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Tendencies of anthropogenic changes and a programme for the active protection of vegetation in the Ojców National Park (S. Poland)

Stefan MICHALIK

1. INTRODUCTION

The Ojcow National Park (1590 ha), established in the year 1956, lies in the southern part of the Cracow-Czestochowa Upland, 22 km NNW of Cracow. It includes rocky valleys and numerous ravines built of Jurassic limestones as well as the adjacent part of the plateau (Figs. 1-3). It distinguishes itself by the highly differentiated microclimatic (KLEIN 1974) and edaphic conditions. The plant cover of the Park is very rich and diversified. There occur about 950 vascular plant species representing various ecological and geographical elements (MICHALIK 1978). A high share of xerothermic and mountain species (ca. 200 and 50 species respectively) is particularly characteristic (MICHALIK 1979, 1983). Plant communities, in a number of over 30, are of a very differentiated ecological character (MEDWECKA-KORNAS and KORNAS 1963). There occur montane sycamore forests *Phyllitido-Aceretum* and beech forests *Dentario glandulosae-Fagetum*, thermophilous beech forest *Carici-Fagetum*, mixed coniferous forests *Pino-Quercetum*, lime-hornbeam forests *Tilio-Carpinetum*, riverside carrs *Alno-Padion*, xerothermic scrub *Peucedano cervariae-Coryletum*, xerothermic grasslands *Origano-Brachypodietum*, *Koelerio-Festucetum sulcatae*, epilithic tuft grass community *Festucetum pallentis*, pastures *Lolio-Cynosuretum*, fresh and wet meadows *Arrhenatheretum medioeuropaeum*, *Cirsietum rivularis*, tall-forb communities *Alliario-Chaerophylletum*, and many others.

Man's economic activity which in the environs of the village of Ojcow began in the early Palaeolith, affected seriously the plant cover, particularly in the last centuries.

Fig. 1. The natural landcape of the Pradnik river valley in the Ojcow village (see Fig. 9).

Fig. 2. The cultivated lanscape of the Pradnik river valley near Grodzisko village.

Fig. 3. The natural forest lanscape of the Saspowka stream valley.

The vegetation of the present Ojcow National Park has been studied since the beginning of the 19th century (BERDAU 1857, BESSER 1809, JELENKIN 1901, PAWLOWSKI 1925). The comparison of the old botanic data with the corresponding ones from the period 1955-1960 permitted a detailed analysis of the anthropogenic changes in the plant cover (MICHALIK 1974). Continuous studies on the trends and rate of changes of the plant and floristic communities have been carried out since the Park was established in 1956. The results of these studies serve as a basis for the elaboration of the programme of active protection of biocenotic diversity and gene resources of the flora.

2. METHODS

The evaluation of the anthropogenic changes of the plant cover was based on an analysis of available published and archival material as well as on oral information. Apart from botanic papers the author made use of maps from different times, old photographs, woodcuts, and illustrations. On this ground the distribution and state of plant communities at the beginning of the 19th century was reconstructed and compared with the results of botanical researches

made in the years 1955-1960 (MICHALIK 1974).
Changes occurring in the plant cover during the last three decades have been characterized on the basis of the detailed investigations carried out by the author. In the years 1989-1990 there was made a map of plant communities in the Park. This map (1:10000), was compared with the corresponding one drawn 30 years ago (MEDWECKA-KORNAS and KORNAS 1963). Changes in the distribution of the vascular plants were estimated on the basis of point maps of localities (1:25000), made in the years 1960 and 1989 as well as on the basis of floristic observations. To control in a more detailed way the trends and rate of changes in vegetation there were established four permanent experimental plots being representative of the whole of biocenotic and floristic diversity of the Park vegetation. On these experimental plots investigations are carried out by means of cartographic, phytosociological methods as well as by help of quantitative ecological methods. These investigations, depending upon their purpose, are repeated in different time intervals and they are a kind of ecological monitoring.

3. RESULTS

3.1. CHANGES IN THE VEGETATION IN THE PERIOD 1809-1956

From 1809-1956 intensive husbandry was carried out on the present territory of the Park, consisting mainly of logging and grazing of livestock. This caused profound changes in all types of plant communities and in the local flora. The area of woods was reduced by 10% and conspicuous changes in the proportion of particular forest communities followed. A decrease in the range of the relict montane sycamore forest *Phyllitido-Aceretum* and in the beech-fir woods *Dentario glandulosae-Fagetum*, as well as in the riverside forests of the *Alno-Padion* association was also noted (Fig. 4).
The mixed acidophilous forests *Pino-Quercetum* and the lime-hornbeam forest *Tilio-Carpinetum* associations did not exhibit any surface changes. Their stands were, however, greatly thinned, chiefly as a result of felling of *Abies alba*.
The xerothermic scrub *Peucedano cervariae-Coryletum*, the epilithic tuft grass community *Festucetum pallentis*, the secondary xerothermic grasslands *Origano-Brachypodietum*, impoverished pastures (*Agrostis vulgaris* community), and fertile pastures, and meadows (*Lolio-Cynosuretum* and *Arrhenatheretum medioeuropaeum*) were spreading. On the whole, at the begin-

