

What You See Is Sometimes What You Miss

By Keith A. Yarborough

Visitors to the national parks want air they can see through, not air they can see! They want to view the grand vistas without a curtain of unnatural haze obscuring their grandeur. This desire underlines one of the main goals of the National Park Service Air Quality Program — to secure undegraded natural visibility and to preserve it in the future.

Since the 1950's public concern has grown as the scenic beauty of many parks was dimmed by air pollution. Often this pollution is emitted at great distances — even hundreds of miles away from the parks. In the 1960's and 1970's the Grand Canyon sometimes was filled with haze and smoke, Yosemite Valley was subjected to smog, Arches was periodically engulfed in smoke, and Capitol Reef almost had a huge coal-fired power plant as its neighbor. Simultaneously, in the east, Great Smoky Mountains became more hazy, but not from the natural haze that gave the park its name. The same was occurring at Shenandoah, Acadia, and others.

In August 1977 the Congress responded by adopting the nation's first visibility protection requirements for national parks and national wilderness areas. In these amendments to the Clean Air Act, the Congress explicitly recognized clean air as a nationally important natural resource which is to be protected. This recognition extends the mandate of the 1916 Organic Act "to conserve the scenery and the natural and historic objects and the wildlife" in the national parks. Visitor enjoyment and health, the preservation of certain fragile cultural resources, and sustaining the integrity of natural resource systems are all dependent on good air quality in the parks.

Inherent in the preservation of the parks' grandeur is the protection of their scenery and inspiring vistas. This protection requires clean air and good visibility . . . the "seeing" of distant objects. Historically, Americans have placed high value on good visibility in the national parks. Judging visibility is a qualitative process — perceiving the characteristics of objects in a vista, their distance from the viewer, the quality of the atmosphere, and the illumination along the sight path. It also involves the nature of the human eye, and the brain's interpretation of the image at the eye.

Beginning in late 1977, the National Park Service developed a comprehensive Air Quality Program. This effort has included both the physical, quantitative measurement of visibility parameters in a

number of parks throughout the system, and the qualitative assessment of its perception by visitors. The Southwest Region has been actively engaged in quantitative work since its inception. Because we needed a means to measure visibility so as to capture details of form, line, size, texture, and color differences when viewing distant objects, a dual purpose research and monitoring program was established.

1. Visibility measurements are made at 9 stations (Bandelier, Big Bend, Capulin Mountain, Carlsbad Caverns, Guadalupe Mountains, Chaco Culture, Navajo, White Sands, and Wupatki), as part of the Servicewide project VIEW (Visibility Investigative Experiment in the West) network of 28 stations. The network concept provides a cost-effective coverage, allowing the results from a few carefully selected sites to be applied to many parks within the network's extent. Each station is important because it supports the greater whole. Furthermore, the network supplies data for a large area, a vital function in view of the fluidity of atmosphere and the ease with which air masses move quickly over vast distances.

The multispectral contrast teleradiometer ("tele" or MCT for short), developed by Drs. Bill (Big Daddy) Malm and Ken O'Dell, was chosen for this work. The instrument measures the brightness (radiance) of a dark-colored target along a sight path, using four different visible light wave lengths (violet, blue, green, and red). It also gives a comparison ratio between the brightness of the target and the brightness of the sky behind the target. Four to six targets are sighted around each park's station. Readings are taken at 9 a.m., noon, and 3 p.m. daily throughout the year.

From this brightness ratio, the visual range (Vr), for each target can be calculated. Vr is a measure of the degree of visibility degradation caused by the "gunk" in the air between the target and

the observer . . . material that scatters and attenuates light along the sight path. Thus, Vr represents the distance at which an object is just barely visible under any set of viewing conditions. The greater the Vr value, the better the visibility is. The measure tells the condition of the air at any time, and permits comparisons to be made among various observation stations in the network.

