

KNOWN VISIBILITY EFFECTS IN NATIONAL PARK UNITS

May 1985

Introduction

Visibility monitoring has shown that in excess of 90% of the time scenic vistas are affected by man-made pollution at all National Park Service (NPS) monitoring locations within the lower 48 United States. Even in remote areas such as Grand Canyon National Park, visitors sometimes cannot see the opposite canyon rim or the canyon depths because of poor visibility. At Yosemite National Park, smoke from fires sometimes obscures the view of the well known massive cliffs and domes. In Shenandoah National Park, the "Blue Ridge" often appears an unnatural white, gray, or brown, and in Great Smoky Mountains National Park, the natural haze is usually overwhelmed by man-made haze. A brief synopsis of the NPS visibility program follows.

Visibility Monitoring

Visibility monitoring has evolved from human observer-based measurements to the use of complex, but highly accurate, automated electro-optical instruments. Over the past years a number of federal agencies have operated and maintained visibility monitoring programs as follows:

- o The longest historical visibility data record is based on the furthest distance large natural targets can be seen. The National Weather Service has recorded "observer determined visual range" at airports since 1948.
- o The National Park Service has established 35 long-term visibility monitoring sites at various remote locations throughout the lower 48 states. The NPS monitoring program was initiated in 1978 at fourteen National Park Service units in the Southwest. Shortly thereafter, visibility monitoring sites were added in the northern Great Plains and northern Rocky Mountains, and in Acadia, Shenandoah and Great Smoky Mountains National Parks. Most recently, visibility monitors have been deployed at parks in the Pacific Northwest and in California.
- o The Bureau of Land Management, United States Forest Service, Electric Power Research Institute and other utility industries have operated shorter term visibility monitoring programs.

Most monitoring programs incorporate, at a minimum, a teleradiometer measuring sky-target contrast at 550 nanometers (green wavelength), a 35 millimeter camera system, and a size selective fine particulate monitor.

Visibility Monitoring Results

The National Weather Service data, although not specifically analyzed for visibility trends within national parks, shows long-term trends for geographic regions that include a number of national park units. Results of this analysis show the following:

- o Summertime visibility over much of the eastern United States has decreased since 1948 more than fifty percent to a current visual range of less than 25 kilometers (km). In the Great Smoky Mountains, median summer visibility is less than 10 km.
- o Although visibility in California's urban and industrial centers has improved since 1967-1968, visibility in California pristine areas has decreased from 1959 to 1976.

It is important to note that in order to simplify the discussion on this complex subject, all the optical data from the visibility monitoring sites has been portrayed in terms of standard visual range, a measure of how far one can see. However, standard visual range is only one of several visibility indices that should be considered in evaluating the degradation of scenic views. Although standard visual range values indicate how far one can see, they do not necessarily indicate how well one can see specific vista features. Other indices would consider color, texture, and proximity of the scene.

Although the NPS monitoring network has not been operated over a sufficient time period to establish long-term trends, it does yield information on seasonal and spatial variation in visibility, as follows:

- o Computations using data at all monitoring locations indicate that even at a specific site, there is a wide range in the estimated standard visual range. Appendix I, attached, lists the standard visual ranges at the 10th, 50th, and 90th percentiles (e.g., at the 10th percentile the visibility is equal to or less than the listed value 10% of the time, or one day out of 10).
- o The standard visual ranges given in Appendix I also indicate that there is great variability (a) from park to park, and (b) among seasons, with the summer visual air quality generally the worst and the winter the best.
- o Atmospheric pollution concentrations are highest during summer months and lowest during winter season.
- o The above points are illustrated in the monitoring results for Grand Canyon National Park as shown in Figure 1. The variations in standard visual range are consistent with the higher pollution concentrations in both fine and coarse mass during summer months and lower pollution concentrations during winter months. The higher concentration of particulates is responsible for reduced visual range. Furthermore, the difference in the scenic view between the 90th percentile standard visual range and the 10th percentile is significant. The 10th percentile at Grand Canyon National Park is a visual range of 105 km, a level at which many features in Grand Canyon cannot be seen, the colors of nearby vistas are washed out and some textural features are lost.

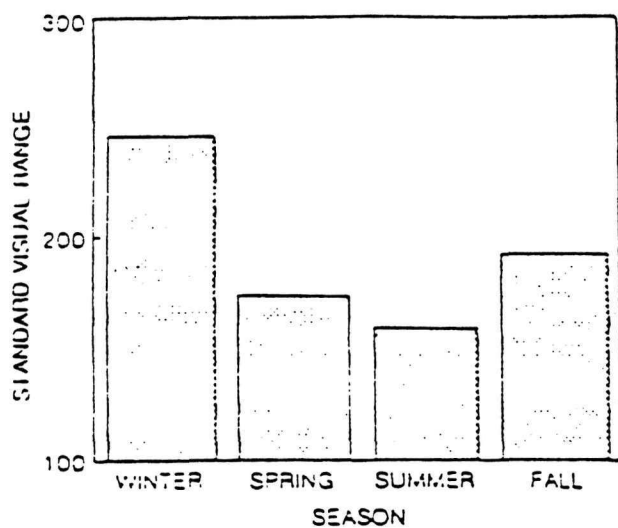


Figure 1a.

