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Changes in the lichen flora influenced by the Bełchatów Industrial Region

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At the beginning of our study, i.e., before opening the Bełchatów brown coal mine and the power station 155 species of lichens were registered in the period 1970-1985. A preliminary estimation of the influence of the Bełchatów Industrial Region (BIR) on the lichen flora has been performed. More than 1% of the lichen flora has entirely disappeared, about 43% of the species have shown partial devastation of their localities and numerous localities of more than 35% of taxa have been threatened.

INTRODUCTION

Regular and noticeable occurrence of lichens in all habitats and communities suitable for their existence adds a new component – characteristic of an unusual sensitivity to climatic changes, water conditions and air pollutions – to the plant cover of the Bełchatów Industrial Region (BIR) (Barkman 1968, Börtitz et al. 1972; Fabiszewski et al. 1983 and others).

Assuming continuous effects of the air pollution with gases and dusts, as well as of the depression cone on the biocoenoses and their habitats within the influence zone of BIR, a hypothesis has been drawn that the lichens, as sensitive organisms, will tend to disappear from their habitats.

The rate and the scale of the lichens decline process under the influence of BIR, i.e., the brown coal mine and power station complex, was to be estimated and the influence zone size to be established by means of lichen indicator features. In the first stage of our studies* species was identified

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within the examined plant group and species variation was determined in the first period of BIR influence, i.e., up to 1985. The investigations were conducted in the mesoregions of the Bełchatów High Plain and of the Szczerców Basin – total area of 400 km^2 (Fig. 1-8), the regions characterized elsewhere by Czyżewska and Olaczek (1983), as well as Czyżewska and Jakubowska-Gabara (1985). Lichenological data were obtained from floristic studies carried-out by the means of grid maps method in the periods 1970-1972 and 1976-1985.

RESULTS

155 taxa of epiphytic, epigaeic and epipetric lichens, associated with epixylic wood have been identified (Czyżewska unpubl.). It has been agreed that the collected data reflect the level of lichen flora resources at the time before the coal mine and the power station, as well as the whole variety and variability of the habitats, indicating, at the same time, the effects of the human economic activity.

The most vital and expansive are the psammophilous epigaeic lichens, associated with psammophilous grasslands and pine forests, e.g., *Cladonia arbuscula* (Wallr.) Rabenh., *C. furcata* (Huds.) Schrad., *C. mitis* Sandst., *C. phyllophora* Ehrh. ex Hoffm., *C. rangiferina* (L.) Willd., *C. subulata* (L.) Wigg., *C. uncialis* (L.) Wigg., *Cetraria islandica* (L.) Ach., *Coelocaulon aculeatum* (Schreb.) Link, *Lecidea uliginosa* (Sachrad.) Ach., plus acid-liable epiphytes of the pine: *Scoliciosporum chlorococcum* (Graewe ex Stenhammar) Vězda, *Lecidea conizaeoides* Nyl. ex Crombie, *Hypocenomyce scalaris* (Ach.) Choisy.

Epiphytes of the deciduous forests are characterized by species decline; among others, within the following families: *Caliciaceae*, *Pyrenulaceae*, *Arthoniaceae*, *Lecideaceae*, *Usneaceae*, which differentiates the zone in question from other areas studied in the lowlands (Zielińska 1967; Czyżewska 1972, 1974, 1981; Cieśliński 1978).

There occur rare taxa – regarding the whole country and the region in question – like *Bacidia assulata* (Koerb.) Vězda, *Calicium glaucellum* Ach. (species distinguished only very recently in Poland), *Hypocenomyce caradocensis* (Leight. ex Nyl.) P. James et G. Schneider (the third location in Poland; Nowak and Tobolewski 1975; Toborowicz 1983), *Porina aenea* (Wallr.) Zahlbr. (from the Wola Wydrzyna forest range), *Parmelia subrudecta* Nyl. (from the Wola Wydrzyna and Wola Grzymalina, Pytowice and Sadulaki forest ranges and from the parks in Łękawa and Kluki), *Ramalina obtusata* (Ach.) Bitter (near Sulmierzyce). *Parmelia acetabulum*

(Neck.) Duby, *Xanthoria fallax* (Hepp) Arn. (from the park in Łękawa), *Strangospora pinicola* (Massal.) Koerb. from Parzniewice (see: Fig. 4-8).

