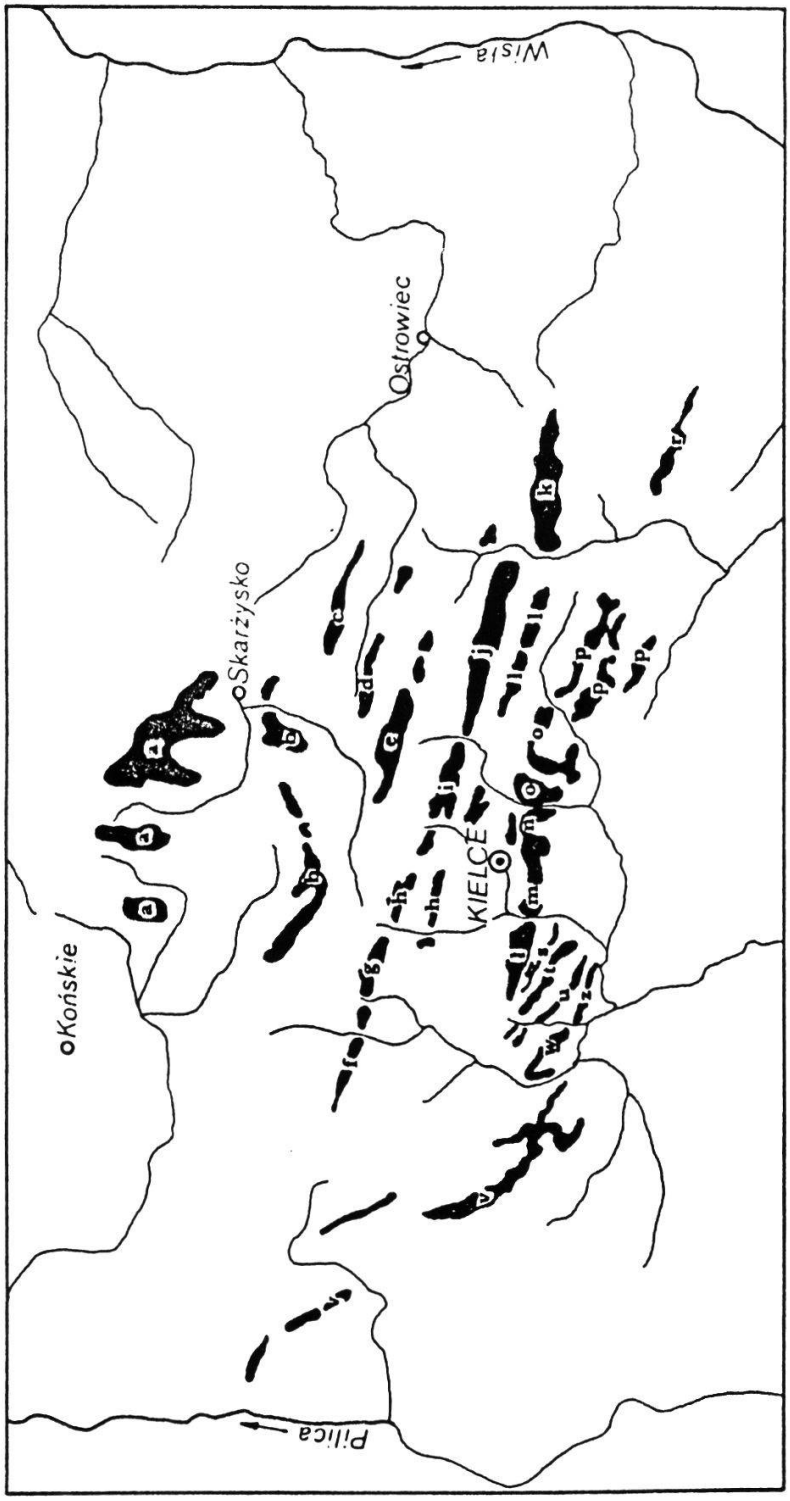

Fig. 2. Important orographic characters of the Gory Swietokrzyskie Mts.
a - Gielniowski Hump, b - Suchedniowskie Tables, c - Bronkowickie Hills, d - Sieradowickie Range, e - Klonowskie Range, f - Dobrzeszowskie Hills, g - Oblegorskie Range, h - Tumlinskie Hills, i - Maslowskie Range, j - Lysogorskie Range, k - Jeleniowskie Range, l - Bielinskie Range, ł - Zagorskie Range, m - Poslowickie Range, n - Dyminskie Range, o - Daleszyckie Range, p - ranges: Orlowinskie, Cisowskie, Ocieseckie, r - Wygielzowskie Range, s - Bolechowicki Ridge, t - Zalejowski Ridge, u - Checinskie Range, v - Przedborsko-Malogoskie Range, w - Grzaby Bolminskie, z - Grzywy Korzeckowskie Hills.

