INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

3rd Quarter 2005 | The IMPROVE Newsletter | Volume 14 / Number 3

Monitoring update

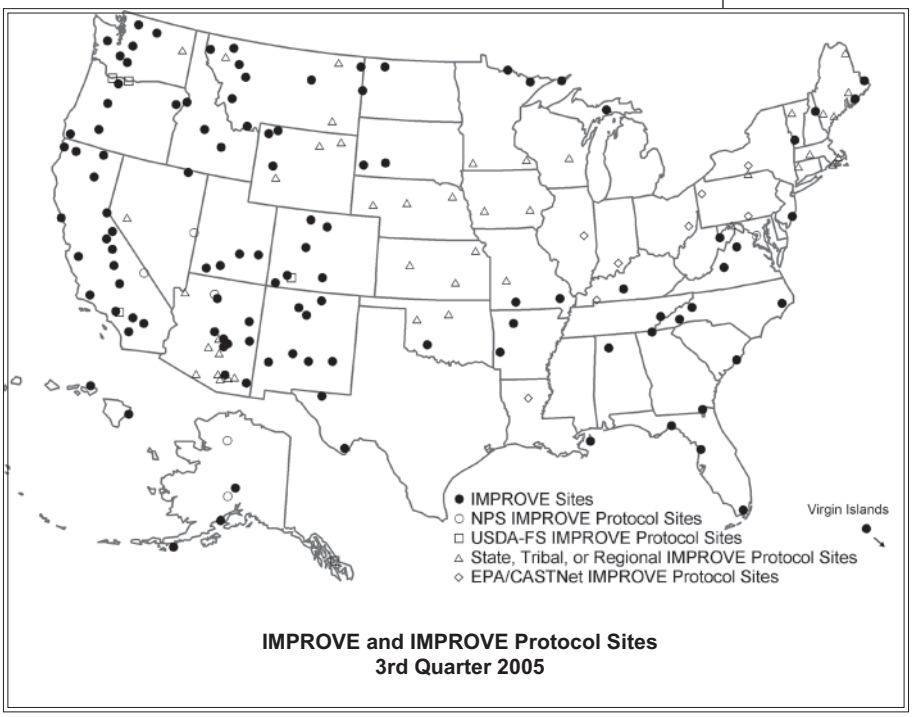
Feature Article: CENRAP studies carbon in region's Class I areas, Page 4

Network operation status

The IMPROVE (**I**nteragency **M**onitoring of **Pro**tected **V**isual **E**nvironments) Program consists of 110 aerosol visibility monitoring sites selected to provide regionally representative coverage and data for 156 Class I federally protected areas. Additional instrumentation that operates according to IMPROVE protocols in support of the program includes:

- 65 aerosol samplers
- 15 transmissometers
- 42 nephelometers
- 10 film or digital camera systems
- 53 Web camera systems
- 3 interpretive displays

IMPROVE Program participants are listed on page 8. Federal land managing agencies, states, tribes, regional air partnerships, and other agencies operate supporting instrumentation at monitoring sites as presented in the map below. Preliminary data collection statistics for the 3rd Quarter 2005 (July, August, and September) are:



IMPROVE and IMPROVE Protocol Sites
3rd Quarter 2005

- Aerosol (channel A only) 95% collection
- Aerosol (all modules) 93% completeness
- Optical (transmissometer) 95% collection
- Optical (nephelometer) 96% collection
- Scene (photographic) (does not include Web cameras) 93% collection

The IMPROVE site at Breton, LA, was destroyed during Hurricane Katrina. Both the sampler and its stand were demolished by the storm. The site was in the Mississippi Delta downstream from New Orleans, just a few miles before the river empties into the Gulf of Mexico. Due to the severe damage throughout the Gulf Coast region, the Breton site is out of service indefinitely. It is hoped that the site can be reestablished sometime in early 2006, perhaps at a different location in southern Louisiana.