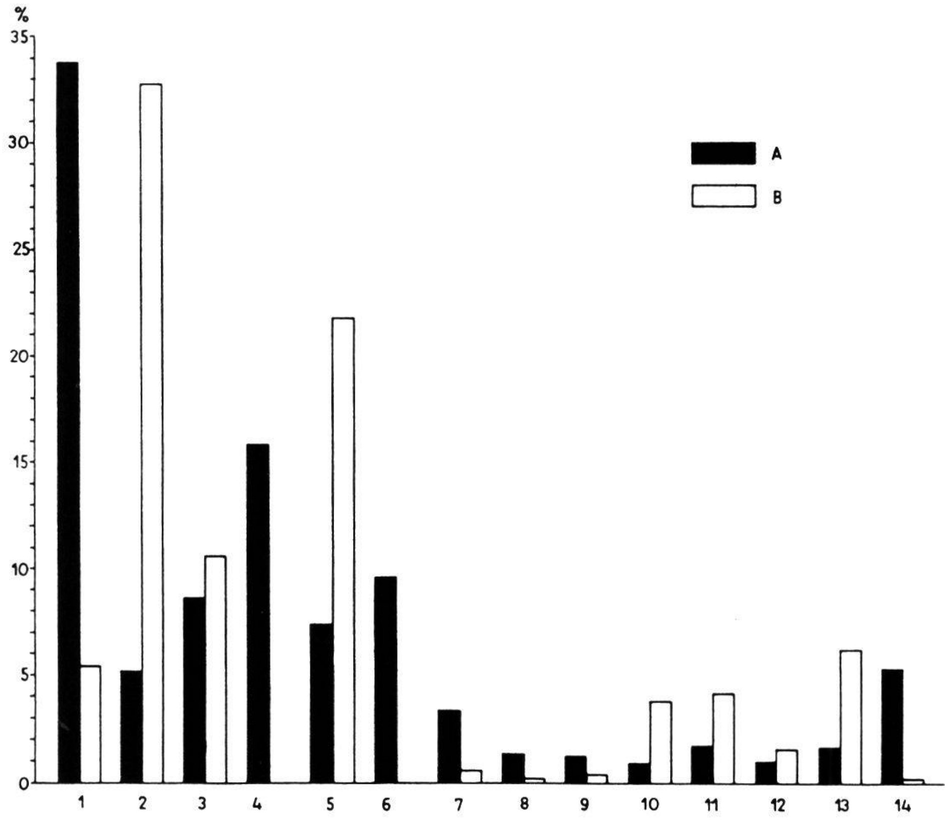

Fig. 4. Contribution of various plant communities in the Ojcow National Park in percentage relation.
A - at the beginning of the 19th century, B - at present.
1 - *Pino-Quercetum* with fir in stand, 2 - *Pino-Quercetum* with pine-oak stand, 3 - *Dentario glandulosae-Fagetum* with beech in stand, 4 - *Dentario glandulosae-Fagetum* with dominating fir, 5 - *Tilio-Carpinetum* with dominance of broadleaved trees, 6 - *Tilio-Carpinetum* with prevailing fir, 7 - *Carici-Fagetum*, 8 - *Phyllitido-Aceretum*, 9 - alluvial forest, 10 - natural xerothermic vegetation, 11 - secondary xerothermic grasslands and pastures from the *Nardo-Callunetea* class, 13 - fertile meadows and pastures of the *Arrhenatheretalia* order, 14 - wet meadows, bogs and open water vegetation.

ning of the 19th century, oligothermic, heliophobic and hygrophilous communities covered about 70% of the area, but in 1956 not more than 15-20%. Thus, a remarkable change in the ecological character of the vegetation took place. The disturbance of native communities and the proportion of synanthropic plants increased correspondingly (Table 1).

In the period 1809-1956 the flora of vascular plants underwent very great changes (Table 2). Those species which had died out or whose number decreased were mainly oligothermic, heliophobic and hygrophilous (Fig. 5). About 21 of the species which had become extinct were connected with damp meadows and aquatic environment (e.g. *Eriophorum latifolium, E. angustifolium, Gentiana pneumonanthe, Iris pseudoacorus, Lathyrus palustris, Po-*

Table 1. Extension of the degree of devastation of the native plant communities in the Ojcow National Park in the last 150 years.

Type of community	Approximate percentage of the territory occupied	
	Beginning of the 19th century	1956
native communities		
original	3	1
natural	70	12
semi-natural	24	73
synanthropic communities	4	13

Table 2. Division of flora of the surroundings of Ojcow depending on reactions of species to human activity during the last 150 years.

Group and subgroup of species	number	rate of the flora (%)
receding species		
extinct	36	3.5
endangered	37	3.5
decreasing	275	27.0
species with no significant quantitative changes	302	29.0
species with increasing participation		
newcomers	33	3.2
expanding in mass	6	0.6
expanding	184	13.2
species of undetermined character	157	15.3

tamogeton perfoliatus), and seven with shady or damp woods (*Alnus incana, Allium ursinum, Festuca altissima, Scopolia carniolica, Taxus baccata, Veratrum album* ssp. *lobelianum*).

Among the mesophilous, ubiquitous, and xerothermic plants, there was a dominant tendency to spread and to increase in population number (Fig. 5). The causes of changes in the vascular plant flora were very varied. The greatest changes were induced by the forest economy and drying out of the terrain (Fig. 6).

Similar tendencies were found also in different systematic groups of cryptogamic plants. In the lichen flora, about 30 species which had been recorded in old studies were not found. Those were mostly epiphytes of shady forest and species growing on rotting wood (NOWAK 1961). Among the Macromycetes about 31 species were not found, among them mainly those typical of primeval forest (WOJEWODA 1975). The situation was similar in the moss flora, where 35 species, mostly of hygrophilous forest (SZAFRAN 1955), were not found. In the flora of liverworts (PALKOWA 1961), among the 17 species not

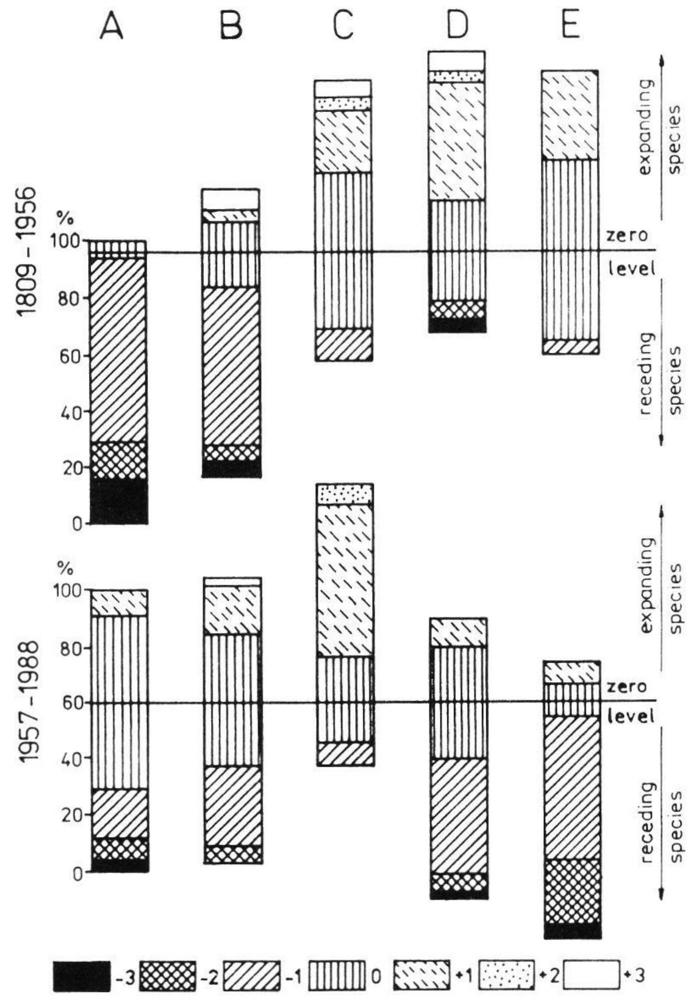

Fig. 5. Types of change in the vascular plant flora of the Ojcow National Park in different periods, in percentage proportion of the retreating species.
-3 - extinct, -2 - endengered, -1 - decreasing in number, neutral (0) and spreading (+1 - increasing in number, +2 - strongly increasing in number, +3 - new to the flora
Ecological groups of species: A - oligothermic, heliophobic and hygrophilous, B - moderately heliophobic and hygrophilous, C - mesophilous and ubiquitous, D - moderately xerothermic, E - strongly xerothermic.

found, the prevailing are typical of streams, swamps, and shady woodland. In the period 1890-1956 a distinct change in the ecological character of the flora took place. The ubiquitous, mesophilous and moderately xerothermic plants gained dominance. Above all, the species with specialized habitat demands died out, which caused a decrease in the ecological diversity of the flora. The number of species occurring on the territory of the Park diminished only slightly. Nevertheless, the receding plants clearly prevailed over the spreading ones. In the case of vascular plants their participation was 36% and 23%, respectively.

