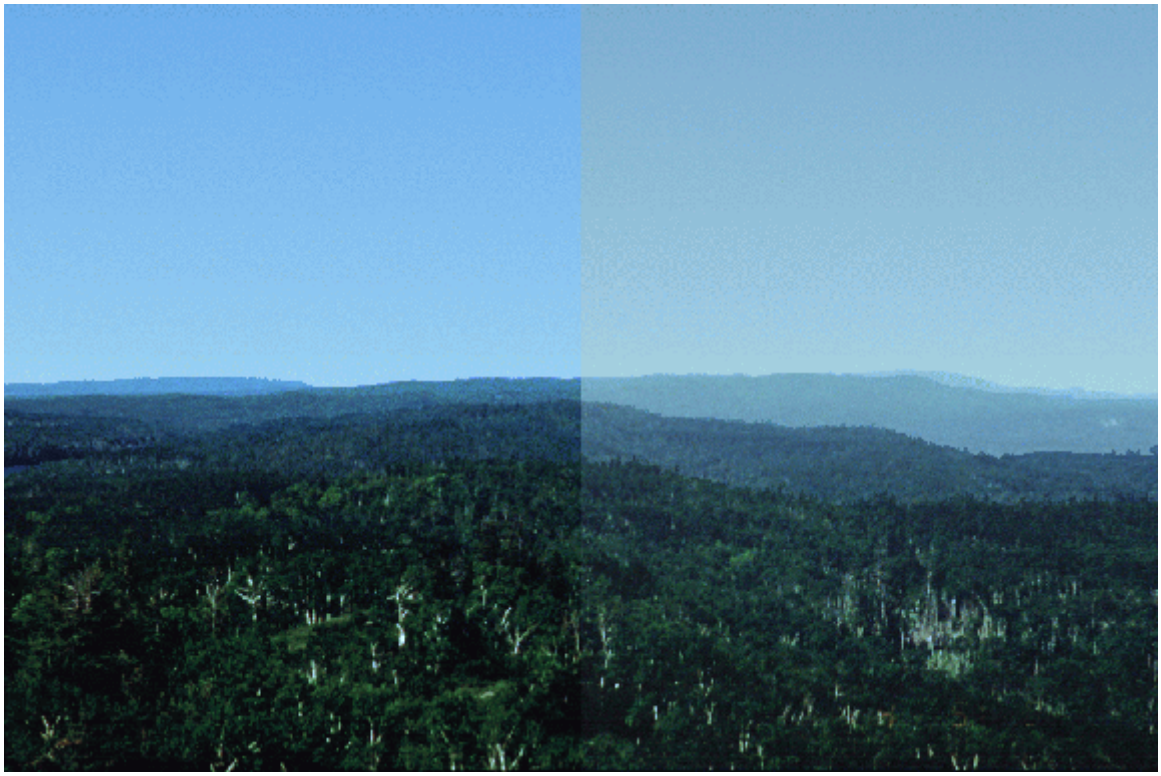
Regional Haze and Visibility in the Upper Midwest

SUMMARY

Isle Royale National Park, MI

Visual Range = 194 km (deciviews = 7) **Visual Range = 53 km (deciviews = 20)**



Midwest Regional Planning Organization
September 1, 2001
Final Draft

For many years, visibility impairment has been considered the ‘‘best understood and most easily measured effect of air pollution.’’ (CEQ, 1978) Visibility impairment due to regional haze is a problem affecting many areas throughout the U.S., especially national parks and wilderness areas. Average visual range in many parks in the western U.S. is 100–150 kilometers, or about one-half to two-thirds of the visual range that would exist without manmade air pollution. In most of the eastern half of the U.S., the average visual range is less than 30 kilometers, or about one-fifth of the visual range that would exist under natural conditions. Surveys have shown that visitors to national parks and wilderness areas consistently rank visibility and clear scenic vistas as one of the most important aspects of their experience.

To address this problem, section 169A of the Clean Air Act requires the “prevention of any future, and the remedying of any existing, impairment of visibility in Class I areas which impairment results from manmade air pollution.” There are 156 mandatory Federal Class I areas across the country, including many well-known parks and wilderness areas, such as the Grand Canyon, Great Smokies, Shendandoah, Yellowstone, and Yosemite[1]. Two mandatory Class I areas are located in the 5-state region in the upper Midwest covered by the Midwest Regional Planning Organization (RPO): Seney National Wildlife Refuge (Wilderness Area) and Isle Royale National Park in northern Michigan.

