INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

Volume 5, No. 3 | **Summer 1996** | **October 1996**

IMPROVE MONITORING UPDATE

Preliminary data collection statistics for the Summer 1996 season (June, July, and August) are:

Data Type	Collection Percentage
Aerosol Data	95%
Optical (transmissometer) Data	94%
Optical (nephelometer) Data	77%
Scene (photographic) Data	91%

Reduced data collection for nephelometers is primarily due to numerous lightning strikes at several sites.

Particulate concentrations through May 1996 have been submitted for all measurements except carbon. Printed seasonal summaries through August 1995 have been delivered.

Figure 1 shows the current IMPROVE and IMPROVE Protocol sites.

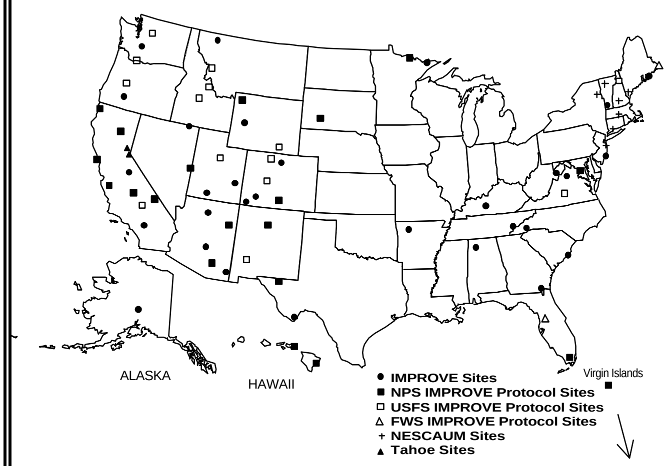

Figure 1. IMPROVE and IMPROVE Protocol Sites October 1996

VISIBILITY NEWS....

Binational Big Bend Regional Air Quality Study

The Binational Big Bend Regional Visibility Study got underway in September for a 30-day data collection effort to determine the source regions and source types responsible for poor visibility conditions at Big Bend National Park, Texas. The study is a cooperative effort between the NPS, EPA, Texas Natural Resources Conservation Commission, Texas Parks and Wildlife Department, and Mexico's Procuraduría Federal de Protección al Ambiente.

Several field monitoring studies are scheduled to be conducted between Summer 1996 and Summer 1998. The September 1996 scoping study included a region extending north-south from south of Houston to north of Tampico, Mexico, and east-west from the Texas-Mexico Gulf Coast to just north and west of Big Bend National Park.

Data from the scoping study will be used to design two intensive studies scheduled for January-February 1998 and July-August 1998. Plans for each intensive call for daily fine particle sampling for a 60-day period. In addition to fine particle sampling, the intensives will also include sampling for sulfur dioxide, surface and upper level winds, and light scattering coefficient. For more information, contact:

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NPS Air Resources Division
Telephone: 303/969-2076

CASTNet Monitoring Program Resumes

After a 10 month hiatus, the optical monitoring component of the CASTNet monitoring program has resurfaced with the installation of two ambient nephelometer systems operating according to IMPROVE protocols.

Objectives of CASTNet, the Clean Air Status and Trends Network, are to collect and analyze visibility data in regions that lack monitoring or that require emissions reductions mandated by the 1990 Clean Air Act Amendments.

An Optec NGN-2 nephelometer began operating at Quaker City, Ohio, and another at Cadiz, Kentucky, on October 1, 1996, and are scheduled to operate through July 31, 1997. The Quaker City site previously monitored with a nephelometer from July 23, 1993 through November 30, 1995.

Big Bend - "How Far Can You See?"

The Division of Interpretation and Visitor Services at Big Bend National Park, Texas, has created a colorful brochure for park visitors, titled "How Far Can You See?"

The brochure displays photographs of various levels of visual air quality and presents short articles explaining the causes of air pollution that influence visibility in the park, what park managers are doing about the problem, pollution studies taking place in the park, pollutants and sources, effects on human health and environment, and what park visitors can do to help.

Visibility News continued on page 7.....