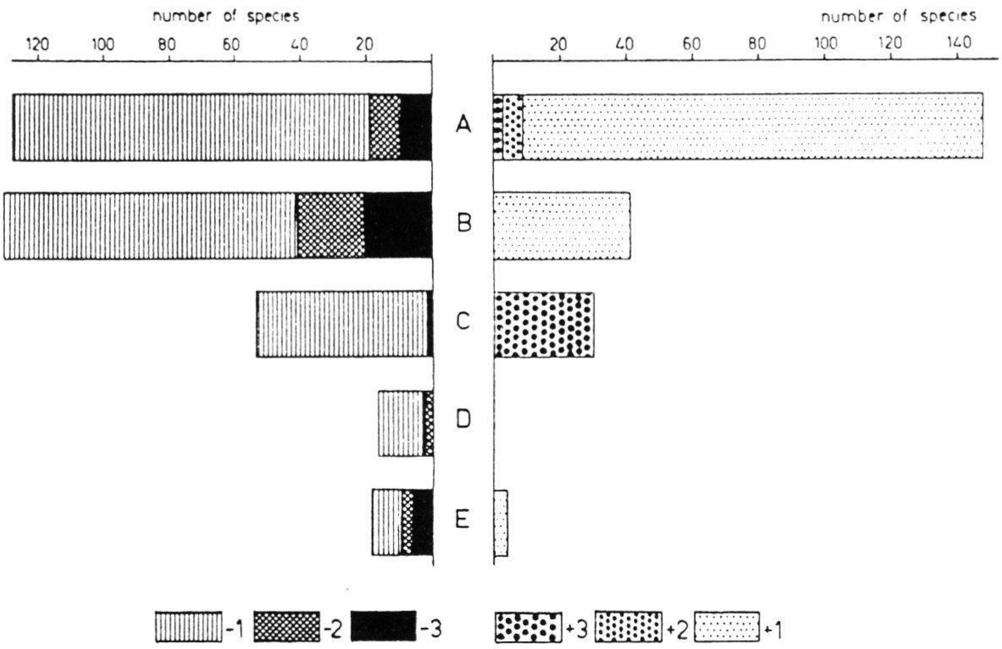

Fig. 6. Effect of different kinds of human activity on changes in the vascular plant flora in the neighbourhood of Ojcow from 1800-1956.
A - forest economy, B - drying out of land, C - various factors causing changes in synanthropic plants, D - picking of plants, E - other or undefined causes.
Species: -1 - decreasing in number, -2 - endangered, -3 - extinct, +1 - increasing in number, +2 - strongly increasing in number, +3 - new to the flora.

3.2. CHANGES IN THE PLANT COVER AFTER ESTABLISHMENT OF THE OJCOW NATIONAL PARK

In the last 30 years there occurred a distinct alteration in the previous anthropogenic trend of changes in the vegetation (Michalik 1985) and they became more rapid. It was found, for example, that in this period one species of the vascular flora died out every two years, whereas in the period 1809-1956 the loss amounted to one species every four years.

After establishment of the Ojcow National Park in 1956 and after introduction of strict protection in the natural forest biocenoses, the safety of typical mountain associations of *Phyllitido-Aceretum, Dentario glandulosae-Fagetum* and the forest associations of *Tilio-Carpinetum* was to a great extent assured and also the rate of extinction of the species connected with them was reduced. In the last 30 years only two species (*Polystichum lonchitis* and *P. braunii*), have died out. Their populations in the sixties consisted of only 1-3 specimens. At the same time, several endangered species such as *Lunaria re-*

diviva, Cypripedium calceolus, Phyllitis scolopendrium and *Arum maculatum* markedly enlarged their populations. The *Pino-Quercetum* mixed forest diminished in spite of strict protection in many cases. The main reason for this was the mass dying of coniferous trees such as *Abies alba* and *Pinus silvestris*, chiefly resulting from strong atmospheric air-pollution by sulphur dioxide and other noxious substances (GRODZINSKA 1978). The admissible norm for SO_2 concentration, 75 $\mu g/m^3/24$ h, has exceeded its limits in the last 15 years by an average 20-70% in the winter months and it shows a tendency to rise. For short periods, concentrations in winter even exceed 1000 $\mu g/m^3$. Dust fallout, which was 60 t/km^2/year in 1968 rose to 83 t/km^2/year in 1984, the admissible norm being 40 t/km^2/year.

In place of the vanishing stands of pine and fir, there is a regrowth of broad-leaved trees, mainly *Fagus silvatica, Carpinus betulus*, and *Acer pseudoplatanus*. This leads to a decline in acidophilous species of the herb-layer and the transformation of the *Pino-Quercetum* into the *Tilio-Carpinetum* association, or impoverished variant of *Dentario glandulosae-Fagetum*. The disappearance of some rare acidophilous species in the studied area was observed. For example, *Chimaphila umbellata* has already died out, and two relic stands of mountain species, *Huperzia selago* and *Galium rotundifolium* are endangered.

The share of the particular forest communities has considerably changed during the past three decades. The area of *Pino-Quercetum* has diminished by about 75% and, if the present rate of the dying of coniferous trees continues, this community may become extinct in a short time. On the other hand, *Phyllitido-Aceretum, Dentario glandulosae-Fagetum, Tilio-Carpinetum*, and alderwoods markedly extended their range. The area of the thermophilous beech forest *Carici-Fagetum* has increased many times and this community has replaced many patches of xerothermic scrub.

The visible tendency towards extinction of the communities and species of damp and aquatic habitats was not curbed after the establishment of the Park. In the last 30 years several plant associations and at least ten plant species such as: *Sanguisorba officinalis, Equisetum variegatum, E. telmateia, Poa palustris, Epipactis palustris*, and *Valeriana dioica* have died out. Also, many species of sedge (e.g. *Carex diandra, C. disticha, C. gracilis, C. vesicaria, C. vulpina*) may have already disappeared or survived only in the form of single specimens.

