

U.S. - ROMANIAN COLLABORATIVE RESEARCH ON AIR POLLUTION EFFECTS ON FOREST ECOSYSTEMS

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ABSTRACT

Collaboration between the Romanian and American scientists and land managers on evaluation of spatial and temporal distribution of ozone and its effects on the Carpathian Mountain forests was part of a large international study conducted in 1997-1999. For the first time we documented that ambient concentrations of ozone in many locations of the Carpathians, including the Romanian sites, are toxic to forest vegetation. Sulfur dioxide & nitrogen dioxide concentrations were also monitored during the Carpathian study and forest health & biodiversity changes were evaluated. Results of the air quality monitoring, injury and growth evaluation of trees were integrated into the ICP-Forests Level II and European Union forest health monitoring networks. Results of the Carpathian study contributed to the substantiation in Romania of the recently issued national regulations regarding protected areas and forest vegetation monitoring. The Carpathian study led to an establishment of a long-lasting U.S. and Romanian scientific collaboration on evaluation of air pollution effects on the North American and European mountain forests. The International Long-term Ecological Research (ILTER) site in Retezat Mountains was established in 2000. During 2000-2002, research in Retezat focused on detailed characterization of air pollution distribution and evaluation of health and biodiversity of forest stands adjacent to the air pollution monitoring sites. In the new 2003-2005 ILTER study, Romanian, Polish, Slovak and American scientists evaluate resources and responses of Swiss stone pine (*Pinus cembra*) in the Retezat and Tatra Mountains to the continuously increasing ambient concentrations of ozone. The USDA Foreign Agricultural Service, the USDA Forest Service International Programs, ICAS and Romsilva have been providing financial aid and field support for the described U.S. and Romanian collaboration.

Keywords: air pollution, ILTER, international cooperation, mountain forests, ozone.

INTRODUCTION

Ambient ozone (O_3) concentrations have been gradually increasing for the past 100 years (Brasseur et al., 2001) and recently have become a major concern for human health, forest health and biodiversity (Wellburn, 1988; Krupa, 1998). Until early 1990s virtually nothing was known on levels and distribution of ambient O_3 in the formerly Communist countries of Central Europe (often called "Central and Eastern Europe" or CEE) including those of the Carpathian Mountains Region, i.e., the Czech Republic, Poland, Romania, Slovakia, and Ukraine. Political and economic changes in that part of Europe initiated in 1989 resulted in reduced industrial pollution, but on the other hand led to higher production of photochemical smog and its main component, O_3 . This is mainly due to a fact that the number of motor vehicles emitting hydrocarbons and nitrogen oxide, compounds that are precursors for ozone production, has drastically increased in Central & Eastern Europe since 1990. It is predicted that this trend in the CEE countries, including Romania, will continue in the future.

Ozone is a well-known phytotoxic pollutant affecting North American agriculture and forestry since 1950s (Taylor, 1984; McLaughlin, 1985). Phytotoxic effects of ozone in Western Europe have been observed since 1980s (Skarby and Johnsson, 1988) and in the Mediterranean Basin since 1990s (Bussotti and Ferretti, 1998). Ozone will continue to adversely affect the health of forests at global and regional scales. Based on the STOCHEM model, it is predicted that while in 1990, 8.3×10^6 km² of global forests (24.4% of all forests) were exposed to levels >60 ppb, by the year 17.0×10^6 km² (49.8% of all forests) will be in this category. This increase is even higher in the temperate and sub-polar areas, increasing from 5.3×10^6 km² (29.1% of all forests) in 1990, to 11.0×10^6 km² (60.2% of all forests) in 2100 (Fowler et al., 1999). Therefore, it is expected that in future years increasing areas of the CEE forests will be affected by elevated concentrations of ambient O_3 .

Monitoring of forest condition in Europe have been coordinated by the International Cooperative Program on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) since 1985 (PHARE, 1999). Despite significant reduction of industrial emissions that took place in the early 1980s, from mid-1980s through mid 1990s condition of forest health in the Carpathian countries deteriorated with the worst condition in the Czech Republic and Poland (Elvingson, 1997). However, since 1996 an improvement of forest health has been noticed in the Czech Republic, Poland, Romania and Slovakia that can be explained by favorable climatic factors during recent years. In contrast, in the Ukraine a sharp deterioration of forest condition has been noted since 1991, resulting in the highest (56%) defoliation in any country in Europe (Elvingson, 2000). In order to comprehend changes in health and biodiversity of the Carpathian forests, a good understanding of O_3 spatial and temporal distribution and effects is needed. In addition, the effects of O_3 and other air pollutants can not be fully understood if other interacting factors, such as nutritional status of trees, water availability, genetic changes in trees or effects of forest pathogens, etc., are not considered.