IMPROVE samplers have operated at several urban sites for about the past year to compare against samplers operated in the EPA Speciation Trends Network (STN). Now that a full year of data have been obtained, this sampling effort is being scaled back. The IMPROVE samplers were removed from the STN sites in Chicago, Houston, and Rubidoux (CA). The IMPROVE samplers in Atlanta, Detroit, and Pittsburgh will remain in place but will operate only one module, the quartz filter module that is used to determine organic and elemental carbon. Full IMPROVE samplers will remain at the STN urban sites in Birmingham, Fresno, New York, Phoenix, and Seattle.

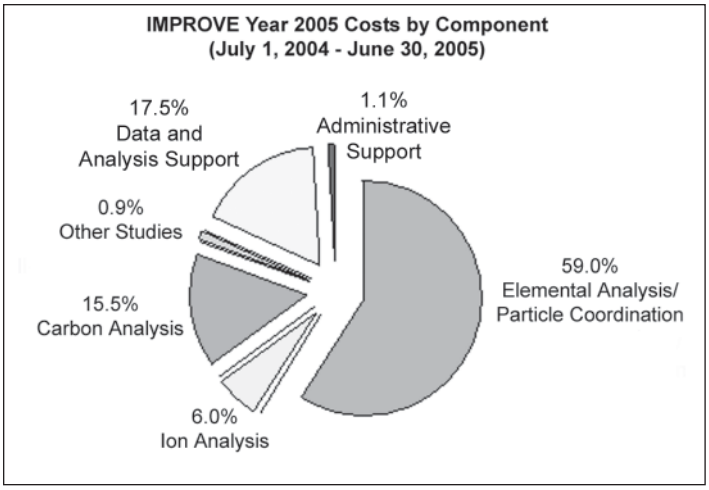
The remote digital camera system at Red Rock Lakes NWR, MT, shut down August 1 per direction of the U.S. Fish and Wildlife Service. It operated since July 2002. Omaha, NE, received a nephelometer and Mount Zirkel W, CO, received a Web camera system, which replaced a digital camera system.

Monitoring update continued on page 6....

Visibility news

IMPROVE 2005 aerosol monitoring budget

The IMPROVE aerosol monitoring program (179 full-year monitoring sites), is funded primarily by the Environmental Protection Agency (EPA). Federal Land Managers (FLMs), however, sponsor eight (8) protocol sites, for $260,000. In addition, the FLMs spend approximately $800,000 annually on site operator costs for 115 sites. The IMPROVE Year 2005 budget was about $6,280,000 (excluding site operator costs), broken down into the categories and percentages as shown below.



The IMPROVE Year 2006 budget (July 1, 2005 - June 30, 2006) is projected to be similar to Year 2005. Two contracts will be up for competitive bid and are expected to be awarded during the first quarter. The estimated cost to operate and maintain an IMPROVE aerosol monitoring site for one year is $32,000 (excluding site operator salary and procurement of new or replacement equipment). Site operator salaries, optical and scene monitoring equipment, and Web cameras are funded separately from the IMPROVE aerosol monitoring program.

For more information contact David Maxwell at the National Park Service Air Resources Division. Telephone: 303/969-2810. Fax: 303/969-2822. E-mail: david_maxwell@nps.gov.

New newsletter format available

We are in the process of making the IMPROVE Newsletter available in electronic format (.PDF) via e-mail distribution. With approximately 500 individuals on the distribution list, we are planning to ensure our e-mail system will work in this capacity.

If you wish future newsletters to be delivered to you via e-mail, please send your request to IMPROVEnews@air-resource.com. Otherwise, you will continue to receive the newsletter via U.S. Mail. We expect to have this system in place by the February 2006 issue.

For more information contact Gloria Mercer at Air Resource Specialists, Inc. Telephone: 970/484-7941. Fax: 970/484-3423. E-mail: gmercer@air-resource.com.

