

Biological Effects of Air Pollution: A Nationwide Perspective

By James P. Bennett

Many of our natural area national parks are experiencing elevated concentrations of air pollutants, including ozone (O₃), sulfur dioxide (SO₂), fluoride (F), toxic trace elements (lead, cadmium, etc.) and acidic precipitation. The effect of these pollutants on the biological resources of our parks has become a matter of widespread concern.

The Air Quality Division of the Office of Science and Technology recently has begun a program to address these concerns: the Air Quality Related Values Effects Research and Biomonitoring Program. It is called this because the legislative authority for the program, the Clean Air Act as amended in 1977, defined air pollution sensitive resources as Air Quality Related Values (AQRVs).

The National Park Service has a mandate under the Act to protect AQRVs from adverse impacts of air pollutants from sources located or planning to locate outside of the national parks. Most of the emphasis of the program is on biological resources, although some considerations for cultural resources are being made. Acid precipitation effects studies have been assigned to the Water Resources Division for programmatic reasons, primarily because aquatic resources are more sensitive than terrestrial resources.

The effects research and biomonitoring needs of the Service have been determined to establish a structure for projects by asking five essential questions:

1. What is sensitive to air pollution?
2. What are their responses and how much do they respond?
3. How does this affect the entire park ecosystem?
4. How much could the park ecosystem change?
5. What is the significance of the change?

These questions provide the backbone for the AQRV Plan, which contains studies in 5 sections corresponding to the questions:

Sections and Generic Studies:

1. Sensitive Receptor Identification
 - Screening studies
 - Biomonitoring plans
 - Effects literature review
 - Ecosystem analysis
2. Sensitive Receptor Quantification
 - Dose/response studies
 - Spatial analyses
3. Ecosystem Integration
 - Primary & secondary productivity
 - Food web dynamics
 - Population growth rates
4. Ecosystem Prediction
 - Temporal
 - Spatial
 - Reversibility
5. Value Judgements
 - Probability & risk analyses
 - Adverse impact determinations

Various factors contribute to determining the biological impacts of an air pollutant, including the toxicity of the pollutant; the importance of the receptor in the ecosystem; the type of effect, whether acute or chronic; the scale of the effect, from the individual up

to the whole ecosystem; the exposure of the individual; the potential for synergisms with other pollutants; and the persistence of the pollutants in the environment. These factors combined with the AQRV Plan and the knowledge of current air quality conditions in the parks led to the establishment of a program to fund projects addressing the data needs of the parks. A set of criteria was developed to rank projects (these criteria are not in any order):

1. Is the resource threatened now by air pollution?
2. Is the resource threatened in the future by many sources, or only one?
3. Are additional funds available from other interested parties?
4. What is the value of the product?
5. Is air quality monitoring equipment already present?
6. Legal mandate, e.g. required for a permit review?
7. What management decisions will the data benefit?

Most of the projects involve work on vegetation rather than wildlife because a great deal of work on plant effects has been done and a good body of literature already exists. Most of it, however, is on agricultural crop species and forest trees and very little on native vegetation. For this reason, many projects will focus on field studies of observable air pollution effects on either dominant species, bioindicator species, or endangered and threatened species in parks that have existing air pollution. In parks without existing air pollution, studies will focus on experimental plant fumigations with controlled levels of pollutants.

Titles and brief descriptions of projects under way are given below for illustration:

Geographic Extent of Air Pollution Injury in Shenandoah National Park – A survey of the conditions of bioindicator species at predetermined locations throughout the park.

Sensitivities of Rare & Endangered Species in Shenandoah National Park – Species will be grown in the greenhouse and exposed to pollutants in fumigation chambers to determine injury symptoms, then checked in the field for the symptoms. A protocol has been established to prevent further endangering the status of the species.

Biomonitoring Plan for Colorado National Monument – Development of methods to survey bioindicator species throughout the park in anticipation of future air pollution. Collection of baseline biological data.

Wildlife AQRVs at Congaree Swamp National Monument – Identification of wildlife species potentially susceptible to air pollutants and predictions of probable effects in anticipation of air pollution.

Sensitivity of Tulip Poplar to Oxidants in Shenandoah National Park – Screening of tulip poplar populations for genetic sensitivity differences using air pollutant enclosure chambers in the park.

Elevated Lead Concentrations in Gt. Smoky Mountains National Park – Detailed examination of lead burdens in 4 tree species and source of lead in leaf litter.

Fluoride Baseline Concentrations in Gt. Smoky

Mountains National Park – Detailed examination of F in foliage and soil of selected species downwind of a F source.

FORAST Plots in Shenandoah, Great Smoky Mountains, and Acadia National Parks – Adds 3 parks to a regional project run by Oak Ridge National Lab, looking at regional effects of air pollutants on forest growth using tree ring analysis.

Lichen Studies – A long-term contract with Dr. Clifford Wetmore, University of Minnesota to do air pollution lichen studies at many parks, including Voyageurs, Theodore Roosevelt, Grand Canyon, Acadia, Chiricahua, and others. Lichens are sensitive bioindicators of SO₂ pollution. A symposium on air pollution and lichens is also being planned for a 1983 national society meeting.

Projects being developed include:

Air Pollution Sensitivities of Epiphytes in Everglades National Park

Trace Elements in Bryophytes of Isle Royale National Park

Bioindicator Survey at Saguaro National Monument

Field Assessments of AQRVs at Selected Parks

In addition, several projects of a service-wide nature are being conducted and developed:

Ranking of Park Service Class I Areas – A project using the Oak Ridge Geocology Database to rank class I parks for potential sensitivities to air pollutants. Sensitivity indices and existing air quality data will be combined into a single index for each of the 48 class I parks. Class I parks were identified in the Clean Air Act as those requiring the most stringent level of protection from air pollutants.

Survey of Adverse Impact Definitions – An evaluation of the state of the art regarding the question of what constitutes significant impairment to an ecosystem, including a survey of definitions and methods of measurement and recommendations for use by the NPS.

Computerized Flora of the Class I Parks – A contract with the Denver Service Center to computerize the existing floras and checklists of the class I parks. A hierarchical database management package (System 2000) will be used to match the taxonomic nomenclature in current use. Entries will be checked for synonymy and scored for native versus exotic status.

Finally, the Air Quality Division is considering the development of an air pollution fumigation facility to enable the Park Service to determine the sensitivities of native plants in various park units to specific air pollutants. Various fumigation techniques are currently under review so that the Service can have the best methods available for use. Different location options for the facility are being considered. The facility is intended only for preliminary screening to determine the relative sensitivities of susceptible plant species in park units with significant air pollution problems.

Planning for FY 1983 is underway and for project information contact Dr. Bennett, program manager, at FTS 234-6620, NPS Air Quality Division, Box 25287, Denver, CO 80225.