

Dear participant in our field expeditions,

We very much appreciate your personal effort in gathering the data and sharing time with us during the 2008 field research expeditions into the Jizera Mts. With your help, we were able to continue already the eighteenth year of the longterm project concentrated on the restoration of headwater catchments and reservoirs affected by the acid atmospheric deposition.

Again, this year, we collected a lot of data, including standard field tests and samples of water, soil and biota in focused watersheds and water reservoirs.

The main outcome from our investigations is the evaluation of decreasing trend in the acid atmospheric deposition (after the extreme load in the late 1980s) and a progress in recovery of mountain waters in the Jizera Mts. However, we also found some warning aspects of adverse impacts: stagnating deposition of nitrogen, increasing acid load under restored spruce plantations, difficult reintroduction of deciduous tree species in the upper plain of the mountains).

We very much enjoyed your company and discussions on variety of topics during the expeditions, and, we really appreciated your interest in our professional disciplines and also in some other aspects of our life (including Czech history and culture).

Many thanks!

Yours faithfully,

*Josef Křeček*

# EARTHWATCH INSTITUTE ANNUAL FIELD REPORT

**Date completed:** 9<sup>th</sup> March 2009

**Completed by:** Josef Krecek

**Period covered by this report:** 1<sup>st</sup> January 2007 to 31<sup>st</sup> December 2007

**Project title:** Mountain Waters of the Czech Republic.

## Reporting on research objectives

1. Provide a summary of progress this year towards each of the objectives stated in your most recent research proposal.

**Objective 1:** To continue the longterm monitoring of the acid atmospheric deposition in focused basins of the Jizera Mts.

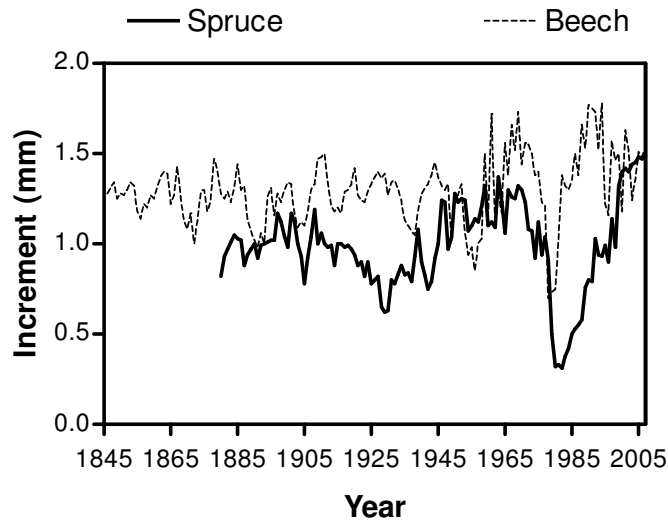
The observation system includes five monitored units (squares of 30 x 30 m): mature semi-natural beech stand, three different spruce plantations, and herbaceous vegetation. The plots are instrumented by 50 rain-gauges (open field precipitation, through-fall under the canopy), 5 stem-flow collectors and 3 fog-drip collectors. The volume of precipitation has been registered, and samples used for chemical analyses.

In 2008, the observed precipitation varied between 840 and 1320 mm. In the open field, the atmospheric load of sulphur varied between 8 and 15 kg ha<sup>-1</sup> year<sup>-1</sup> and nitrogen between 11 and 19 kg ha<sup>-1</sup> year<sup>-1</sup> (78 % N-NO<sub>3</sub>, 22 % N-NH<sub>4</sub>). Considering a longterm trend, since 2001, the load of sulphur seems to be relatively stable while the load of nitrogen is increasing: the annual ratio of N/S deposition in an open field has increased from 0.8 to 1.3. The average pH in sampled rain varied between 4.4 and 4.7. However, under the forest canopy, the deposition of sulphur has increased to 12 – 24 kg ha<sup>-1</sup> year<sup>-1</sup>.

Mean annual concentrations of SO<sub>2</sub> and NO<sub>x</sub> in the air, 3.2 – 5.8 and 10.3 – 15.5 µg m<sup>-3</sup>, did not exceed the “ecological limits” (20 and 30 µg m<sup>-3</sup>, respectively). However, the load of H<sup>+</sup> in investigated plots (1600 – 2300 mol H<sup>+</sup> ha<sup>-1</sup> year<sup>-1</sup>) still exceeded the “critical acid load” for spruce plantations (1463 mol H<sup>+</sup> ha<sup>-1</sup> year<sup>-1</sup>).

