CONTEMPORARY FLORISTIC CHANGES IN THE KARKONOSZE MTS.

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ABSTRACT

The paper presents the transformations of species composition in the main plant communities of the Karkonosze Mts. subalpine and alpine belts during the last 35 years. The investigations of floristic changes were performed in associations: *Carici (rigidae)-Nardetum*, *Carici-Festucetum supinae*, *Crepidi-Calamagrostietum villose* and *Empetro-Vaccinietum*. Signalized are also some vegetation transformations in the remaining belts. The progressing floristic degradation of plant communities in the subalpine and alpine belts consists in: (a) expansion of grasses, (b) decline of rare vascular plants, and (c) elimination of terricolous bryophytes and lichens. In spruce forest belts declining are species connected with old-growth spruce forests like: *Listera cordata* and *Moneses uniflora*. The changes of plant communities of low mountain swards (*Nardetalia*) caused by cessation of pasture and mowing in the cause of retreat of many rare plants, like e.g., *Arnica montana*. The main cause of the still lasting in the Karkonosze Mts. community transformations is the changes in soil environment connected with anthropogenic nitrogen fertilization. The large inflow of mineral nitrogen from the atmosphere (1138 mg/m² sum for vegetation season) is the reason of accelerated rate of decomposition of organic matter and intensified nitrification. The high content of nitrates in soil (5 times higher than in the Tatra Mts. swards) is the reason of expansion of graminoids, mainly *Deschampsia flexuosa*, *Calamagrostis villosa* and *Carex bigelowii* subsp. *rigida*. The over-fertilisation of habitats causes the retreat of rare high mountain vascular plants and the decline of terricolous bryophytes and lichens.

KEY WORDS: Karkonosze Mts., flora, biodiversity, nitrogen mineralization, nitrification.

INTRODUCTION

The Karkonosze Mountains gained recently a bad reputation because of the lasting there, since the 60 s, forest die-back. The die-back of spruce forests, which progresses mainly in the upper forest belt is, however, only one of the sharply appearing symptoms of drastic changes in the mountain vegetation during the last four decades. The elimination of the tree layer or its considerable loosening leads to noticeable changes in ecological conditions, the consequence of which is the transformation in the species composition of the floor vegetation (Fabiszewski et al. 1993; Fabiszewski, Wojtuń 1994). The recently performed investigations (Wojtuń et al. 1995, 1997) revealed that the lasting in the Karkonosze Mts. acidification and eutrophication of habitats exert an unfavourable influence not only upon the forests, but also upon communities of subalpine and alpine vegetation. The transformations of plant communities over the Karkonosze Mts. the forest line are, however, of a more subtle progress, as compared with the impressive die-back of high mountain spruce forests. They

consist in a poorly noticeable, in the initial phase, expansion of one species (usually grass) with a parallel decline of rare species, frequently inconspicuous mountain plants. The latter are the most valuable in respect of their presence, as they decide on the floristic and geobotanical position of our mountains.

The Karkonosze Mts. plant communities have been penetratingly described on the turn of the 60s (W. Matuszkiewicz, M. Matuszkiewicz 1969, 1974). The detailed information from these papers enable comparative studies on the old and present floristic composition of almost all the Karkonosze plant communities.

Our paper tends above all towards a characterization of modifications of the species composition of the main plant communities of the Karkonosze Mts. subalpine and alpine belts during the last 35 years. We cursorily signal also some of the vegetation changes in the remaining belts. The present paper presents also the most important, in our opinion, causes and effects of the still ongoing changes, which lead to loss of floristic diversity of this important European mountain range.

OBJECTIVES AND METHODS OF INVESTIGATION

The objective of the contemporary investigations (1993-1995) were Matgrass swards *Carici-Nardetum*, subalpine and alpine swards *Carici-Festucetum supinae alpinum*, subalpine grasslands *Crepidi-Calamagrostietum villose*, and dwarf shrub heaths *Empetro-Vaccinietum*. Plots for investigation and their localization were selected according to the descriptions of W. and M. Matuszkiewicz (1969, 1974), trying also to stick to the phytosociological method of these authors. Our areas conform strictly to the places investigated in 1960 by the mentioned authors. The presently investigated areas were selected so as to overlap the previously investigated areas. The precise localization of the objectives is described in the papers by Wojtuń et al. (1995, 1997).

