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PIOTR JADCZYK*

NATURAL EFFECTS OF LARGE-AREA FOREST DECLINE IN THE WESTERN SUDETEN

A forest decline in the large area of the Western Sudeten in the late 70's and early 80's brought about severe changes within the abiotic environment leading to deep transformation of forest ecosystems. All environmental and system communities researched were considerably distorted. A decrease in the number of speciemen and in species diversity of communities as well as a change of dominant species were noted. Soil contamination, no habitat for arboreal species, microclimate changes and an increased insolation of undergrowth were the essential causes of these changes. Some disturbances to environmental conditions triggered changes within the composition of organism communities leading to further cascade disturbances within the composition of other organism communities. Deforestation of large areas was beneficial to photophilic and nitrophilous plants as well as to the birds and mammals of open areas and detritivores.

1. INTRODUCTION

A forest decline in the large area of the Sudeten in the late 70's and early 80's caused deforestation of 39 sq. km (15 sq. km on the Polish and 24 sq. km on the Czech side of the Sudeten). In times of natural disaster and forest rescue action, foresters, politicians and the society concentrated their attention on one issue: spruce decline. The reason for that was the economic and environmental significance of that species. Large-area forest dying in the Sudeten as well as in other numerous places throughout temperate climate zone was caused by simultanoeus actions of predisposition, initiation and participation factors. Industrial emissions played a significant role in each of these actions. Large-area forest decline does not only result in economic losses, but it also changes the conditions of environment occupied by a multitude of other species, which leads to deep transformations within the scope of the entire ecosystem [15]. Oftentimes, the changes have the character of cascade (change in number or dying of one species affects the number or dying of other species).

* Institute of Environmental Protection Engineering, Wrocław University of Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland. E-mail: piotr.jadczyk@pwr.wroc.pl

The influence of forest transformations on other organism communities that form forest ecosystems, ranging from protozoa to undergrowth plants and from invertebrate to birds and mammals [10], [19], [25], [31], was investigated extensively in the 80's and 90's in the Western Sudeten, and, in particular, in the Karkonosze Mountains. Changes in the composition of these organisms were caused by the very same factors as in the case of large-area forest stand dying and environmental changes occurring as a result of this phenomenon. The results of this investigation have not been repitulated yet, which is the aim of this work. Presently, the studies of this kind are carried out occasionally.

2. CHANGES OF ENVIRONMENTAL CONDITIONS IN DEFORESTED AREAS

The effects of long-term deposition of industrial imissions include:

- pH decrease in naturally acid soil of the Western Sudeten [4], [17],
- washout of alkaline soil nutrients (Ca, Mg, K) [9],
- transformation of aluminium contained in granite rocks in mother soils into water-soluble form, i.e. assimilable by plants [4], [24],
- an increase in the concentration of nitrate nitrogen and also of ammonia nitrogen but to a smaller extent in the soil; soil in the Western Sudeten is naturally poor in nitrogen compounds [9].

Spruce is naturally capable of acidifying rain water running down its treetop to the ground which intensifies soil acidity [30]. The presence of numerous declining trees in deforested areas was advantageous for mineralization of plant remains to nitrates [7], while the dying forest stand simultaneously limited and ceased to assimilate these from the soil [31].

The effects of thinning the density of gradually dying spruces included:

- intesified undergrowth insolation [24],
- shortage and subsequent lack of habitat for fauna and flora species dependent on dense tree stands [11], [31],
- availability of abundant organic matter in the form of dead trees [7],
- blowing away of snow to lower parts of the mountains [23] and a shorter period of snow cover due to increased hillside insolation [13].

3. CHANGES IN ORGANISM COMMUNITIES

Changes in environmental conditions caused by industrial pollutant emission and dying forests have affected the composition of all communities of organisms occupying all forest levels: from edaphon through levels of undergrowth to epiphytes and

avifauna. Environmental changes which were adverse to some species turned out to be neutral or propitious to others.

