Earthwatch Project
MOUNTAIN WATERS OF BOHEMIA

EARTHWATCH INSTITUTE FIELD REPORT

ACID RAIN: REHABILITATION OF THE AIR POLLUTION DAMAGED HEADWATERS IN NORTH BOHEMIA

Principal Investigators:

JOSEF KRECEK
Department of Hydrology
Czech Technical University

ZUZANA HORICKA
Faculty of Science
Charles University

Prague, Czech Republic, October 2004

INTRODUCTION

Long-term integrated monitoring (multidisciplinary ecological research of reservoirs and streams, and processes in their catchments) is a fundamental principle to better understanding the structure and function of ecosystems as well as the environmental impacts of air pollution.

The aim of the Earthwatch project "Mountain Waters of Bohemia" is to study mountain ecosystems (lakes, water courses, forest stands of spruce and beech, clear-cuts and forest plantations) to assess the level of their resistance, devastation or regeneration, and to contribute to the strategy of a reasonable multi-resource management of headwaters in the Jizera Mountains (North Bohemia, area of 350 km^2).

The year 2004 was the fourteenth year of our research programme supported by the Earthwatch Institute: 21 volunteers and 4 visitors from 8 countries, and 9 research staff members participated in three two-weeks field expeditions (Appendix 1 and 2).

RESEARCH PROGRESS 2004

The main objectives for our 2004 expeditions were:

1) to continue monitoring the acid atmospheric deposition in headwater catchments of the Jizera Mts. (40 rain-gauges, 20 stream profiles, 7 reservoirs, and their basins);
2) to continue the detailed study of forest hydrology and biogeochemistry in two experimental basins (clear-cut of mature spruce stands and forestation at Jizerka, and a control study in mature beech stands at Oldrichov);
3) to continue the research of three drinking water reservoirs (Sous, Bedrichov and Josefodol) in relation to the lake management, and the inventory of forest vitality, and forest practices in their basins;
4) to study stabilisation of soil erosion (namely in skid-roads and truck-roads) related to the spontaneous succession of herbaceous vegetation, amelioration of rills, and the revival of traditional forestry practices.

The detailed field activities were divided into three expeditions of two weeks (May 29 – June 12, June 19 – July 3, and July 10 - 24).

1. ATMOSPHERIC DEPOSITION

The research teams sampled rainwater from 40 gauges exposed within the territory of the Jizera Mts. to evaluate the atmospheric deposition in the open field and under the forest or grass canopy. Four forest stands were instrumented with rain-gauges – Oldrichov (O) - Common beech, elevation of 650 m, Bedrichov (B): Norway spruce, 780 m, Josefodol (JD): Norway spruce, 750 m, and Jizerka (J1) - 980 m) to measure through-fall, stem-flow, and interception of the canopy. At the clear-cut area of the Jizerka watershed (J2), through-fall was observed also under the canopy of invasive grass.

Sulphate still dominates in the acid atmospheric deposition. In 2004, in headwaters of the Jizera Mts., the annual load of sulphate varied from 6.4 to 10.8 kg/ha in the open field, and from 10.6 to 28.7 kg/ha under the canopy (Table 1). The clear-cut areas occupied by invasive grass, and semi-natural beech stands show a lower acid atmospheric deposition in comparison to spruce plantations.