On the basis of earlier investigations (Wojtuń et al. 1997) it was accepted that one of the more important reasons of the decline of the Karkonosze Mts. biodiversity are the changes in soil environment. Our soil investigations included measurements of mineral nitrogen content and rate of mineralization and nitrification. The netto mineralization and nitrification has been studied immediately in field on the basis of intact cores incubated in situ inside polyethylene bags (Piccolo et al. 1994). The mineral forms of nitrogen were extracted by means of water (nitrates) and a 6% solution of KCl (ammonium ions). Ammonium and nitrate concentrations were determined colorimetrically using an automated flow injection system (Braun+Luebe AutoAnalyzer). Ammonium-nitrogen was measured by the indophenol-blue method and nitrate-nitrogen was measured as NO_2 following reduction with during the incuba-

tion a cadmium column. Mineralization was calculated as the change in NH_4 plus NO_3 .

For analyses of nitrogen conversion in the Karkonosze Mts. soils as control plots for the association *Carici-Nardetum* chosen were swards of *Hieracio-Nardetum* in the subalpine belt on the Hala Gąsienicowa in the Tatra Mts. (Mirek, Piękoś-Mirkowa 1995). They have a similar origin and a nearing floristic composition to the Karkonosze swards, particularly the mutual domination of grasses *Nardus stricta* and *Deschampsia flexuosa*. This community covers, so in the Tatra Mts. as in the Karkonosze Mts., the acidic podzol soils, build up of various kinds of granite.

Nomenclature follows Mirek et al. (1995).

RESULTS

Floristic transformations in lower mountain belts

An example of disappearance of rare plants, in result of whole ecosystem degradation of mountain spruce forests, are in the Karkonosze Mts. the deterioration of two species *Listera cordata* and *Moneses uniflora* (Fig. 1), connected with old spruce forests. They die irrevocably together with the disappearance of the oldest and best preserved mountain spruce forests (Fabiszewski, Jenik 1994).

The example of another vanishing species in the Karkonosze Mts. are *Arnica montana* and *Hieracium aurantiacum* (Fig. 2). Its stands shrunk drastically in the whole massif to ca. 10% as compared with old German data (Schube 1903). In general, the remove of range of that species (data from other parts of Europe, e.g. Schwabe 1990, Pegtel 1994; Brej, Fabiszewski 1997) may be decid-

Fig. 1. Plant retreat from mountain spruce forest as an example of old-growth forest decline. 1 – *Listera cordata* (historical data – literature and herbaria), 2 – localities with the same species in 1994, 3 – *Moneses uniflora* (historical data – literature and herbaria), 4 – localities with the same species in 1994.

Fig. 2. Decline of Matgrass sward species in the last 25 years in a part of the Karkonosze Mts. 1 – *Arnica montana*, 2 – *Hieracium aurantiacum*.

ed by chemical changes of soils covered by *Nardetalia* swards, noticed also in the Karkonosze Mts.

The comparison of losses of these and other valuable plants with data from European and Scandinavian mountains frequently does not allow to settle univocally the reasons of their decline. From among single factors in forest belts the transformation leading to an unfavourable forest thinning can be taken into consideration. Many of the declined species were bound with old forests of a natural and a more and more difficult for preservation ecological status. These concerns, among others, the increasingly rare pteridophytes and *Dentaria* genus from both the lower mountain belts connected with forests of order *Fagetalia*.

Floristic changes in alpine and subalpine mountain belts

The clearly visible effect of transformation of the Karkonosze Mts. high mountain phytocenoses are the changes in number of species (Table 1). The number of species decreased during 35 years on average by 30% in all the examined plant communities. The highest decrease was recorded in Matgrass swards *Carici-Nardetum* with a mean of 15.9 species in 1960 and only with ca. 7 species in 1995. The lowest fall in number of species was observed in subalpine swards *Carici-Festucetum supinae*, from 14.0 in 1960, to 12.4 species in 1995. Likewise in number of species, changes occurred also in the Shannon index value H' , which decreased by ca. 20%, on average from 2.5 to 2.00.

A complete decline or substantial reduction of occurrence of many plant localities has caused such a consider-

able decrease of species number in the Karkonosze Mts. subalpine and alpine communities. As can be seen in Table 2, from among 20 species recorded with an at least 10% frequency in 1960, as many as 10 taxa were not found in 1995 and further 10 were met only sporadically. Among those not found were not only rare mountain species, typical for high mountain swards, as e.g., *Luzula sudetica*, *Pulsatilla alba*, *Diphysium alpinum*, *Huperzia selago*, but also plants quite lately frequent in the Karkonosze Mts., like *Ranunculus platanifolius*, *Aconitum firmum*, *Geum montanum* and *Hypericum maculatum*. Astounding is also the decline of some common species in swards as, for example, *Vaccinium vitis-idaea* and *Solidago alpestris*.