er, as a result of the Hercynian folding on the turn of the Carboniferous and Permian Periods (c. 300 million years ago). Their present shape was determined in the Quaternary as a result of processes connected with glaciations (RADLOWSKA 1967, WROBLEWSKI 1977). Intensive weathering and erosion as

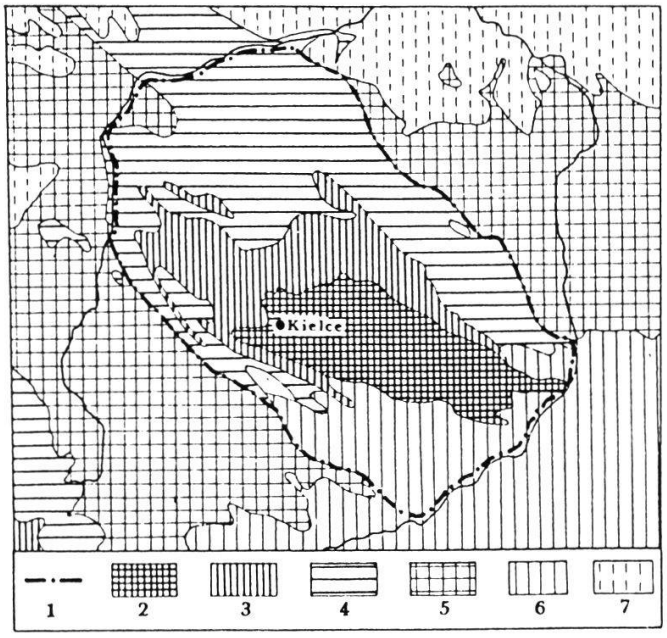

Fig. 3. Simplified geological map of the Gory Swietokrzyskie Mts. and adjacent areas. 1 - structural limits of the Gory Swietokrzyskie Mts., 2 - Palaeozoic, 3 - Trias, 4 - Jura, 5 - Cretaceous, 6 - Tertiary (marine deposits), 7 - Tertiary (continental deposits).

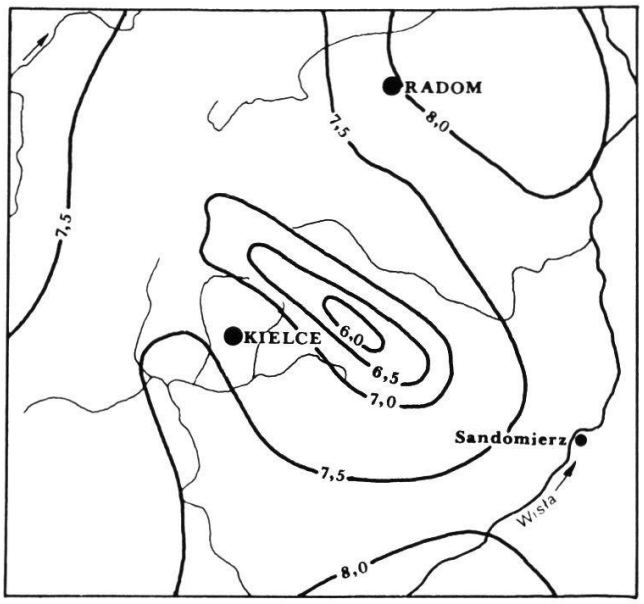

Fig. 4. Yearly isotherm in the area of the Gory Swietokrzyskie Mts.

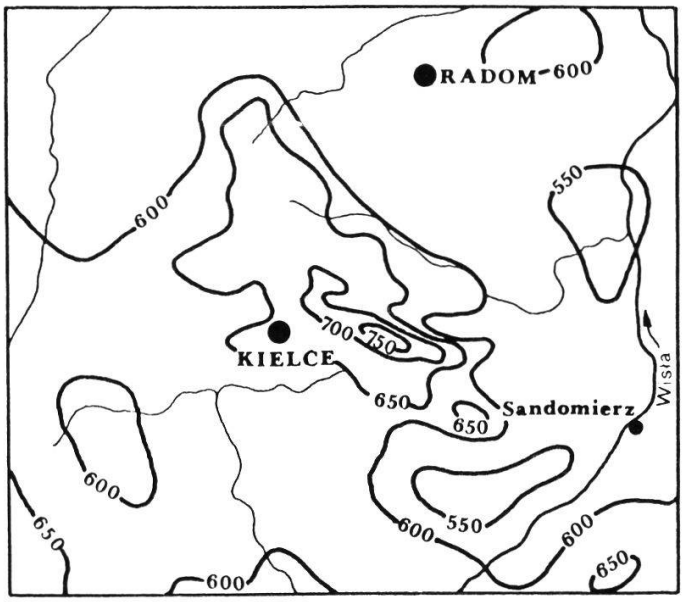

Fig. 5. Mean precipitation on the territory of the Gory Swietokrzyskie Mts.

well as the filling of valleys with deluvial and post-glacial sediments caused the decrease in denivelation and softened their relief. As the oldest orogen in Poland (apart from the Sudety Mts.) the Gory Swietokrzyskie Mts. exhibit an exceptionally complex geological composition, rich lithology and, simultaneously, small elevations (250-612 m a.s.l.). The characteristic morphological feature of the Gory Swietokrzyskie Mts. is the ridge-and-valley arrangement of the ridges and whole hill ranges of a NWW-SEE course (Fig. 2). Their central core is built of the Palaeozoic rocks (quartzites and Cambrian shists, Ordovician, Sylurian and Devonian sandstones, Devonian limestones, and dolomites). The Palaeozoic massif is protected by the Mesozoic formations, mainly the Triassic sandstones and the Jurassic limestones (Fig. 3).