Mown meadows *Arrhenatheretum medioeuropaeum* occupying valley floors have undergone a strong degradation. A large area of meadows has not been utilized for the past 15-20 years and in the course of spontaneous succession transformed into the floristically poor community with *Urtica dioica* (Fig. 7). Meadows constituting a private property have been utilized too intensively (they were strongly fertilized with nitrogen, ploughed, and sown with fodder

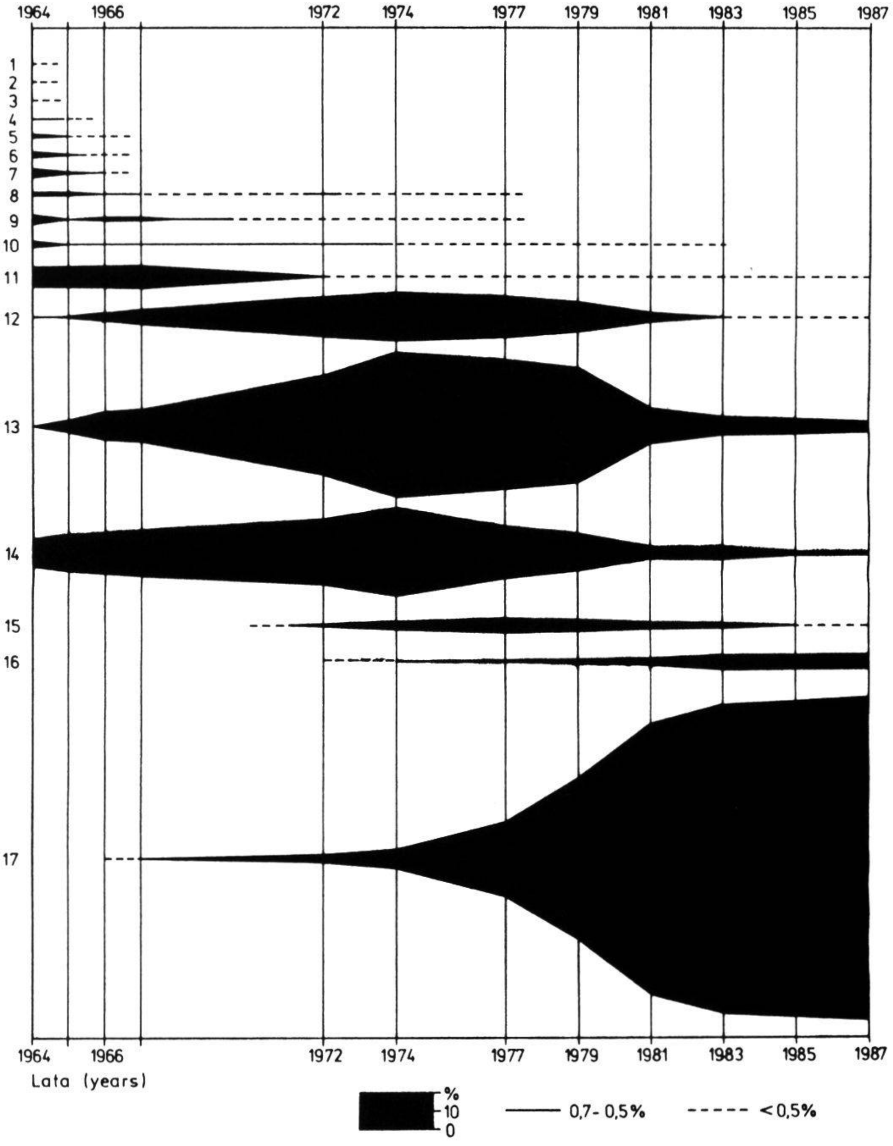

Fig. 7. Changes in biomass percentage of selected plant species during the secondary succession on an unmowed *Arrhehatheretum medioeuropaeum* meadow on the permanent study plot.
1 - *Lotus corniculatus*, 2 - *Glechoma hederacea*, 3 - *Campanula patula* ssp. *patula*, 4 - *Leontodon autumnalis*, 5 - *Trifolium repens*, 6 - *Taraxacum officinale*, 7 - *Plantago media*, 8 - *Carex hirta*, 9 - *Rumex acetosa*, 10 - *Equisetum arvense*, 11 - *Alchemilla crinita*, 12 - *Geranium pratense*, 13 - *Arrhenatherum elatius*, 14 - *Alopecurus pratensis*, 15 - *Elymus repens*, 16 - *Galium aparine*, 17 - *Urtica dioica*.

crops). Their species composition has become considerably impoverished and many localities of valuable meadow plants have disappeared.
At the same time, a very rapid overgrowth of xerothermic grassland with shrubs and trees on valley slopes followed, resulting from severe grazing restrictions (Fig. 8). Grasslands were diminished by ca. 70-75%. Several xero-