A natural difference between swards and dwarf shrub communities is the different growth forms (Fig. 3). For example, in Matgrass swards *Carici-Nardetum* plants of the graminoid form are dominating, while in dwarf shrub heaths *Empetro-Vaccinietum* predominating are dwarf shrubs, and in swards *Carici-Festucetum supinae* there exists a distinct share of other forms, i.e., respectively forbs, dwarf shrubs and lichens. During the last 35 years in the communities at issue a considerable change in share of growth forms took place (Fig. 3). At present, other growth forms do not accompany the considerable share of graminoids in the investigated *Carici-Nardetum* swards. In subalpine swards *Carici-Festucetum supinae* a distinct growth in share of graminoids has also been recorded, and at the same time a threefold decrease of share of dicot forbs and lichens. Together with a moderate growth of the cover

TABLE 1. Plot number, species number and Shannon index H' in 1960 and 1995 for five plant associations from subalpine and alpine belts in the Karkonosze Mts. Figures are means and SD. *** $p < 0.001$, N.S. not significant.

Plant communities	Plot number		Species number		Shannon index H'	
	1960	1995	1960	1995	1960	1995
<i>Carici-Nardetum</i>	22	94	15.9±3.0	7.2±2.8 ***	2.41±0.25	1.53±0.30 ***
<i>Crepidi-Calamagrostietum villosae</i>	16	36	21.8±6.4	13.7±3.6 ***	2.75±0.34	2.27±0.33 ***
<i>Carici-Festucetum supinae</i> subalpine type	13	58	14.0±3.0	12.4±1.5 N.S.	2.41±0.21	2.06±0.14 ***
<i>Carici-Festucetum supinae</i> alpine type	8	19	16.8±1.3	11.71±0.8 ***	2.61±0.08	2.17±0.13 ***
<i>Empetro-Vaccinietum</i>	20	30	17.5±2.8	13.1±2.8 ***	1.11±0.07	0.88±0.64 ***

TABLE 2. Vascular plant species noted (frequency at least 10%) in 1960, but not confirmed (+) or noted only sporadically (*) in 1995.

Community:	Species	
<i>Carici-Nardetum</i>	<i>Diphysastrum alpinum</i>	*
	<i>Huperzia selago</i>	*
	<i>Luzula sudetica</i>	*
	<i>Melampyrum sylvaticum</i>	+
	<i>Pulsatilla alba</i>	+
<i>Crepidi-Calamagrostietum villosae</i>	<i>Aconitum firmum</i>	+
	<i>Adenostyles alliariae</i>	*
	<i>Cicerbita alpina</i>	+
	<i>Geum montanum</i>	+
	<i>Hieracium alpinum</i>	+
	<i>Huperzia selago</i>	*
	<i>Hypericum maculatum</i>	+
	<i>Leontodon hispidus</i>	+
	<i>Potentilla aurea</i>	+
	<i>Pulsatilla alba</i>	*
	<i>Ranunculus platanifolius</i>	*
	<i>Viola biflora</i>	*
<i>Carici-Festucetum supinae</i> – subalpine form	<i>Diphysastrum alpinum</i>	+
	<i>Primula minima</i>	*
	<i>Pulsatilla alba</i>	*
	<i>Solidago virgaurea</i>	*
<i>Carici-Festucetum supinae</i> – alpine form	<i>Pulsatilla alba</i>	*
	<i>Solidago virgaurea</i>	*
	<i>Vaccinium vitis-idaea</i>	*
<i>Empetro-Vaccinietum</i>	<i>Empetrum hermaphroditum</i>	*
	<i>Huperzia selago</i>	*
	<i>Pulsatilla alba</i>	*
	<i>Solidago virgaurea</i>	*

of graminoid species in phytocenoses *Empetro-Vaccinietum* there occurred a drastic decrease in presence of bryophytes and lichens.

Conversion of soil nitrogen in the Tatra Mts. and Karkonosze Mts. swards

In spite of similarities in nitrogen dynamics in high mountain swards, we recorded significant differences between the Tatra Mts. and Karkonosze Mts. areas. These differences consist in the following anthropogenic differences of the Karkonosze Mts.:

– the inflow of nitrogen in the ammonium and nitrate forms is almost three times higher in the Karkonosze Mts. than in the Tatra Mts. (1138 and 369 mg/m² respectively). The proportions between the mentioned forms in both the mountain ranges are identical.

