

# Proceedings of the International Symposium on Air Pollution and Climate Change Effects on Forest Ecosystems

February 5-9, 1996      Riverside, California

Andrzej Bytnerowicz      Michael J. Arbaugh      Susan L. Schilling  
*Technical Coordinators*

## Contents

|   |    |
|---|----|
| Preface .....   | iv |
| <b>SESSION 1: Air Pollution/Climate Change Effects on<br/>Plants: General Topics</b> .....  | 1  |
| <i>William J. Manning and Stefan Godzik, Chairs</i>   |    |
| Biochemical Reactions of Ozone in Plants .....  | 3  |
| <i>J. Brian Mudd</i>  |    |
| Oxidant Induced Alteration of Carbohydrate Production<br>and Allocation in Plants .....   | 11 |
| <i>Robert L. Heath</i>  |    |
| The Use of Plants as Bioindicators of Ozone .....   | 19 |
| <i>William J. Manning</i>   |    |
| State of Polish Mountain Forests: Past, Present, and Future .....   | 27 |
| <i>Krystyna Grodzinska and Grazyna Szarek-Lukaszewska</i>   |    |
| Ozone Injury Responses of Ponderosa and Jeffrey Pine in the Sierra Nevada<br>and San Bernardino Mountains in California .....                               | 35 |
| <i>Paul Miller, Raleigh Guthrey, Susan Schilling, and John Carroll</i>  |    |
| <b>SESSION II: Air Pollution Status of Forest Sites</b> .....   | 43 |
| <i>Paul Miller and Juri Martin, Chairs</i>  |    |
| Ozone Air Pollution in the Ukrainian Carpathian Mountains and Kiev Region ..  | 45 |
| <i>Oleg Blum, Andrzej Bytnerowicz, William Manning, and Ludmila Popovicheva</i>   |    |
| Ozone Monitoring in the Krakow Province, Southern Poland .....  | 51 |
| <i>Barbara Godzik</i>   |    |
| Ozone in the Upper Silesia Region—Concentration and Effects on Plants .....   | 59 |
| <i>Stefan Godzik</i>  |    |
| Ozone Concentrations at the Bulgarian Govedartsi Ecosystem Site in<br>Early Summer of 1994 and 1995 .....   | 65 |
| <i>Evgeny Donev, Karl Zeller, and Christo Bojinov</i>   |    |
| Ozone and Modeled Stomatal Conductance at a High Elevation<br>Subalpine Site in Southeastern Wyoming .....  | 73 |
| <i>Robert C. Musselman, Karl F. Zeller, and Nediako T. Nikolov</i>  |    |
| Bulgarian Rila Mountain Forest Ecosystems Study Site: Site<br>Description and SO <sub>4</sub> <sup>2-</sup> , NO <sub>3</sub> <sup>-</sup> Deposition ..... | 79 |
| <i>Karl Zeller, Christo Bojinov, Evgeny Donev, and Nediako Nikolov</i>  |    |