3.1. CHANGES IN PLANT COMMUNITIES

Of all plants it is the epiphytes that are most sensitive to environmental changes. Industrial emissions had a harmful influence on the following types of lichenes: *Lotaria, Usnea, Alectoria* and *Centraria*. They survived only in the least polluted areas of Wysoki Jesionik and Śnieżnik Massif [3] and in Bystrzyckie Mountains (author's observations – the beginning of the 90's and 2005). At the time of the dying of forests, in the transitional stage between dead and living trees, elimination of epiphytic *Bryophyta*, especially liverworts growing on the lower parts of trunks, was noted. The causes might be an excessive light and humidity decrease. In a young stand of spruce (10–20 years), shading was too dark for its population to reproduce. This posed the danger of floristic disturbances in future, full-grown ecosystems [31].

Changes in the availability of nutrients in the soil and intensified insolation of the undergrowth brought about changes in the composition of species [29]. The highest reproductive rate was noted for two species of grasses: nitrophilous *Calamagrostis villosa* and acidophylic *Deschampsia flexuosa*, the typical elements of the undergrowth in mountainous spruce forests. However, in the forest of undisturbed balance, their density is low. The deforested area was invaded by nitrophilous species (e.g. raspberry, *Rubus idaeus*) which belong to various communities found at the level of 1250–1550 m and subalpine level (e.g. cleavers, *Galium hercynium*), typical lowland species of a wide range of occurrence. Most of these species receded from occupied positions after they had been shaded by regenerating spruce. Due to competition, some expanding species, in particular the grasses of the genera *Calamagrostis* and *Deschampsia*, eliminated *Bryophyta* and shrubby plants of *Ericaceae* family, e.g. *Vaccinium myrtilus*, which need more shade and less nitrogen compounds [4], [8]. Earlier spring thaw results in an earlier beginning of plant growth, which is not profitable for plants. This could be the cause of a precocious start and prolonged duration of particular phenophases of bilberry (*Vaccinium myrtilus*) resulting in its poorer condition and less successful competition [12], [13]. An increase in the competitiveness of photophilic and nitrophilous species eliminated those forest species that found it more difficult to adapt to altered environmental conditions. The changes in the ecosystem had a cascade character.

3.2. CHANGES IN INVERTEBRATE COMMUNITIES

Edaphic organisms play a very significant role in matter circulation. Multicellular soil invertebrates putrefy remains of dead organisms and thus make them more

available for microorganisms and, by eating microorganisms, boost their activity [28]. Organic matter decomposition in soil caused by interaction between saprophytes and microorganisms may be up to five times faster compared to that caused by microorganisms only [22]. Changes in species composition in soil organisms were due to pollution and soil degradation as well as due to change in trophic conditions in the case of some groups of organisms. A decrease in the species diversity of soil protozoa [5], [25], nematodes [27] and colembollas [2] was noted in the deforested areas of the Mountains Karkonosze. Protozoa, unable to escape from a polluted place, are able to "escape in time" which was indicated by an increased number of resting forms of shell amoebae [5]. Nematodes in deforested grass areas were dominated by herbivorous species. Bacteriavorous and omnivorous species were also found in that area. Fungivorous, bacteriavorous and herbivorous nematodes were found to exist in preserved forests [27]. The number of collembolas decreased in deforested areas [25]. The availability of plant remains in deforested areas was favourable to earthworms and, subsequently, their number and species diversity demonstrated positive correlation with the degree of damage to tree stand. The most numerous species was acidophylic earth-worm *Dendrobaena octaedra* [20]. The most numerous inhabitant of the soil of the Karkonosze Mountains was saprophyte *Acari*, whose numbers in degraded areas were higher than in preserved forests. This fact indicated that it contributed greatly to organic matter decomposition of soil in degraded areas [25]. Abundant undergrowth in deforested areas favoured epigeic spiders. They were more numerous in deforested areas than in preserved areas. Deforestation caused a change of dominant species within this group. *Diplocephalus latifrons*, the dominant in the old forest, receded altogether and the dominant position was taken over by *Pardosa riparia* [2]. This species still holds supremacy in the Izerskie Mountains [21].