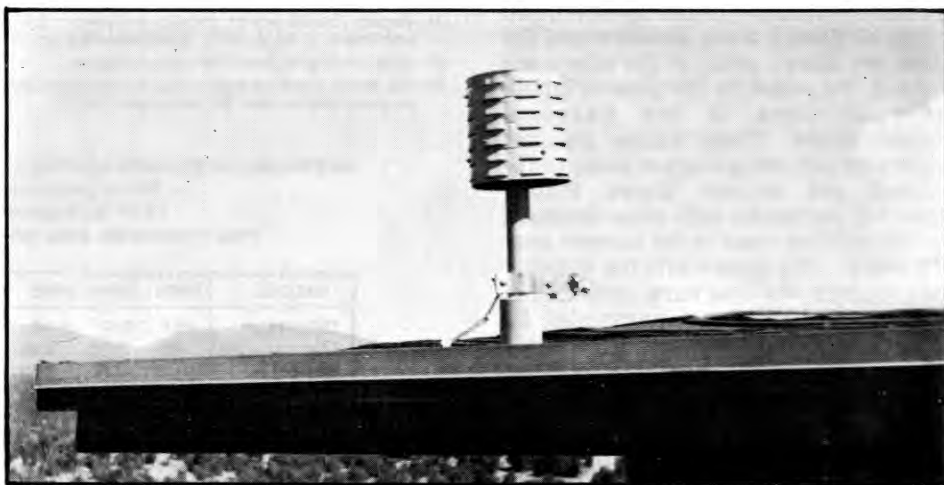
However, Vr should not be taken literally. The targets used in the west can only be seen at a maximum distance of about 200 kilometers (km) because of the earth's curvature. Yet the theoretical upper limit for the cleanest air is 391 km and the visual ranges reported from many Project VIEW stations often exceed 200 km.

2. Total and fine particulate measurements, with chemical analyses, are made in order to determine the nature of the material degrading the visibility at any given time. This material can be of natural origin: blowing dust or water vapor; it can also be produced by emissions from human sources: smelters, steel mills, coal-fired power plants, autos and residential heating in urban areas, etc. Analysis can establish the difference.

The particulate measurements are made at:

A) Nine total suspended particulate (TSP) stations (Aztec Ruins, Bandelier, Big Bend, Capulin Mountain, Guadalupe Mountains, Chaco Culture, Navajo, White Sands, and Wupatki) under a continuing contract with Dr. Jarvis Moyers of The Analytical Center at the University of Arizona in Tucson.

B) Five fine particulate stations (Chaco Culture, Fort Union, Gila Cliffs, Grand Quivira, and Carlsbad Caverns) as part of EPA's Western Fine Particulate network of 40 stations; with analyses done by the Air Quality Physics Group of the University of California at Davis.



Stacked Filter Unit for measuring coarse and fine particulate concentrations at Bandelier National Monument.

Fine particulates (size range from 0.1 to 2.5 microns) are especially important for determining the visibility at a station. These scatter the greatest proportion of light and degrade visibility the most. This effect is especially noticeable in very clean air such as still exists in the Southwestern U.S. For example, if the V_r is 120 miles and a tiny amount of sulfate aerosol is added, the V_r can be reduced to 80 miles. However, for dirty air, the effect is much less noticeable. If the V_r initially is 15 miles, a tiny incremental addition of sulfate aerosol will decrease the visibility to 14.1 miles.

The data from the VIEW network are reported seasonally. Table 1 summarizes the geometric mean values of visual range at the Southwest Region stations. In general, visibility is better in the winter and spring and more degraded in the summer and fall. However, these western visual ranges are very much better than those found in the eastern United States. The best visibility throughout the entire VIEW network has been found consistently at Chaco Culture in northwestern New Mexico. Its overall arithmetic mean V_r for all seasons is 203.5 km with Navajo in northeastern Arizona as a close second. The Four Corners area of Colorado, Utah, Arizona and New Mexico has the best visibility remaining in the contiguous 48 states. No long-term trends are noticeable as yet.

Particulate data are summarized in table 2. These show the TSP and fine mass loadings and selected species. They characterize both natural (Al and Ca from soils/dust) and human-caused emission sources (Carbon, SO_4 , and NO_3 , and Pb). Aztec Ruins is located close to the 2250 megawatt Four Corners Power Plant. Hence, its high TSP, carbon and lead concentration levels. Capulin Mountain, Chaco Culture, and Navajo show cleaner air, while Bandelier and Big Bend are less clean. The Amended Clean Air Act permits incremental increases in the annual TSP geometric mean above the area's baseline of 5 micrograms/cubic meter for Class I air quality areas and 19 micrograms/cubic meter for Class II areas. Bandelier and Big Bend are Class I while all the others are Class II. The values for TSP given in Table 2 give an idea of the baseline concentrations. These values are low compared with those in urban areas and in central and eastern United States. Seasonal particulate data show increases in TSP and fine mass in the summer over the winter. This agrees with the visibility (V_r) findings. Regional haze, generated in southern California and transported by cyclonic air masses, causes considerable visibility degradation in west Texas and in the Four Corners Area. Local smelter and power plant emissions add to this impact.

Support for this work has been supplied by the WASO Air Quality Division since 1978. Especially effective have been the efforts of the team of technical experts of that Division located in Denver (AIR).

Most important, is the work of field managers and personnel at each of the park stations. They continue to make the daily measurements in all kinds of weather, while performing their many other duties in the parks. They grapple with the vagaries of equipment, operating instructions, budget shortages, Regional

and WASO people — with perseverance and good humor. They are the *sine qua non* — the real NPS Air Quality Program.