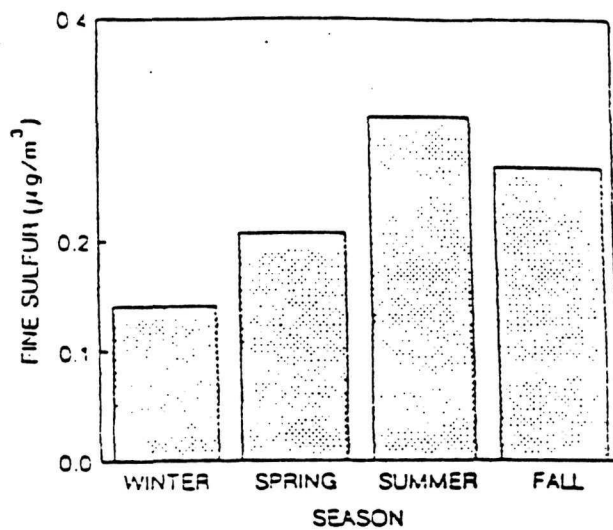


Figure 1b.

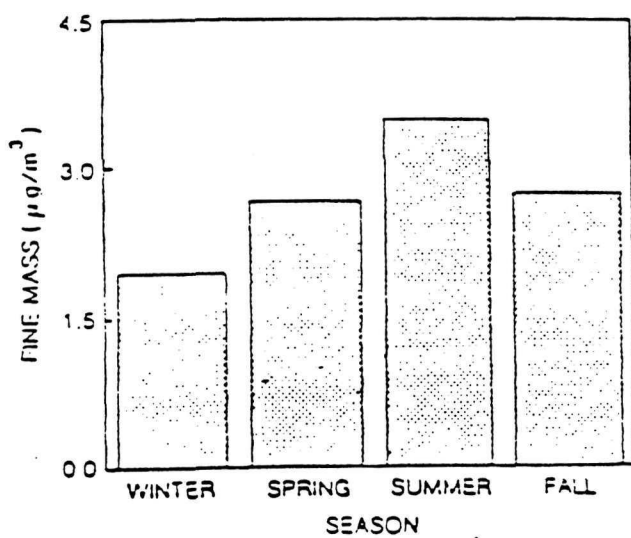


Figure 1c.

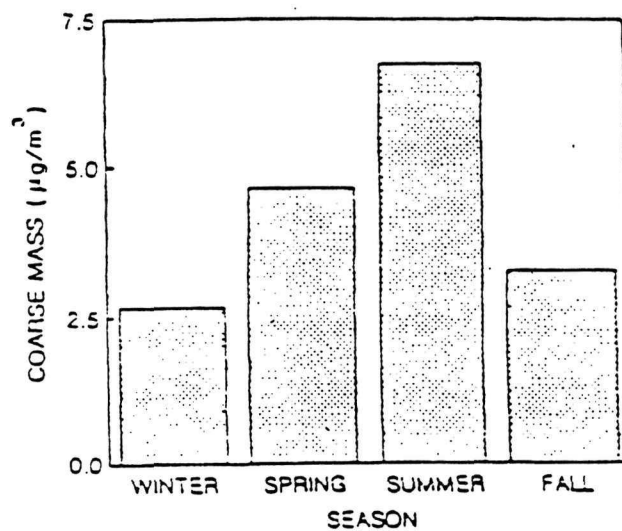


Figure 1d.

Figure 1. Grand Canyon, Arizona seasonal average standard visual range, fine sulfur, and fine and coarse mass concentrations are shown for each season.

- o Eastern visibility degradation from man-made pollution is significantly worse than western visibility degradation. Summertime visual range in the East is typically less than 25 km. A map of visual ranges in the western United States for summer 1982 is shown in Figure 2 (Note: numbers on this map should be compared to the best possible visibility, which is 391 km.). The highest average visual range (180 km), occurs in the northern parts of Nevada and Utah and the southern portion of Idaho. The region with the next highest average visual range (165 km), corresponds to that geographic area that contains Grand Canyon, Bryce Canyon and Canyonlands National Parks, commonly known as the Colorado Plateau. Southern Arizona, New Mexico, and the "Front Range" area of the Rocky Mountains have an average visual range of 140 km. The lowest visual range in the western United States is found in California.
- o The NPS has also documented "pockets" of wintertime layered haze at Bryce Canyon and Mesa Verde National Parks. On winter mornings, for instance, portions of Navajo Mountain as seen from Bryce Canyon were completely or partially obscured as much as 80% of the time.

Particulate Monitoring Results

Fine particles (smaller than 2.5 micrometers in diameter, i.e., one-tenth the diameter of a fine human hair) are generally responsible for a major share of visibility impairment. The National Park Service fine particulate monitoring program shows the following:

- o In most national park units the largest single contributor to fine mass is sulfates which make up 30 to 40% of the fine mass in the western parks and 40 to 60% of the fine mass in the eastern parks. Sulfates are "derivative" pollutants, formed in the atmosphere through the transformation of gaseous sulfur oxide emissions.
- o Generally, southern Arizona, southern New Mexico, and the Big Bend area of Texas have the highest fraction (greater than 40%) of the fine mass as sulfates. In the Great Plains, Colorado Plateau area, and southern California, the proportion of sulfates is between 30 and 40%, while in the remainder of the western U.S., where there is sufficient data to report, the sulfates to fine mass ratio is near 20%. Finally, Shenandoah National Park, an eastern park, shows a 56% sulfates to fine mass ratio. For the western United States, the percent of fine mass that is sulfates for the year 1983 is shown in Figure 3.
- o In the western United States, the highest sulfur concentrations are found in southern California, Arizona, and New Mexico and in the Big Bend area of Texas. Lowest year-round sulfur concentrations were found in northern California and southern Oregon. These spatial variations in sulfur concentration in the western United States for summer 1983 are shown in Figure 4.