Feature Article

IMPROVE Monitoring Report Details Patterns and Trends Analysis of Haze Composition

Introduction

The second in a series of periodic reports that describe the composition of atmospheric haze based on data from the IMPROVE monitoring network has been released. The report, "Spatial and Seasonal Patterns and Long Term Variability of the Composition of the Haze in the United States: An Analysis of Data From the IMPROVE Network," was prepared by James F. Sisler, of the Cooperative Institute for Research in the Atmosphere (CIRA), at Colorado State University.

This report, completed in July 1996, covers three years of the IMPROVE Program, from Spring 1992 through Winter 1995 (March 1992 through February 1995). The first report, completed in February 1993, covered the first three years of the program (Spring 1988 through Winter 1991). Objectives of this second report are:

- To describe spatial and temporal variation of visibility (as measured by the light-extinction coefficient), and the chemical composition of the visibility-degraded aerosol for the three-year period.
- To provide a first estimate of the apportionment of visibility impairment to the fundamental chemical species, including sulfates, nitrates, organics, elemental carbon, and soil.
- To document long-term trends (or lack of trends) of aerosol mass and its principle aerosol species.

In the first report (Spring 1988 - Winter 1991), 36 sites were summarized. This second report includes 43 IMPROVE sites. Each site summarized has collected data for the three-year period using an aerosol sampler (designed specifically for IMPROVE monitoring). Optical monitoring equipment (transmissometers and/or nephelometers) also exist at 26 of these sites.

The report groups these 43 sites into 21 regions according to their relative location, climatology, similarities in concentrations, and seasonal trends. Since the first IMPROVE report, 3 new regions have been created (Mid South, Mid Atlantic, and Lake Tahoe), 1 region has been dropped (Hawaii), and 5 sites either partially or totally discontinued monitoring (Everglades, Voyageurs, Arches, Isle Royale, and Hawaii Volcanoes National Parks).

Figure 2 shows each of the 43 sites summarized in the report. Table 1 lists each site by region.

The report also includes an overview of the IMPROVE Program and technical background regarding visibility impairment, aerosols, and instrumentation used. This article presents highlights from three chapters in the report: Aerosol Mass Budgets and Spatial Distributions, Spatial Distributions of Reconstructed Light Extinction and Light Extinction Budgets, and Temporal Trends and Interrelationships of Aerosol Concentrations.

Figure 2. Location of the 43 IMPROVE monitoring sites included in the report (Spring 1992 - Winter 1995).

Table 1.

IMPROVE Sites Grouped by 21 Designated Regions

Region	Sites
Alaska:	Denali NP
Appalachian Mountains:	Great Smoky Mountains NP Shenandoah NP Dolly Sods W
Boundary Waters:	Boundary Waters Canoe Area W
Cascade Mountains:	Mount Rainier NP
Central Rocky Mountains:	Bridger W Great Sand Dunes NM Rocky Mountain NP Weminuche W Yellowstone NP
Coastal Mountains:	Pinnacles NM Point Reyes NS Redwood NP
Colorado Plateau:	Bandelier NM Bryce Canyon NP Canyonlands NP Grand Canyon NP Mesa Verde NP Petrified Forest NP
Florida:	Chassahowitzka NWR Okefenokee NWR
Great Basin:	Jarbidge W Great Basin NP
Lake Tahoe:	D.L. Bliss State Park South Lake Tahoe
Mid Atlantic:	Edwin B. Forsythe NWR
Mid South:	Upper Buffalo W Sipsey W Mammoth Cave NP
Northeast:	Acadia NP Lye Brook W
Northern Great Plains:	Badlands NP
Northern Rocky Mountains:	Glacier NP
Sierra Nevada:	Yosemite NP
Sierra-Humboldt:	Crater Lake NP Lassen Volcanic NP
Sonoran Desert:	Chiricahua NM Tonto NM
Southern California:	San Gorgonio W
Washington D.C.:	Washington, D.C.
West Texas:	Big Bend NP Guadalupe Mountains NP

NP - National Park
NM - National Monument
NS - National Seashore
W - Wilderness
NWR - National Wildlife Refuge

Aerosol Mass Budgets and Spatial Distributions

Mass budgets are the individual aerosol species that contribute to reconstructed fine particle mass. The report details spatial and seasonal distributions of aerosol concentrations and the chemical composition of the aerosols for the three-year period (March 1992 through February 1995).