Many lichen species occurring in the BIR, some still in abundance, have been included in the „Red List of Threatened Lichens in Poland" (Cieśliński, Czyżewska, Fabiszewski 1986). *Parmelia acetabulum*, *P. subrudecta*, *P. tiliacea* (Hoffm.) Ach., *P. verruculifera* Nyl., *Ramalina fraxinea* (L.) Ach. are included into the category of endangered lichens (E). In the group of vulnerable lichens (V) we can distinguish: *Bryopogon crispus* (Mot.) Bystr., *Arthonia byssacea* (Weigel) Almq., *Bacidia rubella* (Hoffm.) Massal., *Calicium glaucellum*, *C. salicinum* Pers., *Cetraria chlorophylla* (Willd.) Vain., *C. pinastri* (Scop.) S. F. Gray, *C. sepincola* (Ehrh.) Ach., *Chaenotheca chrysocephala* (Turn. ex Ach.) Th., Fr., *Ch. ferruginea* (Turn. ex Sm.) Migula, *Ch. trichialis* (Ach.) Th. Fr., *Chrysotrix candelaris* (L.) Laundon, *Dimerella diluta* (Pers.) Trevis., *Evernia prunastri* (L.) Ach., *Hypogymnia tubulosa* (Schaer.) Havaas, *Ochrolechia arborea* (Kreyer) Almb., *O. subviridis* (Hoëg.) Erichs., *Parmelia caperata* (L.) Ach., *Parmeliopsis aleurites* (Ach.) Nyl., *P. ambigua* (Wulf.) Nyl., *Peltigera canina* (L.) Willd., *P. malacea* (Ach.) Funck, *P. praetextata* (Flk. ex Sommerf.) Zopf, *Pertusaria albescens* (Huds.) Choisy et Werner, *Physcia aipolia* (Ehrh. ex Humb.) Fürnrohr, *Platismatia glauca* (L.) W. Culb. et C. Culb., *Porina aenea* (Wallr.) Zahlbr., *Pseudevernia furfuracea* (L.) Zopf, *Pycnothelia papillaria* (Ehrh.) Duf., *Ramalina farinacea* (L.) Ach., *R. obtusata* (Ach.) Bitter, *R. pollinaria* (Westr.) Ach., *Stereocaulon incrustatum* Flk., *Strangospora pinicola*, *Usnea hirta* (L.) Wigg. em Mot., *Xanthoria candelaria* (L.) Th. Fr., *X. fallax*.

A preliminary estimation of the effects of BIR on the lichens indicates that 1.3% of the region flora has undergone a total destruction (*Peltigera praetextata*, *Pertusaria amara* (Ach.) Nyl. *f. slesvicensis* (Erichs.) Almb.), 42.6% of the species have partially destroyed localities (*Chaenotheca chrysocephala*, *Ch. ferruginea*, *Cladonia sp. div.*, *Parmelia saxatilis*, *P. sulcata*, *Evernia prunastri*, *Buellia punctata*, *Pertusaria coccodes*, *Hypogymnia physodes* and others) and numerous localities of 34.8% of taxa have been considered as threatened (e.g., *Arthonia byssacea*, *Peltigera sp. div.*, *Cetraria sp. div.*, *Hypogymnia tubulosa*, *Ramalina farinacea*, *Porina aenea*, *Coniocybe furfuracea*); 21,3% of the species do not reveal any changes in abundance or ranges.

The destruction includes the lichens of multiple localities and massive abundance, as well as the taxa of single localities and with low abundance.