RESEARCH ACCOMPLISHMENTS

In 1997 -1999, a study sponsored by the USDA Foreign Agriculture Service on evaluation of ambient O₃ distribution in the forested areas of the Carpathian Mountains was conducted. This study was followed by a companion study on the effects of air pollution on forests health and biodiversity of the Carpathian forests (1998-2000). These studies revealed that elevated concentrations of ambient O₃ create a major threat to vegetation of CEE, including large portions of the Carpathian Mountains' forests (Bytnerowicz et al., 2002). Complete results of these studies were presented at the conference held in Stara Lesna, Slovakia in 2001 (Szaro et al., 2002), "Effects of Air Pollution on Forest Health and Biodiversity of the Carpathian Mountains" sponsored by NATO, IUFRO, USDA Foreign Agricultural Service, and USDA Forest Service. Results are also presented in a special issue of Environmental Pollution "Effects of Air Pollution on the Central & Eastern European Mountain Forests" (Bytnerowicz et al., 2004).

The US-CEE scientific collaboration continued with the two studies initiated in 2000 and incorporated into a newly developed network of the International Long-Term Ecological Research (ILTER). The main objective of these studies was to characterize spatial and temporal O₃ distribution and its biological effects in the Tatra Bilateral Park (Poland and Slovakia) and the Retezat National Park in Romania (Figure 1).

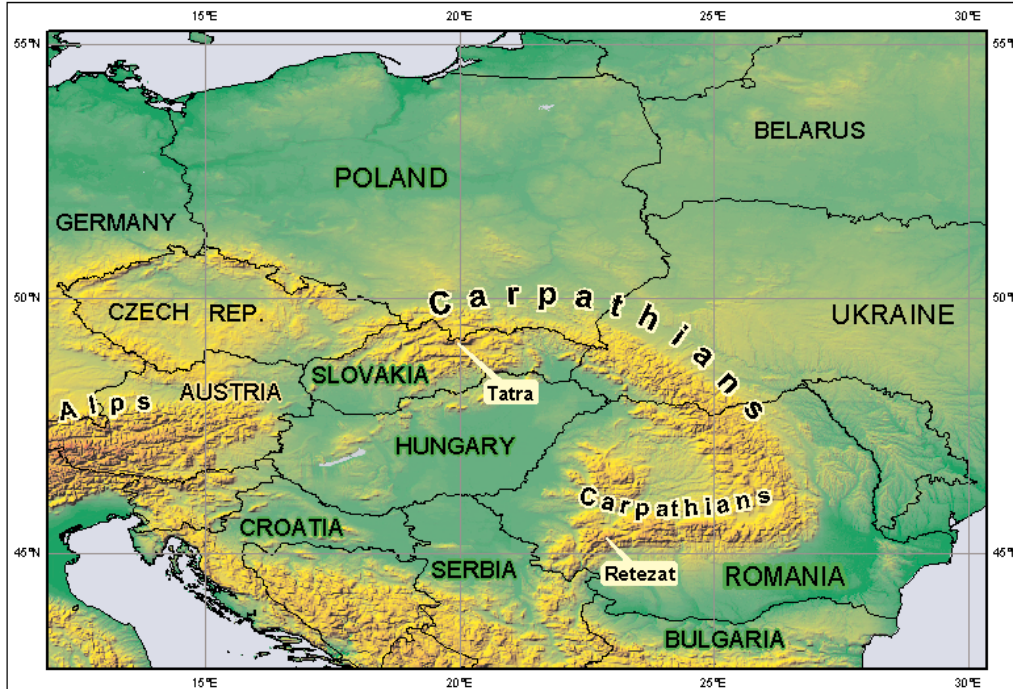


Figure 1. Location of the Retezat and Tatra International Long-term Ecological Research sites in the Carpathian Mountains.