**Objective 2:** To estimate the recovery of forest stands by the diameter-increment analysis.

A dendrochronological study was used to evaluate effects of the extreme acid atmospheric deposition (observed in the 1980s) and a recovery (since the 1990). Samples of Norway spruce (*Picea abies*) and Common beech (*Fagus sylvatica*) were collected from 6 sites of different elevation. The record of diameter-increment represents the period of 1821-2007. For analysed spruce trees, there occurred a significant drop in the increment during the decade of 1980-1990 (cca 50 % of the longterm mean), and a recovery confirmed since 1995. Similar tendency was observed also at beech trees, however, spruce trees are evidently more sensitive to pollution.



**Objective 3:** To evaluate the annual progress in regrowth of forest canopy in the Jizerka experimental basin.

In the Jizerka basin (1 km<sup>2</sup>), *Junco effusi-Calamagrostietum villosae* became a new dominant community after the clear-cut of spruce plantations damaged by the acid rain problem (1984-1990). Reforestation has been complicated by relatively high moisture status, competition of herb communities and a high mortality of spruce seedlings. In 2008, the inventory included measurement of the horizontal canopy and height of all trees in 12 plots (squares of 20 x 20 m) located along the elevation gradient (860 - 970 m a.s.l) within the basin. By the number of trees 1237 per ha (Norway spruce 53%, Colorado blue spruce 26 %, Dwarf pine 16 %, Silver birch 3 %, Mountain ash 2 %); the average horizontal canopy density increased to 27 % and the height of trees to 2.6 m. The average leaf area index (including herbaceous vegetation) was 3.2.

**Objective 4:** To evaluate power of Ellenberg's indices to describe environmental changes in studied basins.

Ellenberg's indicator values (simple ordinal classes of plants with a similar realized ecological niche along a gradient) were tested to describe changing environmental conditions in the Jizerka catchment. Since 1982, plant succession and hydrological phenomena were studied there: *Calamarostis sp.* have been spreading widely with increased light incomes and soil moisture, particularly after the clear-cut of damaged spruce stands.

In 2008, botanical inventory was undertaken to complete changes in Ellenberg's indices (light, temperature, moisture, acidity and nitrogen) in time levels of 1991, 1998, 2002, 2005 and 2008. These changes were compared with observed hydrological parameters (soil water content, stream-flow chemistry and biota). Ellenberg's indicators of soil moisture and light describes well the plant succession related to climatology and hydrology of the clear-cut site. However, the Ellenberg's indices of soil pH and nitrogen were not sensitive enough to describe observed changes in chemistry and biology of soil and surface waters.

**Objective 5:** To evaluate progress in recovery of surface waters.

In 2008, again, the standard observation included 30 stream profiles and 3 water reservoirs. Streams were checked in different hydrological situations (during and after rainfall, and in dry periods), water temperature, conductivity and pH measured *in situ*, and water sampled for chemical analyses. Additionally, discharge in stream profiles was estimated by measuring the cross section, slope, velocity and hydraulic roughness. Water reservoirs were checked seasonally: three times during the summer stratification, and additionally in the autumn, winter and spring time.

The observed values (pH between 4.5 and 6.1, alkalinity from -54 to +65 µeq per litre, sulphate 5 – 18, and aluminium 0.1 – 0.3 mg per litre) confirmed the stagnation of water quality in surface waters of the Jizera Mts. since 2001. The episodically increased level of toxic inorganic aluminium (180 – 230 µg per litre) did not exceed the critical value for the survival of fish (300 µg per litre).

Native fish species in waters of the upper plateau of the Jizera Mts. were brown trout (*Salmo trutta*) and minnow (*Phoxinus phoxinus*). However, fish became extinct there already in the late 1950s. In the 1990s, brook trout (*Salvelinus fontinalis*) was successfully introduced into the reservoirs of Bedřichov, Sous and Josefodol. This North American salmonid is known for its tolerance of low pH but in the Jizera Mts., it shows an adaptation to extreme conditions (low water temperature, low pH with peaks of acidity in snowmelt and flood flows). The survival of the populations is enabled by the occurrence in lake - tributaries “systems” where the brook trout can feed, hide, spawn, and find a place or a water layer with more suitable pH. The individuals reach the age of 3+ years (most females are fertile in the age of 2+), and their average body length is 104 mm in the first year of life, 155 mm in the second, and 201 mm in the third year in Bedřichov; in the limed Souš reservoir, it is 124 mm, 194 mm, and 266 mm. The inventory of 2008 confirmed that, nowadays, there are stabilized, self-reproducing populations of brook trout in all the three reservoirs which, however, are still endangered by episodic acidification events with elevated concentrations of the toxic fraction of aluminium. An experimental reintroduction of brown trout and minnow to the reservoirs was not successful. However, on sites with higher values of pH (in lower parts of some streams), the brown trout wins in competition with brook trout now.