Table 1. **Annual deposition of sulphur under the forest canopy**

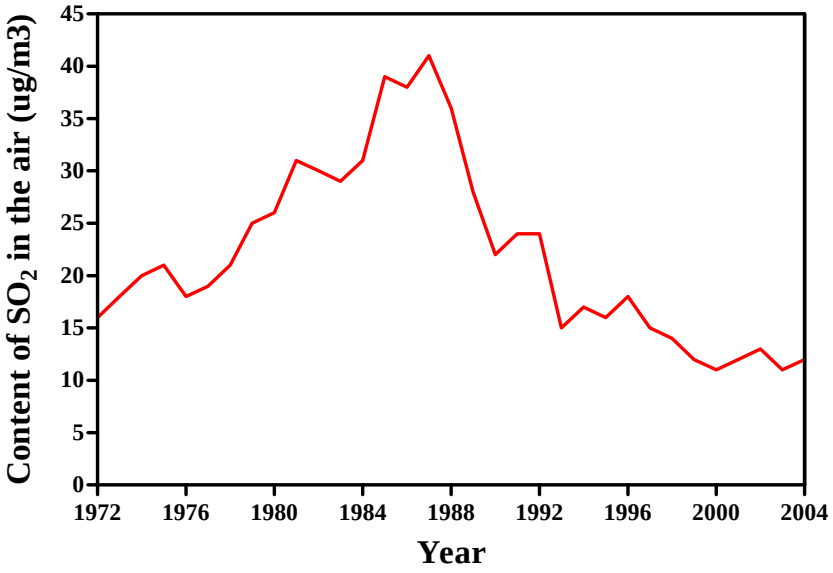
Forest stand	O	JD	B	J1	J2
Elevation (m)	650	750	780	980	980
Vegetation	Beech	Spruce	Spruce	Spruce	Grass
Age (year)	140-150	80-100	80-100	80-100	-
pH of rainfall	4.8	4.5	4.6	4.4	4.4
pH of throughfall	5.0	4.0	3.9	4.1	4.5
Deposition of sulphate in open field (kg/ha)	6.4	8.8	9.2	10.8	10.8
Deposition of sulphur under the canopy (kg/ha)	10.6	27.4	28.7	28.3	11.4

2. BIOGEOCHEMISTRY OF CLEAR-CUT AND REFORESTATION

Significant changes of pH, and concentrations of sulphate and nitrate in the Jizerka stream were found within the last 23 years (1982-2004): n = 23, a = 0.01, r^2 = 0.91, 0.71 and 0.81, respectively, Figure 2). Mean annual pH increased from 4 to 5.7, and concentration of sulphate decreased (from 13 to 6 mg/l) as well as nitrate (from 6 to 4 mg/l). The improvement in stream water quality seems to be a consequence of the reduction in both air pollution (Figure 1) and canopy of spruce plantations (Figure 2).

The reforestation of the Jizerka catchment is probably the main reason for the stagnation of stream water chemistry in the last 6 - 8 years. In the mixed regenerated stands dominates spruce (Norway spruce, Colorado blue spruce), dwarf pine and deciduous species (mountain ash, birch, beech). The observed stands reached the mean density of 15 trees per 100 sq.m. Within the elevation ranged from 880 to 960 m, the height of trees varies from 0.7 to 2.1 m, and the average density of the horizontal canopy is 0.14.

Figure 1. Mean annual content of sulphur dioxide in the air (Jizerka, 1972 – 2004)