For the Retezat study specific research objectives were as follows: a. Characterize spatial and temporal distribution of ozone, sulfur dioxide, ammonia and nitrogen dioxide; b. Evaluate incidence and severity of air pollution injury to vegetation; c. Select native indicators of air pollutants with a special emphasis on ozone; d. Evaluate effects of ozone and other pollutants on forest health and biodiversity; e. Evaluate effects of various land management practices on mountain ecosystems

Air pollution monitoring was performed on a network of 11 sites throughout the Park (Figure 2).

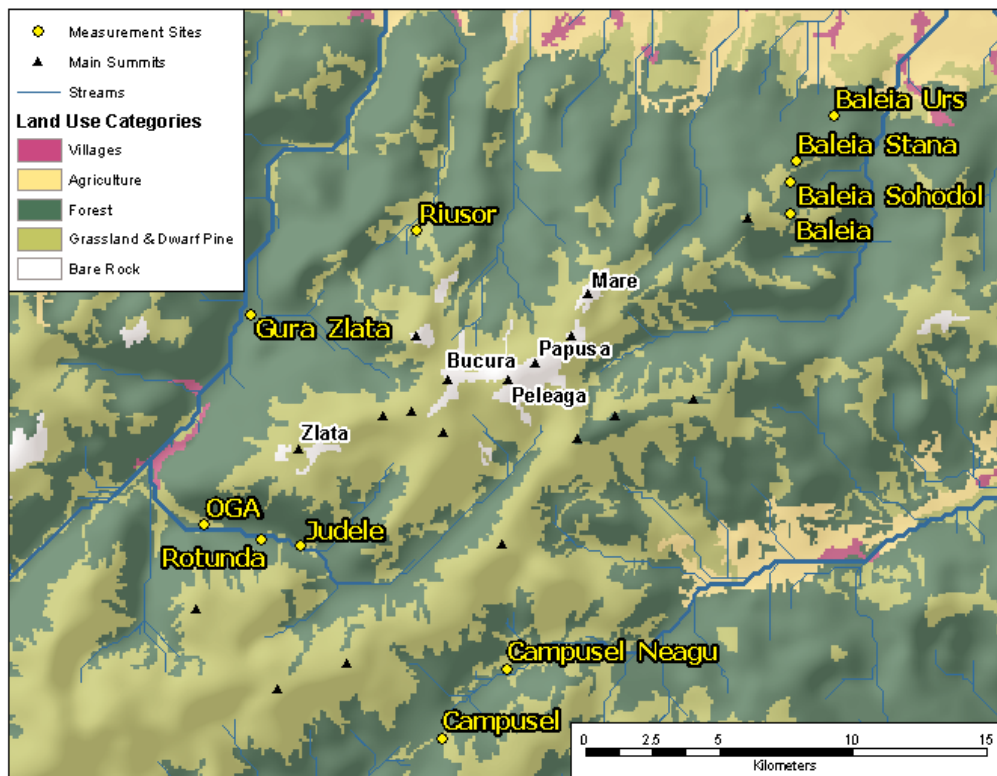


Figure 2. Air pollution monitoring network in Retezat National Park in 2000-2002.

Ozone concentrations at 4 sites in the Baleia area can serve as an indication of the air quality results. For that particular data set, no clear effect of elevation, but large differences between the years, and clear effects of time of season were found. During the July 15 - August 15, 2001 period, O₃ concentrations were especially high in the higher elevation sites (Figure 3). Such levels have a strong phytotoxic potential (Bytnerowicz et al., 2002). Another example of our activities in this project was development of a land use map for the Park and its adjacent areas (Figure 4). Clearly, the Park is surrounded by agricultural land, which may explain why very high levels of ammonia (NH₃) have been occasionally found in some of its locations (Bytnerowicz, unpublished).

More details regarding the ILTER studies in the Tatra and Retezat mountains during the 2000-2002 study can be found in Bytnerowicz et al. (2003).