Figures 3 and 4 present isopleths showing average fine mass and PM_{10} mass concentrations for each site in the IMPROVE network. Major regional patterns discussed in the report include:

- Fine aerosol concentrations are generally highest in the eastern United States (the regions of Appalachian Mountains, Mid South, Mid Atlantic, and Washington D.C.), and in Southern California.
- Fine aerosol concentrations are lowest in the Great Basin region, the Colorado Plateau, Wyoming, and Alaska.
- Organic mass is the largest single component of fine aerosol in western regions (Alaska, Cascade Mountains, Colorado Plateau, Central Rocky Mountains, Coastal Mountains, Great Basin, Northern Rocky Mountains, Sierra Nevada, Sierra-Humboldt, and Lake Tahoe).
- Sulfate is the largest single component of fine aerosol in primarily eastern regions (Appalachian Mountains, Florida, Northeast, Mid South, Mid Atlantic, Washington D.C., and West Texas).
- Organic and sulfate aerosols contribute about equally to fine aerosol in the regions of Boundary Waters, Sonoran Desert, and Northern Great Plains.
- Nitrate is the largest contributing component to fine aerosol only in Southern California.
- Soil is the next largest contributor to fine aerosol, after organics and sulfate, followed by nitrate, and light-absorbing carbon.
- PM_{10} mass concentrations are generally highest in a region east of the Mississippi River and south of the Great Lakes, followed by coastal and southern California.
- Generally, average fine mass concentrations, as well as the organic and sulfate components of fine mass, are highest in the summer.
- Soil concentrations are generally highest in the spring or summer.
- Nitrate concentrations are generally highest in winter or spring.
- Light-absorbing carbon has little seasonal variation.