The maps of lichen distribution (Fig. 1-8) present the condition of the lichen flora in 1970-1985. The localities marked as damaged are those which were found between 1970-1976 and, despite an intensive search, were not

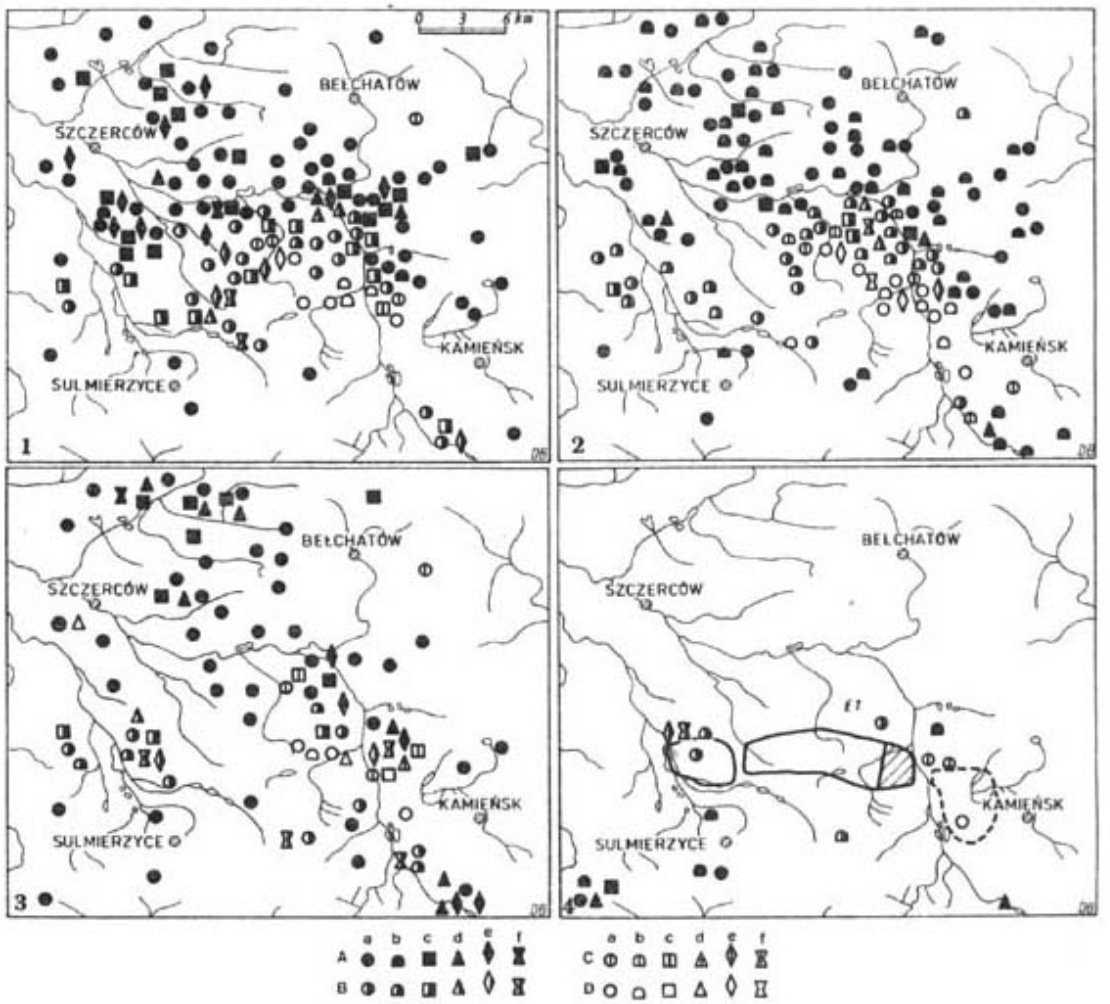
spotted after 1980. Still existing but threatened localities are those which may get destroyed as a result of some direct interference, e.g., by continuous mining works, forest cuts, water drainage, etc.