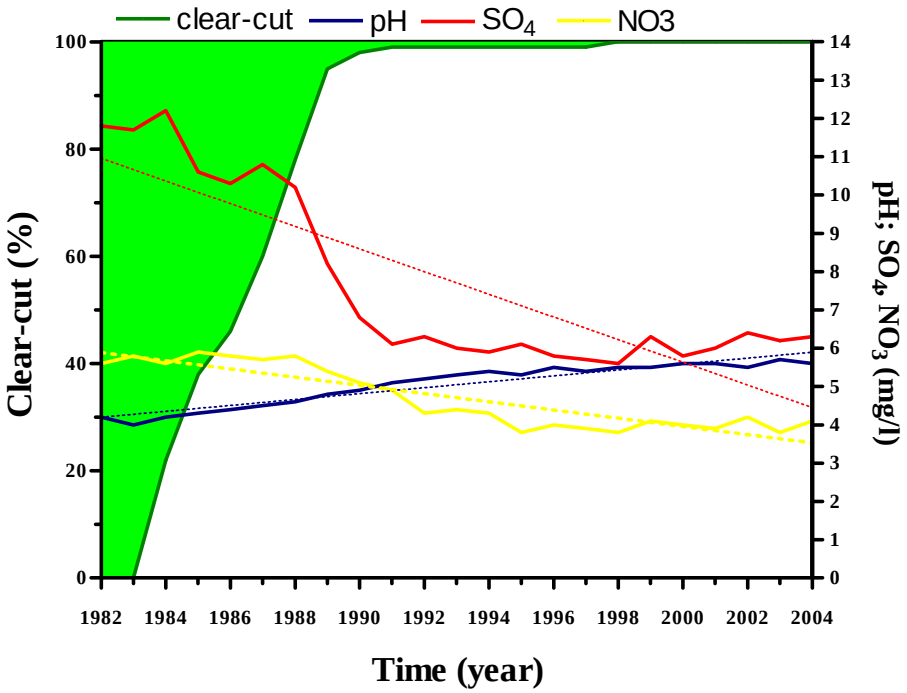


The herbaceous vegetation (invasive grass *Calamagrostis villosa* dominant) covers all the catchment. In the high season, the height of grass varies from 18 to 41 cm, and LAI (leaf area index) from 1.26 to 3.38 (Table.2).

Table 2. Grass characteristics at the transect of Jizerka (June - July 2004)

Length (m)	Height (cm)	Leaves (g)	LAI (-)	Roots (g)	Roots/Leaves
100	25	11.4	2.32	2.4	0.21
200	22	7.9	2.16	4.2	0.53
300	18	13.4	2.45	7.3	0.55
400	22	14.8	2.82	5.3	0.36
500	39	8	2.12	1.5	0.19
600	37	19.3	3.25	2.3	0.12
700	35	9.7	2.34	4.2	0.43
800	41	20.2	3.38	3.9	0.19
900	37	8.3	2.05	1.9	0.23
1000	25	18.9	3.15	0.4	0.02
1100	28	4.8	1.26	1.5	0.31
1200	28	8.5	2.02	1.7	0.20

Figure 2. Clear-cut and chemistry of stream water at the Jizerka catchment in the period of 1982-2004



3. REGENERATION OF DRINKING WATER RESERVOIRS

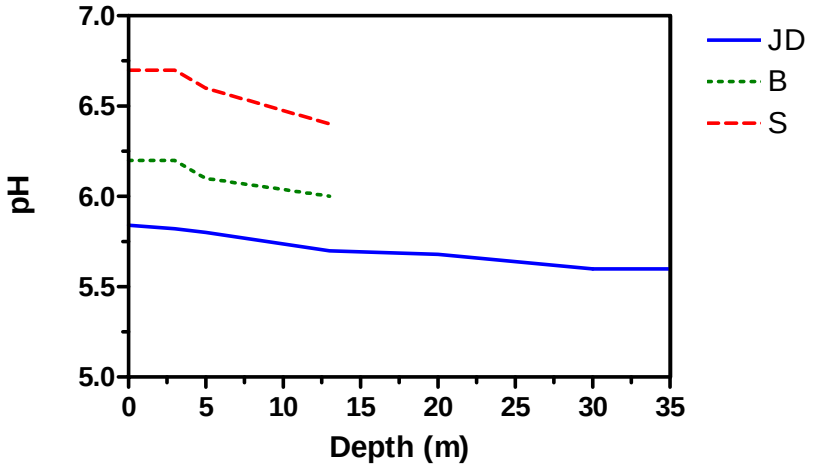
The drinking water reservoirs Bedrichov, Sous and Josefodol are dimictic, with a typical summer stratification of temperature and pH.

In 2004, the research teams collected signs of recovery of the reservoirs. However, the values of pH (5.5 - 6.7), alkalinity (17 - 38 μeq/l), and concentration of major ions (sulphate 8-13 mg/l, nitrate 1-4 mg/l) show still an extent of acidification (Figure 3). The species composition of phytoplankton is limited (low number of taxa, domination of Dinophyceae, namely *Peridinium* sp.). The evidence of zooplankton is scarce; the prevailing species are rotifers (*Brachionus sericus* and *Keratella valga*), crustaceans (*Ceriodaphnia quadrangula*) and Cyclopidae spp. (Copepoda).