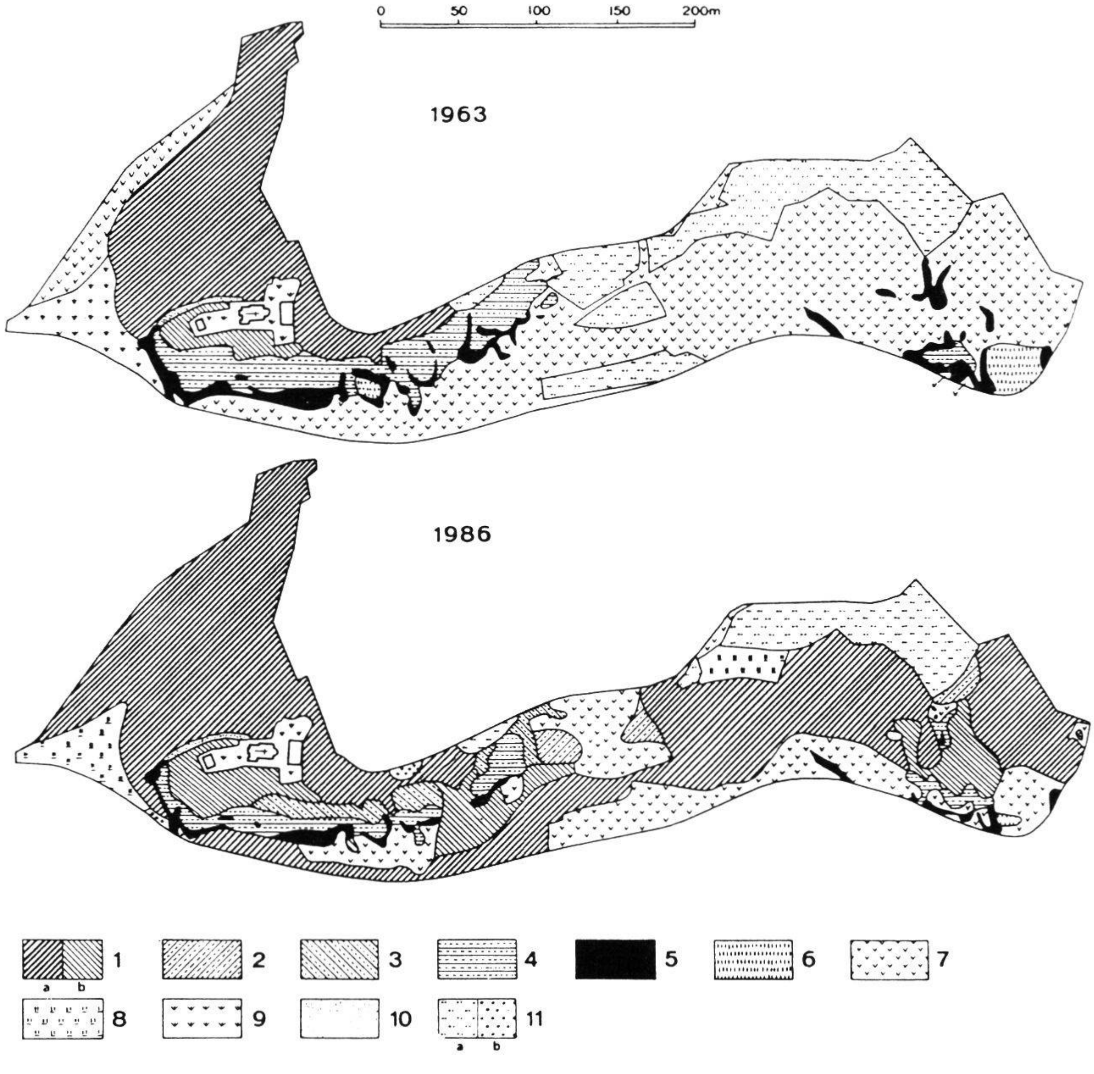

Fig. 8. Simplified plant association maps of the Grodzisko permanent study plot of 1963 and 1986.
1 - lime-hornbeam forest *Tilio-Carpinetum* (a-b - typical subass. thermophilous subass. *Tilio-Carpinetum melittetosum*), 2 - thermophilous scrub *Ligustro-Prunetum*, 3 - degradation stages of xerothermic scrub, 4 - xerothermic scrub *Peucedano cervariae-Coryletum*, 5 - epilithic grassland *Festucetum pallentis sempervivetosum*, 6 - xerothermic grassland *Koelerio-Festucetum sulcatae*, 7 - xerothermic grassland *Origano-Brachypodietum*, 8 - fresh meadow *Arrhenatheretum medioeuropaeum*, 9 - fertilized pastures *Lolio-Cynosuretum*, 10 - community of skiophilous mosses on limestone *Ctenidietalia*, 11 - synanthropic plant communities (a - arable field weeds, b - ruderal plant associations).

Table 3. Changes in the locality numbers of the selected vascular plant species from 1968 to 1988 on the strictly protected "Czyzowki" rocky ridge.

Ecological groups of species	Number of localities 1968	1988	Changes (%)
1. Xerothermal			
Geranium sanguineum	129	29	-77.52
Asperula tinctoria	125	38	-69.60
Seseli libanotis	97	26	-73.20
Stachys recta	51	10	-80.39
Thymus praecox	153	94	-38.56
Trifolium alpestre	26	14	-46.15
2. Moderately xerothermal			
Galium boreale	85	23	-72.94
Agrimonia eupatoria	18	-	-100.00
Anthericum ramosum	173	88	-49.13
Euphorbia angulata	10	7	-30.00
Peucedanum cervaria	132	38	-71.21
Inula salicina	28	-	-100.00
Stachys officinalis	76	12	-84.21
Brachypodium pinnatum	149	27	-81.88
Trifolium rubens	38	7	-81.58
Scabiosa ochroleuca	41	14	-65.85
Coronilla varia	288	32	-88.89
3. Slightly xerothermal			
Digitalis grandiflora	3	1	-66.67
Potentilla alba	257	61	-76.26
Galium schultesii	16	2	-87.50
Pulmonaria mollis ssp.*mollis*	7	-	-100.00
Laserpitium latifolium	342	48	-85.96
Vincetoxicum hirundinaria	221	62	-71.95
Cruciata glabra	546	253	-53.66
Origanum vulgare	15	7	-53.33
4. Thermophilous			
Melittis melisophyllum	129	41	-68.22
Clinopodium vulgare	5	4	-20.00
Melampyrum nemorosum	77	52	-32.47
5. Light-loving and oligothermal			
Valeriana tripteris	756	313	-58.60
Buplerum longifolium	31	20	-35.48
Gymnocarpium robertianum	35	23	-34.29
6. Moderately skiophilous			
Corydalis solida	128	152	+18.75
Isopyrum thalictroides	406	858	+111.33
Mercurialis perennis	1146	2114	+84.47
Aruncus dioicus	20	27	+35.00
Aconitum moldavicum	194	256	+31.96
Dentaria glandulosa	124	152	+22.58
7. Highly skiophilous			
Phyllitis scolopendrium	7	17	+142.86
Asplenium viride	10	15	+50.00
Lunaria rediviva	154	642	+316.88

thermic associations' stands died out as, for example, the only typical stand of *Koelerio-Festucetum sulcatae*. Also some rare species of xerothermic plants (*Onobrychis arenaria, Adenophora liliifolia, Nepeta nuda, Orobanche alba, O. lutea, O. alsatica, Salvia nemorosa, Potentilla recta* var. *fallacina* and *Hieracium echioides*) vanished from the Park. The populations of more than a dozen species, e.g. *Cirsium pannonicum, Aster amellus, Teucrium botrys, Campanula sibirica, Agropyron trichophorum, Carex michaelii, Festuca duriuscula, Gentiana cruciata, Inula ensifolia, Senecio aurantiacus*, fell to a critical number and are likely to become extinct in the near future. The disappearance of communities and xerothermic species from large rock massifs located in the forest areas taken under protection after the establishment of the Park may be observed. The spreading trees cast shade on the xerothermic ve-

Table 4. Changes in percentage of plant communities from 1968 to 1988 on the "Czyzowki" rocky ridge.

Ecological groups of plant communities	Occupied area		Changes (%)
	1968	1988	
1. Xerothermal			
Peucedano cervariae-Coryletum	1.970	0.604	-69
Origano-Brachypodietum	3.684	0.431	-88
Festucetum pallentis sempervivetosum	1.078	0.403	-63
2. Thermophilous			
Tilio-Carpinetum melittetosum	11.735	2.001	-83
Carici-Fagetum	0.491	2.193	+346
Ligustro-Prunetum	0.000	0.784	+100
Arrhenatheretum salvietosum	2.562	3.777	+47
3. Mesophilous			
Tilio-Carpinetum typicum	19.122	21.285	+11
Alno-Padion	1.469	2.950	+100
Pino-Quercetum	0.744	0.215	-71
Arrhenatheretum typicum	9.887	5.123	-48
Arrhenatheretum chaerophylletosum	0.000	17.706	+100
Lolio-Cynosuretum typicum	9.348	0.000	-100
Lolio-Plantaginetum	5.510	1.586	-71
Leonuro-Arctietum	2.001	3.775	+88
Lamio-Veronicetum	1.883	0.823	-56
4. Moderately skiophilous			
Tilio-Carpinetum stachyetosum	11.459	12.090	+ 6
Lolio-Cynosuretum skiophilous variant	2.969	0.000	-100
Alliario-Chaerophylletum typicum	0.000	3.857	+100
Alliario-Chaerophyll. urticetosum	0.000	2.559	+100
5. Highly skiophilous and oligothermal			
Phyllitido-Aceretum	1.492	4.950	+232
Festucetum pallentis neckeretosum	0.717	0.881	+16
Ctenidietalia	3.736	4.499	+20

getation, which for its existence demands full light. The trend of changes in the vegetation of the Ojcow National Park observed in the last 30 years is unfavourable from the point of view of biocenotic diversity and gene resources. They lead to the extinction of non-forest communities and xerothermic and hygrophilous species (Tables 3 and 4, cf. Fig. 5). As a result, there follows a rapid decrease in ecological diversity of plant communities and the impoverishment of the gene resources of the flora.

