TITLE: Intensified Ozone Monitoring and Assessment of Ozone Impacts on Conifers in Southern California

LOCATION: Southern California National Forests.

DURATION: 2 year project **FUNDING SOURCE:** Base

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PROJECT OBJECTIVES: The overall objective of this project is to quantify ambient ozone concentrations and tree conditions that constitute a risk to forest health in southern California national forests. Specific objectives include:
1) Installation of and collection of data from passive ozone monitors at 25 sites in southern California.
2) Evaluation of 50 ponderosa and/or Jeffrey pine at each site for ozone injury, mortality, and damage by other agents such as insects or diseases.
3) Co-location of 4 of the 25 passive monitors with existing active continuous monitors.
4) Analysis of ozone data and tree health data to characterize ozone distribution at landscape or forest stand scales, identify ozone hot-spots, and correlate ozone measurements among active, passive, and biological systems to tree injury and mortality.

JUSTIFICATION:

a) *Linkage to FHM survey and plot data.* The FHM/FIA program monitors ozone on an extensive grid consisting of one ozone biosite per 250,000 to 1,000,000 acres of forested land. In southern California, there are only 8 FHM/FIA ozone biosites in or near the 4 national forests in southern California (San Bernardino, Angeles, Los Padres, and Cleveland); ozone injury has been detected on 5 of these (63%). The low density of FHM/FIA biosites in southern California (8 sites over 1.75 million acres of forest) creates obvious gaps in the ozone detection network for certain forest types or ecoregions. Additionally, there are some areas where a biosite cannot be established because known ozone sensitive species are scarce or unavailable. Passive ozone samplers provide an opportunity to fill the holes in the FHM/FIA biomonitoring grid.

b) *Significance in terms of the geographic scale, biological impact and/or political importance of the issue*. In California, O_3 is the main phytotoxic air pollutant for plants at ambient levels. Classic examples of phytotoxic O_3 effects on forests dominated by ponderosa and Jeffrey pines have occurred for more than forty years in the San Bernardino Mountains. For the last thirty years such effects have also been seen on pines on the western slopes of the Sierra Nevada. Southern California forests are exposed to some of the highest ambient ozone levels in the United States. In recent years, extremely high tree mortality has occurred in these forests; it is thought that the combination of drought, stand densification, ozone stress, and bark beetles are responsible. Current efforts are underway to develop a MOU between federal land management agencies and federal, state, and local air quality enforcement agencies to outline strategies to address ozone non-attainment attainment of state and national ambient air quality standards, and ozone injury to vegetation of federal lands in the Sierra Nevada and Southern California Mountains. Additional data on current ozone levels and distribution, and forest health impacts in southern California national forests will greatly contribute to this effort.

c) *Feasibility or probability that the project will be successfully completed*. There is a high probability that this project will be completed successfully. PI's have 35 cumulative years experience in air pollution and air pollution effects research. They are national and international experts on ozone air pollution effects on natural ecosystems. Dr. Bytnerowicz is one of the leading authorities on passive monitor use in mountain environments. Dr. Arbaugh has helped to develop current ozone evaluation methods for pines, and has extensive experience relating ozone injury to tree growth, mortality and stand composition changes. Both researchers have published numerous research papers and book chapters describing air pollution patterns and injury in California.

DESCRIPTION:

a. Background: Tropospheric ozone is a phytotoxic gaseous air pollutant formed by photolysis from air pollution generated by large metropolitan areas, during transport over long distances to rural areas. Ozone, together with drought and bark beetles, is one of the key stressors affecting forest trees adjacent to urban areas. Species that show a visible foliar response to ozone pollution at ambient levels are used to detect the presence of ozone stress in the forest environment. In western forests, ozone-induced chlorotic mottle on sensitive pine species provides a reliable indication of ozone exposures that have the potential for adverse affects on tree health and growth. The FHM/FIA ozone monitoring protocol is based on utilizing ozone-sensitive species such as pine to detect the presence of ozone at damaging levels (USDA Forest Service, 2004).

