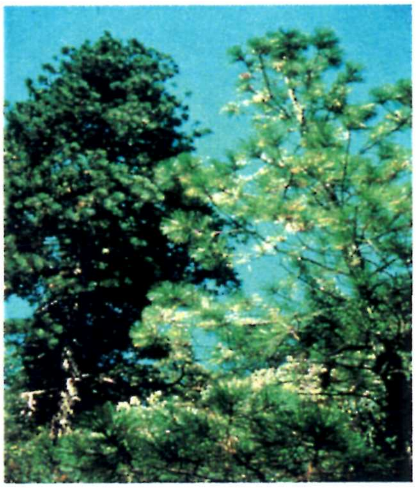
Air Quality Conditions and Trends: An Overview

National Park Service, Air Resources Division February 1999

Ecological Effects of Air Pollution in National Parks

Air Pollution has deleterious effects on sensitive native vegetation and on both aquatic and terrestrial ecosystems within national parks. Researchers catalog sensitive resources, known as air quality related values, and establish dose-response relationships between levels of air pollutants and corresponding effects on ecosystems and populations.

Ozone is generally acknowledged as the air pollutant causing the greatest amount of injury to native vegetation. Ozone enters plants through leaf stomata (openings, usually on lower surface of leaves) and may cause direct physiological injury to plants. Ozone may also weaken sensitive plants, permitting significant injury by secondary stressors. Researchers have documented ozone injury to native hardwood and coniferous trees and herbaceous plants in NPS units across the United States.



Plants in the Sierra Nevada are exposed to chronic high ozone levels. Both growth and foliar effects have been documented on ponderosa and Jeffrey pines since the early 1960's, including plots within Sierran national parks. Changes in plant community structure attributed to ozone have been documented in southern California.

Acidic deposition of nitrogen and sulfur compounds can affect freshwater lakes, streams, ponds, the watersheds surrounding these surface waters, and estuarine ecosystems. Effects of concern include changes in water chemistry that affect algae, fish, submerged vegetation, amphibian, and aquatic invertebrate communities. These changes can result in higher food web impacts.

The regions of concern regarding acid deposition include the mountainous preserves of the Rockies, Cascades and Sierra Nevada, the upland areas of the eastern U.S., and the shallow bays and estuaries along the Atlantic and Gulf Coasts. The NPS has observed acidification of streams in both Shenandoah and Great Smoky Mountains National Parks.

Sensitive Ecological Resources Around the Nation: A Snapshot

Acadia National Park in Maine includes sensitive ecosystems such as alpine lakes and vegetation. This park receives air pollution and acid deposition that is transported up the eastern seaboard, from the Midwestern U.S. and from Canada; it is "at the end of the tailpipe" for the industrial Midwest and Northeast. Ozone concentrations have exceeded the human health standard in the past, and some native plants have visible signs of injury, such as red stipple and chlorosis on leaves.

Ozone and acid rain are becoming less severe in this part of the U.S. because of the Clean Air Act; however, nitrogen deposition still threatens lake and stream quality. Episodes of acid runoff from granite watersheds have been detected. Another threat to parks is airborne toxics. In the "great ponds" within the park, where fishing is an important recreational pursuit, some of the fish have high mercury concentrations. The elevated mercury in fish and fish-eating birds is linked to mercury emissions from power plants and incinerators.