Although the Gory Swietokrzyskie Mts. are not elevated high above sea level, they exhibit marked climatic differences when compared with adjacent regions. Generally, the climate is more severe and colder here (KOZLOWSKA-SZCZESNA and PASZYNSKI 1967). In the central and northern part of the mountains the mean temperature of the year is 6-7C (Fig. 4), and yearly precipitation are 650-900 mm (Fig. 5). The duration of the vegetative season decreases to 200, or even to 150 days, which means that it is shorter for four and two weeks from the vegetative seasons in Cracow and Warsaw, respectively. The differentiation of the local climate is caused by rich relief of the mountains.

2. VEGETATION

2.1. HISTORIC REMARKS

The vegetation of the Gory Swietokrzyskie Mts. was formed almost completely in the Holocene, though, its "roots" reach as early as the Pleistocene. The last severe cooling of the climate on this territory took place during the main pleniglacial of the Baltic glaciation (Würm). The tundra with a proportion of Arctic, Arctic-alpine, and steppe vegetation developed there at that period. These were mainly cryptogamic plant communities, composed of oligothermic and heliophilous mosses and lichens, covering the rocky substratum of mountain ranges. The relicts of the periglacial tundra has been preserved up to our times on bassets and rock debries (especially on the treeless mountain tops of the Lysogory) and they can be found in the specific composition of peat bogs. Forests composed of *Betula*, *Pinus*, and *Larix* were formed towards the close of the Pleistocene (Dryas). The changes in the specific composition that followed are presented in works by SZCZEPANEK (1961, 1989, 1992). It should be pointed out that the trees such as *Abies alba* and *Fagus sylvatica* which are very common at present in this area, became widespread considerably late, i.e., in the Subboreal Period.

2.2. PLANT COMMUNITIES

The landscape of the central and northern part of the region is typically woodland and agricultural. The limestone, SW part of the mountains, is characteristic of the rock material industry, very dynamic and, at the same time, harmful to the natural environment. Forest complexes cover about 35-40% of the area, mainly mountain tops and slopes and other territories not suited for agriculture. The specific composition of wood stands encompasses all native tree species occurring in Poland, some of them (*Abies alba*, *Acer pseudoplatanus*, *Fagus sylvatica*, *Taxus baccata*) reach here the limits of their continuous range in Europe (Fig. 6). The Polish larch (*Larix decidua* ssp. *polonica*) has its centre of distribution here. Because of small absolute altitude, the Gory Swietokrzyskie Mts. do not possess the typical, climatically determined, vegetation belts. The diversification of the vertical distribution of main forest tree species (and of the phytocoenoses connected with them), results from the properties of the substratum (lithological and soil conditions, humidity, edaphic conditions etc.) and, to a certain degree, from the topoclimate. Forest

communities with *Abies alba* (the *Vaccinio-Piceion* alliance) are of the special interest.

As far as the syntaxonomical classification is concerned, forest communities of the region represent four vegetation classes:

a) *Alnetea glutinosae* (associations: *Ribo nigri-Alnetum, Sphagno squarrosi-Alnetum*).
b) *Vaccinio-Piceetea* (associations of the *Dicrano-Pinion* alliance: *Cladonio-Pinetum, Peucedano-Pinetum, Leucobryo-Pinetum, Molinio-Pinetum, Vaccinio uliginosi-Pinetum, Querco-Pinetum*; associations of the *Vaccinio-Piceion* alliance: *Abietetum polonicum, Calamagrosti villosae-Pinetum, Abies alba-Sphagnum girgensohnii* community - strongly correspondent to the boreal association *Sphagno girgensohnii-Piceetum.*
c) *Quercetea robori-petraeae* (*Calamagrosti-Quercetum petraeae* in a borderland form).
d) *Querco-Fagetea* (associations of the *Alno-Padion* alliance: *Circaeo-Alnetum, Carici remotae-Fraxinetum, Ficario-Ulmetum campestris*; of the *Carpinion alliance*: *Tilio-Carpinetum*; of the *Fagion* alliance: *Dentario glandulosae-Fagetum, Dentario enneaphyllidis-Fagetum, Luzulo pilosae-Fagetum*; of the *Quercion petraeo-pubescentis* alliance: *Potentillo albae-Quercetum*).