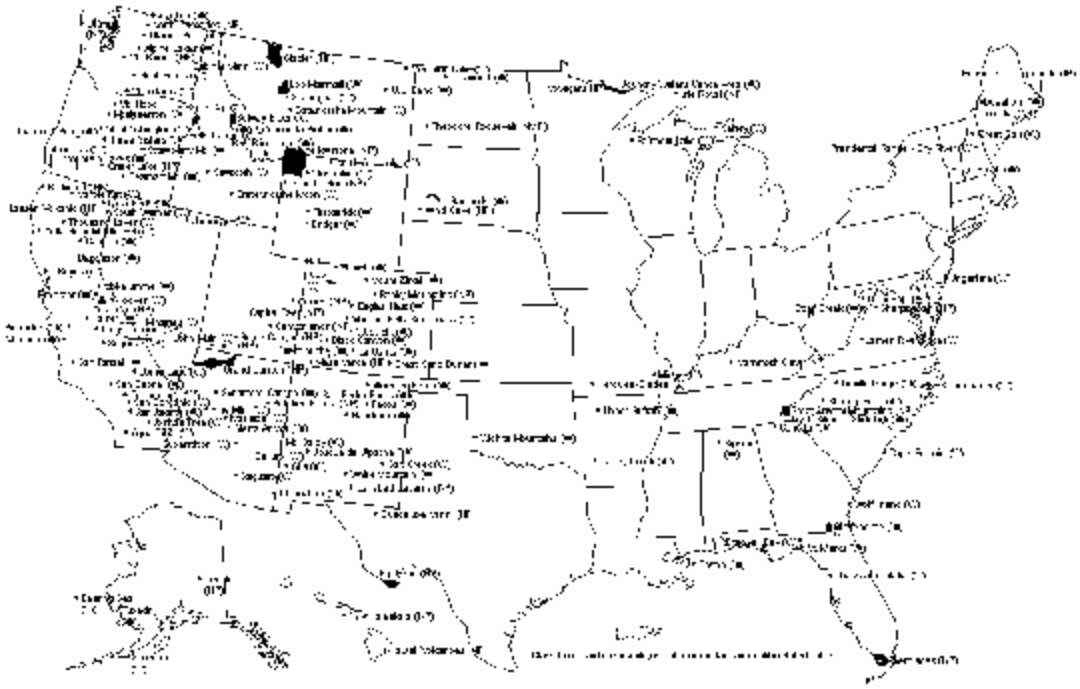


Figure 1. Map of 156 National Park and Wilderness Areas

[1] Areas designated as mandatory Class I Federal areas are those national parks exceeding 6000 acres, wilderness areas and national memorial parks exceeding 5000 acres, and all international parks which were in existence on August 7, 1977.

On July 1, 1999 (64 FR 35714), the U.S. Environmental Protection Agency (USEPA) promulgated regulations to deal with visibility impairment due to regional haze. The goal of these regulations is to achieve "natural conditions" on the 20% most impaired days (by 2064) and ensure no degradation on the 20% least impaired days.

An initial assessment of the regional haze problem in the upper Midwest was performed by reviewing existing reports and analyzing available air quality data. The purpose of this summary document is to review the key findings from this assessment.

KEY FINDINGS

(1) ***Visibility impairment due to regional haze is a problem***.
Regional haze exists in the Class I areas in the upper Midwest:

Visual Range = 194 km
deciviews = 7

Visual Range = 53 km
deciviews = 20

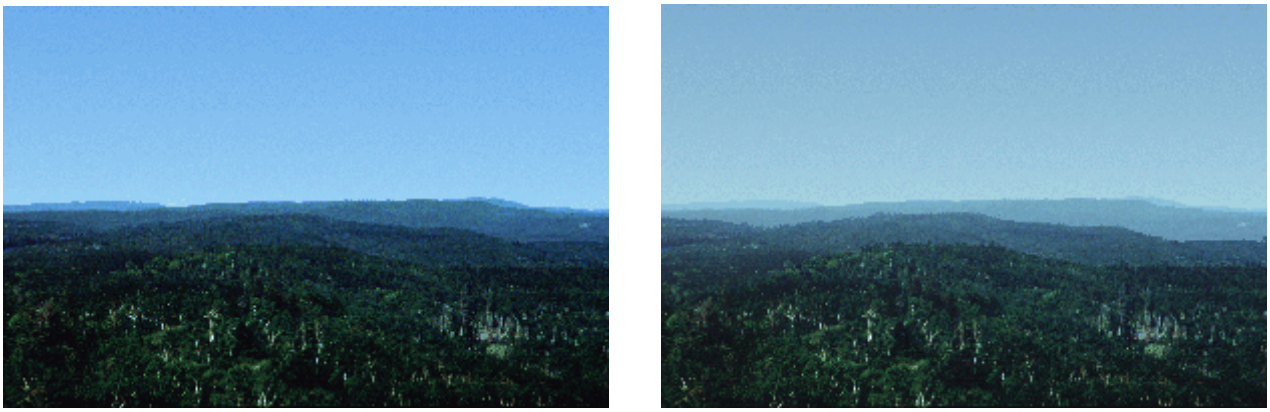


Figure 2. Isle Royale National Park, Michigan on a good (left) and poor (right) visibility day

and other, downwind Class I areas in the eastern half of the U.S.:

Visual Range = 118 km
deciviews = 12

Visual Range = 22 km
deciviews = 29

Figure 3. Shenandoah National Park, Virginia on a good (left) and poor (right) visibility day

Visibility impairment due to regional haze is also a problem in many urban areas in the upper Midwest:

$PM_{2.5}$ = 8 ug/m^3 **$PM_{2.5}$ = 30 ug/m^3**

Figure 4. Chicago, Illinois on a good (left) and poor (right) visibility day

Fine particles not only play a major role in visibility impairment (as seen above), but also pose a threat to public health. In 1997, USEPA adopted a new air quality standard for fine particles (62 FR 38652, July 18, 1997).[2] The figure below shows a large portion of the eastern U.S. with fine particle ($PM_{2.5}$) concentrations which approach (or exceed) the annual standard of 15 ug/m^3.