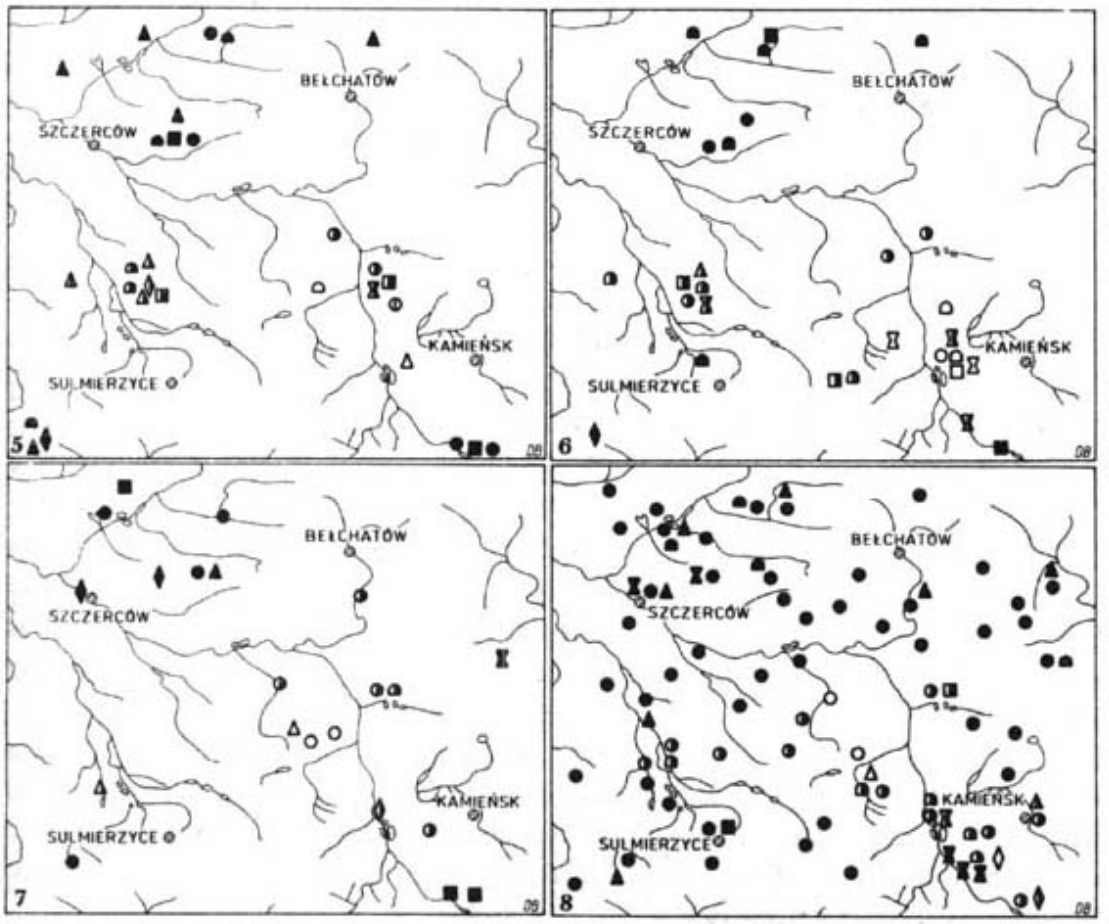
Fig. 1 illustrates the distribution of epigaeic psammophilous lichens. *Cladonia mitis*, characteristic of the pioneer psammophilous grasslands, is an example of the most common lichen in BIR. Other species are rarer components of the grasslands flora.

Epigaeic pine-forest lichens locations are presented by Fig. 2. Interesting and rare components of the old *Cladonia-Pinus* forests or of pine cultures are lichens of the subatlantic character: *Cladonia ciliata* Stirton, *C. portentosa* (Duf.) Zahlbr., *C. scabriuscula* (Delise ex Duby) Nyl.