Substitution techniques for missing data

The Regional Haze Rule (RHR) calls for state and federal agencies to work together to improve visibility in 156 national parks and wilderness areas. This rule requires states to develop and implement air quality protection plans to reduce pollution that causes visibility impairment. The starting point, or baseline period, for the RHR assessment is the five-year period of 2000 through 2004. All collection of information used to develop state plans, for some states, must be completed in 2006, so states are now actively analyzing data from the baseline period.

One of the challenges facing state analysts is to develop approaches to compensate for missing data. EPA guidance indicates that the five-year baseline period haze conditions for each visibility protected area should be determined from at least three calendar years of complete IMPROVE third-day particle speciation data. Speciation data needed to estimate haze using the IMPROVE algorithm includes six major components: sulfate, nitrate, organic carbon, light absorbing carbon, fine soil, and coarse mass. If any of these are missing for a sample period, the sample is not complete. The guidance goes on to suggest that a complete year should have at least 75% of the samples complete annually, 50% complete for each calendar quarter, and not have more than 10 consecutive samples incomplete.

The state of Missouri recently encountered such a challenge when analyzing data from the IMPROVE site at Mingo Wilderness, Missouri. Carbon data at this site were compromised for the final 2½ years of the baseline period, beginning in mid-2002. This site was installed in mid-2000, so only one year of valid data remained, 2001.

The carbon data were compromised due to blockage of the sampler inlet by mud from insects. Reduced carbon concentrations had been noticed by the IMPROVE staff, but the reason was not determined until early 2005, when the blocked inlet was discovered. But only one inlet was blocked, on the sampler module that measures carbon. The other three modules were normal, so data are available for elements, ions, and $PM_{2.5}$ and PM_{10} mass.

Monitoring Site Assistance:
Aerosol sites: contact University of California-Davis
telephone: 530/752-7119 (Pacific time)

Optical/Scene sites: contact Air Resource Specialists, Inc.
telephone: 970/484-7941 (Mountain time)

Scientists from the state of Missouri and from UC-Davis collaborated to devise a substitute for the lost carbon data at Mingo. The substitution is based on hydrogen, which is determined from the $PM_{2.5}$ Teflon filter and is independent of the quartz filter normally used for carbon determination. The hydrogen in an aerosol sample is associated with several types of species, including organic carbon, ammonium sulfate, ammonium nitrate, and water. But the hydrogen measurement is performed in a vacuum, so the ammonium nitrate and water are lost to evaporation. Thus, subtracting the hydrogen associated with ammonium sulfate from the total hydrogen yields the residual hydrogen associated with organic carbon. This approach assumes that the sulfur is fully neutralized and exists as ammonium sulfate. The 1:4 mass ratio of hydrogen to sulfur in ammonium sulfate is used to calculate the hydrogen mass associated with ammonium sulfate from the sulfur measurement.

Data from 2001, when all sampler modules were operating properly, were used to establish the typical ratio of residual hydrogen to organic carbon at Mingo, so that the substitution would be specific to that site. As a trial measure, hydrogen-substituted organic carbon data were then generated for 2001; they were found to match the measured carbon data quite well, even predicting isolated peaks in the concentration. Finally, hydrogen-derived data were substituted for organic carbon beginning in August 2002, when the inlet blockage began. Measured and substituted organic carbon data are shown in Figure 1 below.

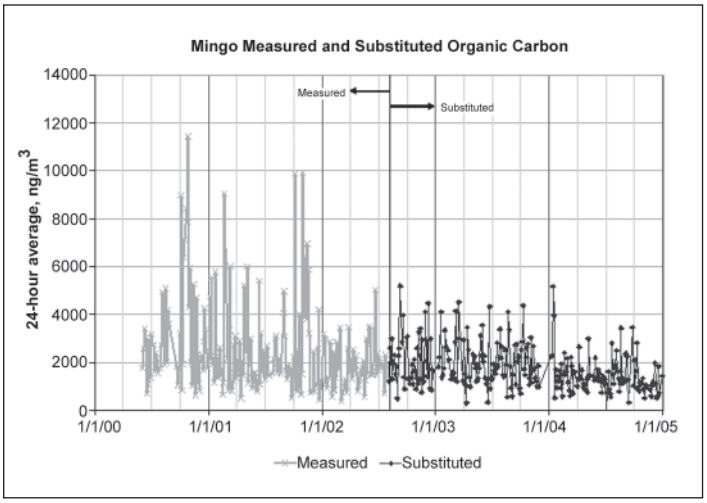


Figure 1. Measured and substituted organic carbon data from the Mingo Wilderness monitoring site during 2000-2005.