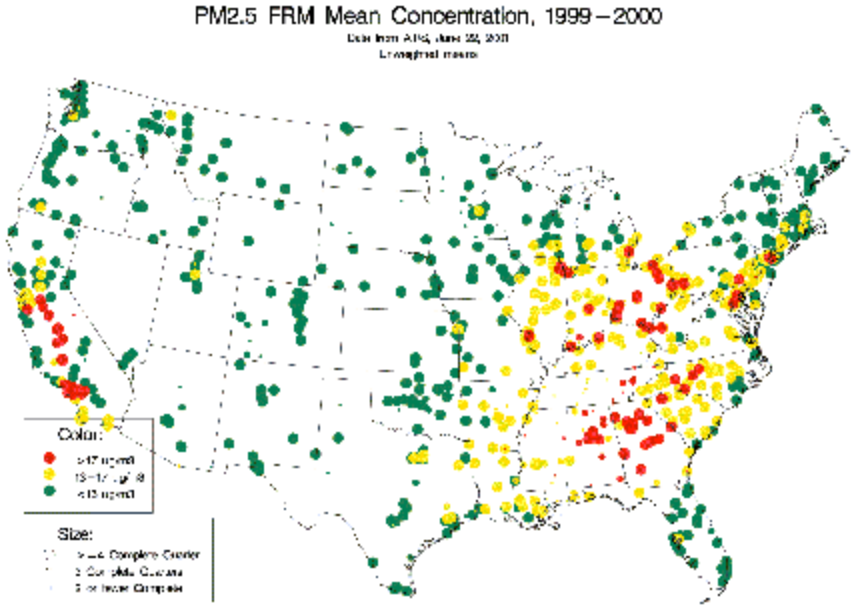


Figure 5. 1999-2000 annual average fine particle concentrations

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[2] On May 14, 1999, a panel of the Court of Appeals for the D.C. Circuit remanded the $PM_{2.5}$ NAAQS to USEPA. In response to USEPA's petition for review of this decision, on February 27, 2001, the U.S. Supreme Court upheld USEPA's authority to set air quality standards under the Clean Air Act and USEPA's position that the Act requires these standards to be based solely on public health considerations. The Court, however, also found USEPA's implementation policy for ozone to be unlawful and on remand they directed the Circuit Court to dispose of any other preserved challenge to the NAAQS.

(2) Visibility levels vary across the eastern half of the U.S.

The spatial distribution of visibility levels for the 20% best and 20% worst days (expressed as deciviews) for the 1997-1999 3-year period is shown in Figure 6. In the Midwest RPO region, the best visibility levels (and lowest $PM_{2.5}$ concentrations - see Figure 5) occur to the north, and the worst visibility levels (and highest $PM_{2.5}$ concentrations) occur to the south (near the Ohio River) .

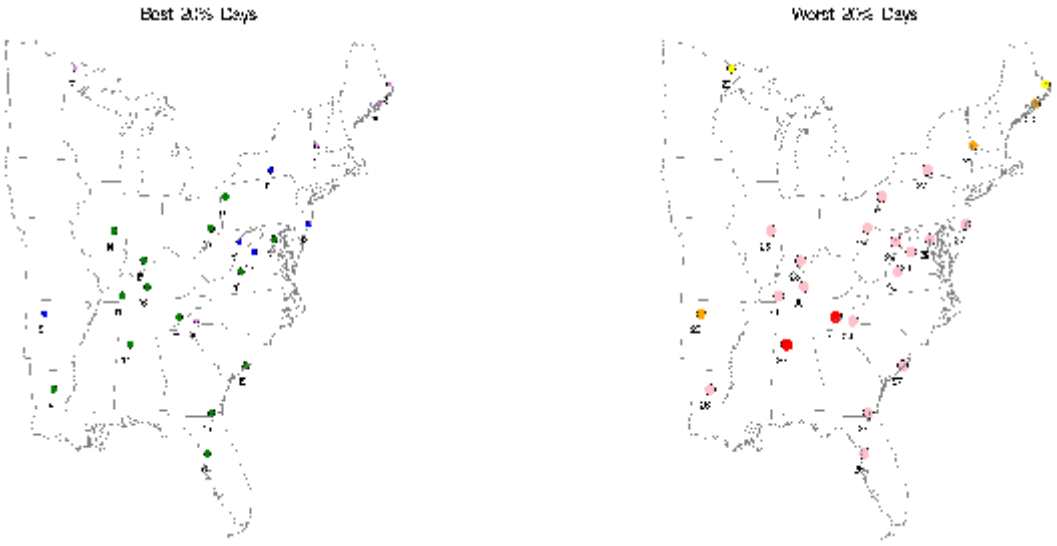


Figure 6. Visibility levels (deciviews) in eastern half of U.S. (1997 - 1999)

The spatial distribution of chemical composition for the 20% best and 20% worst days are shown in Figure 7. The dominant species across the eastern half of the U.S. is clearly sulfate (yellow), contributing about 2/3 to more than 3/4 to light extinction. Other species of note at these rural sites are organics (green) and nitrates (red), especially in the upper Midwest.