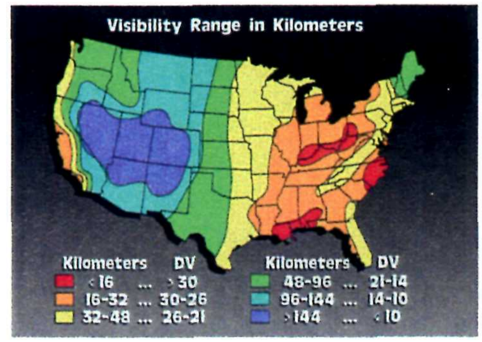
At Shenandoah National Park in Virginia many adverse effects of multiple air pollutants have been documented. Streams with low buffering capacity, found on erosion-resistant bedrock, have been chronically acidified due to sulfate deposition in rain and dryfall. A larger number of streams become temporarily acidified following large rainstorms. These "episodes" can affect native fish species. The periodic high levels of nitrate in streamwater may be caused by several different stresses. Nitrogen can enter streams due to the excess nitrogen in rainfall or due to effects from gypsy moth infestation. Hardwood trees, such as black cherry, show injury on their leaves due to high ozone levels experienced during June-September.

The parks of the Rocky Mountains, including Rocky Mountain, Grand Teton, Yellowstone, and Glacier National Parks, may be "on the edge" of seeing a variety of effects due to nitrogen pollution in rain, snow, cloudwater, and dry deposition. The first sign of changes in natural ecosystems are likely to be found in clear, alpine lakes and streams, which have little buffering capacity to withstand acid and nitrogen-enriched rain and snowmelt.

Since Rocky Mountain National Park is located near urban and agricultural sources of nitrogen pollution, the NPS has focussed considerable research and monitoring in this park.

Sensitive, high elevation lake basins in the park and in adjoining wilderness areas seem to be leaking nitrogen from soils into lakes and streams. This is accompanied by depression in pH and buffering capacity in very dilute waters of lakes and streams during spring snowmelt. Responses to these chemical changes by aquatic plants and animals have not been observed, but it is possible that soil microbes are being affected by nitrogen delivered via the air pathway. There is less nitrogen in the rain and snow at other Rocky Mountain parks, but there is concern about the possible transport of nitrogen oxides to Grand Teton National Park from planned oil and gas development in SW Wyoming. A lake and stream monitoring program for sensitive lakes and streams in these parks is needed to detect possible changes in water chemistry due to polluted rain and snow and local man-made sources.

Veiled Views: Air Pollution Degrades Visibility in all National Parks



- Spectacular scenic views need to be seen to be appreciated; yet air pollution (primarily in the form of fine particles) impairs views to some degree virtually all the time in all of our national parks. Natural conditions account for some of this visibility impairment. Fine particles of natural origin contribute about 15% and 25% to visibility impairment in much of the East and West, respectively. Visibility reduction due to air molecules determines the best possible visibility in particle-free air, theoretically, 391 kilometers.
- NPS has been monitoring visibility conditions in many parks since 1979. This monitoring includes measurements of the fine particles responsible for visibility impairment.
- Visibility impairment due to fine particles is much greater in the East than in the West. Nationwide, the principal atmospheric constituents responsible for visibility impairment include sulfate and nitrate compounds, elemental carbon, and organic compounds.
- Sulfate compounds are almost exclusively a product of fossil fuel combustion and smelter operations. Nitrate compounds and elemental carbon are the result of industrial fuel combustion and mobile sources. Mobile and natural sources (e.g., vegetation) can lead to the formation of organic particulates. Wildland fires and agricultural burning can also contribute significantly to organic compounds and elemental carbon levels.
- Sources responsible for visibility impairment can be relatively nearby or hundreds of kilometers away.

Eastern Visibility

Though visibility is affected by recognized natural components in the East, as evidenced by the names Great Smoky Mountains and the Blue Ridge Parkway, these natural views are frequently obscured by hazes due to man-made air pollution. Views that should extend to 150 kilometers have been reduced to as low as 40 kilometers on the average. In the East fine sulfate compounds account for about 1/2 to 3/4 of the visibility impairment due to fine particles.