– the mean content of mineral nitrogen in soils of both the areas was in the vegetation season 1.30 mg/100 g s.m. (Table 3). In both the areas ammonium nitrogen is predominating. The share of nitrates in the total content of mineral nitrogen is small, however, it is emphasized that in Karkonosze Mts. swards *Carici-Nardetum* this anion occurred in five time higher amounts as compared with the *Hieracio-Nardetum* in the Tatra Mts.

– field mineralization of nitrogen calculated as accumulation of ions NH₄ and NO₃ in soil differs distinctly in the two studied communities in the Tatra Mts. and Karkonosze Mts. The increment of mineral nitrogen in soils of Karkonosze Mts. swards was three times higher than in

TABLE 3. Nitrogen deposition (monthly average and sum for vegetation season) in the Tatra Mts. and the Karkonosze Mts. ecosystems in 1992–1993 and amounts of nitrogen in soil of *Hieracio-Nardetum* and *Carici-Nardetum* (values are means for vegetation season of 1995).

	N-NH ₄	N-NO ₃	N (NH ₄ + NO ₃)
Monthly average			
for vegetation season (mg/m ²)			
HALA GASIENICOWA ¹	50	49	92
KARKONOSZE ²	152	133	285
Sum for vegetation season (mg/m ²)			
HALA GASIENICOWA ¹	201	195	369
KARKONOSZE ²	607	531	1138
Amounts in soil (mg/100 g s.m.)			
<i>Hieracio-Nardetum</i>	1.31	0.019	1.33
<i>Carici-Nardetum</i>	1.19	0.097	1.29

¹ according to Wathne et al. 1993

² according to Zwoździak et al. 1995 and Kmiec et al. 1994

Tatra Mts. swards (Fig. 3). The dominant form of nitrogen which was accumulated during field mineralization in *Carici-Nardetum* (Karkonosze Mts.) were the nitrates, whereas in *Hieracio-Nardetum* soils (Tatra Mts.) ammonium ions were predominating.

DISCUSSION

The Karkonosze Mts. plant communities are for several decades under a strong pressure of various stress factors connected with air pollution containing hydrogen ions, nitrogen and sulphur compounds and heavy metals. The transported pollutants produce a number of chain changes, beginning with abiotic environment and stopping at floristic changes. Unfortunately, we do not know much about changes taking place in whole ecosystems. The most dangerous from among the progressing here processes of ecosystemic influence are eutrophication and acidification of natural habitats (Fabiszewski, Wojtuń 1994; Żołniercz et al. 1994; Wojtuń et al. 1997).

Degradation of vegetation

Quantitative and qualitative investigations of the floristic composition of plant communities and changes in share of growth forms in various associations in the years 1960–1995, as well as, investigations of nitrogen conversion in soil revealed a number of phenomena, which add up to a progressing process of floristic degradation in plant communities, particularly of the subalpine and alpine belts. Among the most significant ones belong: the expansion of grasses, decline of rare vascular plants and the elimination of terricolous bryophytes and lichens.

The expansion of grasses and grass-like species progresses with various intensity in all the studied phytocenoses. The species of highest expansiveness is *Deschampsia flexuosa*, the cover of which since 1960 till to-day increased 3–4 times almost in all the communities. A high expansiveness shows also the sedge *Carex bigelowii* subsp. *rigida*, which expands most in Matgrass swards *Carici-Nardetum*.

Together with the expansion of grasses and decline of the ground layer of cryptogamic plants in phytocenoses,

Fig. 3. Plant functional growth forms in three subalpine plant communities in 1960 and 1995. L – lichenes, B – bryophytes, G – graminoids, F – forbs, DS – dwarf shrubs.

Fig. 4. Soil concentration of ammonium and nitrate in different sward associations in the Karkonosze Mts. and Tatra Mts. (measure of 62 days of mineralization). CN – *Carici-Nardetum*, HN – *Hieracio-Nardetum*, 1 – start of mineralization (August 5, 1995), 2 – end of mineralization (October 5, 1995).

particularly alarming for florists and conservators is the decline of many vascular species (Table 2). Many plants which occurred (some of them rarely) in 1960, but in as many as 79 phytosociological relevés, have now not been found, despite 237 relevés have been made. To these species belong, among others, *Rhinanthus alpinus*, *Amica montana*, *Leucorchis albida*, *Lycopodium clavatum*,

Hypochoeris uniflora, *Crepis conyzifolia*, and *Carex atrata*. Most of the mentioned species represent the typical high mountain flora, characteristic for the upper belt of the Karkonosze Mts., the decline of which deprives the terrain under discussion of significant individuality, as compared with other European mountains. These declining plants are known already only from few localities in the Karkonosze Mts. and all of them belong to the group of threatened species.