4. PROGRAMME OF ACTIVE VEGETATION PROTECTION

The present vegetation of the Ojcow National Park is still characterized by and outstanding richness and diversity. Numerous studies carried out in the area of the Park and its surroundings (MEDWECKA-KORNAS and KORNAS 1963, MICHALIK 1974, 1978) have revealed that this diversity is to a great extent the result of the previous human economy (Fig. 9), which led to the development of new semi-natural biocenoses extremely abundant in species (grasslands and xerothermic scrub, meadows, pastures, shallow peat bogs). Several natural biocenoses (e.g. epilithic tuft grasslands), very rare in the past, spread widely as a result of a partial deforestation of the area. The vegetation gained a mosaic spatial structure. The biocenotic and specific diversity of the Park vegetation approached its optimum from 1960-1970 (MICHALIK 1978, 1985). In those years, in this 1590 ha area, over 35 communities and about 1000 vascular plant species were observed, representing the most diverse ecological groups and greatly varied geographical element.

The protection of this exceptional diversity is the main task of the Park. It demands a carefully designed spatial network of total of partially strict reserves and precise and diversified routine protection measures. When elaborating the foundations and detailed protection programme, the thirty-year experience of the Park activity, as well as the results of miscellaneous scientific studies were taken into consideration. The area of the Park was divided into two units with separate protective functions (Fig. 10).

1) The southwestern part is intended for protection of the natural woodland landscape with its relic biocenoses and mountain species. In the future, almost the whole of this area will be taken under strict protection. Only small patches of hay meadow (*Arrhenatheretum medioeuropaeum, Cirsietum rivularis* and others) will be left at the bottom of the valley in order to protect the gene resources of the flora and to secure the landscape and didactic values.

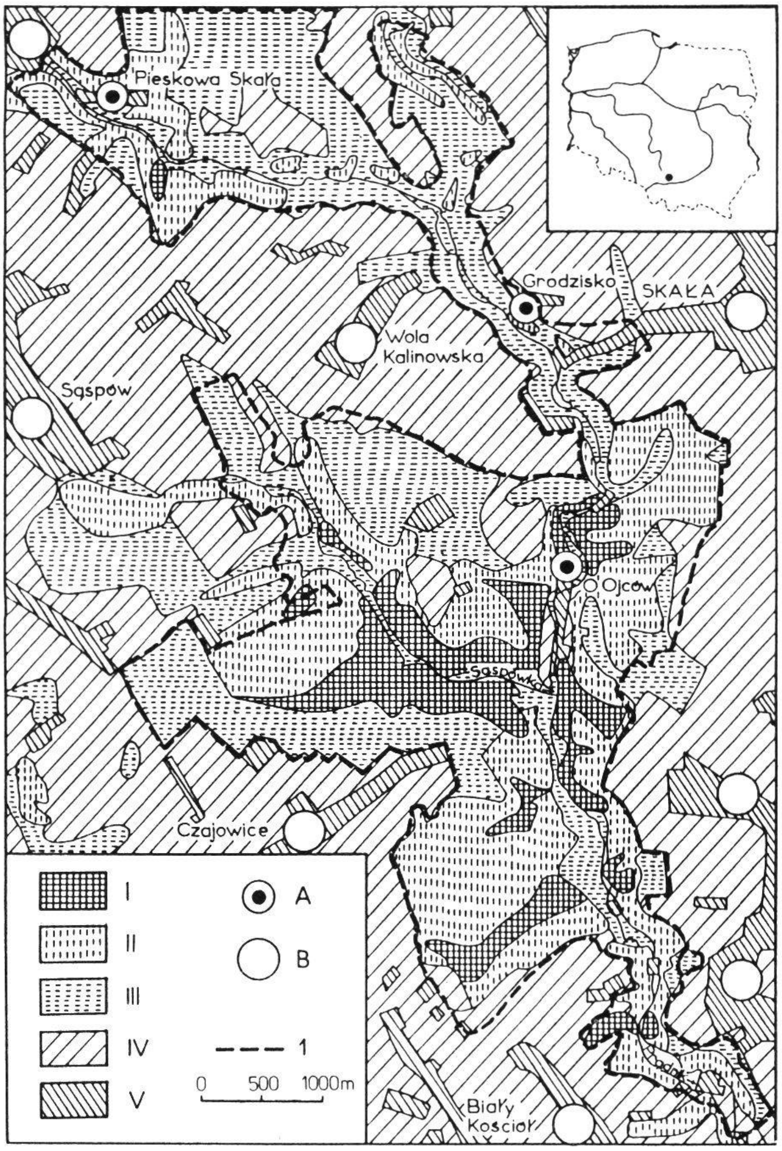

Fig. 9. Present situation of anthropogenic transformation of landscape and plant cover of the Ojcow National Park and its vicinity.

1 - Park limit

I - natural landscape (well preserved natural vegetation with small fragments of communities almost primeval in character), II - natural landscape in the phase of degradation (natural, severely deformed vegetation with a distinct proportion of semi-natural communities). III - cultivated landscape (with dominant communities of semi-natural meadows, grasslands, scrub, and transformed woods and fairly numerously occurring synanthropic vegetation), IV - arable landscape (with dominant synanthropic vegetation of arable land, scarce, semi-natural communities, occurrence of ruderal weed communities), V - urbanized landscape (dominant ruderal weed communities, considerable areas completely bereft of vegetation).

Main centres of human influence: A - oldest centres of synanthropization in the surroundings of the castle and their emplacements in the Pradnik river valley, B - younger centres of synanthropization on the plateau.

2) The northern, eastern and southeastern part of the Park, which includes the rocky Pradnik Valley, is intended for protection of te cultivated landscape with a mosaic spatial structure of the main plant formations (wood, scrub and grasslands).