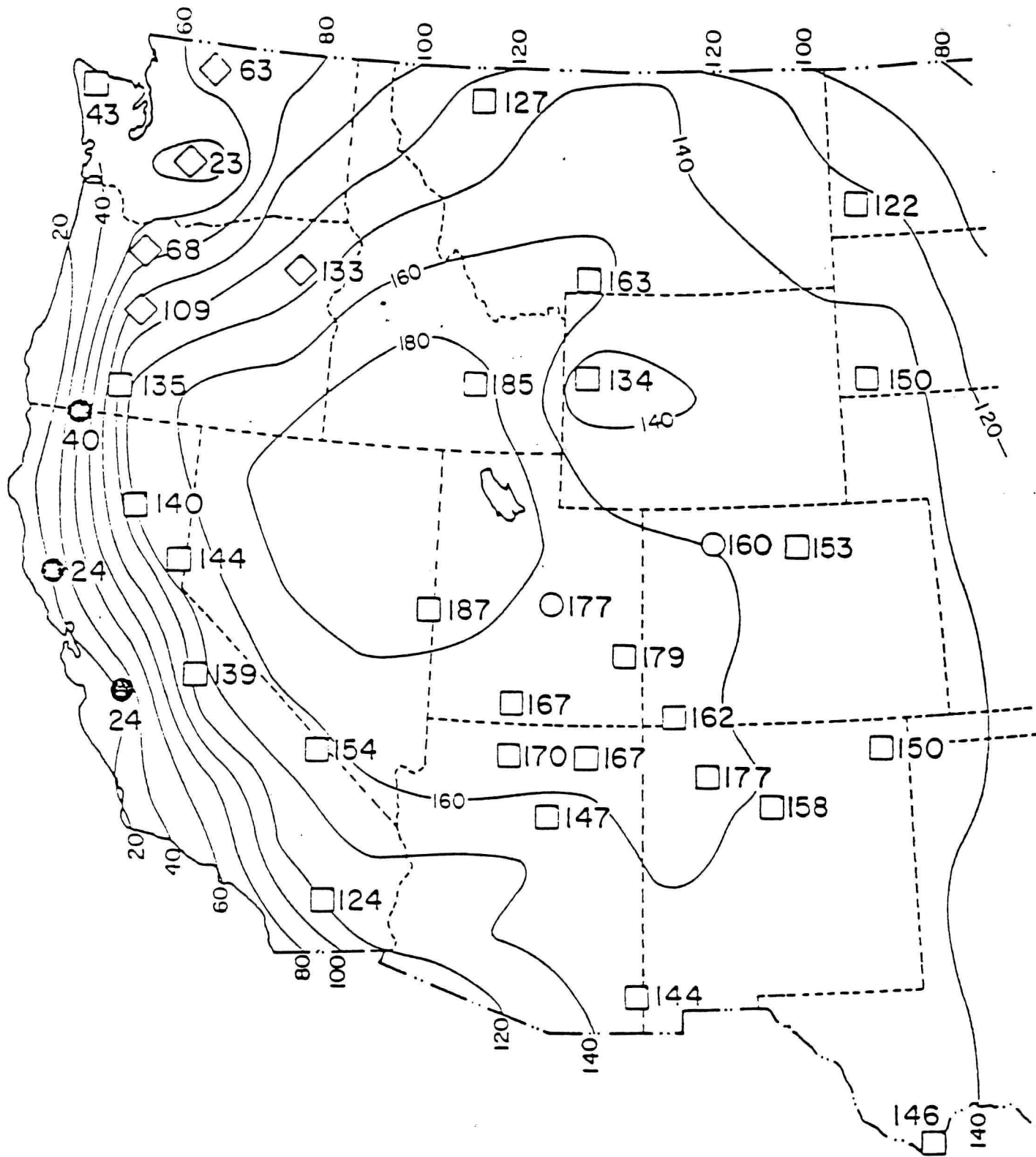


Figure 2. Isopleths of Standard Visual Range over the western United States for Summer, 1982.