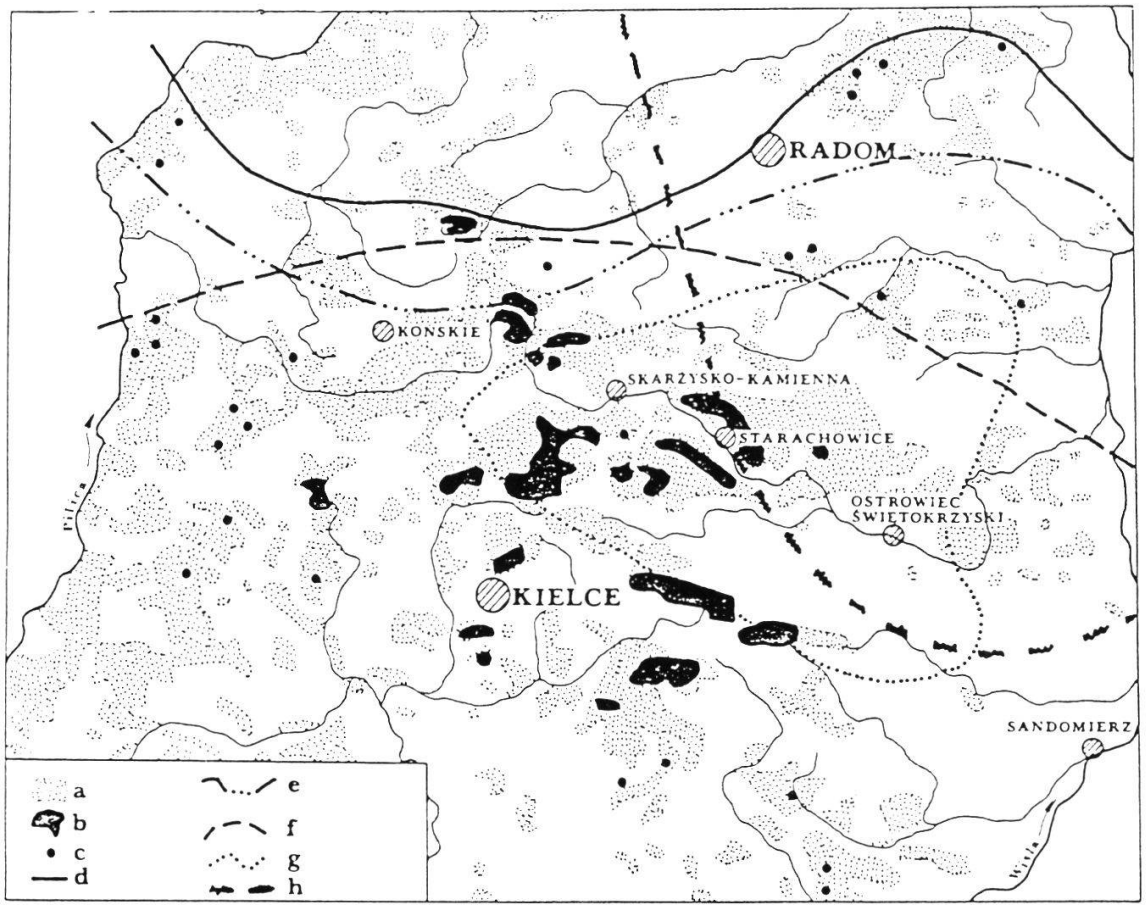

Fig. 6. Distribution of woods with *Abies alba* in Swietokrzyski region and the limits of some tree species: a - woods, b - woods with *Abies alba*, c - dispersed localities of *Abies alba*, d - N limit of *Abies alba*, e - NE limit of *Fagus sylvatica*, f - N limit of *Acer pseudoplatanus*, g - area of frequent occurrence of *Larix decidua* ssp. *polonica*, h - E limit of *Taxus baccata.*

On deforested, limestone and rocky hills of the Checinski subregion, there occur xerothermic grassland communities of the *Festuco-Brometea* class. They were used in the past as pastures. At present, as a result of successive processes, they gradually overgrow with xerothermic scrub and forest vegetation. In humid and marshy valleys, marked areas are occupied by meadows of the *Molinietalia* order. Slightly less important, because of the limited area of appropriate habitats, is the aquatic and bog vegetation of the *Phragmitetea* class, peat bog of the *Oxycocco-Sphagnetea* vegetation and *Scheuchzerio-Caricetea fuscae* classes, and sand grassland of the *Sedo-Scleranthetea* class, occurring in natural and semi-natural habitats of the whole region.