Also in 2008, the Sous reservoir was limed in early May after the snowmelt: air sprinkled fine crushed limestone (particle size of less 0.2 mm) was applied (12.0 g of calcite powder per 1 m<sup>3</sup> of water volume) on the water surface of the reservoir. Therefore, water pH increased from 4.5 to 7.5 and did not fall below 7.0 in the whole summer period. Zooplankton, phytoplankton and fish in the lake Sous has been monitored, and effects of liming evaluated later with longer record of observation. Nowadays, just longer fish individuals in comparison to the control sites are evident.

## Project development

1. What logistical or scientific challenges have you encountered in the past season and how will you address these during the next field season?

In 2008, we did not face any problem in the project development. Considering the research objectives, we plan to concentrate a little bit more on the study on liming effects in the Sous reservoir: to evaluate a cost benefit analysis including benefits in drinking water treatment, environmental impacts, and some alternatives (liming the watershed, conversion of forests to mixed or deciduous stands).

## Non-technical summary of results

1. Give an account of the data collected and results (inputs and data) for the period covered by this report, mentioning any emerging trends.

The gathered data consist of the output from field data-loggers (5 pressure sensors of 15-minutes water levels, two automatic climate stations; multi-labs: values of pH, conductivity, oxygen level, temperature and depth in vertical profiles of 5 reservoirs collected 5 times a year), and data collected manually (350 water samples, collecting benthic organisms in 20 sections of streams; 60 grass samples, 60 soil and root samples; 500 soil moisture readings; 300 readings of tree-vitality, 800 forest canopy data: height of trees, stocking, canopy density, and digging 5 soil pits upto 60-80 cm).

2. How do these data contribute to achieving **conservation impacts?** (e.g. actions based on results, management plans, site protection)

The outputs helps to identify the status of the local environment, and also the progress in the long-term restoration of mountain lakes and watersheds affected by the acid atmospheric deposition.

3. What is/ are the **significance/ benefits** of your research at the following levels?

- Local (to the area of the research site)
  - Progress in the management of mountain watersheds
  - Better local environment
  - Improved quality in local water resources
  - Restocking the fish in upper streams of the Jizera Mountains
  
- National / Regional
  - Water Resources Control: know-how to the Watershed Authority of the Elbe River
  - Better understanding the relationship between a mountain lake and related watershed
  - Better evidence of headwater wetland spots
  - Contribution to the high education: undergraduate and graduate courses (Czech Technical University, Charles University and Czech Agricultural University, Prague, Czech Republic)
  
- International
  - Outcomes are used by the permanent discussion process between the academic staff, decision makers, practitioners, NGOs and the public organized by EFC (European Forestry Commission) and FAO (Food and Agricultural Organization of the United Nations) on watershed management in European mountain regions.
  - The results are also used by IAHC (International Association on Headwater Control) in the preparation of Guidelines on Revitalization in Headwater Catchments of Central Europe.
  - High Education in Geography – MSc thesis at Oxford Brookes (Oxford, UK) and University of St Andrews (Scotland, UK)

## Communication of results

Printed:

Křeček, J. (2008): Impacts of climate change on distribution and melt of snow in high altitudes and latitudes. In: Proceedings of EFC/FAO Working Party on the Management of Mountain Watersheds, METLA, Muhos, 32 – 38

Křeček, J. & M. Chalupa (2008): Management of mountain watersheds in the Czech Republic. In: Proceedings of EFC/FAO Working Party on the Management of Mountain Watersheds, METLA, Muhos, 51-53

Křeček, J. & Z. Hořická (2008): Recovery of mountain water reservoirs exposed to the acid atmospheric deposition. In: Revitalisation of water systems in the landscape affected by antropogenic changes. Proceedings of the Czech Technical University in Prague, MSM 684077: 118-121