Fig. 3 presents forest epiphytes associated with the boreal zone, they are to be found in the BIR on old pines, birches and junipers.

Figs. 4-6 illustrate the distribution of forest epiphytes of deciduous trees, e.g., oaks, hornbeams, alders, ash and fir. All of them species occur in old





Figs. 1-8. Distribution of selected lichen species and their changes caused by the Bełchatów Industrial Region

1 – present in 1984-1985; B – present in 1984-1985, however, evidently threatened; C – partially destroyed; D – totally destroyed; (Limits of brown coal mine, mine dump and power station (E_1) area – see Fig. 4)

1-8; 1-D_a – 1. Cladonia mitis, 2. Cetraria islandica, 3. Pseudevernia furfuracea, 4. Chaenotheca chrysocephala, 5. Parmelia saxatilis, 6. P. subrudecta, 7. P. tiliacea, 8. Xanthoria parietina; A-D_b – 1. Pycnothelia papillaria, 2. Cladonia rangiferina, 3. Usnea hirta, 4. Chaenotheca ferruginea, 5. Parmelia caperata, 6. Dimerella diluta, 7. Parmelia acetabulum, 8. Xanthoria candelaria; A-D_c – 1. Cladonia foliacea, 2. C. ciliata, 3. Platismatia glauca, 4. Chaenotheca trichialis, 5. Ramalina farinacea, 6. Micarea prasina, 7. Bryopogon crispus, 8. Xanthoria fallax; A-D_d – 1. Cetraria ericetorum, 2. Cladonia portentosa, 3. Cetraria chlorophylla, 4. Coniocybe furfuracea, 5. Arthonia spadicea, 6. Calicium glaucellum, 7. Ramalina fraxinea, 8. Caloplaca decipiens; A-D_e – 1. Stereocaulon condensatum, 2. Cladonia scabriuscula, 3. Cetraria sepincola, 4. Hypocenomyce caradocensis, 5. Porina aenea, 6. Calicium salicinum, 7. Micarea denigrata, 8. Caloplaca holocarpa; A-D_f – 1. Cladonia cariosa, 2. C. crispata, 3. Cetraria pinastri, 4. Bacidia assulata, 5. Pertusaria albescens, 6. P. coccodes, 7. Strangospora pinicola, 8. Thelocarpon laureri

forests under strictly specific humidity, light and air conditions. Due to a small number of localities, the resources of the species in question are especially endangered.

Fig. 7 presents a group of lichens connected with old park-trees, churchyard-trees, roadside-trees; they are also likely to be found on old fences, bridge rails, fallen tree trunks, etc. These are single localities, valuable for the lichen flora of the BIR.

Fig. 8 presents three groups of lichens. The species of genus *Xanthoria* are epiphytes of park-trees or roadside-trees. The species of genus *Caloplaca* are epipetric most frequently found on plasters and *Thelocarpon laureri* is an example of taxon spreading along with the BIR development (it was not known 10 years ago, however, intensively searched).

CONCLUSIONS

The special zone of changes and destructions of the lichen flora up to 1985 did not reach the limit determined on the grounds of the vascular flora changes and forest and peat-bog vegetation (Czyżewska, Jakubowska-Gabara 1985, see Figs. 1-8). Note that the visual range of the floristic changes caused by the cone of depression effect does not reflect the real degree of water drainage. The reaction of flora to water drainage declines with the distance from the drainage centre, where the decay of lichen species occurring in biocoenoses on hydrogenic soils proceeds really fast. The transformations in this group of plants have been caused by the following factors: the erection of the Bełchatów coal mine and power station complex (coal mine and power station area, roll fields of the cap-rock, ashes and slags store area, infrastructure, forest economy intensification – previous total cuttings) and the effects of the depression cone – and not the influence of air pollution. The effects of the above factors on the vascular plants are identical (Czyżewska, Jakubowska-Gabara 1985).