2.3. FLORA

The vascular flora of the region includes 1'400 native species and permanently naturalized anthropophytes (which constitutes c. 60% of the Polish flora). Beside the common taxa widespread throughout Europe there occur interesting geographical, altitudinal, ecological, and historic elements when compared with lowland and upland part of Poland. Many of the species reach their distribution limits here, or they occur in insular stands, very often of a disjunctive character. Among about 90 mountain species (Fig. 7), the subalpine plants are of special interest: *Allium victorialis, Avenula planiculmis, Arnica montana, Bupleurum longifolium, Centaurea mollis, Doronicum austriacum, Festuca amethystina, Lathyrus laevigatus, Polystichum lonchitis, Veratrum album* ssp. *lobelianum*. At the same time they are of a great historic value and together with other oligothermic and heliophilous boreal and mountain-boreal species e.g. *Asplenium septentrionale, Betula humilis, Hammarbya paludosa, Ligularia sibirica, Pedicularis sceptrum-carolinum, Polemonium coeruleum, Salix myrtilloides, Saxifraga hirculus, Stellaria crassifolia*) they are, most probably, glacial relicts. Some mosses (*Bryum elegans, Cynodontium polycarpum, Dicranum longifolium, Rhacomitrium rhabdocarpum, R. hypnoides, Tetraplodon angustatum, Timmia bavarica* and epilithic lichens (*Parmelia stygia, P. incurva, P. soretida, P. intestiniformis, Rhizocarpon geographicum, Umbilicaria polyphylla, U. hyperborea,* and others) are of similar age and values.

On the territory of Poland, the xerothermic flora of limestone and dolomite hills also includes numerous species of the rare, Pontic subelement and Mediterranean elements e.g., *Achillea pannonica, A. nobilis, Agropyron intermedium, Aster amellus, Asperula cynanchica, Cirsium pannonicum, Glechoma*

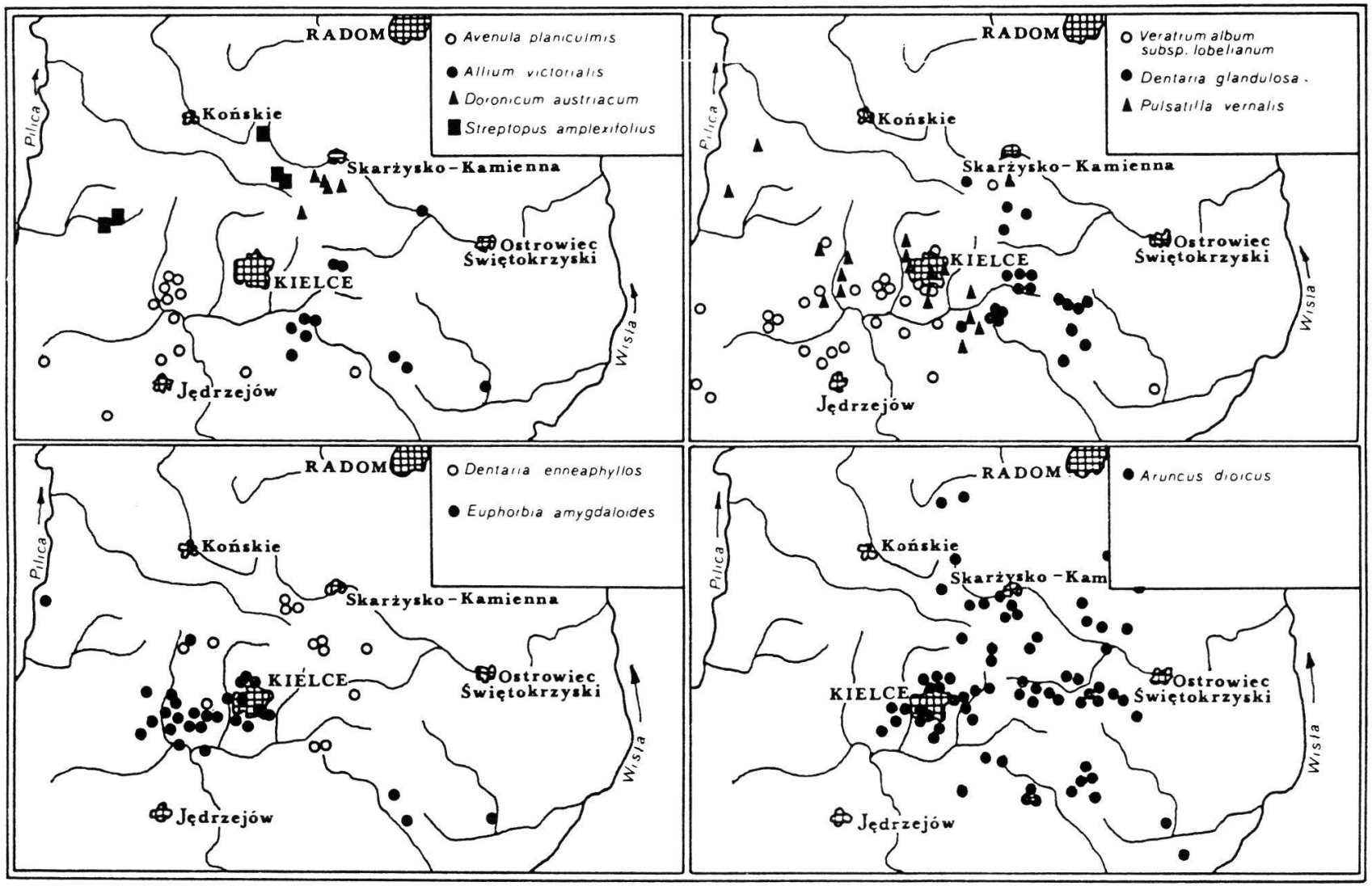

Fig. 7. Distribution of some mountain species in the Gory Swietokrzyskie Mts.