Figure 7. Chemical composition in eastern half of U.S. (1997 - 1999)

(3) Visibility levels and chemical composition vary seasonally

The 20% worst days occur throughout the year in the upper Midwest (as represented by data from the Boundary Waters Canoe Area), whereas they occur mostly in the summer in the eastern U.S. (as represented by Shenandoah National Park) - see Figure 7 below. There are also differences in the chemical composition, with sulfates (yellow), nitrates (red), and organics (green) being important in the upper Midwest, while sulfates (yellow) are the major contributor to visibility impairment in the eastern U.S.

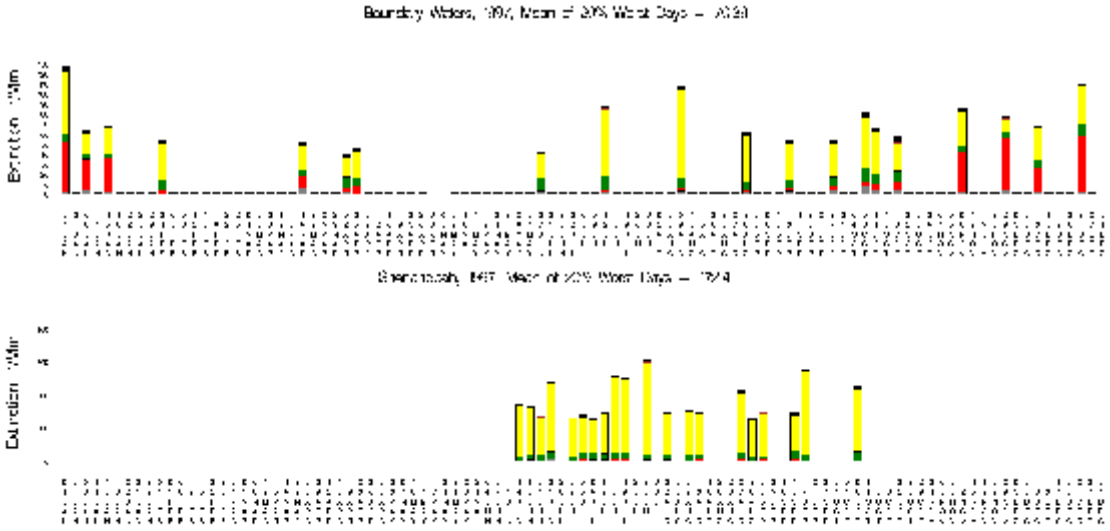


Figure 7. Distribution of 20% worst days in Boundary Waters Canoe Area (top) and Shenandoah National Park (bottom) during 1997

The 20% best days also occur throughout the year in the upper Midwest, whereas they occur mostly in the winter in the eastern U.S. - see Figure 8 below.

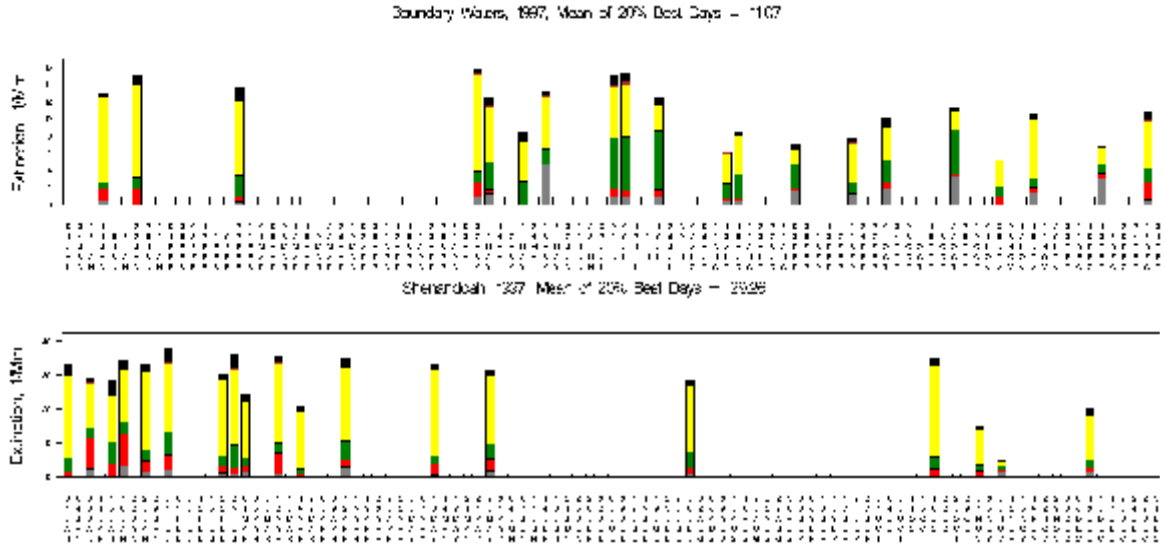


Figure 8. Distribution of 20% best days in Boundary Waters Canoe Area (top) and Shenandoah National Park (bottom) during 1997