At present the processes occuring in the lichens proceed in two different ways:

– Regressive tendency is typical of all stenotopic species, first of all, of the epiphytes of deciduous trees (their decay is mainly caused by the depression cone effect) and of old park and roadside trees.

The entire decline of the epiphyte species, noted in the deciduous forests, is to be regarded in a broader context than the direct effects of the BIR. It is to be explained mainly in the light of the quick decay of lichens connected with the supraregional air pollution intensity, with the changes of the local climatic and water conditions and with the forest economy activities.

Attention should be paid to rare and very rare lichens of single localities – like *Hypocenomyce caradocensis*, *Bacidia assulata*, *Calicium glaucellum*, which occur in the BIR only at the Wola Wydrzyna forest range. The effect of the depression cone and the planned minning works in the „Szczerców" field mean a total destruction to the lichens in question. The changes of the lichen cover lead also to the decrease in resources or to the damage of the localities of many taxa which are either endangered or strongly threatened in Poland (Cieśliński, Czyżewska, Fabiszewski 1986), while they appear

in the BIR often in abundance (*Parmelia subrudecta*, *P. tiliacea* and others).

– Progressive tendency is characteristic of the grassland psammophytes, eurytopic acid-liable epiphytes and *Thelocarpon laureri*. The formation of new localities of grassland lichens is mainly connected with the increase in the area of the sand-grass lands.

Prognosis

1. The localities of the acid-liable psammophilous pine-forest lichens may increase still for some time, despite the decline of their resources at the first stage of the BIR influence. In a short time, however, a reversal of the phenomenon may occur. The stress factor leading to the decay of this group of plants will be local air pollutions by gases (SO_2 and other). The inhibiting effect of which on the growth and development of lichens has been fairly well analysed (Fabiszewski et al., 1983).

2. The localities of *Scoliciosporum chlorococcum* and of *Lecanora conizaeoides*, the lichens recognized as toxytolerant, will also probably spread (Ahti 1965; Ahti, Vitikainen 1974).

3. With regards to the strength and intensity of the influence of the regional and supraregional factors destructive to the flora of the BIR, we may assume that the rate of the lichens decay will increase, leading finally to their complete extinction on a considerable area.

The specific structure and features plus their extreme sensitivity to any environmental changes of the plants in question, makes impossible any transfer even of the most valuable taxa to another area or a future reconstruction of the whole species range, at present naturally existing under the climatic and habitat conditions of the BIR.

REFERENCES

Ahti T., 1965, Notes on the distribution of *Lecanora conizaeoides*. Lichenologist. 3: 91-92.

Ahti T., Vitikainen O., 1974, *Bacidia chlorococca*, a common toxitolerant lichen in Finland. Mem. Soc. Fauna Flora Fenn. 49: 95-100.

Barkman J. J., 1968, The influence of air pollution on bryophytes and lichens. in: Proceed. of the First European Congress on the Infl. of Air Pollution on Plants and Animals. Centre for Agric. Publ. and Document., Wegeningen: 197-209.

Börtitz S., Ranft H., 1972, Zur So_2 – und HF Empfindlichkeit von Flechten und Moosen. Biol. Zbl. 91:613-623.

Cieśliński S., 1978, Porosty rezerwatu Zagożdżon w Puszczy Kozienickiej. Fragm. Flor. Geobot. 24: 467-484.

Cieśliński S., Czyżewska K., Fabiszewski J., 1986, Czerwona lista porostów zagrożonych w Polsce – Red list of threatened lichens in Poland. in: K. Zarzycki, W. Wojewoda (eds), Lista roślin wymierających i zagrożonych w Polsce – List of threatened plants in Poland. PWN, Warszawa: 83-107.

Czyżewska K., 1972, Porosty rezerwatu leśnego „Spała". Zesz. Nauk. Uniw. Łódzkiego, ser. II. 51: 145-158.

Czyżewska K., 1974, Materiały do flory porostów województwa łódzkiego. Porosty rezerwatu modrzewia polskiego Trębaczew. Fragm. Flor. Geobot. 20: 243-253.