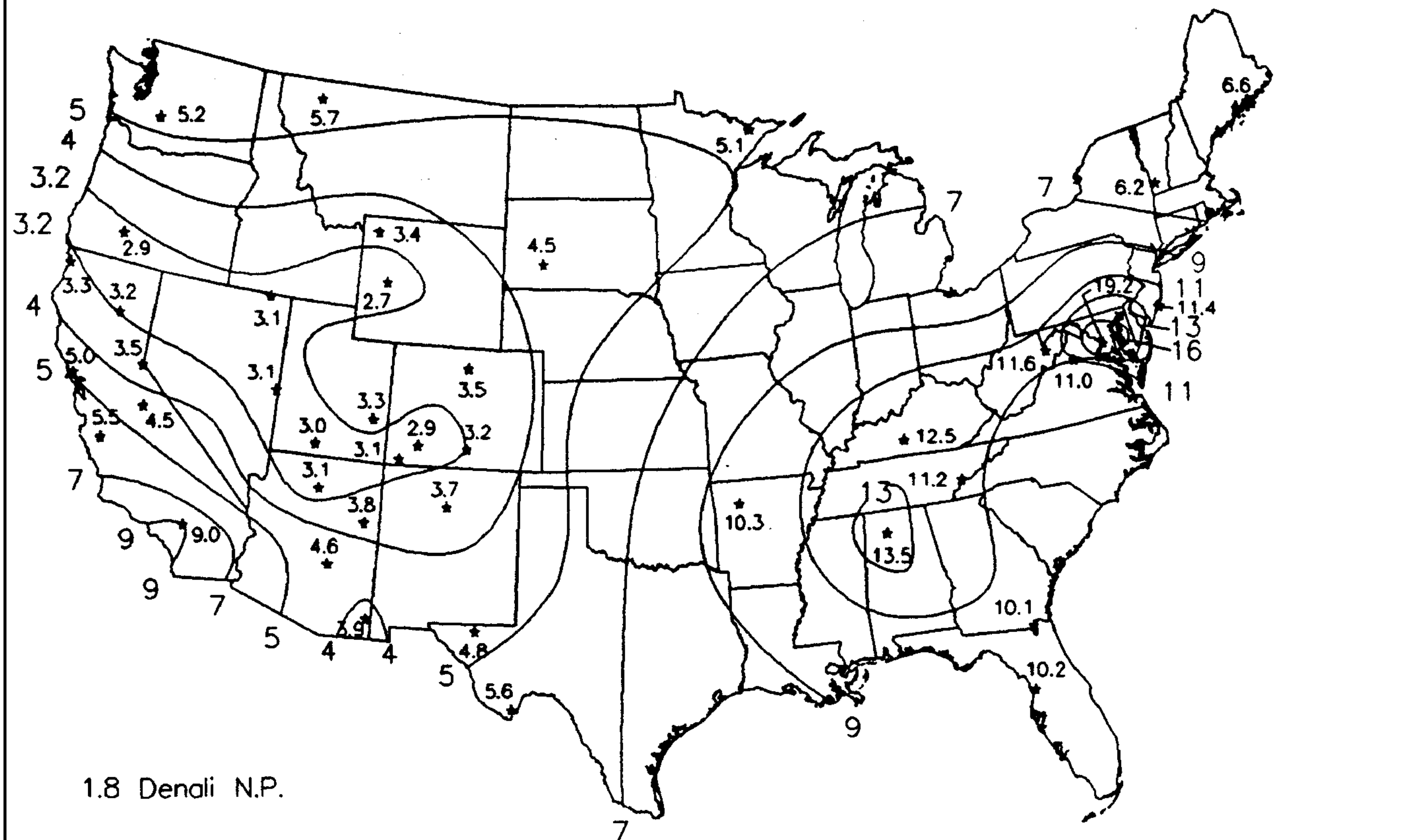

Figure 3. Average fine mass aerosol concentrations (in 7g/m^3), for each site in the IMPROVE network (Spring 1992 - Winter 1995).