On the other hand, ozone passive samplers monitor levels of atmospheric ozone rather than injury; they allow O_3 distribution to be characterized at landscape or forest stand scales. Because they are inexpensive, easy to use and do not require electricity to operate, passive samplers are especially suited to remote areas. Large-scale evaluations have already been performed for the entire range of Sierra Nevada. Some passive monitors have been placed at locations in San Bernardino, Angeles and Los Padre National Forests, but not the coordinated placement needed to relate ambient ozone with ozone injury to pines. Passive samplers are valuable screening tools for evaluating air pollution conditions and ozone hot spots in and around populated areas missed by active and continuous ozone monitors. They have been used successfully to fill gaps in traditional EPA-approved sampling networks that surround population centers and they could be equally useful for the forest based FHM/FIA network, providing detection-level air quality information in areas that would otherwise remain blank.

In the late 1960's and early 1970's, ozone injury monitoring sites were established in southern California National Forests. Some sites were maintained by research, such as the San Bernardino Mountain sites, and a few were maintained by R-5 Air Quality Management program in the Angeles and Los Padres NF. As funding allowed, sites were evaluated for ozone, insect, and drought damage but no comprehensive evaluation has been conducted since the early 1970's. As a result we have little information on regional changes in ozone injury and the relationship of ozone injury to tree mortality. Additionally, the FHM/FIA biosites were only established over the last 5 years, with many installed as recently as 2004, so that long-term change data is not available from them either. Analyzing the condition of long-term sample trees with historical and present ozone injury will help clarify the role of air pollution and mortality rates, and provide insight into future stand mortality locations and rates.

b. Methods: All previously established ozone pine injury plots in which Cleveland, San Bernardino, Angeles and Los Padre National Forests will be revisited and Ogawa passive samplers installed nearby to each site. A few sites have been destroyed due to fire or insect mortality. Comparable replacement sites will established and evaluated in place of the original sites. Fifty ponderosa/Jeffrey pine trees will be evaluated at each site using the established OII western pine ozone injury protocols (Miller et al. 1990). These protocols include standard silvicultural measurements (such as tree height, live crown height and dbh) as well mortality and observations of diseases and insect damage that the tree maybe experiencing. Ogawa passive samplers (Koutrakis et al., 1993) will be used for determination of 2-week long averages of ozone concentrations. Samplers will be prepared and analyzed at the Riverside Forest Fire Laboratory in Riverside, CA. At least 4 of the 25 passive ozone monitors will be co-located with active continuous monitors. This will provide important information on the correspondence of ozone measurements among active, passive, and biological systems and help to quantify ambient ozone concentrations and conditions that constitute a risk to forest health (Arbaugh and Bytnerowicz, 2003). Passive ozone monitor information will be used to calculate ozone exposure index (SUM0), which has been shown to be useful for estimating ozone injury in the Sierra Nevada and San Bernardino Mountains (Arbaugh et al. 1998). These indices will be correlated with measured ozone injury to determine if SUM0 is useful to describe patterns of ozone injury for all of Southern California. In addition, individual tree ozone injury scores will be compared with historical scores to determine long-term changes in regional injury patterns, and ozone injury levels will be related to mortality patterns using survival analysis to determine the role of ozone injury in past and present tree mortality.

c. Products: A final report and scientific publication will be prepared that describes the relationship between ozone concentrations, ozone injury and mortality of conifers in Southern California. Both will include tables, graphs and maps of ozone concentrations for southern California and correlation with long-term tree-specific ozone injury history. A poster will be prepared at the end of each year for the national FHM meeting outlining interim or final results of the project.

d. Schedule of Activities: Ozone monitoring will be performed between May 1 and October 30, 2005 and 2006 at 25 locations in California. Foliar injury surveys will be conducted between August 15 and September 30, half in 2005 and half in 2006.

e. Progress/Accomplishments: This is a 2-year study. A one-year interim update will be provided to the FHM program (along with a poster for the national FHM meeting). The final report and publication will be produced at the end of the study.

COSTS: We are requesting $26,000 total support in Year 1 and $24,000 total support in Year 2.

	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR 1				
Administration	Salary	15,000	15,000	Research Appropriation
	Overhead	5,000		
	Travel	0	2,500	Research Appropriation
Procurements	Contracting	0		
	Equipment	1,400	2,000	
	Supplies	1,600		
	Analysis	3,000		
Total		**26,000**	**19,500**	

	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR 2				
Administration	Salary	15,000	15,000	Research Appropriation
	Overhead	5,000		
	Travel	0	2,500	Research Appropriation
Procurements	Contracting	0		
	Equipment	0	500	

	Supplies	1,000		
	Analysis	3,000		
Total		**24,000**	**18,000**	

References:

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