(4) Transport patterns differ on worst and best visibility days

The worst visibility days (red) in the upper Midwest and eastern U.S. generally reflect southerly-westerly flow, and the best visibility days (blue) northerly flow, especially for the more northern Class I areas (Boundary Waters Canoe Area and Acadia National Park), as seen in Figure 9 below.

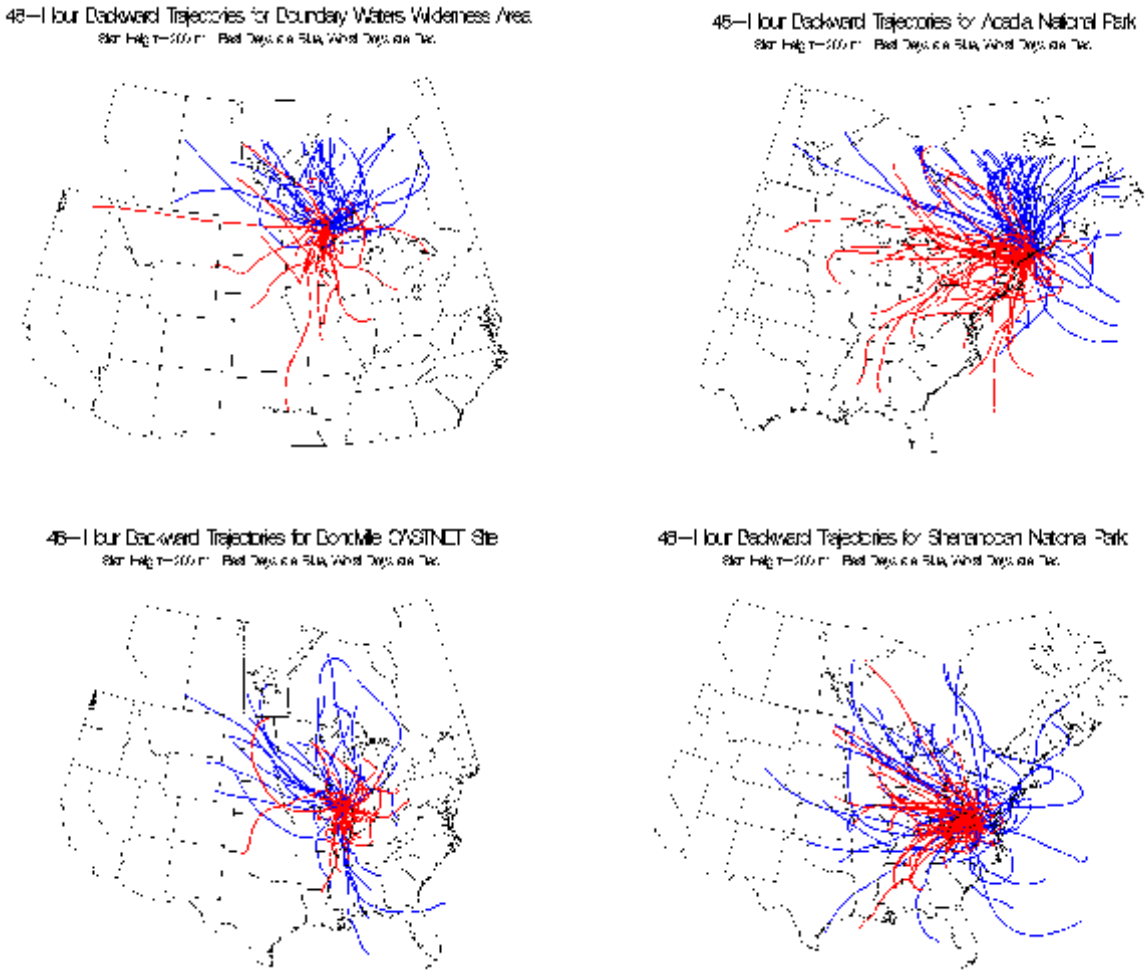


Figure 9. Back Trajectories for 20% best (blue) and 20% worst (red) days in Boundary Waters Canoe Area (top left), Acadia National Park (top right), Bondville, IL (bottom left), and Shenandoah National Park (bottom right), 1997-1999

(5) Poor visibility conditions are related to high fine particle and ozone concentrations

Periods of poor visibility generally occur in conjunction with elevated levels of other regional pollution, such as fine particles (throughout the year) and ozone (primarily only during the summer) - see Figure 10 below. Existing scientific evidence shows that regional haze, fine particles, and ozone have common precursor pollutants, emission sources, atmospheric processes, spatial scales of transport, and geographic areas of concern. It is, therefore, desirable to integrate visibility control strategies with those for fine particles and ozone.