Pacific Southwest  
Research Station

USDA Forest Service  
General Technical  
Report  
PSW-GTR-166

September 1998

|  |            |
|--|------------|
| Fire in Siberian Boreal Forests—Implications for Global Climate and Air Quality . . . . .  | 87         |
| <i>Susan G. Conard and Eduard P. Davidenko</i>   |            |
| Nutrient Fluxes in Forests of the Eastern Sierra Nevada: Comparisons with Humid Forest Systems . . . . .   | 95         |
| <i>Dale W. Johnson, Richard B. Susfalk, Randy A. Dalgren, Virginia Boucher, and Andrzej Bytnerowicz</i>  |            |
| Concentrations and Deposition of Nitrogenous Air Pollutants in a Ponderosa/Jeffrey Pine Canopy . . . . .   | 105        |
| <i>Andrzej Bytnerowicz, Mark E. Fenn, and Michael J. Arbaugh</i>   |            |
| Predicting Nitrogen Flux Along a Vertical Canopy Gradient in a Mixed Conifer Forest Stand of the San Bernardino Mountains in California . . . . .                  | 115        |
| <i>Michael J. Arbaugh, Andrzej Bytnerowicz, and Mark E. Fenn</i>   |            |
| Indicators of Nitrogen Status in California Forests . . . . .  | 123        |
| <i>Mark E. Fenn and Mark A. Poth</i>   |            |
| Nitrogen Deposition Effects on Coastal Sage Vegetation of Southern California . . . . .  | 131        |
| <i>Edith B. Allen, Pamela E. Padgett, Andrzej Bytnerowicz, and Richard Minnich</i>   |            |
| <br>   |            |
| <b>SESSION III: Air Pollution/Climate Change Effects on Forests: Results of Gradient and Case Studies . . . . .</b>  | <b>141</b> |
| <i>Reginald Noble and Alicja Breymeyer, Chairs</i>   |            |
| Transect Studies on Pine Forests Along Parallel 52° North, 12-32° East and Along a Pollution Gradient in Poland: General Assumptions . . . . .                     | 143        |
| <i>Alicja Breymeyer</i>  |            |
| Geographical Differentiation of the Floristic Composition and Structure of the Herb Layer of Forest Permanent Plots in East Germany, Poland, and Belarus . . . . . | 151        |
| <i>Ewa Roo-Zielinska and Jerzy Solon</i>   |            |
| Herb Layer Diversity and Phytoindicative Evaluation of Habitat Conditions of Forest Permanent Plots in Poland . . . . .  | 161        |
| <i>Ewa Roo-Zielinska and Jerzy Solon</i>   |            |
| Spatial and Vertical Distribution of Soil Physico-Chemical Properties and the Content of Heavy Metals in the Pedosphere in Poland . . . . .                        | 169        |
| <i>Marek Degorski</i>  |            |
| Transect Studies on Pine Litter Organic Matter: Decomposition and Chemical Properties of Upper Soil Layers in Polish Forests . . . . .                             | 179        |
| <i>Alicja Breymeyer, Marek Degorski, and David Reed</i>  |            |
| Geographic Information System (GIS) Analysis of Ecosystem Response to Industrial Pollution in the Niepolomice Forest in Southern Poland . . . . .                  | 187        |
| <i>January Weiner, Stefan Fredro-Boniecki, David Reed, Ann Maclean, Marshall Strong, and Michael Hyslop</i>  |            |
| Chemical Composition of Needles and Cambial Activity of Stems of Scots Pine Trees Affected by Air Pollutants in Polish Forests . . . . .                           | 197        |
| <i>Wojciech Dmuchowski, Ewa U. Kurczynska, and Wieslaw Wloch</i>   |            |
| Ectomycorrhizae of Young and Mature Scots Pine Trees in Industrial Regions in Poland . . . . .   | 205        |
| <i>Barbara Kieliszewska-Rokicka, Maria Rudawska, and Tomasz Leski</i>  |            |

|  |            |
|--|------------|
| Impact of Urban Environmental Pollution on Growth, Leaf Damage and Chemical Constituents of Warsaw Urban Trees . . . . .     | 215        |
| <i>Waldemar Chmielewski, Wojciech Dmuchowski, and Stanislaw Suplat</i>   |            |
| Seasonal Influences on Ozone Uptake and Foliar Injury to Ponderosa and Jeffrey Pines at a Southern California Site . . . . . | 221        |
| <i>Patrick J. Temple and Paul R. Miller</i>  |            |
| Effect of Ozone Exposure on Seasonal Gas Exchange of Five Western Conifers. . . . .  | 229        |
| <i>Nancy E. Grulke, Paul R. Miller, and Theodor D. Leininger</i>   |            |
| Mature Ponderosa Pine Nutrient Use and Allocation Responses to Air Pollution. . . . .  | 239        |
| <i>Mark A. Poth and Mark E. Fenn</i>   |            |
| <b>SESSION IV: Forest Health Monitoring: National Perspectives . . . . .</b>   | <b>249</b> |
| <i>Paul Miller and Oleg Blum, Chairs</i>   |            |
| Assessment of Forest Quality in Southwestern Poland with the Use of Remotely Sensed Data . . . . .                           | 251        |
| <i>Zbigniew Bochenek, Andrzej Ciolkosz, and Maria Iracka</i>   |            |
| Response of Scots Pine Stand Vitality to Changes in Environmental Factors in Poland, 1991-1995 . . . . .                     | 255        |
| <i>Jerzy Wawrzoniak</i>  |            |
| Air Pollution and Forest Health Studies along a South-North Transect in Poland . . . . .                                     | 259        |
| <i>Stefan Godzik, Jerzy Szdzuj, Tomasz Staszewski, and Wlodzimierz Lukasik</i>   |            |
| Forest Health Status in Russia. . . . .  | 267        |
| <i>Vladislav A. Alexeyev</i>   |            |
| Air Pollution and Climate Change Effects on Health of the Ukrainian Forests: Monitoring and Evaluation . . . . .             | 271        |
| <i>Igor F. Buksha, Valentina L. Meshkova, Oleg M. Radchenko, and Alexander S. Sidorov</i>                                    |            |
| Forest Condition in Latvia . . . . .   | 281        |
| <i>Madis Sipols</i>  |            |
| Forest Health Monitoring and Forestry Implications in the Czech Republic. . . . .  | 287        |
| <i>Martin Cerny and Pavel Moravcik</i>   |            |
| Dynamics of Forest Health Status in Slovakia from 1987 to 1994 . . . . .   | 293        |
| <i>Julius Oszlanyi</i>   |            |
| Forest Health Status in Hungary . . . . .  | 299        |
| <i>András Szepesi</i>  |            |
| Forest Health Monitoring Indicators and Their Interpretability: A Lithuanian Case Study . . . . .                            | 313        |
| <i>Romualdas Juknys and Algirdas Augustaitis</i>   |            |
| <b>SESSION V: Photosynthetically Active Radiation (PAR) Measurements and Their Use in Forest Health Monitoring . . . . .</b> | <b>321</b> |
| <i>Craig Palmer, Chair</i>   |            |
| Photosynthetically Active Radiation Measurements in Pure Pine and Mixed Pine Forests in Poland . . . . .                     | 323        |
| <i>Jaroslav Smialkowski</i>  |            |
| Remote Sensing Applied to Resource Management . . . . .  | 327        |
| <i>Henry M. Lachowski</i>  |            |