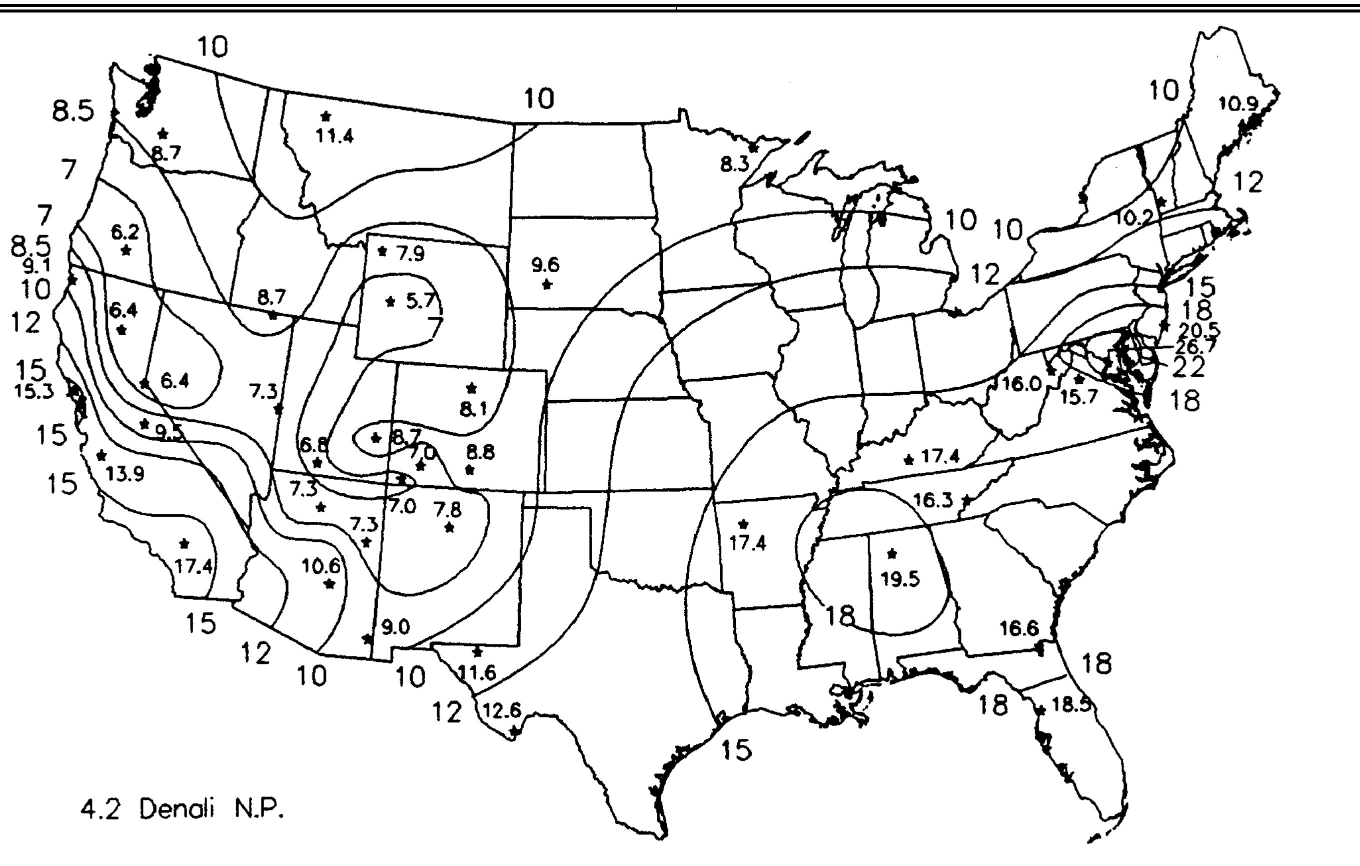

Figure 4. Average PM_{10} mass aerosol concentrations (in 7g/m^3), for each site in the IMPROVE network (Spring 1992 - Winter 1995).

Spatial Distributions of Reconstructed Light Extinction and Light Extinction Budgets

The report discusses in detail the relationship between light extinction and aerosols. The light extinction coefficient (b_{ext}) was calculated by multiplying the concentration of each aerosol species by its light extinction efficiency, then summing the extinctions of all species. The report also presents spatial and seasonal light extinction budgets for the three-year period (Spring 1992 - Winter 1995).

Figure 5 presents isopleths showing the average reconstructed light extinction coefficient for each site in the IMPROVE network.

Spatial trends of reconstructed light extinction from aerosol measurements generally follow fine aerosol concentration patterns. Generally, the highest extinction occurs in the eastern United States and southern California, and the lowest occurs in the Intermountain West, with the lowest extinction of all occurring in Alaska. However, since relative humidity is higher in the East than in the West, the difference between eastern and western light extinction is even more pronounced than the difference in aerosol concentrations.

Major regional patterns discussed in the report include:

- Sulfate light extinction is highest in the eastern United States and is lowest in Oregon, Nevada, Idaho, and Wyoming. Sulfate was found to be the single largest contributor to light extinction in 14 of the 21 regions.
- Organic carbon light extinction is largest in the eastern United States and in the Pacific Northwest. It is lowest in southern Utah and northern Arizona.
- Sulfate is comparable with organics as the most significant contributor in 3 other regions (Northern Rocky Mountains, Central Rocky Mountains, and Sierra-Humboldt).
- Nitrate light extinction is the single largest contributor only in Southern California. It is relatively high in the Washington D.C. area.
- Light absorption is highest in the Pacific Northwest and in the eastern United States, and lowest in the nonurban West.
- Coarse material light extinction is highest in the regions of Coastal Mountains, West Texas, Mid South, Florida, Appalachian Mountains, and Mid Atlantic. It is lowest in the Northeast, Colorado Plateau, and portions of the Central Rocky Mountain regions.
- Reconstructed light extinction is generally highest in the summer and lowest in the winter, with many exceptions to the finding.

Visibility trends were analyzed in the report using the deciview (dv) index. Because higher extinction coefficients lead to higher deciview, the geographic trends in visibility follow the trends in reconstructed light extinction. Figure 6 presents isopleths showing the average visibility deciviews for each site in the IMPROVE network. Visibility trends discussed in the report include:

- Seasonal trends generally follow the annual trend. The least impairment, or lowest deciviews, generally occur in all or part of the Great Basin, Colorado Plateau, and Central Rocky Mountain regions.
- The best visibility in the West occurs in winter. These regions include Sierra-Humboldt, Sierra Nevada, Great Basin, Central Rocky Mountains, and the northwestern half of the Colorado Plateau.
- The best visibility in the East is split between winter and spring. The best visibility occurs in the Northeast and Florida regions in winter, while in the Appalachian Mountains and the Midwest, the best visibility occurs in the winter or spring, depending upon individual sites.
- The worst visibility generally occurs in the summer, except for the Coastal Mountains of California. The worst areas are Washington D.C., Shenandoah National Park, and Sipsey Wilderness.
- Visibility during spring and fall are comparable.