Western Visibility

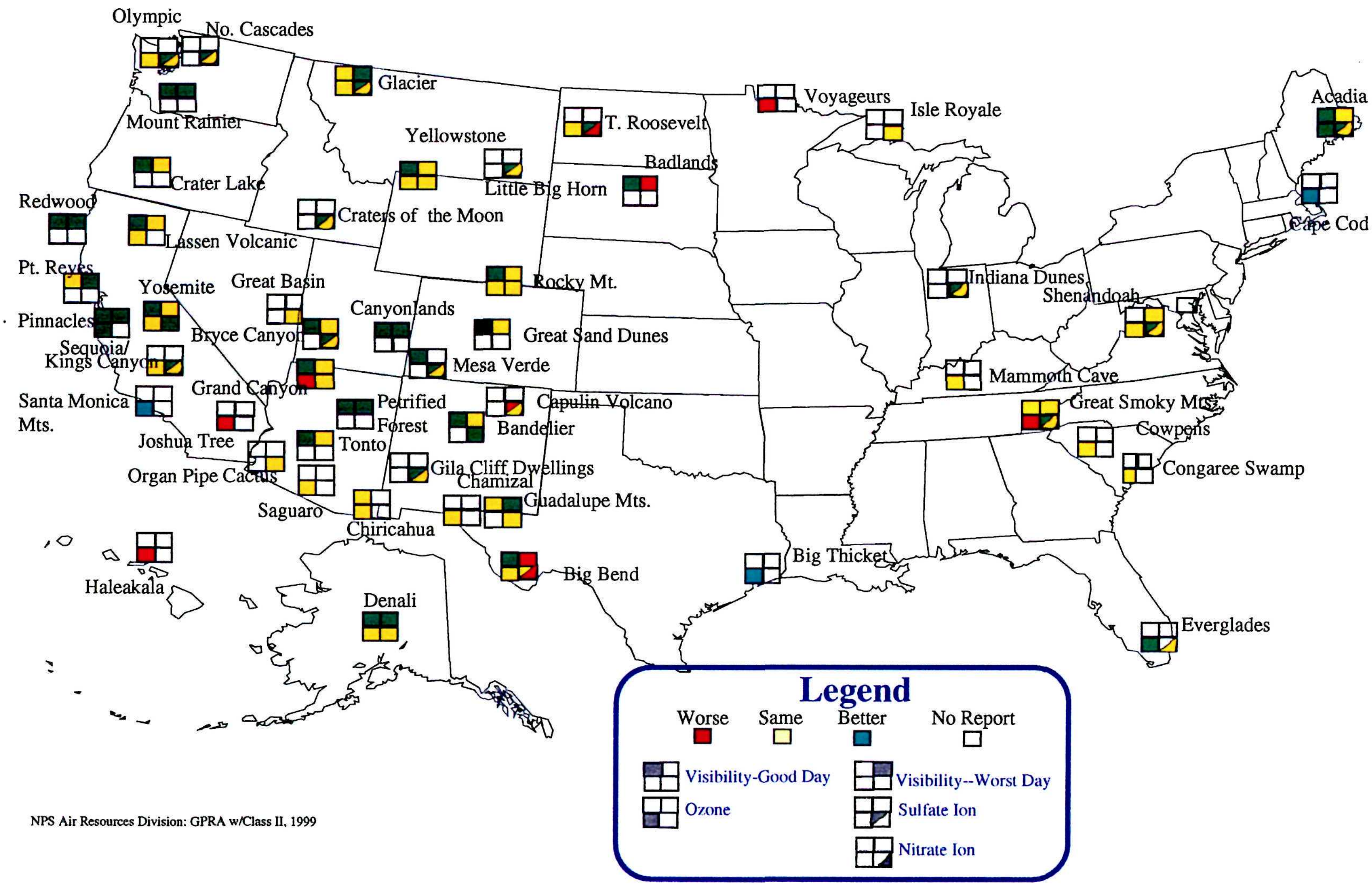
In the West, views that should extend to 230 kilometers have been reduced to as low as 125 kilometers on the average. Sulfate particles account for 1/4 to 1/2 of the visibility impairment at most Western sites, with the exception of Southern California where nitrates are the largest single contributor to visibility impairment. Organic particulates make a greater fractional contribution to visibility impairment at Western sites than they do in the East. The clearer air in the West, however, makes visibility more sensitive to increases in pollution.