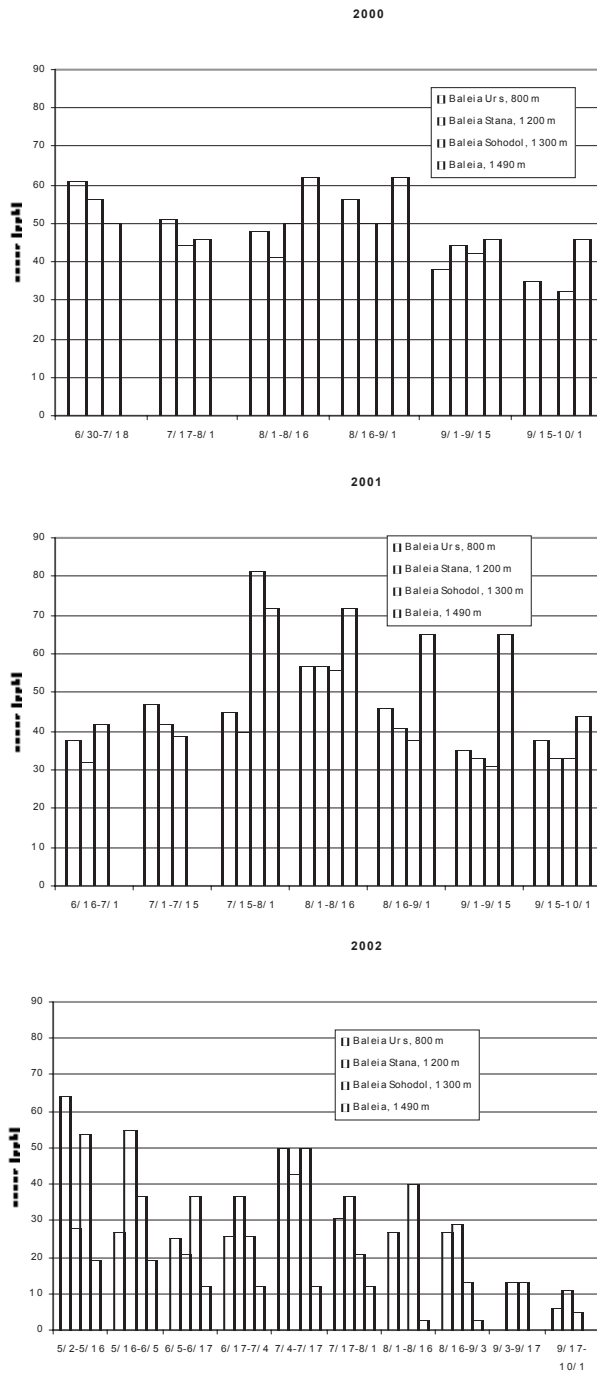


Figure 3. Concentrations of ozone at the Baleia area, Retezat National Park, in summer seasons of 2000-2002.