The relatively high pH measured in waters of the Sous reservoir corresponds to the treatment of massive aerial liming (the middle of May 2004).

The population of acid-tolerant fish (brook trout) has been reintroduced in all three reservoirs during the last few years. It is evident that this population can survive and reproduce (well-proportioned age structure and individual growth, success in nutrition). The fish concentrates in reservoirs during the snow-melt and flood events, and in inlets during the summer base flow, following thus higher values of pH and lower contents of toxic aluminium.

Figure 3. Vertical profiles of pH in reservoirs Josefodol (JD), Bedrichov (B) and Sous (S) during the summer stratification (July 2004)



4. STABILISATION OF SOIL EROSION

In the late 1980s, commercial forestry practices deteriorated the soil surface at extensive clear-cut areas of the Jizera Mts. In the Jizerka catchment, skidding the timber by wheeled tractors enlarged the network of skid-roads and periodical drainage from 1.3 to 4.7 km/sq.km. The depth of rills was related to their slope and the frequency of skidding, and limited by the depth of shallow podzolic soils (up to 1.5 m). The erosion of soil increased from 0,01 to 1,34 mm/year.

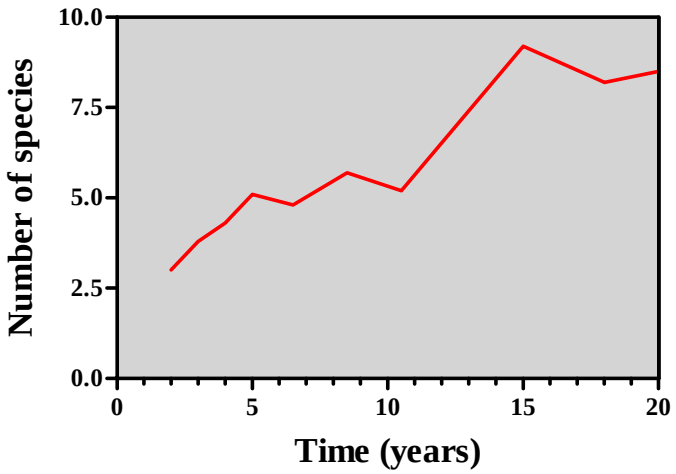
In the summer of 2004, research teams investigated the stabilisation of soil erosion related to the spontaneous succession of herbaceous vegetation in existing erosion rills (4 x 4 m phytosociological relevés, Braun-Blanquet scale). The observed herb vegetation in rills was studied in relation to their depth, slope and age (e.g. duration of succession). The depth of rills was classified into three categories: < 25 cm, 25 - 50 cm, and > 50 cm. Corresponding data were taken in the herb layer of forest clearings, and in stands of forest dieback.

The main factor affecting the recovery of erosion rills is their depth (Table 3). In the rills deeper than 50 cm, only a pure succession of herb plants (and limited protection of soil surface) was found.. Concerning the time (age of rills), positive significant relation was found namely to the number of species, and the occurrence of phanerophytes and chamaephytes (Figure 4). The results indicate also positive impact of the time on the occurrence of plant forming clusters, and negative impact on plant forming tillers.

Table 3. Correlation of the herb succession with depth, slope and age of rills

	Correlation coefficient r^2		
	Depth	**Slope**	**Age**
Cover percentage	**0.65**	0.07	008
Number of species	0.17	0.15	**0.54**

Figure 4. Number of species related to the age of rills



Therefore, the spontaneous succession of herbaceous vegetation is an important factor of the soil surface protection in skid-roads of the Jizera Mts. Concerning the stabilisation of soil erosion, higher number of shallow rills (<25 cm) seems to be better than few deeper rills.

ACKNOWLEDGEMENTS

Our special thanks are due to the volunteers and scientific colleagues who succeeded in field and laboratory data collection as well as data processing. We would also like to acknowledge our thanks to the staff of the Earthwatch Institute, particularly to *Heather Pruiksma* and *David Pavlik* for their assistance in managing our research teams.