

**Final Report
for the JFSP project
“Forest Fires and Air Quality Issues”**

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Andrzej Bytnerowicz, PI

Background

The interaction between smoke and air pollution creates a basic conflict between public health and fuels treatments. Fuels treatments (prescribed fire and mechanical removal) proposed for the National Forest lands are intended to reduce fuel accumulations and wildfire frequency and severity, as well as to protect property located in the wildland-urban interphase (USDA, 2001). However, prescribed fires produce gases and aerosols that have instantaneous and long-term effects on air quality (Fang, 1999). If fuels treatments are not conducted, however, then wildland fires become more severe and frequent causing worse public health and welfare affects. A better understanding of air pollution and smoke interactions is needed in order to protect the public health and allow for socially & ecologically acceptable use of fire as a management tool. This could be accomplished by innovative wide-scale monitoring efforts (field and remotely sensed), and development of models predicting spatial and temporal distribution of air pollution and smoke resulting from forest fires and other sources.

Similarly, very little is known about the role of ambient air pollution in predisposing forests and other ecosystems to catastrophic fires. Ambient ozone (O₃) has been documented to weaken trees, predispose them to bark beetle attacks, and increase their foliar senescence and fuel build-up (Takemoto et al., 2001). Elevated levels of nitrogen (N) deposition, resulting from N pollutant emissions, have been observed to increase biomass production and water stress during drought periods (Fenn et al., 1998). However, because air pollution and fire research are largely separate research areas, there is little awareness of the fact that changes in forest ecosystems impacted by air pollution may be creating increased fire hazards in forests near urban areas.

Fires are complex combustion processes involving various types of fuel and fire behavior that change over time depending on available fuel and weather conditions. Smoke from fire is composed of hundreds of chemicals in gaseous, liquid, and solid forms that undergo complex chemical reactions and transformations (Ottmar, 2000). As a result, substantial concentrations of elemental carbon, volatile organic compounds (VOCs), carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxides (NO_x), O₃ and particulates matter (PM) may be found downwind of the fires, sometimes thousand miles from the source areas (Cheng, 1998). Some of these compounds are classified criteria pollutants (pollutants with established air quality standards) under the Clean Air Act, including O₃ and PM. Ozone threatens public and forest health, while PM affects human health and causes visibility reduction (Billington et al, 2000). Such problems impact the general public, land managers and policy makers, especially if urban areas or

wildland/urban interface are affected. In the United States, EPA in cooperation with federal land managers, States and Tribes issued the Interim Air Quality Policy on Wildland and Prescribed Fire (EPA, 1998) to protect public health and welfare by mitigating the impacts of air pollutant emissions from wildland fires on air quality.

Fire plays a key role in shaping ecosystems. In the United States, the patterns of fire frequency, intensity and severity have been gradually altered by the use of fire suppression as the prevailing management strategy. The result has been a dramatic reduction in the acreage burned in the 20th century that has contributed to conditions that encourage high severity fires (USDA, 2001). Catastrophic forest fires in Southern California in 2003 and 2007 clearly demonstrated the consequences of widely spread drought, poor management practices, long-term air pollution effects and bark beetle infestation in western US forests. Similar calamities also take place in forests and other ecosystems all over the globe.

Cited References:

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- Fang, M., Zheng, M., Wang, F., To, K., Jaafar, A., Tong, S. 1999. The solvent-extractable organic compounds in the Indonesia biomass burning aerosols-characterization studies. *Atmospheric Environment* 33, 783-795.
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Accomplishments

1. International Scientific Symposium "Forest Fires and Air Quality Issues"

The symposium was associated with a bi-annual IUFRO Research Group 7.01 "Impacts of Air Pollution and Climate Change on Forest Ecosystems" hosted by the USDA Forest Service, PSW Research Station, Atmospheric Deposition Research Work Unit in the Historical Mission Inn, Riverside, California, on September 11, 2006

The objective of the symposium was to present state-of-science information and discussion of broadly defined air pollution and forest fire issues. The following topics were discussed: effects of forest fires on air quality in the remote and urban-wildland interface forests; effects of forest fires on air quality of nearby urban communities;

management and ecological factors predisposing forest to fires (including catastrophic one as those in southern California in 2003); remote sensing of fire events and smoke/air pollution plumes; effects of climate change on probability of fire occurrence; models describing generation of air pollutants such as ozone and particulate matter down-wind from fires; effects of fires on water quality of mountain watersheds; effects of fires on nitrogen and carbon cycling (including effects on C resources); ecological changes in forest caused by fires.

About 100 participants attended the symposium at which 22 invited papers were presented. Program and abstracts of the scientific papers presented at the meeting are included in Appendix A.

2. Elsevier book “Wildland Fires and Air Pollution”, Series “Developments in Environmental Science”, Series Editor: Dr. S. V. Krupa, Book Editors: *Andrzej Bytnerowicz, Michael Arbaugh, Christian Andersen and Allen Riebau*

Based on the papers presented at the above described symposium, and other invited contributions, a peer-reviewed book is being prepared. The book will provide much needed information about number of issues related to forest fires and air pollution at the global, continental and regional scales. Presently this information is scattered over literature in several disparate research fields. The book will combine knowledge from these areas into a single integrated focus. This is being accomplished by inviting leading international experts on in the fields of forest fires, air pollution, climate change, ecology, and land management to participate in production of this book.