The hydrogen data were also used to predict elemental carbon concentrations. Again using the data from 2001, the typical ratio of elemental to organic carbon concentration was established at Mingo. This ratio was applied to the simulated organic carbon data to develop a set of simulated elemental carbon data.

A few other IMPROVE sites suffer from lost data, and a variety of approaches are under consideration to fill the gaps. At some sites, like Mingo, data from other sampler modules can be used to develop substituted data. At other sites, data from all sampler modules have been lost for extended periods, so adjacent data are not available. At these sites, data from adjacent sites, some even from other networks, are being considered as substitutes. Other approaches for dealing with lost data include reconstructing a year with data from the same seasons in other years, and demonstrating the representativeness of less than three complete years of data. The solutions will be site-specific, as the conditions and challenges are unique to each site.

For more information contact Chuck McDade at the University of California-Davis. Telephone: 530/752-7119. Fax: 530/752-4107. E-mail: mcdade@crocker.ucdavis.edu.

New aerosol inlets to resolve problems

The IMPROVE aerosol sampler inlets at several sites have been found to be blocked by mud and webs deposited by insects and spiders. At three of these sites, all in the southeastern United States, the blockage was sufficient to reduce the sampled particulate matter by a significant amount. Although the blockage was enough to reduce the measured concentrations, it did not alter the flowrates. Thus, the problem was not apparent from routine flowrate checks and could be discerned only by removing and examining the inlets.

Tests of blocked inlets at UC-Davis have demonstrated that an inlet must be almost completely blocked before concentrations are affected. Inlets that were less than 98% blocked (as determined by visual inspection) did not exhibit reduced ambient particulate concentrations.

To reduce the occurrence of blocked inlets, site operators have been asked to inspect the inlets during their weekly site visits and to notify UC-Davis if they observe significant mud deposits or spider webs. Inlets that are beginning to show signs of blockage will be cleaned. Also, all of the inlets in the network are being retrofitted with a new design which is easier to disassemble for cleaning and, by its design, is less likely to become clogged. This new inlet design has been incorporated in all samplers manufactured since 2002, and will now become the standard for the network.

For more information contact Chuck McDade at the University of California-Davis. Telephone: 530/752-7119. Fax: 530/752-4107. E-mail: mcdade@crocker.ucdavis.edu.

Feature article

CENRAP studies carbon in region's Class I areas

(by M. Pettyjohn, Arkansas Department of Environmental Quality)

Defining carbon

Carbonaceous 2.5 micrometer atmospheric particulate matter ($PM_{2.5}$) are comprised of thousands of compounds in which carbon is the principal element. These usually consist of elemental carbon (EC) and organic carbon (OC). Elemental carbon, also known as black carbon (soot) or light absorbing carbon (LAC), is a by-product of the incomplete combustion of carbonaceous fuels and is directly emitted into the atmosphere; therefore, with the exception of biomass burning, the sources of this pollutant are anthropogenic. Organic carbon is a light scattering pollutant which can be emitted directly into the atmosphere or formed in the atmosphere from volatile and semi-volatile organic compounds, known as secondary organic aerosols (SOA). SOA can result from anthropogenic and biogenic sources. The majority of the carbonaceous $PM_{2.5}$ is organic carbon.