Transboundary Air Pollution

In various NPS areas in the Southwest along the US-Mexico border, visibility is much poorer than in other areas of the West. At Big Bend National Park, Texas, summer visibility averages only 80 kilometers obscuring the scenic vistas for which the park is known. Studies have shown that the transport of air pollution, particularly sulfate compounds, over regions in Mexico contribute substantially to visibility degradation at the park. Since 1993, NPS has been involved in scientific studies and negotiations with the Government of Mexico to identify the causes and sources of visibility degradation at Big Bend. At issue is the extent to which Mexican emissions, including those of the Carbon I and Carbon II coal-fired power plants located only 20 miles from the US-Mexico border, contribute to visibility degradation. The US and Mexican governments have committed to conducting an extensive tracer-release study in 1999 to identify the extent to which sources in the US and in Mexico are responsible for the observed hazes at Big Bend and other areas in the Southwestern US.

Air Quality Trends in National Parks

(significance at the 0.15 level)



NPS Air Resources Division: GPRA w/Class II, 1999

Interpretation of Air Quality Trends Map

Any assessment of trends is a function of the time period, measures, and methods used to conduct the analysis. Different trends may be revealed if a different approach were used. For this map:

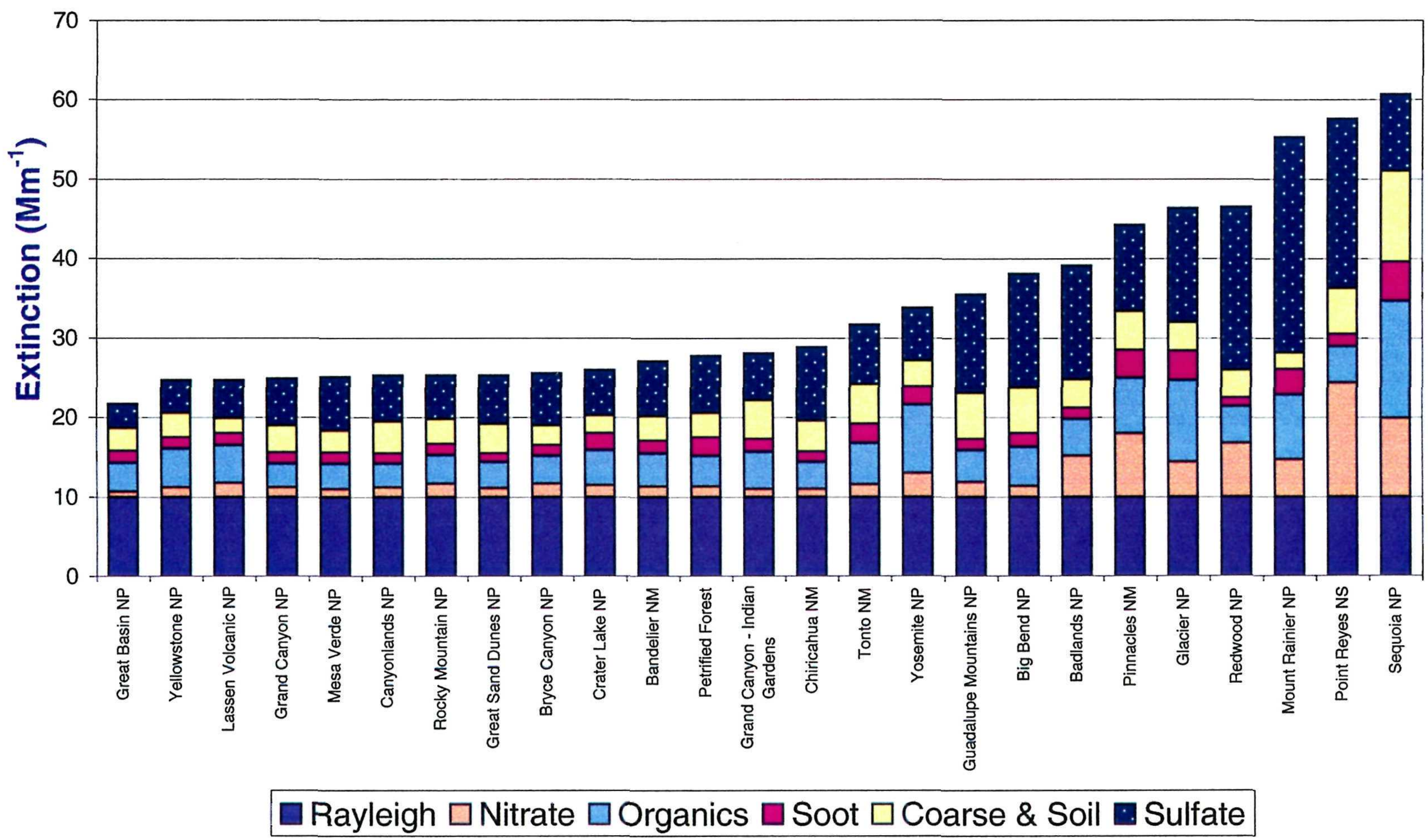
Visibility trends are based on analyses of reconstructed extinction derived from fine particle data (24-hour concentrations) collected from 1988 through 1997. Symbols indicate whether there is a statistically significant (at the 0.15 level) trend in the slope of the annual extinction means on the average, as well as on the best days and worst days (mean of the top and bottom 20 percentile).