Undergrowth and brushwood spiders were less numerous in deforested areas than in spruce forests. Ecological disaster did not contribute to a decrease in diversity of diptera in the Karkonosze Mountains. Proportions were altered between trophic groups. The dying of forests drastically limited the food resource for phytophaga and abruptly enlarged the resource for insects feeding on dead wood. The groups of diptera started to dominate saprophytic species. The number of the imagines of diptera in deforested areas were lower than in preserved spruce forests [5]. Colonizing deadwood by xylophage such as bark beetle favoured the reproduction of predatory insects feeding on them. That is the reason why the underbark in the Karkonosze Mountains was most numerously inhabited by predatory species representing *Staphylinidae* accompanying *Scolytinae* [16]. The number of ants, their species diversity and nest density were the greatest in deforested areas and in ecotonic zone between the upper zone and subalpine level. These were a relevant element transforming the ecosystem of the Karkonosze Moutnatins [19].

3.3. CHANGES IN VERTEBRATE COMMUNITIES

The impact of ecological disaster in the Western Sudeten on the population of such land vertebrates as birds and minor mammals was investigated. On the other hand, any studies on changes in herpetofauna were not carried out.

Table

The number of birds nesting in preserved and dead spruce

Area of studies	Number of pairs per 10 hectares		Source
	Preserved forest	Dead forest	
The Karkonosze Mts.	49.5	19.5	[14]
KRNAP	26.8–36.0	18.5–23.0	Flousek – oral information – in [14]
The Izerskie and Karkonosze Mountains	31.9–43.0	16.0–21.5	[10]

In the spruce forests of upper zone, the average bird concentration decreased from 44.3 pairs/10 ha [6] to 9.6 pairs/10 ha due to ecological disaster [11]. Bird concentration depended on the density of treetops [10], [14]. The concentration was twice as low in dead forests as in preserved ones (the table). Destruction of forests also contributed to the decrease in the number of breeding species in the upper zone: from 13 to 4 species per 10 ha on average. Environmental changes in deforested areas are responsible for the following phenomena:

- receding (*Regulus ignicapillus*) or decrease in the number of forest species (e.g. woodpecker),
- increase in the number of species inhabiting open and ecotonic areas, e.g. tree pipit (*Anthus trivialis*),
- the number of species inhabiting diverse habitats were the least affected, e.g. chaffinch (*Fringilla coleobs*).

Changes in the number of other bird species made the chaffinch population amount to 73% of overall bird population despite a slight change in the absolute number of chaffinch. Ecological disaster in the Izerskie Mountains led to the re-creation of numerous clearings. This contributed greatly to the preservation of black grouse (*Tetrao tetrix*) and a gradual rise of its numbers [18].

As forests receded and grasses spread, minor forest mammal species (bank vole (*Clethrionomys glareolus*) and mice (*Apodemus* spp.)) were replaced by species inhabiting open areas (field vole (*Microtus*)) [10] and the species diversity of minor animals was lower in degraded areas than in preserved ones. The population of dominant field vole (*Microtus agrestis*) always exceeded 50% of overall population in degraded areas [1]. It caused damage to crops and its numbers correlated with the degree of damage to forest crops [10].

Numerous cervoid species also caused damage to crops. The environment of the Western Sudeten being transformed by disaster was rich in food (forest crops), and grasslands proved to be similar to their original environment and gave shelter from frost and wind in preserved forests. Their numbers were not regulated by predators (wolf, lynx, bear) which had become extinct in the Sudeten by the 18th century.