Carbon analysis

To determine if organic carbon plays a large role in the light extinction budget for the 20% worst days at the 10 Class I Areas in the CENRAP region, an analysis of the IMPROVE data from the following 10 areas was performed:

- Caney Creek Wilderness, AR (CACR)
- Upper Buffalo Wilderness, AR (UPBU)
- Breton National Wildlife Refuge, LA (BRET)
- Boundary Waters Canoe Area Wilderness, MN (BOWA)
- Voyageurs National Park, MN (VOYA)
- Hercules-Glades Wilderness, MO (HEGL)
- Mingo National Wildlife Refuge, MO (MING)
- Wichita Mountains Wildlife Refuge, OK (WIMO)
- Big Bend National Park, TX (BIBE)
- Guadalupe Mountains National Park, TX (GUMO)

The analysis was performed on IMPROVE data collected during the years 2002 and 2003. As Figure 1 indicates, the contribution of organic carbon to light extinction (b_{ext}) in CENRAP Class I areas plays a major role in the 20% worst days. The contribution ranges from 3.0 Mm^{-1} at Mingo to 27.9 Mm^{-1} at Upper Buffalo. The average and median contribution of organic carbon is 12.2 Mm^{-1} and 10.9 Mm^{-1} respectively.

There also appears to be a seasonal contribution of organic carbon to b_{ext}. As Figure 1 shows, the peak organic carbon contribution to light extinction occurs in the winter for Breton,

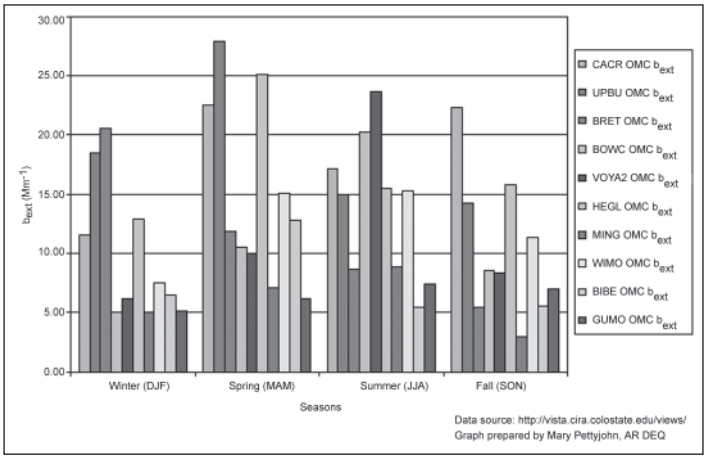


Figure 1. Contribution of organic carbon to the aerosol light extinction in CENRAP Class I areas for the 20% worst days (2002-2003).

while the peak contribution occurs in the spring for Upper Buffalo, Hercules-Glades, and Big Bend. Data from the two Minnesota Class I areas, Boundary Waters Canoe Area and Voyageurs, exhibit a peak organic carbon contribution during the summer. A similar pattern was observed at the Missouri site, Mingo, and one Texas site, Guadalupe Mountains; albeit the peaks for Mingo and Guadalupe Mountains are not huge jumps. Of the 10 Class I areas in CENRAP, Caney Creek and Wichita Mountains are the only two sites that exhibit peak organic carbon concentrations in the spring and fall.

While Figure 1 indicates that organic carbon has the greatest impact on light extinction at the Arkansas and Missouri sites, Figure 2 shows that organic carbon has a greater percent impact on the light extinction budget at the two Minnesota sites, Boundary Waters and Voyageurs, during the 20% worst days. The percent of organic carbon contributing to the 20% worst days in CENRAP range from as low as 2.1% at Mingo and as high as 39.4% at Voyageurs.

In 2001, William Malm, of the National Park Service, suggested that if the ratio of organic carbon to elemental carbon was in the range of 3 to 5, the source of organic carbon would be fossil fuel combustion; hence, the sources would be anthropogenic in nature such as coal-fired power plants and vehicle emissions. Malm also indicated that fire emissions would result in the aforementioned ratio of 7 or greater. He also suggests that a high ratio of organic carbon to elemental carbon may result from a mix of sources "from either inefficient combustion (vegetation fires) or secondary organic aerosols."