hirsuta, Inula ensifolia, I. conyza, I. hirta, Lathyrus pisiformis, Prunus fruticosa, Rosa gallica, Scorzonera purpurea, Thymus pannonicus. With the warm and dry habitats are also connected Eurasiatic plants of a continental character (so called "Sarmatic species"), e.g. *Adenophora liliifolia, Anemone sylvestris, Cimicifuga europaea, Cotoneaster niger, Crepis praemorsa, Cytisus ratisbonensis, Pulsatilla pratensis, Seseli libanotis, Trifolium lupinaster, Vicia pisiformis* and others.

The Atlantic subelement has a very scarce representation and it includes e.g., *Carex arenaria, Genista pilosa, Hydrocotyle vulgaris, Lepidotis inundata, Pedicularis sylvatica.* Other more interesting species of a western type of distribution in Europe are as follows: *Dianthus gratianopolitanus, Gentianella germanica, Potentilla tabernaemontani, Pulsatilla vernalis.*

3. HUMAN ACTIVITY AND ITS INFLUENCE ON VEGETATION WITH A PARTICULAR CONSIDERATION OF THE OLD POLISH INDUSTRIAL CENTRE

The Gory Swietokrzyskie Mts. and their northern forelands had a very important economic function in the past. Because of the abundance of different, easily accessible raw materials (flint, ore-iron, lead, copper, and other) and favourable natural conditions, the whole region became a centre of mining and metallurgy on the European scale, that is the reason why it is called the "Old Polish Industrial Centre"

The oldest traces of the presence and activity of the Neanderthal man on these territories go back 50-60 thousand years, to the Palaeolithic Period. They indicate that the contemporary mammoth hunters used local raw materials rock debris, flint, haematite) for the production of primitive tools and for obtaining the mineral dye. Towards the close of the Paleolithic Period (c. ten thousand years ago) these minerals were systematically exploited opencast.

In the Neolithic Period, on the eastern outskirts of the Gory Swietokrzyskie Mts. (in the valley of the Kamienna river and on loess uplands of the Sandomierz Upland), there occurred first settlements. Some of the Neolithic tribes of the "funnelneck beakers" and "globular amphorae" colonizing the neighbourhood of a big, flint-bearing basin (the present "Krzemionki Opatowskie" reserve) apart from agriculture and cattle raising they specialized in mining and processing of flint. This was the underground mining activity on Polish territories.

In the Iron Age, and particularly in the period of the Roman influence (2nd

century B.C. to 4th century D.C.), the northeastern part of the Gory Swietokrzyskie Mts. (subregion Lysogory) belonged to the biggest iron metallurgy centres in Europe. The haematite mines (Rudki) and a number of places with primitive, underground metallurgic furnaces were preserved to our times. The number of furnace places localized to date (c. 4'000) and about 300'000 smelting furnaces bears evidence to the importance of the ancient production of iron in the region (ORZECHOWSKI 1992). After the downfall of the Roman Empire the mining and metallurgic activity was continued, though not on a big scale, till 9-10th century.

The intensification of the Swietokrzyski iron smelting took place again in the period of the Late Middle Ages and in Renaissance. This is connected with the introduction of the new technology to the process of smelting, namely the introduction of ironworks where the power of the running water was utilized. On the turn of the 17th and 18th centuries simultaneously with the introduction of the blast-furnace way of iron smelting, mining and metallurgy spread to the northwestern part of the Gory Swietokrzyskie Mts. (Konecki subregion).

As late as the 18th century, the Swietokrzyski region was still the biggest industrial centre in Poland with many ironworks and about 170 active iron-ore mines. In spite of numerous new and bold investments made at the beginning of the 19th century, a gradual downfall of the centre took place in the second half of the 19th century.

In the past, the Gory Swietokrzyskie Mts. were not only an important centre of mining and smelting of iron-ore. Exploitation and processing of non-ferrous metal ore (mainly lead, copper, and silver) date back to the 12th century. It included most of limestone, ore-bearing hills of the Checiny subregion and of the vicinities of Kielce. The activity was continued through many centuries (its optimum occurred in the 15th and 16th centuries) and it was stopped in the 20th century after the sediments had been exhausted. The area was also an inexhaustible source of carbonate rock exploited as building stone and as a row material for calcining. In the 17th century, the mining of marble was developed on a big scale and it is continued at present.

Industry concentrated in the Checiny subregion and based on the exploitation of local rock material decided markedly the present appearance of the region. The region called the Kielce Region of Carbonate Material Exploitation" occupies an area of 670 km^2.

Exploitation of limestone rock on a gigantic scale for the purposes of the building material industry caused a continuous and irreversible devastation of

natural landscape. Dusts emitted by the cement-lime factories constitute an additional burden to the natural environment.