Křeček, J. , Z. Hořická & J. Nováková (2008): Environmental impacts of the acid atmospheric deposition and forest clear-cut in a mountain catchment. In: Taniguchi, M. (ed.), From Headwaters to the Ocean, Taylor & Francis Group, London, 105 - 110

Kubin, E. and J. Křeček (2008): Impact of forestry practices on groundwater quality in the boreal environment. In: Taniguchi, M. (ed.), From Headwaters to the Ocean, Taylor & Francis Group, London, 91 - 96

Van de Griend, A., J-P, Wigneron, P. Waldteufel & J. Křeček (2008): The European SMOS for large-scale water balance and climate modelling studies In: Taniguchi, M. (ed.), From Headwaters to the Ocean, Taylor & Francis Group, London, 375 - 380

#### **Visual:**

Photographs from the field are attached.

#### **Meetings and conferences:**

Two presentations in the *International Workshop of FAO/EFC: Twenty-sixth Session of the Working Party on the Management of Mountain Watersheds*, Oulu (Finland), August 18-22, 2008:

- Invited lecture on Impacts of climate change on distribution and melt of snow in high altitudes and latitudes
- Presentation of the Czech National Paper on Management of mountain watersheds in the Czech Republic

One presentation in the *International Conference HydroChange2008: Hydrological Changes and Management from Headwaters to the Ocean*, Kyoto (Japan), October 1-3, 2008:

- Invited lecture on Environmental reconstruction of mountain lakes and watersheds affected by the acid atmospheric deposition.

#### **Educational resources:**

The field data have been used in lessons applied by undergraduate and graduate courses at Czech universities: Czech Technical University, Charles University and Czech Agricultural University (Prague, Czech Republic); as well as by the preparation of BSc, MSc and PhD thesis in following academic institutions: Czech Technical University, Charles University and Czech Agricultural University (Prague, Czech Republic), Oxford Brookes University (Oxford, UK) and University of St Andrews (Scotland, UK).

## **Educational Opportunities**

1. Our project activities are involved by following groups:

- **Local communities**

We continue the cross-sectorial debate on restoration of mountain lakes and watersheds in the Jizera Mts. in cooperation with FAO started in 1997.

- **Students**

The results and data of the project are used in lectures of both undergraduate and graduate courses held at

- Czech Technical University: **Hydrology and Climatology** (J. Křeček), **Applied Hydrology** (J. Křeček) and **Quantitative Hydrology** (J. Křeček)
- Charles University: **Hydrobiology** (Z. Hořická)
- Czech Technical University: **Landscape Ecology** (J. Nováková), and **Applied Botany** (J. Nováková).

The data of the field expeditions were used for the MSc thesis of graduate student Jiří Kremša (Czech Technical University) and BSc thesis of undergraduate student Jiří Vrtiška (Czech Technical University).

- **Early career scientists**

Graduate (PhD) students Petr Punčochář and Pavel Veselý are staff-members of our EW field expeditions, the gathered field data are used in their thesis.

2. Has your project contributed to the completion of Masters' or PhD theses or degrees, or other educational research findings?

- In January of 2009, student Jiří Kremša (Czech Technical University) graduated with his MSc thesis based on the data from our field collected in seasons of 2007 and 2008.
- In December of 2008, student Miloš Rydval (University of St Andrews, Scotland, UK) completed MSc thesis using the field data collected in the Jizera Mts. in the summer of 2008.
- In May of 2007, our past volunteer Ryan Scott (student of Oxford Brookes University, Oxford, UK) finished MSc. thesis using the data collected during our field expeditions in 2006.
- In April of 2007, Zuzana Hořická (Charles University in Prague), finished PhD thesis using the longterm data of our project.

## Other

Is there anything else you would like to tell us about?

In 2008, we continued the process in evaluating the educational progress considering the knowledge of our volunteers. We still plan to summarize the results and publish them in the Journal of Geography in Higher Education (probably in 2009).

## Acknowledgements

Our thanks are going to volunteers and visiting scientists participating in the field expeditions into the Jizera Mts., and to the staff of the Earthwatch Institute, particularly to Jen Alger, Natalie Rothwell and Rowena Millard (Earthwatch Europe) for their assistance in managing our field research teams. We also would like to thank to Nikon Corporation (Tokyo, Japan) for providing us with field microscope and camera.