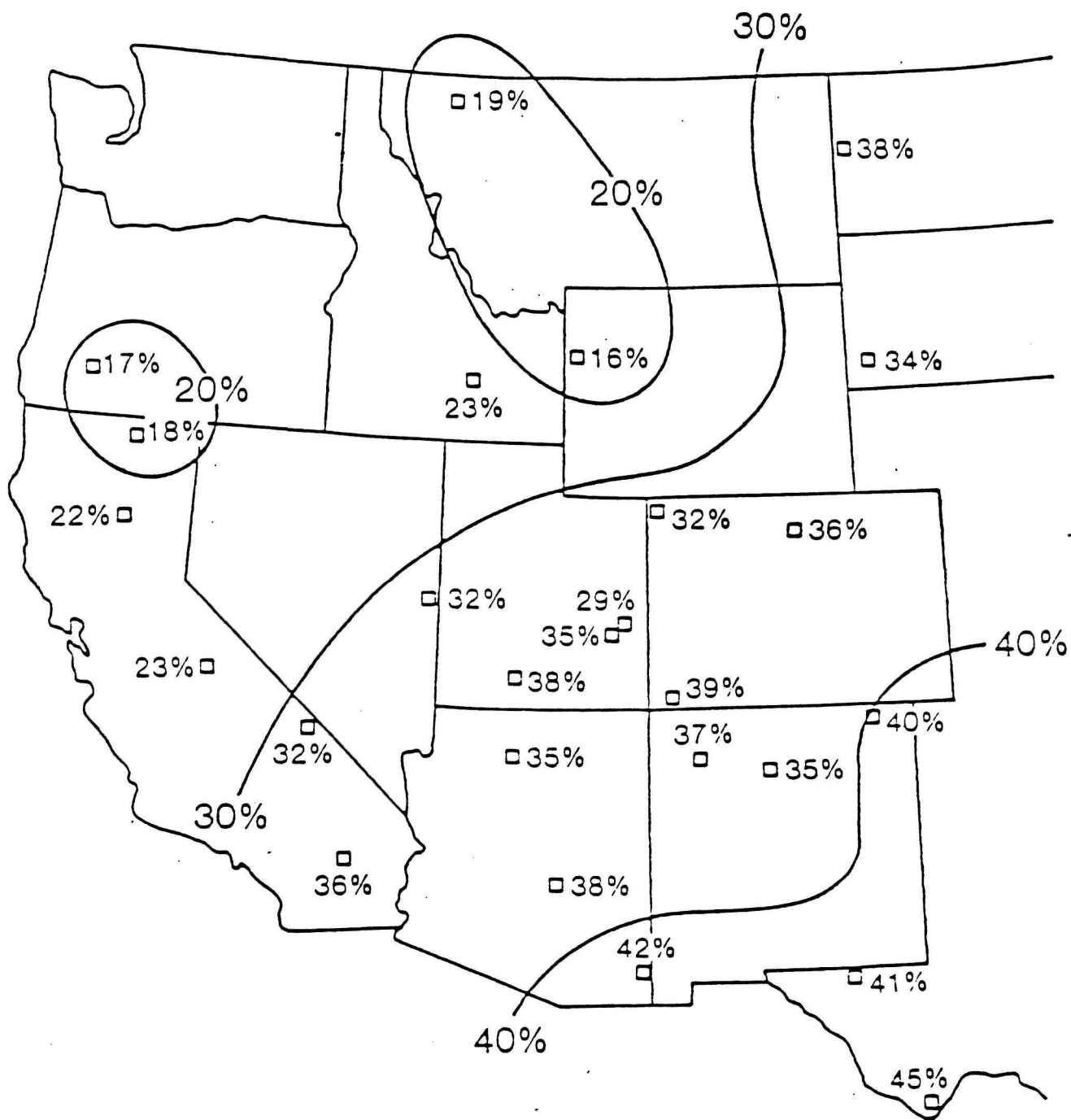
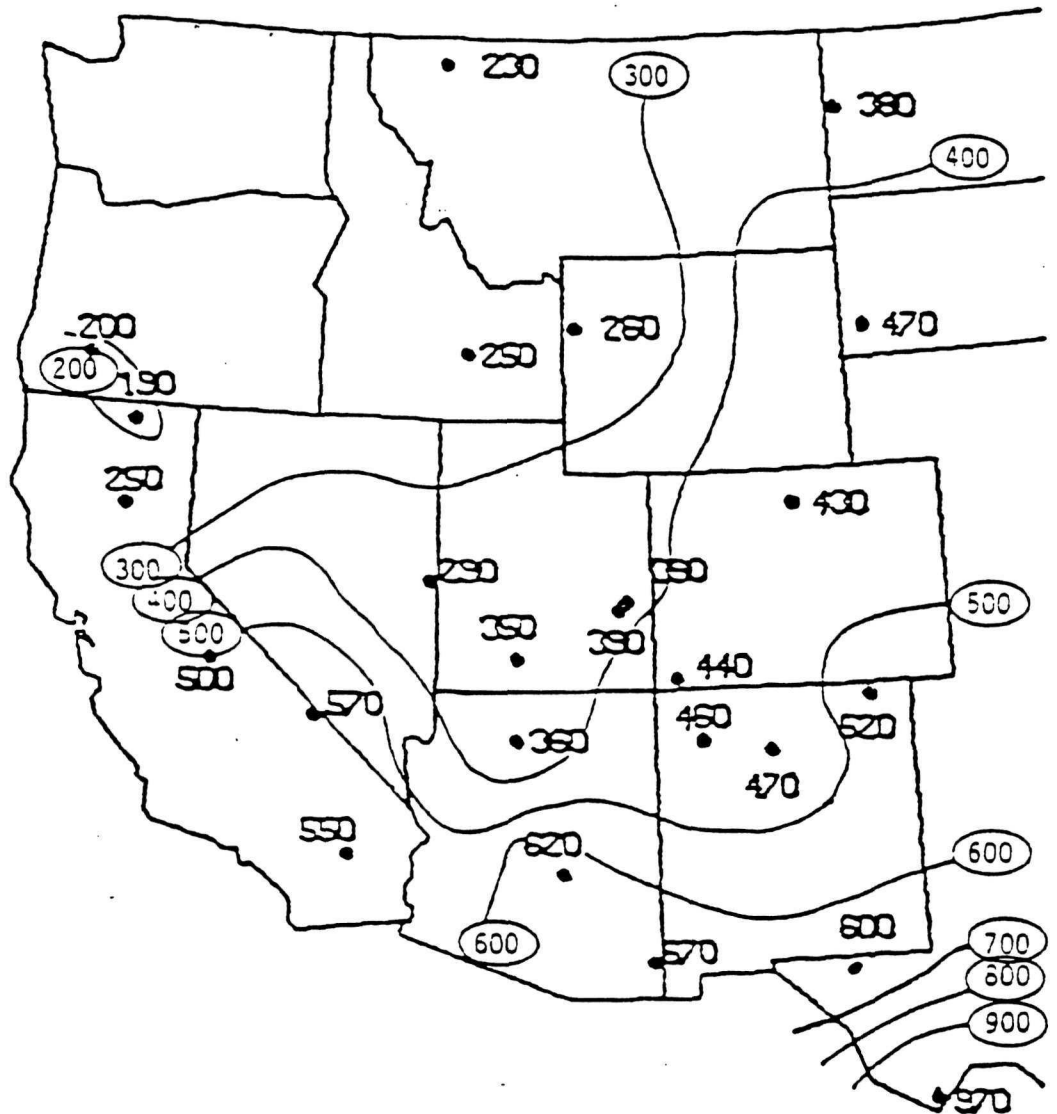