Several thousand years of human activity influenced markedly the landscape and vegetation of the region. In the Old Polish Industrial Centre the mining-smelting industry was a specific form of anthropopression and its traces can still be observed. The exploitation of mineral products (mainly iron-ore), apart from causing morphological deformations, induced deep changes in the range of physical and chemical properties of the soil (SWALDEK 1983). Secondary post-industrial soils formed on post-mining workings are particularly widespread on the vast ore-bearing territories of the Konecki subregion. They are more abundant habitats (rich in clay-argillitic components, with a high proportion of calcium, potassium, and other biogenic elements) than the intact primary soils. Owing to this, old mine workings dominated the secondary meso- and eutrophic forest phytocenoses from the *Querco-Fagetea* class. The mining activity on the trophically poor territories had, in this case, a positive influence.

The old Polish industry and particularly the smelting industry based on charcoal, devoured huge quantities of timber. Hard timber, especially that of beech and oak was most useful. The long-term selective exploitation of these species had a negative influence on their proportion in the tree-stand of the Swietokrzyski Forest.

Extirpation of forests, the growing number of vast post-mining workings and burned-out patches of forest which accompanied the mining-smelting industry promoted the spread of the pioneer photophilous tree species. Therefore, it is supposed that the expansion and abundant occurrence of *Abies alba* and *Larix decidua* ssp. *polonica* in the area of the Old Polish Industrial Centre is, among others, the result of human activity.

Part of the exploited and cleared territories (limestone hills in particular) survived in a treeless state up till now as a result of anthropogenic influences (cattle grazing).

In the Swietokrzyski region, similarly to the whole Poland, the disappearance of numbers of hemerophobous components of the native flora has been intensified recently (BROZ 1990). The regional "red list" includes a total of 197 species of vascular plants (c. 15% of species native to the Swietokrzyski region). The total includes also 23 already extinct and missing taxa and 63 directly endangered taxa. Particularly strong tendencies toward regression are exhibited by the species of some systematic groups (e.g. *Orchidaceae, Gentianaceae, Lycopodiaceae, Filicinae*), ecological groups (plants of wet and

shady woods, meadows, and peat bogs), and geographical elements (especially mountain plants). They are mostly endangered by changes of abiotic environmental factors (mainly hydrological conditions, microclimate, light conditions) induced by the direct human activity. Particularly threatening is the rock material mining development on a great scale and the cement-lime industry.