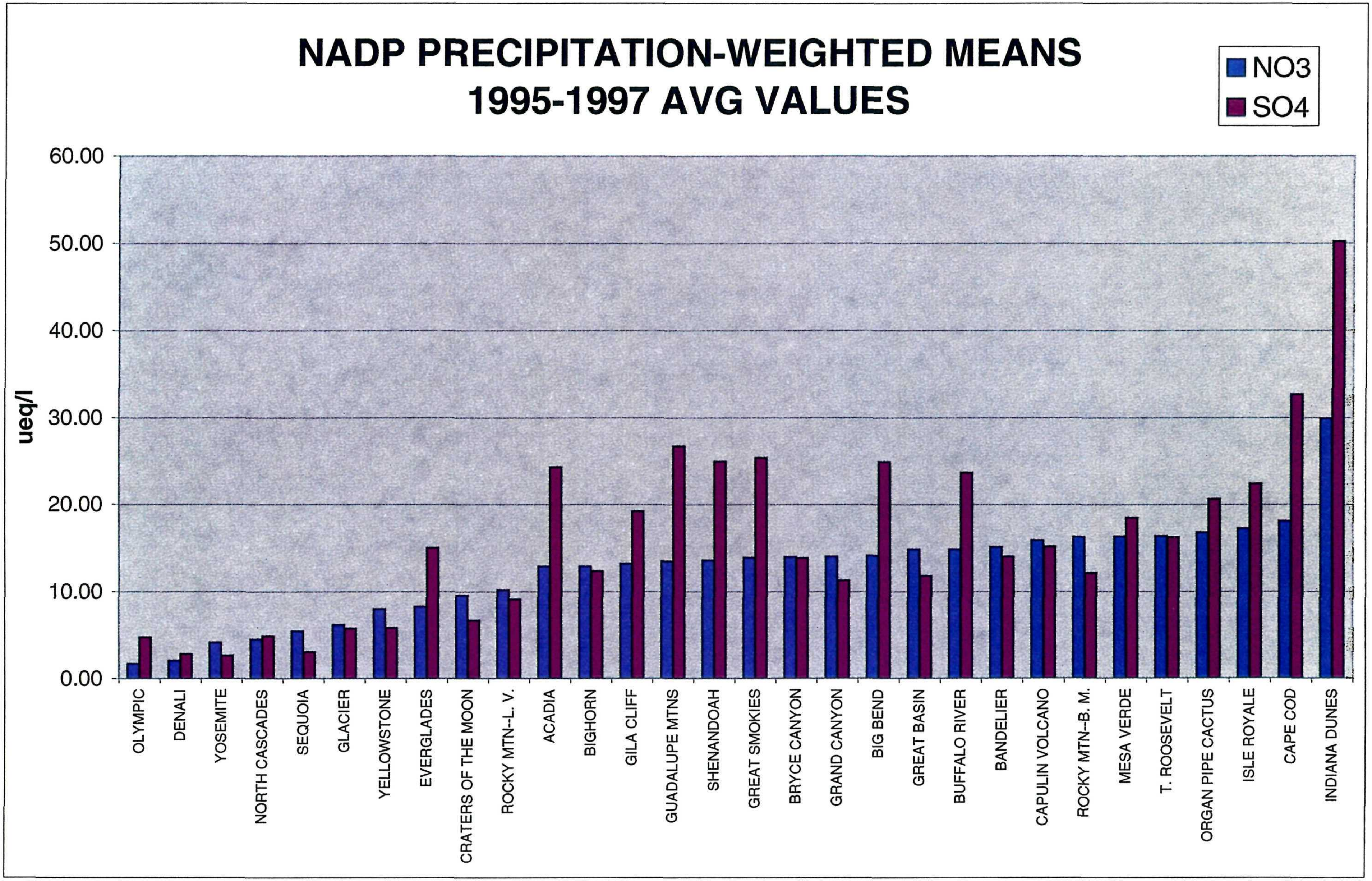
For **Acid Deposition trends**, weekly precipitation volume and chemistry measurements from each site that met the completeness criteria were accumulated from 1985-1993 into bimonthly precipitation totals and volume-weighted mean concentrations of ions. Trends in sulfate and nitrate ion concentrations were evaluated using a two-stage, least squares general linear model. Trends with negative slope estimates (p-values < 0.15) were categorized as getting better and trends with positive slope estimates (p-values < 0.15) were getting worse. Trends with p-values > 0.15 were determined to be insignificant and categorized as staying the same (Lynch et al. 1995).