Figure 3. Isopleths of fine sulfate to fine mass ratio in western United States for Summer, 1983.

NPS PARTICULATE MONITORING NETWORK
JUN - AUG 1983 (SUMMER)
CONTOUR MAP OF FINE SULFUR



CONTOUR LINES SHOW REGIONS OF EQUAL CONCENTRATIONS
BASED ON INDICATED AVERAGES IN NANOGRAMS/M³.
CONTOUR LEVELS AT EVERY 100 NANOGRAMS/M³.

Figure 4. Isopleths of Sulfur Concentrations in western United States for Summer, 1983.

Causes of Visibility Impairment

Visibility data, when combined with particulate composition and concentration, allow for developing an understanding of which of the many atmospheric constituents are responsible for visibility reduction ("light extinction budgets"). Because different size particles reduce visibility with varying degrees of efficiency, it does not automatically follow that an aerosol species making up a certain fraction of total mass will be responsible for that same fraction of visibility reduction. Sulfates are especially important contributors to visibility impairment because their size usually makes them very effective scatterers of light. Therefore, the relative contribution of sulfates to visibility reduction can be significantly greater than their percentage contribution to the total airborne mass. Statistical analysis of currently available visibility and particulate data show the following:

- o Sulfates are the single most important contributor to visibility impairment in NPS units except in the northwestern United States, where fine carbon plays a more prominent role.
- o In the Colorado Plateau, an area containing Grand Canyon, Bryce Canyon, and Canyonlands National Parks as well as a number of other park units, sulfates are responsible for 40 to 60% of visibility impairment.
- o In Shenandoah National Park, sulfates appear to be responsible for over 70% of visibility degradation.
- o On the average, soil-related ("crustal") material is responsible for 10-30% of the visibility impairment.
- o Typically, 20% of the visibility reduction is associated with other fine mass, which is comprised of organic carbon, elemental carbon, and nitrates.

Appendix II, attached, summarizes the relative importance of various particulates to visibility reduction at several national park units.

APPENDIX I Standard Visual Ranges at the 10th, 50th, and 90th percentiles at a number of NPS monitoring sites. The visual range numbers listed in this table reflect the effects of meteorological conditions as well as atmospheric pollution.

STANDARD VISUAL RANGE (KM): FREQUENCY OF OCCURENCE (%)

SITE	Winter 1982			Summer 1982		
	10%	50%	90%	10%	50%	90%
Acadia NP	40	76	146	40	75	140
Bandelier NM	112	207	379	107	166	257
Big Bend NP	93	186	374	79	139	242
Bryce Canyon NP	163	274	*	113	159	222
Canyonlands NP	80	204	*	125	176	247
Capitol Reef NP	100	212	*	106	160	242
Capulin Mountain NM	155	253	*	89	140	221
Chaco Culture NHP	159	233	342	139	177	226
Chiricahua NM	128	228	*	80	139	240
Colorado NM	122	223	*	-	-	-
Craters of the Moon NM	-	-	-	109	170	265
Death Valley NM	119	214	384	65	110	185
Grand Canyon NP	156	259	*	105	153	223
Grand Teton NP	77	128	213	81	127	198
Great Smoky Mountains NP	2**	67**	176**	5**	24**	47**
Guadalupe Mountains NP	137	175	222	90	129	185
Joshua Tree NM	-	-	-	64	113	200
Lassen Volcanic NP	-	-	-	84	143	242
Lehman Caves NM	-	-	-	120	188	293
Mesa Verde NP	184	241	316	117	162	226
Navajo NM	160	241	363	102	155	221
Olympic NP	-	-	-	36	65	117
Rocky Mountain NP	95	169	299	64	118	216
Shenandoah NP	-	-	-	3	17	78
Theodore Roosevelt NP	59	122	249	72	122	206
Wind Cave NP	-	-	-	70	123	217
Wupatki NM	92	186	376	86	141	232
Yellowstone NP	90	184	376	-	-	-

* Indicates undefined

** TVA data

APPENDIX II.