Attempts to control rodents and intensive culling aimed at reducing the number of cervoid species were not fully successful [26]. The number of rodents inhabiting open areas went down after the undergrowth had been shaded by young spruce. The number of cervoid species fell due to a series of harsh winters at the beginning of the 21st century. Once again it was proved that bringing nature back into balance disturbed by anthropopressure is beyond man's power.

4. CONCLUSION

Changes in environmental conditions in degraded forests of the Western Sudeten had an impact on all communities under study. A decrease in the number of specimens and categorized species as well as a change in dominant species were observed in many cases. Environmental changes turned out to be favourable to photophilic and nitrophilous plant species, invertebrate involved in decomposition of accumulated organic matter, birds and mammals inhabiting open areas. In some cases, a decrease in numbers of one species entailed a decrease in numbers of another (the cascade effect).

The majority of studies, the results of which form the basis of comprehensive description of changes within forest ecosystems of the Western Sudeten, were carried out 10–15 years after the trees had died. They were usually short-term studies. Based on the results obtained it is not possible to estimate the rate of regeneration of degraded ecosystems and to allow the nature to recover equilibrium disturbed by man. This would require a cyclical repetition of at least the part of the studies carried out at the end of the 20th century.

LITERATURE

[1] ADAMCZEWSKA-ANRZEJEWSKA K., *Dynamika liczebności i struktura zgrupowania drobnych ssaków w zdegradowanych i niezdegradowanych środowiskach Karkonoszy*, [in:] Sarosiek J., Štursa J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 15–18 X 1997, WPHU „Arcus" Poznań, 1997, t. 2, 45–51.

[2] ANDRZEJEWSKA L., *Zespoły zwierząt bezkręgowych gleby i warstwy zielnej w kilku degradowanych środowiskach Karkonoszy*, [in:] Fischer Z. (ed.), *Karkonoskie Badania Ekologiczne*, II Konferencja. 17–19 I 1994, Oficyna Wydawnicza Instytutu Ekologii PAN, Dziekanów Leśny, 1994, 251–267.

[3] BALCAR V., VACEK S., HENŽLÍK V., *Dynamika poškození lesních porostů v horských oblastech*, [in:] Jurásek A., Vacek S. (ed.), *Stav horských lesů Sudet v České Republice*, VÚHLM, VS Opočno, 1994, 73–100.