This will permit the maximum specific richness and ecological diversity of vegetation to be obtained. In order to achieve maximum diversity, the spatial arrangement of communities cannot be fortuitous. It must be carefully programmed and strictly connected with the habitat conditions of the area. In the Park, where especially the oligothermic, heliophobic alpine species, hygrophilous, and photophilous xerothermic plants are dying out, protection of the diversity of communities and of the gene resources of the flora resolves itself above all into securing appropriate conditions for these plant groups. The

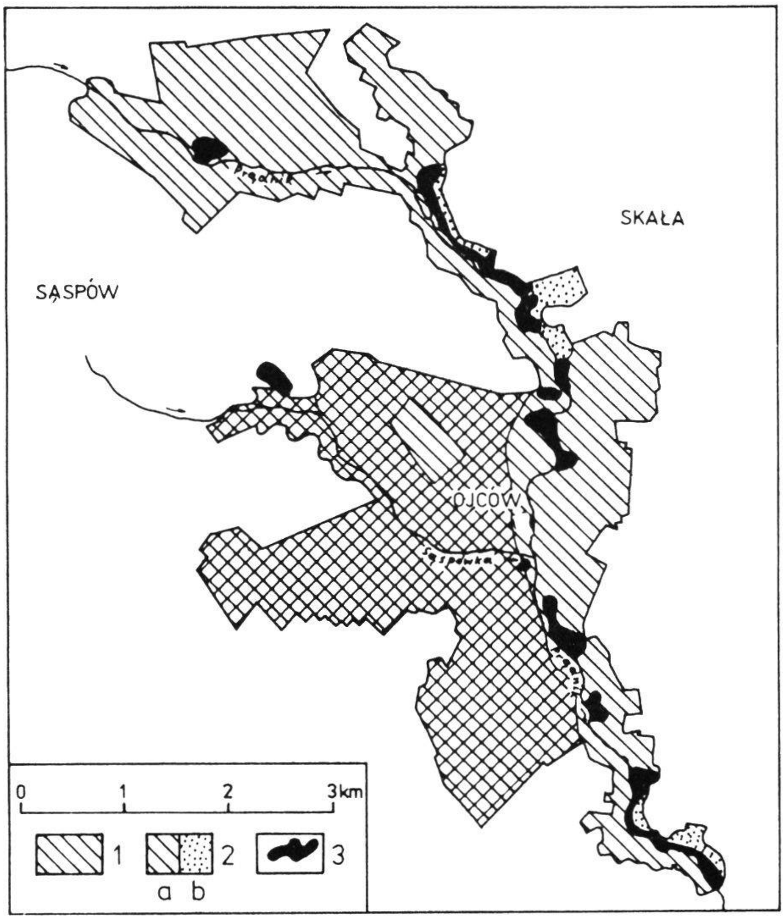

Fig. 10. Division of the Ojcow National Park area into units with different forms of protection.
1 - strict protection applied and restitution of natural woodland landscape, 2 - active shaping of cultivated landscape with maximum biocenotic and species diversity (a - with dominance of natural woodland biocenoses, b - with dominance of secondary xerothermic grasslands), 3 - projected refuges of the xerothermic flora

most important factor deciding the occurrence and numbers of the groups of species mentioned is the microclimate (MICHALIK 1983), which most strongly depends on the relative insolation and relief of the territory (KLEIN 1973). The microclimatic conditions in the ground air-layer can, to a greater extent, be modified by the appropriate distribution of plant formations (woods, scrub, single-layer grassland communities). Taking into consideration the aspects mentioned above, studies were carried out on model, comparable (also as far as surface and habitat are concerned) sections of valleys, which differed as to the spatial distribution of plant formations (Fig. 11). Exposure, gradient of valley slopes, distribution of relative insolation, and the resulting potential differentiation of the microclimate, were identical in all the valley sections investigated. The maximum diversity of communities and flora was found in a valley whose southern slopes were covered by grassland vegetation with

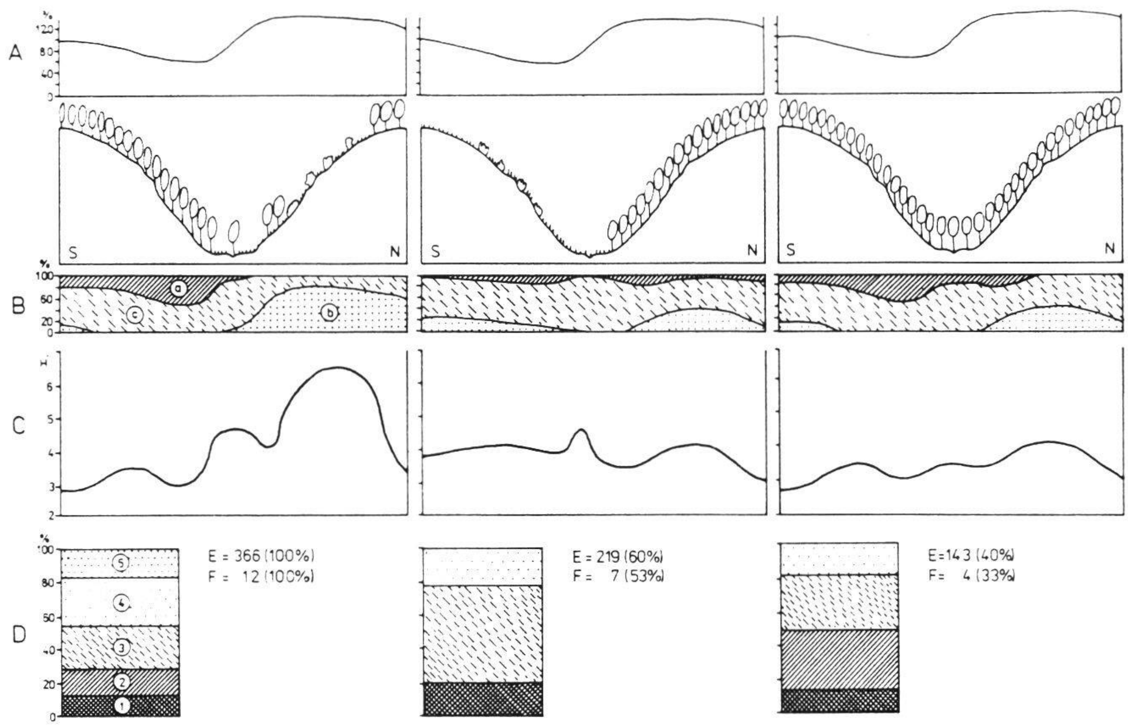

Fig. 11. Ecological structure and numbers of the vascular plant flora in the model section of the valley with various distribution of plant formations (woodlands, scrub, grasslands). A - relative insolation, B - percentage coverage in the herbaceous layer by species (a - montane oligothermic, b - xerothermic, c - other species), C - value of the diversity coefficient H' (simplified curve), D - ecological structure of the flora in percentage participation (1 - strongly oligothermic and heliophobic, 2 - moderately oligothermic and heliophobic, 3 - mesophilous and ubiquitous, 4 - moderately xerothermic, 5 - strongly xerothermic species), E - approximate number of vascular plant species occurring on 0.25 km^2, F - approximate number of plant communities occurring on 0.25 km^2.

clumps of sparse thickets and small patches of woodstands.