The proposed work has almost been completed. An agreement has been signed with the the Elsevier Publishing Company for production of the book. Funds needed for printing of the color graphs have been transferred to the Publisher according to the mentioned agreement. The original deadline for delivering all chapters to the Publisher (December 15, 2007), has been be postponed until February 15, 2008 since some of the chapters had not been completed. It is expected that by the new deadline (already approved by the Publisher) the entire project will be completed.

Status of the book as of today:

Preface (Sagar Krupa) - in preparation

Introduction (Andrzej Bytnerowicz, Michael Arbaugh, Christian Andersen and Al Riebau) – final draft ready, needs technical editing.

Section I “General Information and Emissions”

Impacts of vegetation fire emissions on the environment, human health and security – a global perspective (Johann G. Goldammer, Meinrat O. Andreae and Milt Statheropoulos) – final revisions after technical editing are being made

Climatic and weather factors affecting fire occurrence and behavior (Randall Benson et al.) - completed

Characterizing sources of forest fire emissions (Roger Ottmar, Ana Isabel Miranda, David Sandberg) – completed

The chemical composition of wildland fire emissions (Shawn Urbanski, Wei Min Hao and Steve Baker) - completed

Effects of wildland fire on regional and global carbon stocks in a changing environment (Allen Solomon and Sue Conard) – final revisions before technical editing are made

Airborne remote sensing of wildland fires (Philip Riggan and Robert G. Tissell) – final draft after peer reviews received – under editorial review

Section II “Ambient Air Quality, Visibility and Human Health – Regional Perspectives”

Effects of forest fires on air quality and visibility in North America (Douglas Fox, Roger Ames, and Allen Riebau) – final revisions after technical editing are being prepared

Assessment of forest fires impact and emissions in the European Union based on the European Forest Fire Information System (Paulo Barbosa, Ilaria Palumbo, Jan Kucera, Andrea Camia, Jesus San-Miguel, and Guido Schmuck) – final revisions are being prepared

Forest fires and air quality issues in southern Europe (Ana Isabel Miranda, Enrico Marchi, Millan Millan, and Marco Ferretti) – completed

Spatial and temporal trends in distribution of forest fires and gaseous emissions in Central and Eastern Europe (Ryszard Szczygiel, Barbara Ubysz and Tomasz Zawila-Niedzwiecki) - completed

The 2002 Mega-fire event in Central Russia: meteorological, radiative and optical properties of the atmosphere and possible consequences for sub-boreal forest plants (Nataly Ye. Chubarova, Nickolay G. Prilepsky, Alexei N. Rublev, and Allen R. Riebau) - completed

Radioactive emissions from forest fires near Chernobyl, Ukraine (Wei Min Hao et al.) – final revision after reviews is being prepared

Effects of Applications of Wildfire on Air Quality in China (John J. Qu, Allen Riebau, and Yongqiang Liu) - completed

Smoke from wildfires and prescribed burning in Australia: health and environmental issues (Tina Bell and Mark Adams) - completed

Estimating contributions of wildland and prescribed fires on diurnal patterns of ozone in Southern Sierra Nevada, California (Haiganoush Preisler, Sharon Zhong, Annie Esperanza, and Julide Koracin) - completed

Section III “Ecological Impacts of Forest Fires and Air Pollution”

Global warming and stress complexes in forests of western North America (Don McKenzie, David Peterson, and Jeremy Littell) – completed

A probabilistic view of chaparral and forest fire regimes in southern California and northern Baja California (Richard A. Minnich and Ernesto Franco-Vizcaino) - completed

Air pollution increases forest susceptibility to wildfires in southern California (Nancy E. Grulke, Richard A. Minnich, Timothy Paine, Alex Dunn, Steve Seybold, and Deborah Chavez) - completed

Fire Effects on Carbon and Nitrogen Cycling in Forests of the Sierra Nevada Mountains (Dale W. Johnson, Mark Fenn, Wally Miller, and Carolyn Hunsaker) - completed

Spatial analysis of critical load exceedances, including the effects of fire, on mixed conifer forests in southern California (Benjamin S. Gimeno, Mark E. Fenn, Joan Breiner, Andrzej Bytnerowicz, and Dale W. Johnson) – in preparation

Interactive effects of wildland fires and air pollution on forests and other ecosystems – a synthesis (Nancy Grulke) – in preparation

Section IV “Management Issues”

Fire Danger and Fire Behaviour Modeling Systems in Australia, Europe, and North America (Francis M. Fujioka, A. Malcolm Gill, Domingos X. Viegas, B. Mike Wotton and Shyh-Chin Chen) - completed

Regional Real-Time Smoke Prediction Systems applicable for land management (Susan M. O'Neill, Narasimhan K. Larkin, Jeanne Hoadley, Graham Mills, Joseph K. Vaughan, Roland Draxler, Glenn Rolph, Mark Ruminski, Sue A. Ferguson) - final revisions after technical editing are being made

Managing smoke from wildfires and prescribed burning in southern Australia (Alan Wain, Graham Mills, Lachlan McCaw, and Tim Brown) - completed

Managing forests affected by air pollution, climate change and altered fire regimes near urban areas (Michael Arbaugh, Trent Procter, and Annie Esperanza) – in reviews

Integrating forest fires and air quality research - needs and recommendations (Andrzej Bytnerowicz, Michael Arbaugh, Christian Andersen, and Allen Riebau) – in preparation

IV. Concluding Section

Summary and Conclusions (Andrzej Bytnerowicz, Michael Arbaugh, Christian Andersen, and Allen Riebau) – in preparation