PARK:	Grand Canyon	Bryce Canyon	Canyonlands	Chaco Culture	Theodore Roosevelt	Big Bend	Shenandoah
% VISIBILITY IMPAIRMENT DUE TO:							
Sulfate	63%	61%	66%	36%	49%	64%	76%
Other Fine Mass	17%	23%	10%	23%	32%	17%	--
Coarse Mass	20%	16%	24%	41%	19%	19%	--

KNOWN AIR POLLUTION EFFECTS ON VEGETATION IN NATIONAL PARKS

May 1985

The Biological Effects Program of the National Park Service's Air Quality Division, begun in 1978, includes the following categories of projects:

Effects Survey: Determines symptoms of air pollution injury on sensitive species and determines geographic extent, severity, and types of effects. May also include installation of biomonitoring plots and lichen surveys.

Sensitivity Screening: Determines what species are sensitive to expected air pollutants using dominant species, bioindicator species, rare and endangered species, and lichens. May be done in the laboratory or the field.

Trace Element Survey: Same as Effects Survey but the focus is on accumulations of toxic trace elements in park food chains.

Ecological Survey: Determines extent, severity and type of effects on plant communities containing large abundances of air pollution sensitive species. Requires installation of permanent plots.

What follows are the results to date of various projects of the types listed above funded by the National Park Service that demonstrate air pollution effects on vegetation in the indicated park units. Although all the following studies demonstrate vegetation effects, they are organized below under two general subheadings, "Effects Studies" and "Biomonitoring," that reflect differences in study approach and purpose.

Effects Studies

The following results come from various projects of the types listed above, collectively called "effects studies", that examine air pollution effects on vegetation as well as monitored concentrations of pollutants. The pollutant concentrations reported below are from NPS monitors physically located in national park units.

<u>Park</u>	<u>Pollutant</u>	<u>Vegetation Effects</u>
Acadia NP	Ozone (Four exceedances of NAAQS* in 1983 & 1984; the maximum hourly average during these years has been 0.14 ppm.)	Of 300 eastern white pine trees studied in 1984, 58% showed some slight ozone injury. A few individuals showed severe ozone injury throughout the entire canopy. The injury appears to be correlated with decreased width of tree rings, i.e. growth.

* National Ambient Air Quality Standards (NAAQS):

Ozone: 0.12 ppm/1/hour/1 day

Sulfur Dioxide: 0.50 ppm/3 hour
0.14 ppm/24 hour
0.03 ppm/annual average

<u>Park</u>	<u>Pollutant</u>	<u>Vegetation Effects</u>
Shenandoah NP	Ozone (No exceedances of NAAQS since 1980; however, maximum hourly averages during summers reach as high as 0.12 ppm; monthly means are increasing by .003 ppm.)	Widespread ozone injury in 1982 and 1984 on white pine, tulip poplar, black locust, wild grape, clematis and milkweed. These species were selected for study because they represent diverse parts of the ecosystem and they were known to be ozone sensitive. Injury on the most sensitive species (milkweed) occurred on 90% of the plants observed each year. About 8% of the least sensitive species (black locust) were injured. The injury appears to be correlated with decreased productivity and plant diversity. A survey of trees at elevations above 3000 feet revealed abnormally high mortality of some species.
	Sulfur oxides and heavy metals (Levels of sulfur dioxide are about 20% of the 3 hour NAAQS and 30% of the 24 hour NAAQS.)	Elevated concentrations of sulfur and lead are found in lichens. At some sites, the concentrations are above the normal range for lichens from unpolluted areas. Such concentrations have been associated with lichen decline and food web effects in other studies.
Great Smoky Mountains NP	Ozone (Data collected by TVA show numerous exceedances of NAAQS; however, latest data collected by Tennessee show attainment of NAAQS.)	Between 25-30% of eastern white pine trees show ozone injury. Preliminary evidence indicates that sensitive genotypes may be disappearing and that growth is decreasing.
Saguaro NM	Ozone (No exceedances of NAAQS since 1982; hourly average has reached .110 ppm during the summer.)	Almost all of 225 ponderosa pine trees studied in 1984 showed some ozone injury, with the average foliar injury being almost 12%. Some slight ozone injury was also observed on oak and walnut trees.

<u>Park</u>	<u>Pollutant</u>	<u>Vegetation Effects</u>
Sequoia NP	Ozone (The maximum hourly average during the summer has consistently exceeded or equalled NAAQS since 1981.)	Over one-third (36%) of 540 ponderosa pine trees studied periodically since 1980 show moderate to severe ozone injury. Injury is also common on oak trees. Foliar symptoms, like ozone injury observed in laboratory studies, have been recently observed on giant sequoia seedlings in the park.
Santa Monica Mountains	Ozone and sulfur dioxide (Summer 1984 ozone levels exceeded NAAQS on numerous occasions with the highest hourly average being 0.22 ppm; currently, no sulfur dioxide monitoring is being conducted in the park.)	A study of all types of foliar injury on 7 selected species showed that air pollution injury averaged 40% of all injury. The injury has been related to reduced biomass production which probably destabilizes soil and increases fire fuel loading. In portions of the park, lichens are no longer found ("lichen desert"), indicating long-term exposures to sulfur dioxide.
Indiana Dunes NL	Ozone and sulfur dioxide (Numerous exceedances of ozone NAAQS since 1983; highest ozone hourly average recorded has been 0.16 ppm; sulfur dioxide concentrations are 73%, 64% and 47% of 3 hour, 24 hour, and annual NAAQS.)	Foliar ozone injury is common on 16 species studied in 1984 including white and jack pines. Ozone injury is greater on juveniles than adults. Growth of jack pine juveniles and white pine adults is reduced in areas highest in ozone. A "lichen desert" also exists here indicating long-term exposures to sulfur dioxide.
Cuyahoga Valley NRA, Saratoga NHP & Acadia NP	Ozone	In a simultaneous fumigation exposure study, ozone injury on quaking aspen genotypes from these parks was significantly less than injury on aspen genotypes from Voyageurs & Isle Royale NPs, which are more remote and probably less polluted, indicating that sensitive genotypes are probably absent, thus diminishing the species gene pool.