For **Ozone trends**, the average of the daily maximum 1-hour ozone concentration during the growing season (May-September) was used to assess changes in ozone air quality in parks. Data from 1988-1997 from monitoring sites with at least a 60% data capture are included. Ozone levels were considered to be improving if the data exhibits a statistically significant improving trend at an alpha level of 0.15.

One caveat on ozone trends: the 1998 summer ozone season was one of the worst on record for national park sites. Data from 1998 is not included in this analysis and will likely affect trends at several units.

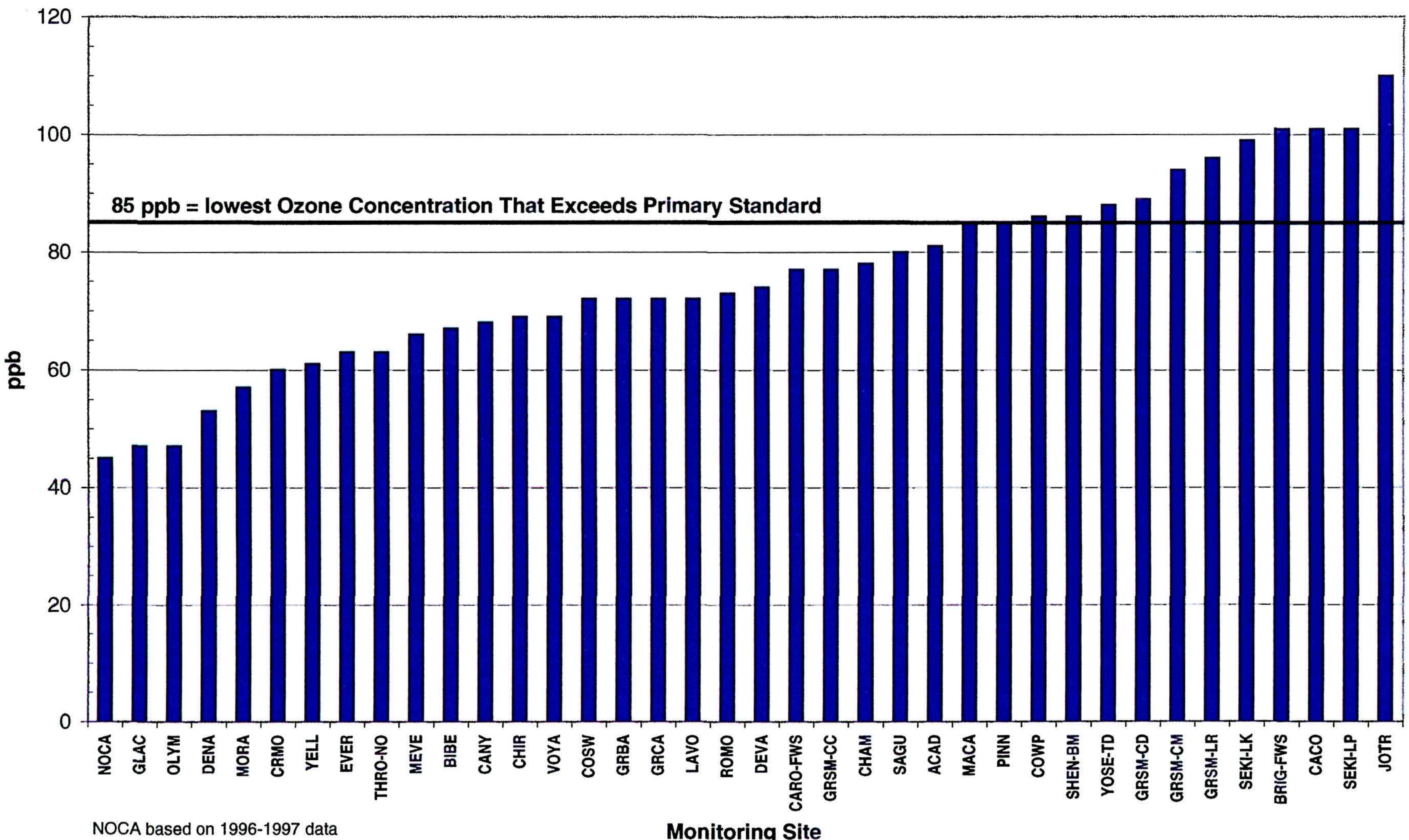
ANNUAL MEAN RECONSTRUCTED EXTINCTION
3/1993 - 2/1998





NADP PRECIPITATION-WEIGHTED MEANS
1995-1997 AVG VALUES
NO3
SO4
60.00
50.00
40.00
30.00
20.00
10.00
0.00
ueq/l
OLYMPIC
DENALI
YOSEMITE
NORTH CASCADES
SEQUOIA
GLACIER
YELLOWSTONE
EVERGLADES
CRATERS OF THE MOON
ROCKY MTN--L. V.
ACADIA
BIGHORN
GILA CLIFF
GUADALUPE MTNS
SHENANDOAH
GREAT SMOKIES
BRYCE CANYON
GRAND CANYON
BIG BEND
GREAT BASIN
BUFFALO RIVER
BANDELIER
CAPULIN VOLCANO
ROCKY MTN--B. M.
MESA VERDE
T. ROOSEVELT
ORGAN PIPE CACTUS
ISLE ROYALE
CAPE COD
INDIANA DUNES

1995-1997 Average of 4th Highest Daily Maximum 8-hour Ozone Concentrations



NOCA based on 1996-1997 data
SEKI-LP based on 1997 data