Another strongly marked feature in the non-forested belts is the decline of terricolous bryophytes and lichens. From phytocoenoses retreat or drastically reduce their cover such characteristic and once common mosses, e.g., *Dicranum scoparium*, *Pleurozium schreberii*, *Hylocomium splendens* and *Politrychum* spp., and epigeic lichens like *Cetraria* spp. div., *Cladonia* and *Cladina* spp. div., *Thamnolia vermicularis* and *Alectoria ochroleuca*. This caused an almost total decline of the ground layer of cryptogamic plants and lichens in almost all the communities studied. This process is particularly strongly marked in *Carici-Nardetum* and *Empetro-Vaccinietum*, where during the last 35 years the cover of the bryophytes and lichens layer decreased more than ten times. The elimination of the „d” layer leads to the decline of specific microhabitats, retaining moisture and preventing erosion during moist periods, and during drought conduces to deflation of whole turfs and fragments of vegetation.

A simplified picture of floristic changes in various vegetation belts in the Karkonosze Mts. is presented in Figure 5.

Similar changes, like those presented above for the Karkonosze Mts. phytocoenoses, have also been described in many forested and non-forest communities of eastern, central and northern Europe, for example, in the high

Fig. 5. Examples of invasive and retreat (italics) plants against a background of vegetation belts in the Karkonosze Mts. 1 – submontane belt, 2 – low mountain belt, 3 – high mountain belt, 4 – subalpine belt, 5 – alpine belt.

mountain phytocoenoses of the Czech part of Karkonosze Mts. (Štursova 1985; Štursova, Kocianova 1995), in the Alps' swards (Hegg 1984; Dahler 1992a, b) and in the Czech spruce forests (Kubíková 1989), in Germany (Heinsdorf 1993), and in Scandinavia (Rosén et al. 1992).

Ecological consequences of excessive nitrogen supply

The recorded by us inflow of mineral nitrogen to the Karkonosze Mts. ecosystems, as compared with the Tatra Mts., burdens with that element the high mountain soils. This is revealed in the mineralization of nitrogen and in the predominance of nitrification and in consequence in a higher content of nitrates in the association *Carici-Nardetum*.

The high mineralization rate in *Carici-Nardetum* swards is probably the result of the long lasting in this territory large inflow of mineral nitrogen from the atmosphere. Many authors point to the stimulating influence of permanent nitrogen inflow upon the mineralization process of organic matter, particularly in habitats with shortage of this element (Hanson et al. 1994; Aber et al. 1998). The higher content of nitrogen in organic matter (over 1.4%) makes it more susceptible to decomposition (Haynes 1986). As Bieńkowski (1995) notifies, the concentration of total N in the above ground parts in three grasses *Deschampsia flexuosa*, *Calamagrostis villosa* and *Nardus stricta* in the Karkonosze Mts. is 1.85 to 2.07%. The produced organic matter is probably susceptible to rapid decomposition and release of soil nitrogen, particularly NH_4 ions (Haynes 1986; Chapin et al. 1995). Thus, it can be stated that large amounts of nitrogen flowing up together with rains to the Karkonosze Mts. swards increased not only the accessible pool of nitrogen saturation, but also changed the quality of organic matter. It simply became more susceptible to decomposition and release of nitrogen. The evidence supporting this view is, in the vegetation season, the found correlation of decomposition of fresh organic matter and mineralization rate in the Karkonosze Mts. subalpine belt with amount of nitrogen forms flowing up from the atmosphere, particularly in ammonium form (Pietr et al. 1995). The importance of NH_4 accessibility during nitrification has been noticed in other terrains by Haynes (1986), Tamm (1991) and Nadelhoffer et al. (1997).

Hence, the reason of the high nitrification role in soils of *Carici-Nardetum* swards is the large amount of substance produced during mineralization of organic nitrogen and the inflow of ammonium ions from the atmosphere.