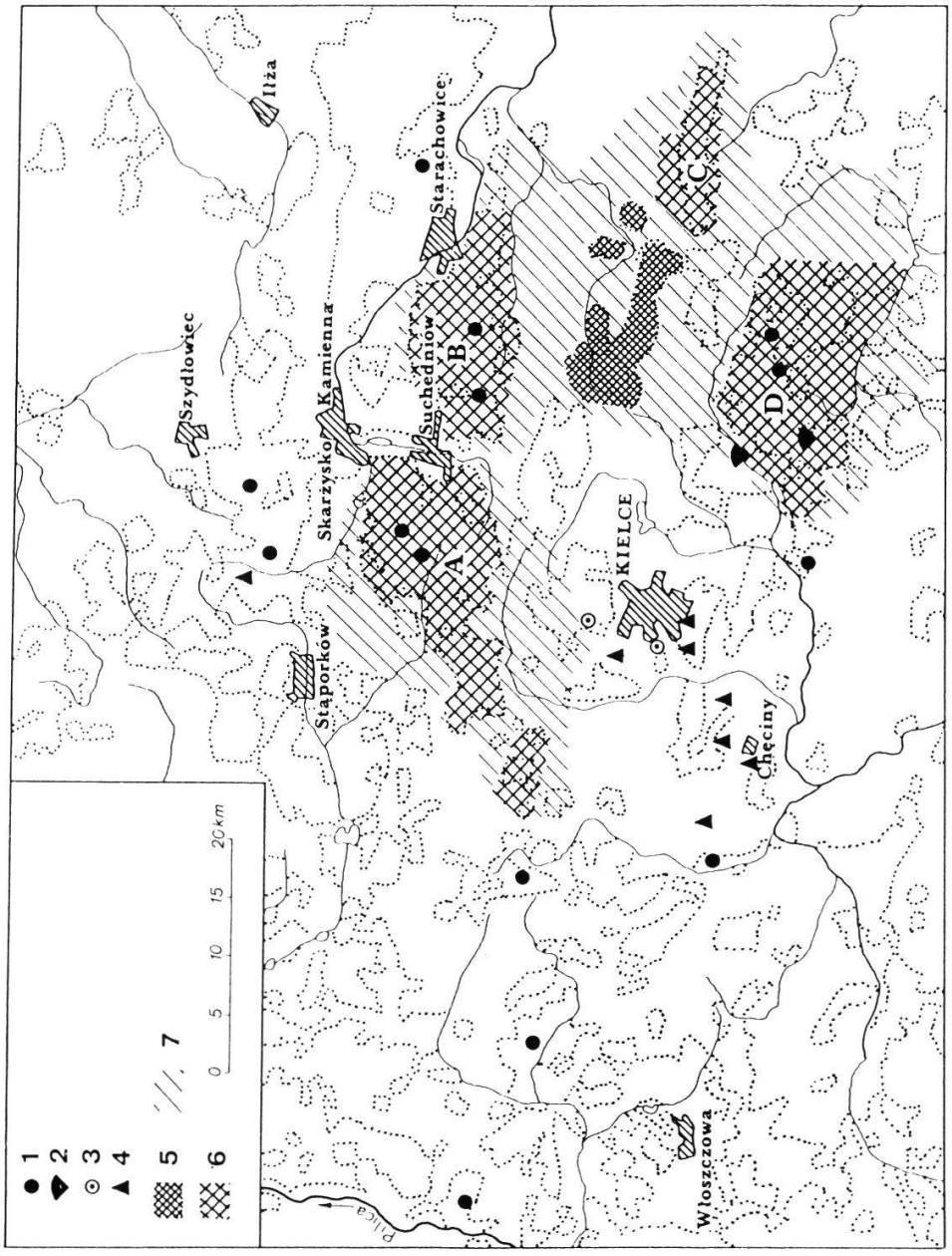

Fig. 8. Protected objects and areas in the Gory Swietokrzyskie Mts. region: 1 - forest reserves, 2 - peat bog reserves, 3 - landscape-forest reserves, 4 - inanimate nature reserves (geological), 5 - the Swietokrzyski National Park, 6 - Complex of Landscape Parks (A - Suchedniowsko-Oblegorski, B - Sieckierzynski, C - Jeleniowski, D - Cisowsko-Orlowinski), 7 = protected zone of the Swietokrzyski National Park and Landscape Parks.

4. NATURE PROTECTION

Objects and territory of the Gory Swietokrzyskie Mts. are subject to multidisciplinary forms of protection. These are nature monuments, strictly controlled and partial nature reserves, the Swietokrzyski National Park, and the Complex of Landscape Parks of the Gory Swietokrzyskie Mts. (Fig. 8). The main and most valuable protected object is the Swietokrzyski National Park (SZAFER 1959). It is simultaneously the central part of the vast system of protected areas, composed, beside the National Park, of four landscape parks: Cisowsko-Orlowinski (21'362 ha), Jeleniowski (4'745 ha), and Suchedniowsko-Oblegorski (21'474 ha). These objects include the biggest and best preserved forest complexes of the Gory Swietokrzyskie Mts. The territory of the Gory Swietokrzyskie Mts. includes also 25 nature reserves: 13 forests, 2 landscape-forests, 2 peat bogs, and 8 inanimate nature reserves.

Besides, it is planned to establish the Biosphere reserve "Blizyn" within the limits of the Suchedniowsko-Oblegorski National Park. The establishment of a rational net of floristic reserves in order to protect ("in situ") the dying out and endangered species conditions the protection of gene pool of the local flora. At present, the delimitation of such areas and determining the forms and methods of the protection of particular species is the most important task of the regional nature protection. A very important part in the protection ("ex situ") of gene pool of the local flora should be played in the future by the organized Swietokrzyski Botanical Garden in Kielce.

SUMMARY

The Gory Swietokrzyskie Mts. (250-612 m a.s.l.) were formed on the turn of the Cambrian and Ordovician Period (Hercynian orogneiss). Their central core consists of Palaeozoic rocks (mainly quarzites, sandstones, schists, limestones and dolomites). The Palaeozoic massif is protected by Mesozoic rocks. The contemporary landscape and plant cover of the Swietokrzyski region have been formed under the influence of natural conditions as well as of intensive human activity (c. 5'000 years). Because of the abundance of different accessible raw materials (flint, iron-ore, lead, copper) the whole region became a centre of mining and metallurgy in Poland ("Old Polish Industrial Centre"). Industry based on the exploitation and processing of local rocks shaped markedly the present appearance of the region.

The Gory Swietokrzyskie Mts. do not possess the typical climatically determined vegetation belts. Their plant cover is typical for the Uplands of S. Poland. Forests which occupied 35-40% of the area contain 20 plant associations. The semi-natural plant associations belonging to the following classes are of high geobotanical value: *Festuco-Brometea, Molinio-Arrhenateretea, Oxycocco-Sphagnetea, Scheuchzerio-Caricetea fuscae*. The vascular

flora of this region includes more than 1'400 species. The mountain, boreal-mountain (c. 90 taxa), Pontic and Mediterranean plants constitute particularly valuable elements of this flora.

The disappearance of hemerophobous components of the native flora from the Swietokrzyski region has been recently intensified. The regional "red list" included 197 species of vascular plants. The main and most valuable protected area is the Swietokrzyski National Park. The protected areas apart from the Swietokrzyski National Park include also four landscape parks and 25 nature reserves.

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