The differentiation of microclimatic conditions in the ground-layer was, in this case, intensified through a proper distribution of plant communities. The smallest differentiation of the flora was found in a valley, whose southern slopes were completely forested and the northern ones deforested. This distribution of communities reduced the differentiation of the microclimate and thus eliminated the two most contrary groups of species, namely the markedly oligothermic mountain plants and strongly xerothermic plants representing the southern geographic element. Very interesting are the values of the coefficient of diversity H', which is the function of the number of species and the structure of their domination, calculated for the herbaceous vegetation (for 100 m^2). On the northern slope its values for woodland and grassland communities are similar. However, the replacement of woods with grasslands and thin scrub on the southern slope markedly increases the value of the coefficient.

From the studies described above it appears that in order to protect the gene resources of the flora and the diversity of the vegetation in the conditions of the Ojcow National Park it would be most favourable to give preference to grassland communities and thin scrub on the southern slopes and dense woods on the northern ones. If we assume that in this optimal model of protection the habitat potential is utilized about 100%, then in the other exemplary valley sections analysed it is utilized on only 60% and 40% (Fig. 11). The model of protection of vegetation diversity presented here may be useful in upland territories with very varied morphology and located in the moderate climatic zone. It stresses the great importance of active and conscious shaping of the vegetation landscape to preserve the gene resources of plants and maximum ecological diversity of the plant cover. These active forms of protection are applicable mainly in reserves and national parks exposed to great pressure of human activity, where the possibilities of natural landscape protection are few. A properly shaped cultivated landscape, with a mosaic spatial structure of its biocenoses and great variety, shows greater stability and resistance to the destructive effect of anthropogenic factors.

5. CONCLUSION AND DISCUSSION

The Ojcow National Park and its environs belong to those few areas in Poland in which the whole of the anthropogenic transformations of the plant cover has been examined (Michalik 1974, 1976a,b). Different forms of man's impact on vegetation in the environs of the village of Ojcow were in their initial phases of a very selective character. They caused the extinction of the most sensitive (stenotopic) rare species and biocenoses responding particularly quickly to changes in habitat conditions. Simultaneously, as a result of man's economic activity, new plant communities (meadows, pastures, xerothermic scrub and grasslands) were formed and a patchy spatial distribution of biocenoses was created. This enabled the invasion of many new species (particularly heliophilous and xerothermic) from the adjacent areas.

The results of the present investigations show that in the initial phases of synanthropization (or the transition between the natural forest landscape and cultivated one) biocenotic diversity increases. The number of species per determined area unit grows and ecological differentiation of the flora increases. These indices attain their maximum values in the cultivated landscape and they rapidly diminish in the further phases of synanthropization. The ecological structure of the flora undergoes significant changes, too. In the natural landscape hygrophilous and heliophobic species clearly dominate. In the middle phases of synanthropization (cultivated and agricultural landscape) their share decreases in favour of xerothermic and heliophilous species. The share of mesophilous and ubiquitous species also grows and they predominate in the last phase of synanthropization (urbanized landscape).

The course of the process of anthropogenic changes in the plant cover of the Park corresponds with the results of studies carried out in other areas (WHITTAKER 1965, 1975, FUKAREK 1979, and many others).

In the last three decades two main trends of anthropogenic changes in the plant cover of the Park have been observed. The first one is the mass dying of coniferous trees. This changes clearly the plant landscape of the Park but does not cause a significant reduction of biocenotic and species diversity. The dying of coniferous trees is and effect of air pollution over large areas. The Park administration practically has no possibility to counteract these unfavourable factors.

The second general trend of the anthropogenic changes in the vegetation of the Park is the process of succession leading to the overgrowing of meadow and grassland biocenoses as well as tall-forb biocenoses with shrubs and trees. This process has intensified in the last decades due to the limitation or elimination of old, traditional forms of the management of the Park area. Successional processes cause a quick decrease of biocenotic diversity of the flora through the elimination of plant communities and numerous plant species. The limitation or even total elimination of these unfavourable tendencies is in the power of the Park administration. The programme of active protection of vegetation in the Ojcow National Park shown in this paper and already realized corresponds with the commonly accepted strategy of the protection of biodiversity (NICHOLSON 1957, DUFFEY 1973, 1974, SOULE and WILCOX 1980, MYERS and SHELTON 1980) and is based on the principles of the protective management of biocenoses (DUFFEY and WATT 1971, and many others).

SUMMARY

The Ojcow National Park (1590 ha) is situated in the southern part of the Cracow-Czestochowa Upland, 22 km NNW of Cracow. It distinguishes itself by a very picturesque landscape (Figs. 1, 2, 3) and a great richness of plant communities and of the flora. The vegetation of this area has been investigated since the beginning of the 19th century (BESSER 1809, BERDAU 1857, JELENKIN 1901). The comparison of old botanical data with the corresponding ones from the years 1960 and 1989 allowed to make a detailed analysis of the rate and trends of the anthropogenic changes in the vegetation and to elaborate the programme of active protection.

In the years 1809-1956 in the present area of the Park intensive husbandry was carried out. A large part of forests were felled and replaced by semi-natural communities of meadows, pastures, xerothermic grassland and scrub (Fig. 4). A natural forest landscape was transformed into a cultivated one of a patchy spatial structure of forest and non-forest communities. In the period 1950-1960 biocenotic and species diversity attained their maximum apart from the fact that over 30 species of vascular plants (mainly oligothermic, heliophobic, and hygrophilous) became extinct (Fig. 5).

After the establishment of the Ojcow National Park in the year 1956 its forests have been taken under strict protection. Due to this the relict mountain forests (*Phyllitido-Aceretum, Dentario glandulosae-Fagetum*) as well as lime-hornbeam forests (*Tilio-Carpinetum*) spread out. The process of extinction of heliophobic forest species has been stopped. On the other hand, the increase of air pollution has resulted in the rapid dying of coniferous trees and some acidophilous herb layer species. A severe limitation of grazing and mowing xerothermic grasslands caused their strong degradation (Fig. 7). In the past three decades about 70% of these communities have overgrown with shrubs and forests (Fig. 8). As a result of the extinction of xerothermic and heliophilous species (e.g. *Nepeta pannonica, Orobanche alba, O. lutea, Onobrychis arenaria, Hieracium echioides, Cirsium pannonicum*) there have occurred a decrease of biocenotic diversity and rapid impoverishment of genetic resources of the flora. To counteract these unfavourable trends and to maintain the whole differentiation of the plant cover of the Park a special programme of active protection has been introduced recently Fig. 10). In part of the Park area an appropriate spatial structure of forest and non-forest communities in being created by help of adequate measures such as felling trees and shrubs, mowing, grazing etc. It is in conformity with habitat conditions and it secures the maximum diversity (Fig. 11).

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