[4] BREJ T., FABISZEWSKI J., CAPECKI Z., *Zmiany antropogeniczne różnorodności roślinnej w Masywie Śnieżnika*, Annales Silesiae, 1997, XXVII, 63–74.
[5] DĄBROWSKA-PROT E., *Problemy różnorodności biologicznej fauny w warunkach niszczenia borów świerkowych w Karkonoszach*, [in:] Sarosiek J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 13–15 X 1994, Wydawnictwo „Arcus" Poznań, 1995, 129–134.
[6] DYRCZ A., *Ptaki polskiej części Karkonoszy*, Ochr. Przyr., 1973, 38, 213–284.
[7] FABISZEWSKI J., BREJ T., *Some ecological consequences of forest decline in the Sudety Mts*, Botanikertagung 13. bis, September 1992, Berlin.
[8] FABISZEWSKI J., MATUŁA J., SOBIERAJSKI Z., WOJTUŃ B., ŻOŁNIERZ L., *Zmiany ilościowe roślin runa sudeckiego boru górnoreglowego w drzewostanach o różnym stopniu degradacji*, [in:] Fischer Z. (ed.), *Karkonoskie Badania Ekologiczne*, I Konferencja, 3–4 XII 1992, Oficyna Wydawnicza Instytutu Ekologii PAN, Dziekanów Leśny, 1993, 77–85.
[9] FABISZEWSKI J., WOJTUŃ B., *Zjawiska ekologiczne towarzyszące wymieraniu lasów w Sudetach*, Pr. IBL B, 1994, 21, 195–209.
[10] FLOUSEK J., *Společenstva ptáků a drobných savců v imisemi postižených ekosystémech Krkonoš*, Vacek S. (ed.), *Monitoring výzkum a management ekosystémů na území Krkonošského národního parku*, VÚHLM, VS Opočno, 1996, 64–71.
[11] GRAMSZ B., *Zmiany awifauny pod wpływem degradacji lasów w Sudetach Zachodnich*, [in:] Sarosiek J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 13–15 X 1994, Wydawnictwo „Arcus" Poznań, 145–148.
[12] GWOREK B., WASIŁOWSKA A., *Analiza wybranych parametrów populacyjnych oraz zawartość metali ciężkich w różnych organach borówki czarnej (Vaccinium myrtilus L.)*, [in:] Sarosiek J., Štursa J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 15–18 X 1997, WPHU „Arcus" Poznań, 1997, t. 1, 257–263.
[13] KOSATKA K., WOJTUŃ B., MAKAREWICZ W., *Reakcja fenologiczna borówki czarnej Vaccinium myrtilus na zamieranie boru górnoreglowego w Karkonoszach*, [in:] Sarosiek J., Štursa J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 15–18 X 1997, WPHU „Arcus" Poznań, 1997, t. 1, 317–321.
[14] LEMBERK V., *Srovnávání ornitocenóz smrkových lesů Krkonoš podle stupně poškození imisemi*, Opera Corcontica, 1989, 26, 131–143.
[15] MANION P.D., *Tree disease concept*, Prentice Hall Inc., New Jersey, 1981.
[16] MAZUR A., *Chrząszcze kusakowate (Coleoptera, Staphylidae) w faunie polskiej części Karkonoszy*, [in:] Sarosiek J., Štursa J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 15–18 X 1997, WPHU „Arcus" Poznań, 1997, t. 2, 53–61.
[17] NOVÁKOVÁ E., SCHWARZ O., ŠTURSA J., *Ekologická únosnost území národního parku a biosférické rezervace Krkonoše*, [in:] Sarosiek J., Štursa J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 15–18 X 1997, WPHU „Arcus" Poznań, t. 2, 1997, 217–226.
[18] PAŁUCKI A., *Czynna ochrona głuszca Tetrao urogalus i cietrzewia Tetrao tetrix w Karkonoszach i Górach Izerskich*, Przyroda Sudetów Zachodnich, 1998, 1, 69–76.
[19] PĘTAL J., *Próba oceny zespołów mrówek w różnych siedliskach Karkonoszy*, [in:] Fischer Z. (ed.), *Karkonoskie Badania Ekologiczne*, II Konferencja, 17–19 I 1994, Oficyna Wydawnicza Instytutu Ekologii PAN, Dziekanów Leśny, 1994, 287–291.
[20] PIŽL V., *Žižaly (Oligochaeta, Lumbricidae) Krkonoš*, [in:] Sarosiek J., Štursa J. (ed.), *Geoekologiczne Problemy Karkonoszy*, materiały z sesji naukowej w Borowicach, 15–18 X 1997, WPHU „Arcus" Poznań, t. 2, 1997, 115–120.
[21] RYBAK J., *Effect of sulphur contaminants on macroinvertebrates in the Karkonosze Mountains (Sudeten, Poland)*, Environment Protection Engineering, 2009, Vol. 35, No. 1, 111–118.