The outcome of high nitrification rate is the considerable content of nitrates in soil, which together with decomposition of mineral nitrogen stimulate the expansion of plants, capable of rapid use of the increasing amounts of nitrogen. Such plants are, most certainly, grasses, which are of highest negative importance in transformation of floristic composition in Karkonosze Mts. communities (Fig. 3). Rosén et al. (1992) have also observed a close relation between the growth of *Deschampsia flexuosa* floor vegetation in Swedish spruce forests, and excess of soil critical loads of nitrogen (mainly nitrates) in soils. The increase of the cover of fast growing grass species as response to inflow of mineral components, particularly nitrates, is mainly noted in habitats from nature short in mineral elements (Jonasson 1992; Press et al. 1995; Shevtsova, Neuvoonen 1997).

In the dwarf shrub tundra Press et al. (1998) observed, among others, a high decrease in share of bryophytes, a

phenomenon confirmed in our phytocoenoses. The reason of elimination of terricolous bryophytes and lichens could be the overfertilization of habitats and/or grass competition. Terricolous lichens are usually typical nitrophobic and/or oligotrophic species. The elimination of bryophytes depends probably on light reduction by grasses (Chapin, Komer 1994). The density of the „d” layer decreased most in those Karkonosze Mts. communities, in which a considerable increase of grass cover took place, i.e., in swards *Carici-Nardetum* and *Carici-Festucetum supinae*, and in a lower degree in dwarf shrub heaths *Empetro-Vaccinietum*.

Reasons of fall of floristic diversity

The expansion of one or more species causes usually the retreat of other taxa from the community and in result a fall in species abundance of the phytocoenosis (Whittaker 1977; Rosén et al. 1992). In Karkonosze Mts. communities very similar phenomena were observed. The species diversity of communities (expressed by the H' index) decreased by 30-40%, whereas the number of species fell even twice. Species significant for the Karkonosze Mts. flora died out in all the phytocoenoses or occur there only sporadically, that is, species, which in the 60s were frequently met. This concerns particularly high mountain plants like *Diphysastrum alpinum*, *Potentilla aurea* and *Huperzia selago*. Long term observations of permanent plots of the association *Sieversio-Nardetum* from the Alps (Hegg 1984; Dahler 1992a, b) have shown that NPK fertilization was the reason of decline of many, typical for these swards, species, e.g., *Arnica montana*, *Solidago virgaurea*, *Potentilla aurea* and *Geum montanum*.

The decline of rare flora elements and the general impoverishment of the Karkonosze Mts. plant communities have certainly various causes and effects. The presented above data indicate the significant role of anthropogenic cycling of nitrogen in ecosystems. The subsistence of a high diversity of species in phytocoenoses depends among others on spatial environmental heterogeneity of habitats (Tilman 1985). In ecosystems abundant in microhabitats there persists usually a higher number of species than in homogenic habitats. The simple geological structure of the Karkonosze Mts., the rather uniform soil cover, and the poorly diversified microrelief, never classified that massif among mountains of high biodiversity. It is, however, a massif of distinct individual and peculiar character of flora and vegetation cover. The anthropogenic changes tending towards a fall of the Karkonosze Mts. biodiversity and domination of their vegetation by several species of monocots is highly unfavourable for ecosystem structure, particularly in the subalpine and alpine belts.

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WSPÓŁCZESNE PRZEMIANY W SKŁADZIE FLORY KARKONOSZY

STRESZCZENIE

W pracy przedstawiono zmiany składu gatunkowego w głównych zbiorowiskach roślinnych Karkonoszy w piętrze subalpejskim i alpejskim w ostatnich 35 latach. Postępujące w ciągu tego czasu ubożenie i dgradacja zbiorowisk roślinnych wyrażają się ekspansją kilku gatunków traw, zanikaniem wielu typowych naczyniowych gatunków górskich oraz eliminacją naziemnych mszaków i porostów. W reglu górnym znamienne jest wypieranie roślin naczyniowych związanych ze starymi borami świerkowymi, jak *Listera cordata* i *Moneses uniflora*. W niższych piętrach zmiany częściowo wynikają z zaniechania wypasu i koszenia na łąkach górskich (np. zanik stanowisk *Amica montana*). Główną przyczyną przemian flory i szaty roślinnej są jednak zmiany środowiska glebowego związane z antropogenicznym transportem azotu. Opad mineralnego azotu, wynoszący 1138 mg/m² w ciągu sezonu wegetacyjnego, powoduje szybszy rozkład materii organicznej i intensywną nityfikację. Antropogeniczne przenawożenie Karkonoszy jest prawdopodobnie głównym czynnikiem sprawczym zaniku wielu miejscowych gatunków górskich jak również intensywnej ekspansji traw.

SŁOWA KLUCZOWE: Karkonosze, flora, bioróżnorodność, mineralizacja azotu, nityfikacja.