## Preface

**I**ndustrial air pollution has been identified as one of the primary causes of severe damage to forests of central Europe in the past 30 to 40 years. The mountain forest ecosystems have been affected considerably, resulting in extensive areas of severely deteriorated forest stands (e.g., the Krusne Hory of the Czech Republic or the Izerske and Sudety Mountains along the Polish and Czech border). In addition, the increase of motor vehicles in central Europe has caused a higher amount of nitrogen oxide and hydrocarbon emissions. Under particular weather conditions (high solar radiation, high temperatures, temperature inversions), these compounds may undergo complex chemical transformations resulting in the formation of photochemical smog and a build-up of potentially phytotoxic ozone concentrations. Ozone has already been responsible for injury to ponderosa pine stands in the San Bernardino Mountains in southern California and to forest vegetation in the eastern United States and western Europe. Elevated concentrations of nitrogenous components in photochemical smog and the emissions of ammonia from agricultural activities have caused eutrophication of natural ecosystems, including forests, both in Europe and North America. In addition, changing climatic factors, especially the amount of precipitation, temperature and solar radiation (including ultraviolet-B), modify responses of plants to air pollution, and must be considered when these effects are evaluated.

To successfully prevent additional deterioration of forest health both in central Europe and in the United States, well-coordinated research activities are needed in the areas of air pollution and forest health monitoring, investigations of the effects of air pollution and climate change on forest functioning, and selection and implementation of proper response strategies. These studies may result in stricter air pollution standards in the forested areas and more effective control strategies. Reduction of air pollution and the simultaneous improvement in understanding forest functioning and the application of research results should help prevent future forest decline and rebuild the already damaged forests. Cleaner air also results in the preservation of valuable biological resources and healthier living conditions of people.

Since 1991, U.S. agencies such as the USDA Forest Service (FS), USDA International Cooperation and Development (ICD), and U.S. Environmental Protection Agency (EPA), and the European institutions such as the Polish Academy of Sciences have sponsored a collaborative scientific program entitled "The Effects of Atmospheric Deposition and Climate Change on Forest Ecosystems in Central and Eastern Europe and the United States." This program has resulted in several cooperative studies between U.S. and Polish scientists, introduced the European cooperators to the forest health monitoring procedures used in the U.S., and provided training in using plants as bioindicators of air pollution phytotoxicity. Other cooperative studies, sponsored mainly by the FS, ICD, and European institutions, have been conducted in Bulgaria, Poland, the Czech Republic, and Ukraine. Thanks to the financial support provided by the U.S. State Department, FS, and EPA, and governments of the European countries, the European participants have received advanced training in the U.S. Forest Health Monitoring methodologies, and selected countries have implemented this system. In addition, funds received from the USDA FS Pacific Global Change Research Program and the Southern California Edison Company made possible collaborative research between Polish, U.S., and Canadian scientists on the effects of elevated levels of nitric acid vapor (an important component of photochemical smog) on California tree species.

Partial presentation of the developing plans for this cooperative research and some of the preliminary results were presented at the international conference "Climate and Atmospheric Deposition Studies in Forests" organized by the Polish Academy of Sciences and the USDA Forest Service in October 1992 in Nieborow, Poland. In addition, at the Nieborow meeting, Ann Bartuska of the FS suggested that the Pacific Southwest Research Station, USDA FS organize an international symposium in Riverside, California in 1995/1996. The purpose of such a meeting would be to present and discuss the continuing progress of the U.S.-European research cooperation.