Biomonitoring Studies

The following parks are either exhibiting elevated concentrations of the indicated elements in biosphere organisms or components, or frequent foliar injury from gaseous pollutants. The ecological significance of these effects is unknown but it does indicate that the elements or pollutants are above normally expected levels and that man-made influences are present.

<u>Park</u>	<u>Pollutant</u>	<u>Biosphere Organism or Component</u>
20 Eastern Parks	Ozone	Common milkweed: foliar injury.
Hampton NHS Gettysburg NMP Fredericksburg/ Spotsylvania NMP Petersburg NB	Ozone	Black cherry, white ash, wild grape, sassafras, tulip poplar, dogwood, milkweed, witchhazel, redbud, white pine, Austrian pine: foliar injury.
Isle Royale NP Theodore Roosevelt NP Everglades NP Shenandoah NP Great Smoky Mountains NP	Sulfur	Lichens: abnormally high concentrations.
Shenandoah NP	Lead	Lichens: abnormally high concentrations.
Great Smoky Mountains NP	Lead	Leaf litter: abnormally high concentrations.
Big Thicket NP	Sulfur, heavy metals	Spanish moss: abnormally high concentrations.
Mt Rainier NP	Arsenic	Subalpine fir foliage: abnormally high concentrations.
Great Smoky Mountains NP	Heavy metals	Red spruce: abnormally high concentrations in tree rings.

KNOWN AIR POLLUTION EFFECTS ON WILDLIFE IN NATIONAL PARK UNITS

Wildlife species are generally less sensitive to air pollutants than plants, and consequently the Biological Effects Program has concentrated all of its efforts on vegetation. Nevertheless, animals can be affected by the accumulation of certain non-biodegradable pollutants in foliage, a process called biomagnification. Among such non-biodegradables are fluorides, and heavy metals such as lead, chromium, arsenic, and mercury.

Fluoride emissions near Glacier National Park, spanning a 20-year period up to the 1970s, injured vegetation and accumulated in insects. The emissions have since been curtailed and current studies show no more fluoride injury.

Elevated concentrations of arsenic have been found in wildlife in Everglades National Park and in vegetation in Mt. Rainier National Park. In the latter park, the arsenic levels in fir needles at high elevations are twice what they are at low elevations in the park, but they are still not high enough to cause toxic effects to wildlife. A project is underway to sample wildlife to look for effects further up the food chain.

High levels of other heavy metals, including lead, are found in vegetation and soils in other parks, as shown in the previous table. It is not known if these concentrations are causing wildlife effects.

KNOWN AIR POLLUTION EFFECTS ON AQUATIC SYSTEMS IN NATIONAL PARK UNITS

May 1985

Aquatic Systems:

The Service has 27 areas which are monitored for wet deposition of SO_4 , NO_3 and other pollutants under the Interagency National Acid Precipitation Assessment Program. We also are conducting watershed research projects under NAPAP in four National Parks (Rocky Mountain NP; Sequoia-Kings Canyon NP; Olympic NP; and Isle Royale NP). These projects focus on changes in water chemistry and soil chemistry associated with acid precipitation. This research was initiated in fiscal year 1982, and the effects of acid deposition on watershed systems and watershed ecosystem processes in these four parks have not yet been established. We do know, however, from this and other research that certain streams and lakes in parks do exhibit elevated levels of acidity following acid rain events (see attached).

Currently the Service is cooperating with a number of agencies and institutions, including the U.S. Geological Survey, to study parks in the Rocky Mountain Region, the southern Appalachians, and the Sierras. The Great Lakes Basin parks are being studied to determine how acids correlate with water quality. Northwestern lakes and streams in Mt. Rainier and North Cascades are being monitored to determine if acid precipitation has affected them.

Our research will establish the long-term effects of airborne pollutants on park watersheds, including lakes, streams, and the associated riparian systems. We also will examine the influence of different management practices in protecting aquatic resources against acidification.

NATIONAL PARK SERVICE
SUMMARY OF EFFECTS OF POLLUTANTS ON
AQUATIC SYSTEMS IN PARKS

<u>Park</u>	<u>Pollutant</u>	<u>Effects</u>
27 areas monitored for wet deposition (list attached)	SO ₄ , NO ₃ , H ⁺	Unknown; NPS areas are receiving acid deposi- tion.
Great Smoky Mountains NP Tennessee-North Carolina	H ⁺	Sensitive stream acidity temporarily elevated following acid rain events.
Isle Royale NP, Michigan	H ⁺	Temporary increase in acidity of surface waters following acid rain events.
Shenandoah NP, Virginia	H ⁺ , SO ₄	Decreases in alkalinity and available soil nutrients in sensitive streams.
Sequoia NP, California	H ⁺	Temporary increases in lake acidity following summer storms.