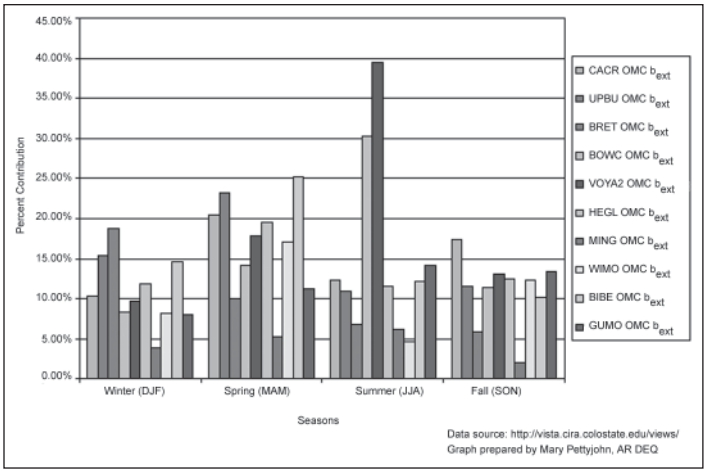


Figure 2. Percent contribution of organic carbon to the aerosol light extinction in CENRAP Class I areas for the 20% worst days (2002-2003).

As shown in Figure 3 and Table 1, 9 of the 10 Class I areas located in CENRAP have a ratio greater than 5. Therefore, the primary sources contributing to poor visibility at these sites can be assumed to be emissions from vegetation fires or secondary organic aerosols. The following CENRAP Class I areas have a ratio greater than seven (7): Upper Buffalo, Boundary Waters Canoe Area, Voyageurs, Hercules-Glades, Big Bend, and Guadalupe Mountains. Data from these areas may suggest fire emissions are the primary source of organic carbon. Breton is the only site within CENRAP that has ratios for each season below five (5), suggesting the primary source of organic carbon is due to fossil fuel combustion.

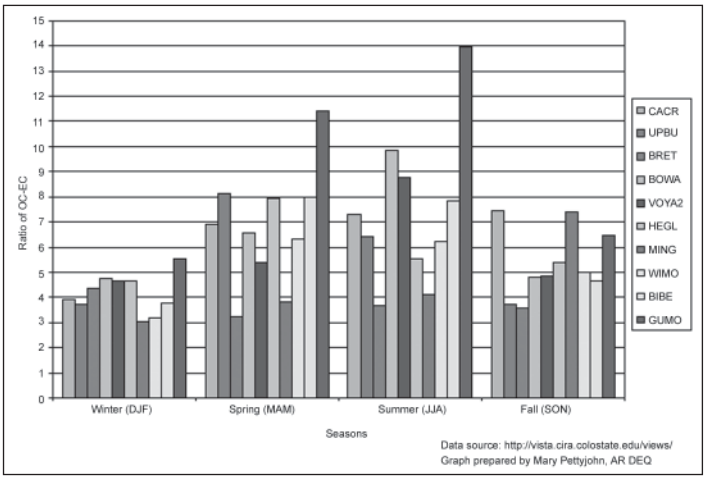


Figure 3. Ratio of organic carbon to elemental carbon for the 20% worst days (2002-2003) for CENRAP Class I areas.

Carbon studies

Although carbon is a large contributor to visibility impairment in CENRAP's Class I areas, very few carbon speciation studies have been performed in rural areas. Therefore, due to the lack of in-depth knowledge about the sources contributing to the rural carbon fraction of regional haze and the large contribution of carbon to the 20% worst days in CENRAP's Class I areas, CENRAP issued a work order to Air Resource Specialists, Inc. (ARS) to perform a Carbon Speciation Scoping Study to research the following:

1. Document the state of carbon speciation science in the U.S. and Europe;
2. Identify carbon and analysis techniques;
3. Recommend a field study design; and
4. Recommend a process for implementing a CENRAP carbon speciation study.