Thanks to the financial support of the USDA ICD, the USDA FS, and a grant from the Southern California Edison, the International Symposium on Air Pollution and Climate Change Effects of Forest Ecosystem was held in the recently renovated historic Mission Inn in downtown Riverside on February 5-9, 1996. The primary goal of the meeting was to discuss the effects of air pollution and climate change and modification of these effects by other abiotic and biotic factors on forest ecosystems. Seventy scientists, forest managers, and decision makers from Belarus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, Slovakia, Ukraine and the United States participated in the meeting.

The participants of the symposium were greeted by the Mayor of the City of Riverside, Ronald Loveridge, who is also a member of the South Coast Air Quality Management District, and James Space, Director of the Pacific Southwest Research Station, USDA Forest Service. In his opening remarks James Space stated, "The issues of global climate change and human-made air pollution are closely intertwined and have been the subject of major inter-governmental research programs, both locally and worldwide. The implications are vital to the long-term sustainability of our forest ecosystems." William T. Sommers, Director of the Forest Fire and Atmospheric Sciences Research Staff, USDA Forest Service, outlined the domestic and international activities of the FS related to air pollution and climate change effects on forests and the U.S. forest health monitoring activities. Whetten Reed, Director of the USDA International Cooperation and Development, discussed international cooperative research sponsored by the USDA in central and eastern Europe.

These introductory speeches were followed by five scientific sessions in which more than 40 papers by European and U.S. forest scientists and managers were presented. Session 1 included the mechanisms of the effects of oxidant air pollutants on plants, the use of plants as bioindicators of air pollutants, and the effects of air pollution and climatic factors on mountain forests of southern Poland and the San Bernardino Mountains and Sierra Nevada of California. At Session 2 papers were presented on air pollution status in European and U.S. forest sites, effects of fire on the Siberian boreal forests, and deposition of nitrogen air pollutants to forests and its effects on the health and ecology of natural ecosystems. At Session 3 the results of case studies addressing air pollution and climate change on forests, both in Europe and the United States, were discussed. Session 4 included information on the status of forests in the individual countries, based on the results from the Forest Health Monitoring networks. Session 5 dealt with measurements of photosynthetic active radiation (PAR) and its use for forest health monitoring efforts; and a video, "Integrating Remote Sensing with GIS," produced by the USDA FS, was shown. In general, the meeting provided an update on forest health and air pollution status in forests, mechanisms of air pollution and climate change on forest vegetation, and an evaluation of the possible ecological effects of air pollution and climatic factors in forests of the represented countries.

After 2 days of sessions, three field trips were offered to the symposium participants: (1) in the San Bernardino National Forest and Joshua Tree National

Park in California, the air pollution monitoring efforts, effects of air pollution on natural resources of forest and desert ecosystems, and programs that involve school children in nature preservation were presented; (2) at the Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, software used for forest health monitoring activities in the United States and some of the central European countries was demonstrated, and the participants received hands-on training of the presented methodologies; and (3) at the Pacific Southwest Research Station, USDA FS in Riverside visitors were acquainted with scientific activities related to the effects of air pollution and climate change on forests, various aspects of research and management related to fire presence in forests, meteorology and fire severity forecasting, and wildland recreation and the urban culture research, and visited the Botanic Garden of the University of California, Riverside and natural history collections of the Riverside Municipal Museum.

Future research cooperation between the U.S. researchers and their European colleagues may include climatic gradient studies in Poland, Belarus, and Russia or cooperation between the Czech Republic, Poland, Slovakia, Ukraine and the United States on ozone distribution studies and phytotoxicity in forests of the Carpathian Mountains. In addition, a similar meeting may be organized in a few of years in one of the European countries to discuss and evaluate progress of the ongoing cooperative work.

The Organizing Committee for the Symposium on February 5-9, 1996 consisted of Alicja Breymeyer, Polish Academy of Sciences; Andrzej Bytnerowicz, USDA Forest Service; William Manning, University of Massachusetts; and Reginald Noble, Bowling Green State University. The Local Arrangements Committee consisted of Michael Arbaugh, Linda Burkholder, Andrzej Bytnerowicz, Paul Miller, Mark Poth and Susan Schilling, Pacific Southwest Research Station, USDA Forest Service.