[22] SKUBAŁA P., *Rozwój fauny roztoczy na hałdach, czyli jak przyroda walczy z przemysłem*, Kosmos, 2002, 51(2), 195–204.
[23] SOUČEK J., VACEK S., PODRÁZSKÝ V., *Sněhové poměry a jejich vliv na vývoj výsadeb na strmých svazich v Krkonoších*, [in:] Vacek S. (ed.), *Monitoring, výzkum a management ekosystémů na území Krkonošského národního parku*, VÚHLM, VS Opočno, 1996, 108–113.
[24] SOUKUPOVÁ L., *Víceletá dynamika rozvoje Calamagrostis villosa v acidifikovaných horských smrčinách středních Sudet*, [in:] Vacek S. (ed.), *Monitoring, výzkum a management ekosystémů na území Krkonošského národního parku*, VÚHLM, VS Opočno, 1996, 321–326.
[25] SZTRANTOWICZ H., *Formowanie się zespołu mikroorganizmów glebowych w różnie odkształconych ekosystemach leśnych Karkonoszy*, [in:] Fischer Z. (ed.), *Karkonoskie badania ekologiczne*, II Konferencja, Wojnowice 17–19 01 1994, Oficyna Wydawnicza Instytutu Ekologii PAN, Dziekanów Leśny, 1994, 321–325.
[26] SZUKIEL E., *Threats to Forest in Western Sudety Mountains, Caused by Herbivorous Mammals and Possibilities for Limitation of Damage*, Sylwan, 1993, CXXXVII (12), 11–25.
[27] WASILEWSKA L., *The influence of acid rain on soil nematode communities: a comparison of contaminated habitats in the belt of the Karkonosze and Izerskie Mountains (south-west Poland) with uncontaminated areas in other regions of Poland*, Ekol. Pol., 1996, 44 (1–2), 73–110.
[28] WOJEWODA D., KAJAK A., SZANSER M., *Rola mezo- i makrofauny w funkcjonowaniu gleby*, Kosmos, 2002, 51(1), 105–114.
[29] ZIENTARSKI J., CEITEL J., SZYMAŃSKI S., *Syntetyczny zarys historii gospodarki leśnej w Sudetach*, [in:] Paschalis P., Zajączkowski S. (eds.), *Protection of forest ecosystems*, Selected Problems of Forestry in Sudety Mountains, 1994, 11–28.
[30] ZIMKA J.R., STACHURSKI A., *Forest decline in Karkonosze Mts. (Poland)*. Part II. *An anlysis of acidity and chemistry of atmospheric precipitation, throughfall and forest streamwaters*, Ekol. Pol., 1996, 44 (1–2), 135–177.
[31] ŻOŁNIERZ L., FABISZEWSKI J., WOJTUŃ B., MATUŁA J., SOBIERAJSKI Z., *Zmiany ilościowe i jakościowe na obszarach o różnym czasie wylesienia w reglu górnym Karkonoszy*, [in:] Fischer Z. (ed.), *Karkonoskie Badania Ekologiczne*, II Konferencja, 17–19 I 1994, Oficyna Wydawnicza Instytutu Ekologii PAN, Dziekanów Leśny, 1994b, 153–161.

PRZYRODNICZE SKUTKI WIELKOOBSZAROWEGO ZAMIERANIA LASU W SUDETACH ZACHODNICH

Wielkoobszarowe zamieranie lasu w Sudetach Zachodnich na przełomie lat 70. i 80. spowodowało drastyczne zmiany w środowisku abiotycznym, prowadząc do głębokiego przeobrażenia ekosystemów leśnych. Znaczącym zmianom uległy wszystkie badane zespoły środowiskowe i systematyczne. W wielu przypadkach nastąpił spadek liczby osobników i różnorodności gatunkowej zespołów oraz zmiana gatunków dominujących. Istotnymi przyczynami tych zmian było zanieczyszczenie gleb, brak siedlisk dla organizmów nadrzewnych, zmiany mikroklimatu oraz zwiększenie intensywności nasłonecznienia w piętrze runa. Niektóre zaburzenia warunków środowiska powodowały zmiany w składzie zespołów organizmów, będąc przyczyną dalszych zaburzeń w zespołach innych organizmów na zasadzie kaskady. Wylesienie znacznych obszarów było korzystne dla roślin światło- i azotolubnych, ptaków i ssaków terenów otwartych i saprofagów.