Temporal Trends and Interrelationships of Aerosol Concentrations

The IMPROVE monitoring network was established in March 1988. Prior to IMPROVE, many of the aerosol sites were operated by the National Park Service with stacked filter units (SFUs) from as early as 1979. IMPROVE sites that also operated with SFUs have an almost unbroken record of fine mass and sulfur from as early as 1979, and b_{abs} from 1983. These data provide an excellent opportunity to look for evidence of temporal trends in aerosol concentrations. Changes in sampling protocol (SFU vs. IMPROVE) appear to have a minimal affect on observed concentrations of aerosols. The report presents seasonal and long-term temporal trends. Major patterns discussed in the report include:

- Seasonal sulfate trends show concentrations highest during summer and lowest during winter. Sites with the most sulfate seasonality are in the East and southern California, while sites in the Intermountain West have little or no seasonality.
- Seasonal absorption trends show concentrations generally highest during summer and early fall. Seasonality is strongest in the West, where controlled burning and wildfires have a strong influence.

IMPROVE Monitoring Report continued on page 7.....

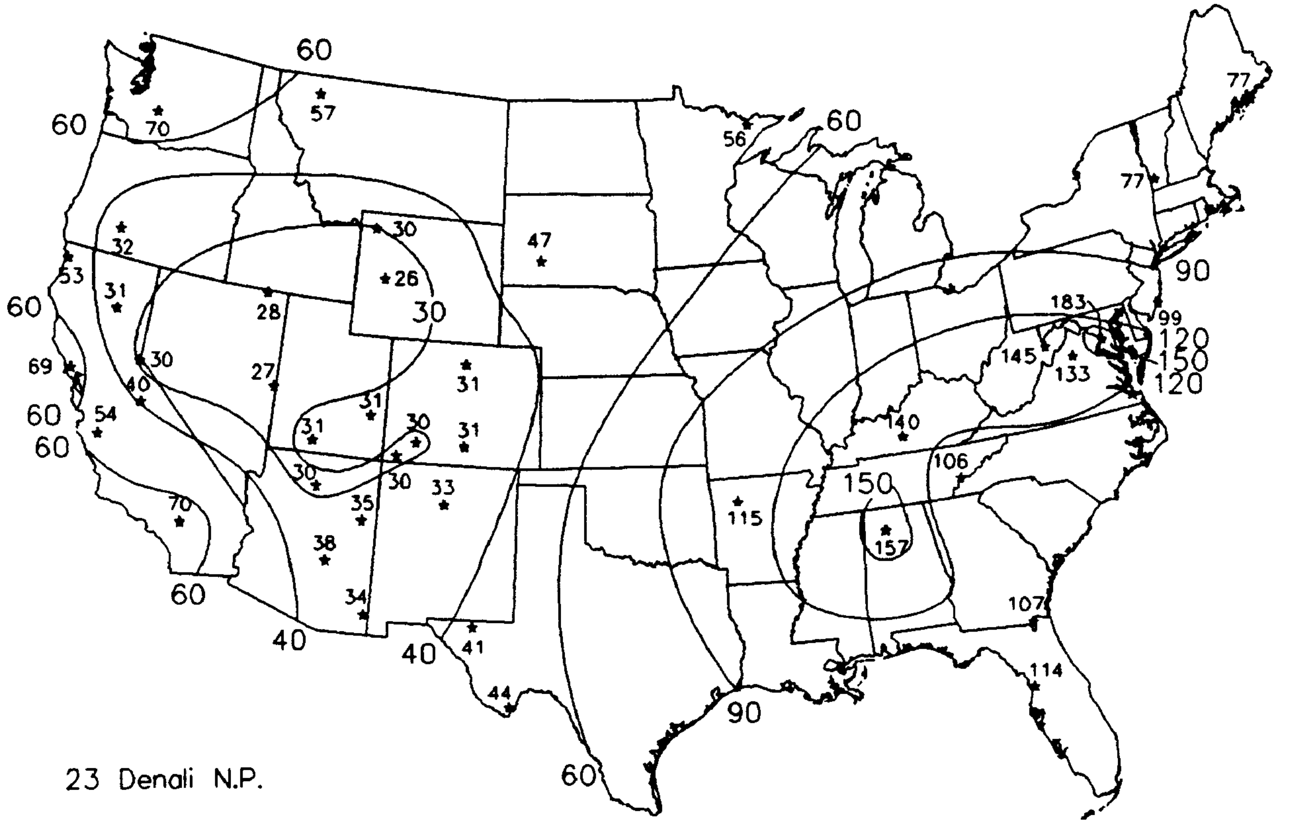

Figure 5. Average total reconstructed light extinction coefficient b_{ext} (Mm^{-1}) for each of the reported sites in the IMPROVE network (Spring 1992 - Winter 1995).