Andrzej Bytnerowicz,  
*Technical Coordinator*



**Publisher:**

Albany, California  
Mailing address:  
PO Box 245, Berkeley CA  
94701-0245

(510) 559-6300

<http://www.psw.fs.fed.us>

**September 1998**

**Pacific Southwest Research Station**

Forest Service  
U.S. Department of Agriculture

**Abstract**

Bytnerowicz, Andrzej; Arbaugh, Michael J.; Schilling, Susan L., technical coordinators. 1998. **Proceedings of the international symposium on air pollution and climate change effects on forest ecosystems**; 1996 February 5-9; Riverside, CA. Gen. Tech. Rep. PSW-GTR-166. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 332 p.

The purpose of the International Symposium on Air Pollution and Climate Change Effects on Forest Ecosystems held February 5-9, 1996 in Riverside, California, was to summarize results of several years of scientific collaboration between the United States and European specialists about air pollution and climate change effects in Central European and North American forests. More than 40 technical presentations given by scientists and forest managers from the United States and Central Europe were divided into 5 sessions discussing mechanisms of air pollution and climate change effects on plants; air pollution status of forests; results from several gradient and case studies on the effects of air pollution/climate change on forests; information on forest health in several Central European countries; and information regarding photosynthetic active radiation measurements and their use in forest health monitoring.

*Retrieval Terms:* effects on forests, monitoring, nitrogen deposition, ozone, sulfur dioxide

**Technical Coordinators**

**Andrzej Bytnerowicz** is Ecologist, **Michael J. Arbaugh** is Statistician, and **Susan L. Schilling** is Computer Programmer with the Atmospheric Deposition Effects in Western Forest Ecosystems Research Unit at the Pacific Southwest Research Station, USDA Forest Service, 4955 Canyon Crest Dr., Riverside, CA 92507.



United States  
Department  
of Agriculture

Forest Service

Pacific Southwest  
Research Station

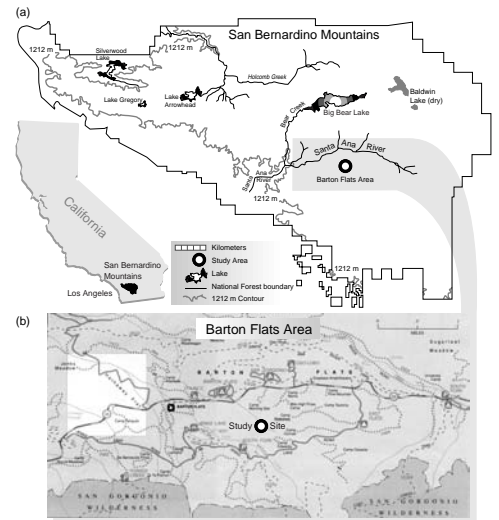
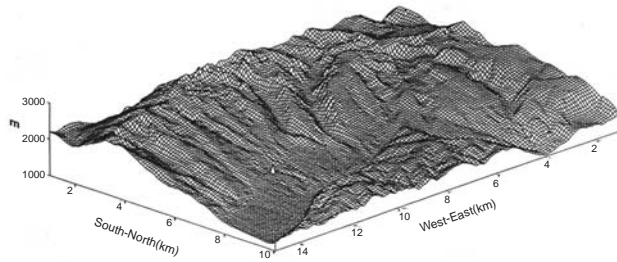
General Technical Report  
PSW-GTR-166



# Proceedings of the International Symposium on Air Pollution and Climate Change Effects on Forest Ecosystems

February 5-9, 1996

Riverside, California



United States  
Department  
of Agriculture  
Forest Service  
**Pacific Southwest  
Research Station**

General Technical Report  
PSW-G-TR-166



# **Proceedings of the International Symposium on Air Pollution and Climate Change Effects on Forest Ecosystems**

**February 5-9, 1996    Riverside, California**

**The Forest Service, U.S. Department of Agriculture, is responsible for Federal Leadership in forestry.**

It carries out this role through four main activities:

- Protection and management of resources on 191 million acres of National Forest System lands
- Cooperation with State and local governments, forest industries, and private landowners to help protect and manage non-Federal forest and associated range and watershed lands
- Participation with other agencies in human resource and community assistance programs to improve living conditions in rural areas
- Research on all aspects of forestry, rangeland management, and forest resources utilization.

**The Pacific Southwest Research Station**

- Represents the research branch of the Forest Service in California, Hawaii, American Samoa, and the western Pacific.



The United States Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or familial status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at 202-720-2600 (voice and TDD).

To file a complaint of discrimination, write

USDA, Director  
Office of Civil Rights  
Room 326-W, Whitten Building  
14th and Independence Avenue, SW  
Washington, DC 20250-9410

or call

(202) 720-5964 (voice or TDD).

USDA is an equal opportunity provider and employer.