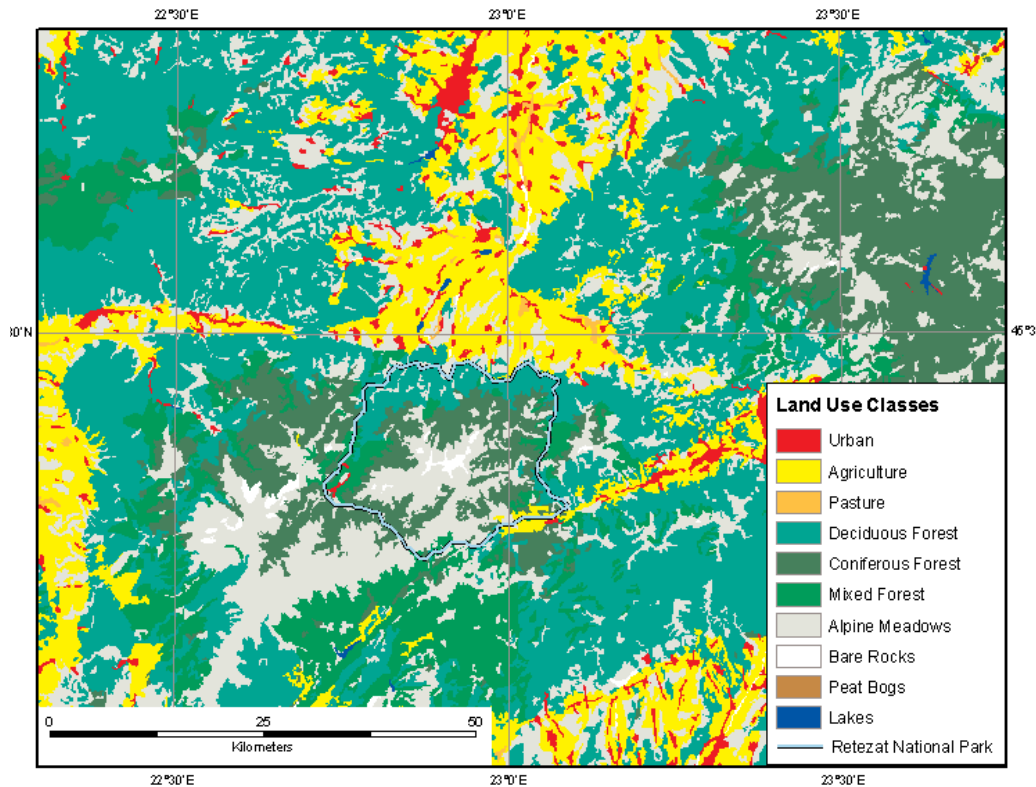


Figure 4. Land-use in Retezat National Park and the surrounding area.

NEW ILTER STUDIES

Starting in 2003, the collaboration between the US, Polish, Romanian and Slovak scientists and managers within the ILTER network focuses on evaluation of the resources of Swiss stone pine (*Pinus cembra*) and responses of this species to ambient O_3 concentrations in the Tatra and Retezat National Parks. *Pinus cembra* is a very important species in high elevation forests because of the following reasons: (1) may be used for reforestation of the sub-alpine zone to raise the timberline to its former limits. There this species plays a leading role in slowing water flow, stabilization of avalanche areas and reducing the effects of flush waters; (2) is crucial for establishment of spruce-larch-stone pine stands in high elevations in order to increase resistance to windthrow and establishment of windbreaks; (3) its wood has a high value for handicrafts and furniture making; (4) it has high resistance to blister rust caused by *Cronartium ribicola*; (5) its seeds are rich in turpentine and are valuable for pharmaceutical industry (Bugala, 1979; Badea and Tanase, unpublished).

Research objectives for the new 2003-2005 ILTER study in Retezat Mountains are: a. characterize ambient ozone concentrations at selected *P. cembra* stands; b. evaluate

growth, health and structure of *P. cembra* stands ; c. evaluate development of visual O₃-injury symptoms on *P. cembra* and understory vegetation; d. evaluate changes in health & biodiversity of the selected Retezat forest stands; e. evaluate condition and genetic characteristics of Swiss mountain pine stands.

CLOSING REMARKS

Regional monitoring efforts and knowledge obtained from intensive ILTER sites will help in developing risk assessment models for O₃ and other environmental stressors in the European forests. Coordination of the European efforts with similar endeavors in North America (including those under the auspices of the North American Forestry Commission) should greatly help in better understanding O₃-risks to forests and other ecosystems in the North Hemisphere. In this regard, the European and North American efforts should also be linked to similar activities in Russia, China and other Asian countries. This could be done with support of various international organization and networks such as IUFRO, ILTER, ICP-Forests, North American Forestry Commission or other UN and EU agencies.

There is also a clear need for more effective collaboration between forest scientists and management needed for developing science-based forest management plans. Such collaboration seems to be working well in Romania. Forest management plans for the Romanian forests are prepared by the scientists of the Forest Research and Management Institute (ICAS), tested in the Institute's experimental forests, and later implemented at a large scale in national forests. The Academy of Agricultural and Forestry Sciences supervises research activities of ICAS, while funding is provided by the national forests (Regia Nationala a Padurilor, 2000). Although information on the air pollution status of the Carpathian Mountains has been published in scientific literature (Bytnerowicz et al., 2002; 2004), these results should be translated into more informed management planning and environmental policies specifically designed for the Carpathian Region. In this regard, interactions between the scientists of the USDA Forest Service Pacific Southwest Research Station and the USDA Forest Service Region 5 air quality managers could be used as an example of the successful collaboration. Results of monitoring of ozone and N pollutants in the Sierra Nevada of California in summer 1999, allowed for establishing areas of potential risks to forests from ambient levels of the pollutants (Plymale et al., 2003; Procter et al., 2003). These results will help in planning various management activities on federal lands, including use of prescribed fires for fuel management, issuing permits for potential new industrial and agricultural activities, recommendations regarding implementation and revisions of federal and state air quality standards, and others. Exchange of information is also now beginning between forest managers in CEE and the US regarding air quality effects on forest ecosystems and management response.

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