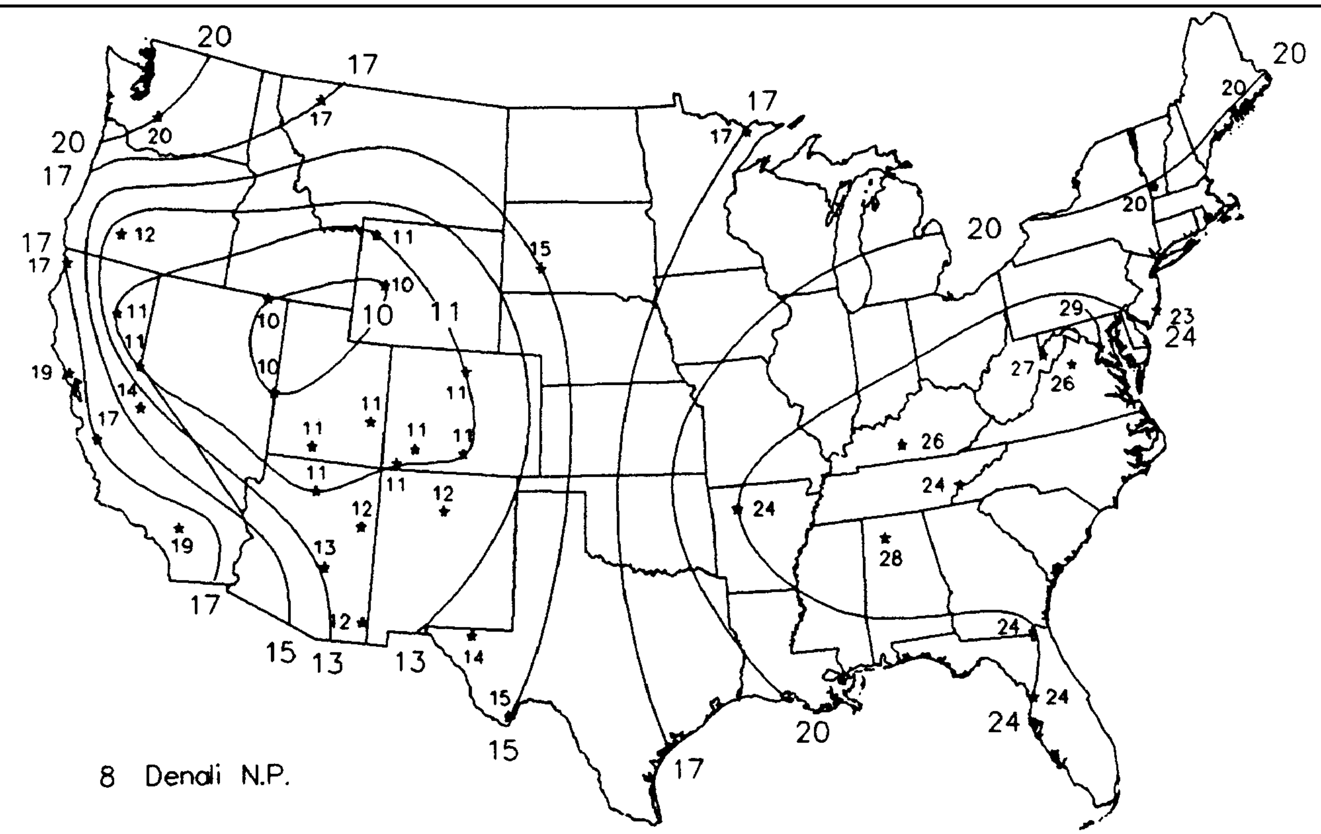

Figure 6. Average visibility impairment in deciviews calculated from total (Rayleigh included) reconstructed light extinction for each of the reported sites in the IMPROVE network (Spring 1992 - Winter 1995).

***IMPROVE Monitoring Report** continued from page 5....*

Long-term trends fall into three categories: increases, decreases, and variable. Using data beginning with 1979, long-term trends based on seasonally-averaged data include:

- Long-term fine mass trends show increases in Bryce Canyon National Park and at Grand Canyon National Park in summer and fall. A decrease is seen at Crater Lake National Park in the winter.
- Long-term absorption trends show dramatic decreases in Crater Lake National Park and Rocky Mountain National Park, and an increase in the fall at Great Smoky Mountains National Park. No clear trends were seen at Grand Canyon National Park in winter or Chiricahua National Monument in summer.
- Long-term sulfur trends show decreases at Chiricahua National Monument and in the fall at Guadalupe Mountains National Park. Increases are seen in the fall at Grand Canyon National Park and Great Smoky Mountains National Park. No trends were seen at Bryce Canyon National Park, Rocky Mountain National Park, or Crater Lake National Park.

The most notable observation from a national perspective is the lack of a clear, uniform trend of absorption or sulfur concentration. The majority of the sites show little or variable long-term trends.

Spatial and Seasonal Patterns and Long Term Variability of the Composition of the Haze in the United States: An Analysis of Data From the IMPROVE Network

Copies of the comprehensive three-year report are available from:

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Fort Collins, CO 80523
Telephone: 970/491-8292
Fax: 970/491-8598

Copies are available for $10.00 each.

Recommended Future Research

The three-year IMPROVE monitoring report concludes by presenting and discussing various topics for future research:

- Organic aerosol measurements; the measurement of organic mass is still responsible for the most uncertainty in estimates of how various aerosols affect visibility.