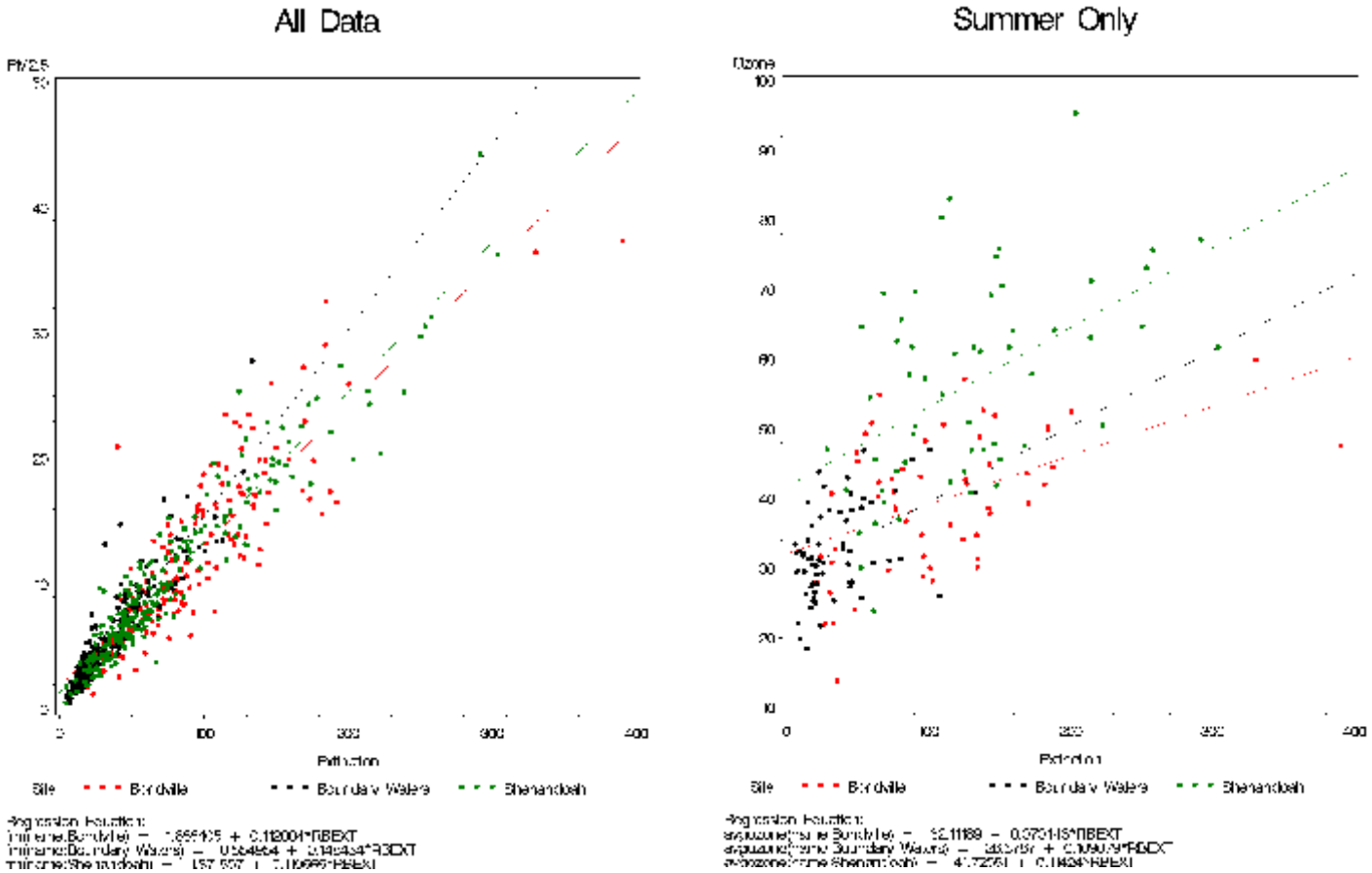


Figure 10. Correlation between fine particle concentrations and visibility (left) and ozone (summer only) and visibility (right)

(6) Visibility levels have changed over time

Trends in visibility indicate deteriorating conditions over the last half century, with some improvement in recent years. Airport records show that visibility has declined significantly since about 1950 (see Figure 11).

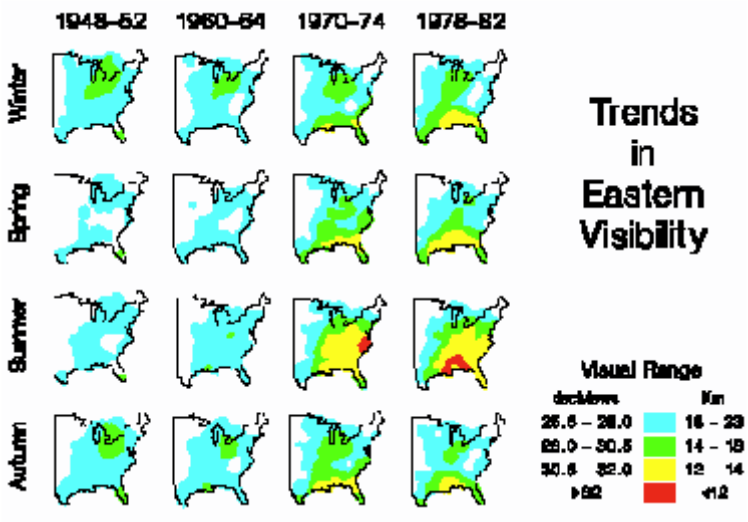


Figure 11. Trends in median visual range in the eastern half of the U.S.