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Telephotometer, affectionately referred to at Bandelier NM as "our artillery for fighting air pollution," is read by Christi Daugherty, Student Conservation Association worker at the Monument.

TABLE 1
SEASONAL VISUAL RANGE (V_r) for SWR STATIONS
— (Geometric Means) km.

SEASON	STATION								
	BAND	BIBE	CAMO	CACA	CHCU	GUMO	NAVA	WWSA	WUPA
Summer 1978	172	148	NI	157	187	NI	192	118	166
Fall 1978	155	130	NI	179	203	NI	191	125	122
Winter 78/79	226	212	NI	245	No Data	NI	No Data	190	188
Spring 1979	284	163	NI	151	188	NI	160	143	201
Summer 1979	148	154	NI	139	198	NI	164	114	159
Fall 1979	149	146	NI	142	198	NI	175	115	162
Winter 79/80	186	174	NI	206	298	NI	264	159	215
Spring 1980	174	168	137	197	176	NI	145	132	141
Summer 1980	164	138	139	3)	180	NI	168	119	158
Fall 1980	176	146	207	3)	213	NI	230	139	180
Winter 80/81	221	208	273	3)	257	NI	256	177	166
Spring 1981	187	183	180	3)	177	NI	192	141	170
Summer 1981	147	139	160	3)	163	NI	152	112	141
Fall 1981	176	143	201	3)	208	NI	218	133	176
Arithmetic Mean	183.2	160.9	185.3	177.0	203.5	—	192.8	136.9	167.5

REMARKS:

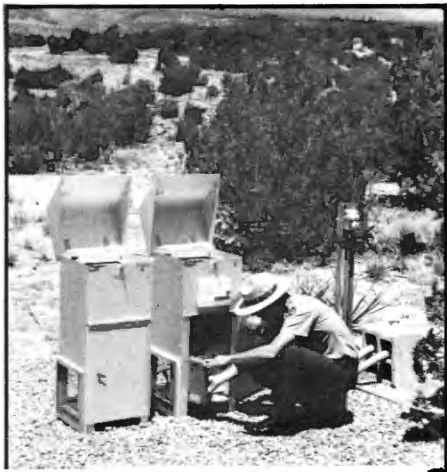
- 1) NI = No Instrument
- 2) Automatic Teleradiometer installed at GUMO in February 1982
- 3) Manual Teleradiometer initially installed at CACA changed to Automatic instrument in April 1980. Automatic Data still to be analyzed
- 4) Snow on targets precludes data collection
- 5) The White Sands station measures more the impact of nearby Alamogordo, NM — an urban area — than the areawide visibility.

6) Legend

AZRU = Aztec Ruins
BAND = Bandelier National Monument
BIBE = Big Bend National Monument
CAMO = Capulin National Monument
CACA = Coronado National Monument
CHCU = Chaco Culture National Historical Park
NAVA = Navajo National Monument
WWSA = White Sands National Monument
WUPA = Wupatki National Monument

TABLE 2
AVERAGE CONCENTRATIONS OF PARTICULATE SPECIES at SWR STATIONS
— Micro gms/cubic meter of air (geometric means)
(TSP data taken from May 1980 to May 1981)
Fine Particulate data taken from August 1979 to October, 1980)

SPECIES	STATION									
	AZRU	BAND	BIBE	CAMO	CHCU	NAVA	FOUN	BICL	GRQU	CACA
TSP/Mass	43.7	31.7	34.8	26.2	25.5	25.1	—	—	—	—
Carbon	4.6	3.78	3.93	3.3	2.12	2.77	—	—	—	—
SO_4	1.37	2.2	3.63	1.43	1.35	1.41	—	—	—	—
NO_3	0.53	0.47	0.72	0.60	0.32	0.31	—	—	—	—
Al ⁺⁺⁺	1.92	0.77	1.09	0.75	0.83	0.93	—	—	—	—
Ca ⁺⁺	0.72	0.41	1.35	0.46	0.34	0.62	—	—	—	—
Pb	0.45	0.12	0.09	0.06	0.08	0.08	—	—	—	—
Fine Part Mass	—	—	—	—	4.50	—	3.90	4.22	4.42	5.67
S/SO_4	—	—	—	—	0.39	—	0.32	0.45	0.39	0.48
Soils	—	—	—	—	1.26	—	0.95	0.87	0.92	1.46



John Lissoway, Chief of Resources Management at Bandelier, adjusts particulate monitoring equipment that measures both coarse and fine particulates. (Fine particulates degrade visibility most because of their light-scattering action.) (Story on page four).