- Light-absorbing carbon measurements; the work presented in the report suggests that absorption estimated from LIPM (Laser Integrating Plate Method) is a more accurate measure than that derived from elemental carbon measurements.
- Hygroscopicity of aerosols; the relative humidity correction terms applied to sulfate and nitrate need to be reevaluated. The terms of both chemicals are based on ammonium sulfate, but specific curves should be developed for ammonium nitrate. Also, the hygroscopicity of organics is not currently well understood.
- Long-term trends; analysis of long-term trends of fine mass concentrations, sulfur concentrations, and absorption are based on descriptive statistics and inspection. Protocol changes in aerosol samplers and duration of samples needs to be looked at for correct interpretation of trends.

***Visibility News** continued from page 1....*

Green River Basin Visibility Study

In May 1991 the Wyoming Air Quality Advisory Board requested that visual air quality issues in the Green River/Ham's Fork Basin be addressed. In response to this request, the Green River Basin Visibility Study Steering Committee was formed to oversee a scientifically defensible study to characterize the current status of visual air quality in the basin. The committee is comprised of representatives from government, industry, and private citizens.

The study's overall purpose is to characterize the current visual air quality in a designated area within the Green River/Ham's Fork Basin by designing and operating a visibility monitoring system. The Steering Committee approved a monitoring approach and monitoring began in late July 1996. IMPROVE protocol instrumentation include a transmissometer, ambient nephelometer, IMPROVE modular aerosol sampler, three (3) 35 mm automatic cameras, and wind speed, wind direction, temperature, and relative humidity sensors. The program is currently funded for one year. For further information, contact:

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IMPROVE STEERING COMMITTEE

IMPROVE Steering Committee members represent their respective agencies and meet periodically to establish and evaluate program goals and actions. IMPROVE-related questions within agencies should be directed to the agency's Steering Committee representative. Steering Committee representatives are:

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