Air quality data from IMPROVE monitors in select Class I areas (see Figure 12) show both that the worst days in the western U.S. are only slightly more impaired than the best days in the eastern U.S., and that in the eastern U.S., the worst days have improved by about 1.5 deciviews since 1992. This improvement corresponds to the reduction in SO_2 emissions which has occurred during the 1990's in the eastern half of the U.S.

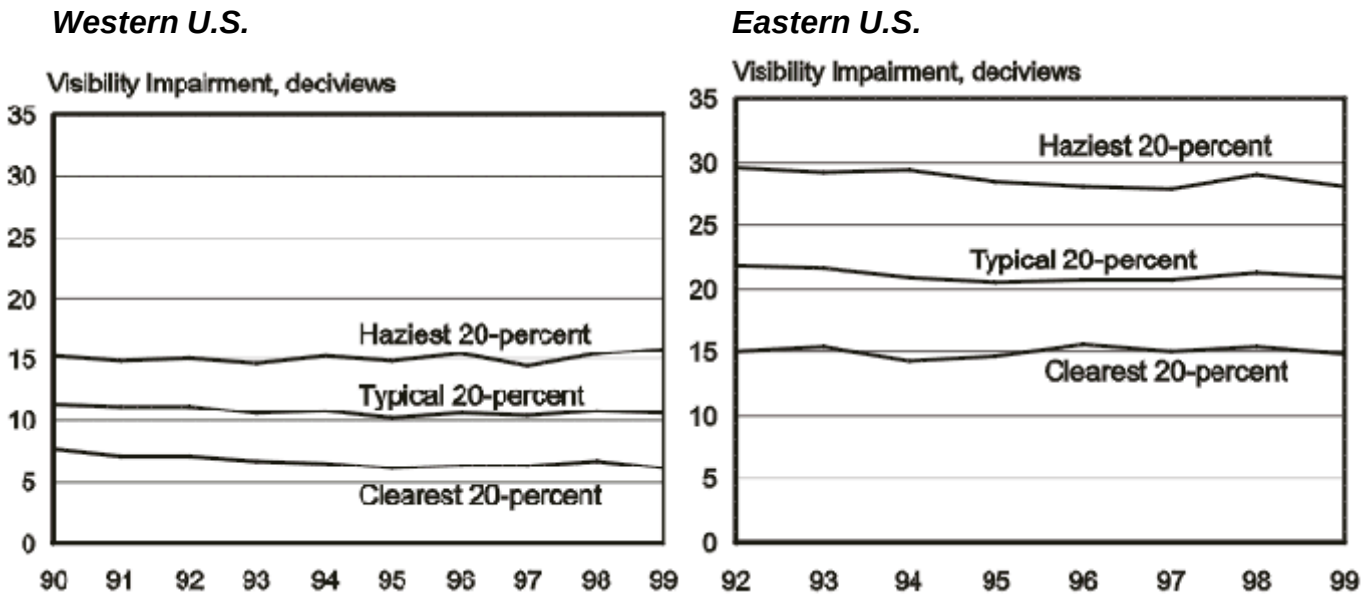


Figure 12. Trends in visibility for the 20% worst, 20% median, and 20% best days in the western U.S. (left) and eastern U.S. (right)

SUMMARY

An initial assessment of the regional haze problem in the upper Midwest (i.e., the five-state region covered by the Midwest RPO) was performed by reviewing existing reports and analyzing available air quality data. The key findings of this initial assessment are as follows:

- Visibility impairment exists in the two Class I areas in the upper Midwest, in downwind Class I areas in the eastern half of the U.S., and in other areas (e.g., major urban areas in the upper Midwest). Although current conditions in the upper Midwest Class I areas approach "natural conditions" on the 20% best visibility days, they are significantly worse on the 20% worst visibility days (see Figure 13). Fine particles, which play a major role in visibility impairment, reach unhealthy levels across a large portion of the eastern U.S..

- Visibility levels and $PM_{2.5}$ concentrations vary...
  - spatially: best visibility, lower $PM_{2.5}$ occur to north (near Class I areas in the upper Midwest)

    worst visibility, higher $PM_{2.5}$ occur to south (near Ohio River Valley)
  - seasonally: worst and best visibility occur throughout the year in Class I areas in the upper Midwest

    worst visibility occurs during summer, best visibility during winter elsewhere in eastern U.S.
  - chemically: sulfates dominate on worst visibility days during summer (organics distant second)

    nitrates important on worst visibility days during winter/fall (sulfates also important, organics distant third)

  (Note: these points suggest that the air quality situation in the Class I areas in the upper Midwest differs from that in other Class I areas in the eastern U.S.)