Czyżewska K., 1981, Flora porostów Wzgórz Radomszczańskich. Acta Univ. Lodz., Folia bot. 1: 225-256.

Czyżewska K., 1986, Changes in the lichens flora influenced by the Bełchatów Industrial Region. in: Czyżewska K. (ed.), 47 Zjazd PTB – 47th Congress of the Polish Botanical Society. Absreacts of lectures and posters, Łódź, Sept. 3-6, 1986. Wyd. Uniw. Łódzk., Łódź: 32.

Czyżewska K., Flora porostów i jej zmiany pod wpływem oddziaływania BOP (mscr.).

Czyżewska K., Jakubowska-Gabara J., 1985, Szata roślinna przyszłego Bełchatowskiego Okręgu Przemysłowego oraz zachodzące w niej zmiany we wstępnym okresie inwestycji. in: Liszewski S. (ed.), Zmiany w środowisku przyszłego Bełchatowskiego Okręgu Przemysłowego. PWN, Warszawa-Łódź: 127-140.

Czyżewska K., Olaczek R., 1983, Bełchatowski Okręg Przemysłowy w badaniach Instytutu Biologii Środowiskowej Uniwersytetu Łódzkiego. Acta Univ. Lodz. Folia sozol. 1: 89-123.

Fabiszewski J. et al., 1983, Fitoindykacja wpływu huty miedzi na środowisko biologiczne. Prace Wrocł. Tow. Nauk., ser B. 207: 1-109.

Nowak J., Tobolewski Z., 1975, Porosty polskie. PWN, Warszawa-Kraków: 1-1177.

Skye E., 1968, Lichens and air pollution. Acta Phytogeogr. Suecica. 52: 1-123.

Toborowicz K., 1983, Porosty Obszaru Chęcińskiego w Górach Świętokrzyskich. Fragm. Flor. Geobot. 29: 121-188.

Zielińska J., 1967, Porosty Puszczy Kampinoskiej. Monogr. Bot. 24: 1-129.

Zmiany we florze porostów pod wpływem oddziaływania Bełchatowskiego Okręgu Przemysłowego

Streszczenie

Badania prowadzono w latach 1970-1985 na obszarze 400 km^2. Zarejestrowano 155 gatunków, które obrazują stan wyjściowy zasobów porostów przed uruchomieniem kopalni węgla brunatnego i elektrowni „Bełchatów". Cennymi składnikami flory są porosty rzadkie w skali kraju lub tym regionie, np. *Bacidia assulata*, *Calicium glaucellum*, *Hypocenomyce caradocensis*, *Parmelia acetabulum*, *P. subrudecta*, *Porina aenea*, *Ramalina obtusata*, *Strangospora pinicola*, *Xanthoria fallax*. Wszystkie ich stanowiska cechuje mała zasobność. Prawie 26,5% flory jest obecnie notowana w „Czerwonej liście porostów zagrożonych w Polsce" (Cieśliński, Czyżewska, Fabiszewski 1986) jako gatunki wymierające (E; 5 gatunków) oraz narażone (V: 36 gatunków).

Szacunek wstępny wpływu budowy Bełchatowskiego Okręgu Przemysłowego (BOP) na porosty wykazuje, że całkowitemu zanieczyszczeniu uległo 1,3% flory; 42,6% gatunków posiada część stanowisk zniszczonych, a liczne stanowiska 34,8% taksonów są zagrożone. Tylko około 21,5% gatunków nie wykazało zmian w zasobności i zasięgach. Dla niektórych gatunków przedstawiono rozmieszczenie oraz stopień przekształcenia wywołany budową BOP (Figs. 1-8).

Jak dotychczas, zmiany następują w wyniku działań bezpośrednich, m.in. przez kontynuację robót górniczych, wycinanie lasów, oddziaływanie leja depresyjnego, nie zaś przez wpływ zanieczyszczeń powietrza.