KNOWN AMBIENT AIR QUALITY IN NATIONAL PARKS

May 1985

Introduction

Criteria pollutant monitoring conducted in national parks has shown that park units are not immune from the impacts of sulfur dioxide and ozone pollution. Elevated levels of these pollutants are not limited to parks adjacent to or near large urbanized areas. Although levels of sulfur dioxide are well within the primary and secondary National Ambient Air Quality Standards, ozone levels have exceeded or have equalled the National Ambient Air Quality Standards at various national parks. A brief synopsis of the NPS criteria pollutant monitoring program follows.

Criteria Pollutant Monitoring

Criteria pollutant monitoring in national parks has evolved from a few isolated research projects funded primarily through universities to a growing network of stations coordinated by the Natural Resources Program. By the summer of 1985, the network will have expanded to include sulfur dioxide monitoring at 11 parks, ozone monitoring at 19 parks, and total suspended particulates at 16 parks. Additionally, nitrogen dioxide is monitored at two parks and hydrogen sulfide at one. Monitoring methods used in the collection of data are those listed under EPA's List of Recommended Reference and Equivalent Methods and the Quality Assurance Requirements of 40 CFR Part 58 have been or are currently being implemented at all locations. This will allow for the direct comparison of NPS-collected air quality data with that collected by EPA and state air pollution control agencies.

The criteria pollutant monitoring program is carried out through the use of park personnel, cooperative agreements with state agencies, and through the help of environmental consulting firms at an average cost of \$250,000 per year.

Monitoring Results

The accompanying tables show that ozone levels at several parks have exceeded the NAAQS on numerous occasions whereas sulfur dioxide levels are below the standards. Violation of the standards are not limited to parks near large urbanized areas (Santa Monica Mountains NRA - Los Angeles; Indiana Dunes National Lakeshore - Chicago, Gary) but also occur at remote locations in the high Sierras (Sequoia/Kings Canyon National Park) and the northeast (Acadia National Park). Additionally, parks in the mid-Atlantic region such as Great Smoky Mountains and Shenandoah show levels equalling the NAAQS. Available data show a slight but statistically significant increase in ozone monthly means at Shenandoah.

Although sulfur dioxide levels are below the NAAQS at all parks where monitoring is conducted, levels as high as 48 percent of the secondary standard are being recorded at Olympic National Park. At Theodore Roosevelt National Park, the Park Service working in close cooperation with the North Dakota Department of Health have implemented control actions which have resulted in a 75 percent reduction in short-term (3 hour and 24 hour) ambient levels recorded at the park. At other parks, there are insufficient data to make an adequate assessment of air quality trends.

AIR POLLUTION EFFECTS ON NATIONAL PARK SERVICE CULTURAL RESOURCES

As yet, field testing has not been in place at National Park Service cultural resources sites long enough to establish the exact cause and effect relationship between specific pollutants and damage to historic and prehistoric building materials.

However, we know that hydrogen ions (H^+) and sulfur dioxide (SO_2) speed the degradation of limestone, marble, mortar, and bronze. Marble and limestone dissolution rates derived from controlled experimental exposure testing show that a reduction in the rain pH from 5 to 4, doubles the rate at which marble dissolves. We suspect that other pollutants, e.g. nitrogen oxides (NO_x), airborne particulate matter, and ammonia; and natural agents, e.g. moisture and freeze-thaw cycles, also play a role in the weathering process. What we don't know is how much longer cultural resources would survive in the absence of air pollution as compared to their potential life span in the current environment.

To establish cause and effect links between specific environmental agents and cultural resource deterioration, long-term (5 - 20 year) in situ monitoring of the resource in question and the environment to which it is exposed is needed. Two such monitoring projects have begun recently at Mesa Verde National Park, southwestern Colorado, and Independence National Historical Park, Philadelphia,

Pennsylvania. Neither of the projects has been in operation long enough to specifically state the relationship between the pollution level and the deterioration of the resource. Additional monitoring for cultural resource damage is planned for installation at National Park Service sites at a rate of one site each year for the next six years.

In the absence of incontrovertible evidence of air pollution damage to cultural resources derived from on-site monitoring, damage estimates can be calculated by intersecting three sets of information:

- 1) Damage functions, mathematical expressions derived from scientific experiments, that relate the concentration of pollutants to quantity of material loss.
- 2) Maps identifying the locations of sensitive cultural resources.
- 3) Histories of environmental exposure at specific sites, including current deposition, for areas where cultural resources are located.

Estimates of damage to cultural resources are being prepared for stone resources listed on the National Register of Historic Places and for monuments and outdoor sculpture for 17 states in the Northeast, Mid Atlantic and Mid West U.S. These estimates are planned for inclusion in the 1985 Assessment prepared by the Interagency Task Force on Acid Precipitation and scheduled for release in September 1985.

Attached are summary tables of the sensitive resources in the National Park System.

NATIONAL PARK SERVICE CULTURAL RESOURCES SENSITIVE TO AIR POLLUTION DAMAGEMonuments

<u>Park Name</u>	<u># Bronze Statues</u>	<u># Stone Monuments</u>
Custer Battlefield NM	62	
Mount Rushmore NM		1
Saratoga NHP		13
Antietam NB	8	95
National Capitol Parks	42	59
Manassas NB	1	14
Gettysburg NMP	58	379
Petersburg NB		15
Valley Forge NHP	3	37
Andersonville NHS	3	17
Guilford Courthouse NMP		27
Chickamauga & Chattanooga NMP	23	607
Kings Mountain NMP		12
Shiloh NMP		24
Vicksburg NMP	174	463
Lincoln Boyhood NM		13

Buildings# Brick# Stone

327

850