- Worst visibility days are associated with southerly-westerly flow for many sites in the eastern U.S., best visibility days with northerly flow

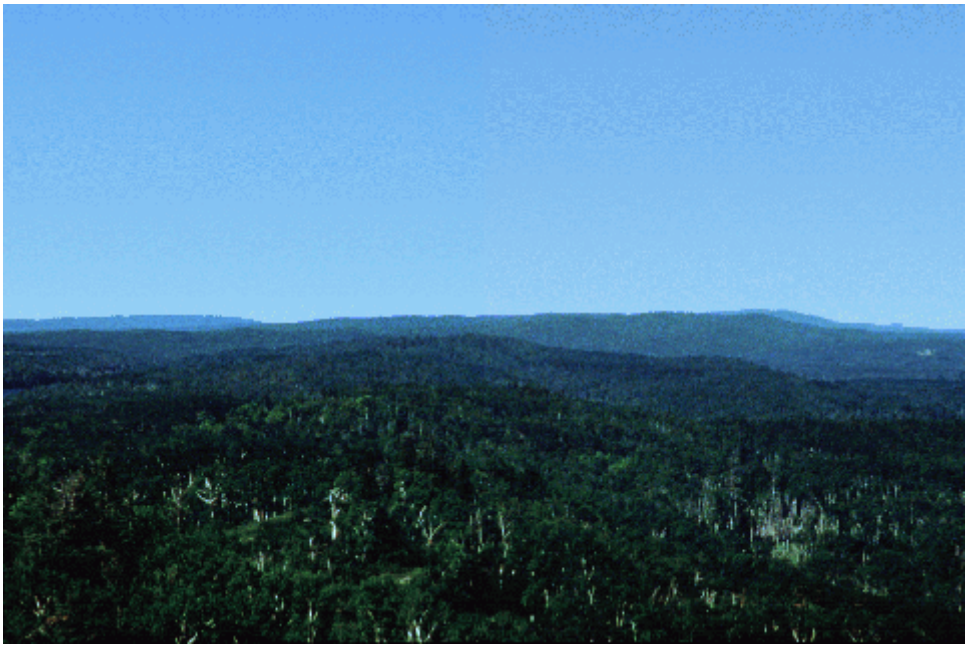
- Poor visibility is related to elevated concentrations of fine particles and (during the summer) ozone

- Visibility levels deteriorated during the last half century, but appear to be improving in recent years due to SO_2 emission reductions

20% Best Days

Natural Conditions
(deciviews = 3.7)

Current Conditions
(deciviews = 7.0)



20% Worst Days

Natural Conditions
(deciviews = 11.3)

Current Conditions
(deciviews = 20.0)

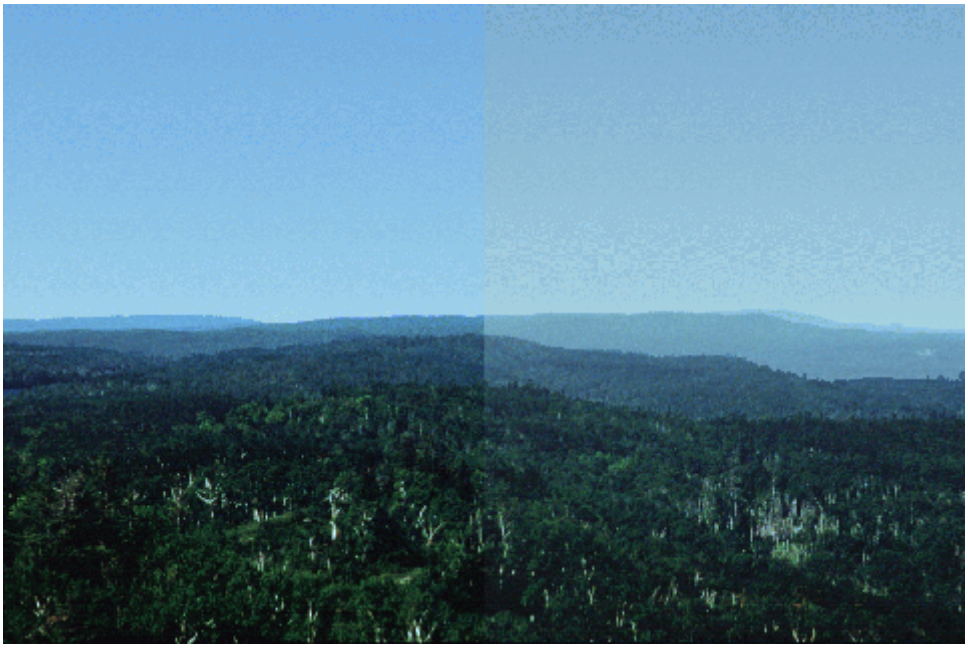


Figure 13. Natural conditions v. "current" conditions on 20% best (top) and 20% worst (bottom) days – Isle Royale National Park, Michigan