The scoping study revealed that as of this date, there have only been three completed rural carbon speciation studies performed that focused on Class I areas (Yosemite NP, CA; Big Bend NP, TX; and Seney W, MN). Carbon studies are currently underway at five areas (Acadia NP, ME; Mohawk Mountain SP, CT; Cape Romain W, SC; Mammoth Cave NP, KY; and Shenandoah NP, VA). The methods currently used for collection and analysis of carbon are: filter-based collection, thermal organic and elemental carbon analysis, gas chromatography mass spectrometry for analysis of species of organic carbon, carbon isotopic tracers to differentiate between new (Carbon-14, biogenic) and fossil (Carbon-12, anthropogenic) organic carbon, and continuous collection methods for black carbon, organic carbon, and elemental carbon. Field studies can be designed to collect appropriate samples that can be analyzed and evaluated to evaluate the carbon contribution to visibility impairment in specific Class I areas.

***CENRAP's carbon study** continued on page 6....*

Table 1. Seasonal distribution of the ratio of organic carbon to elemental carbon in CENRAP Class I areas.

Class I area	Ratio of Organic Carbon to Elemental Carbon by Season			
	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Caney Creek, AR	4	7	7	7
Upper Buffalo, AR	4	8	6	4
Breton, LA	4	3	4	4
Boundary Waters Canoe Area, MN	5	7	10	5
Voyageurs, MN	5	5	9	5
Hercules-Glades, MO	5	8	6	5
Mingo, MO	3	4	4	7
Wichita Mountains, OK	3	4	4	7
Big Bend, TX	4	8	8	5
Guadalupe Mountains, TX	6	11	14	6

Monitoring update continued from page 1 ....

Data availability status

Data are available on the IMPROVE Web site, at *http://vista.cira.colostate.edu/improve/Data/data.htm.* IMPROVE and other haze-related data are also available on the VIEWS Web site, at *http://vista.cira.colostate.edu/views*.

Aerosol data are available through December 2004. Transmissometer and nephelometer data are available through December 2003 and March 2005 respectively. Photographic slide spectrums are also available on the IMPROVE Web site, under *Data*. Real-time Web camera displays are available on a variety of agency-supported Web sites.

Egbert, Ontario newest monitoring site

During August 2005 an IMPROVE sampler was installed at Egbert, Ontario, Canada. This site will provide a side-by-side comparison of an IMPROVE sampler to its counterpart sampler in the Canadian aerosol monitoring network.

The IMPROVE sampler is located at the Centre for Atmospheric Research Experiments (CARE), a testing site for new methods to measure air pollution, climate, and weather conditions. The CARE facility, operated by Environment Canada, is in rural southern Ontario in an area of mixed deciduous/coniferous forest.

The IMPROVE sampler at Egbert will operate on a non-standard schedule, within the 24-hour sampling period beginning at 8 a.m. instead of the IMPROVE standard of midnight. An 8 a.m. start will allow us to match the Canadian sampling schedule, so that data from the two samplers can be compared directly.

CENRAP's carbon study continued from page 5....

Conclusion

In conclusion, carbonaceous $PM_{2.5}$ is an important constituent of haze in the CENRAP region. However, there has been a minimal effort to study this component. Of the 156 federally mandated Class I areas in the U.S., only five percent have been or are in the process of speciating the carbon component. As for the CENRAP region, only one (Big Bend NP) out of ten of the Class I areas has analyzed the carbon fraction. As the scoping study report reveals, the science is there not only to collect the ambient air concentration of carbon, but to perform chemical analysis as well. More studies aimed at speciating the carbon fraction found in the visibility impairing pollutant $PM_{2.5}$ seem to be called for.

For more information contact Mary Pettyjohn at Arkansas' Department of Environmental Quality. Telephone: 501/682-0070. E-mail: pettyjohn@adeq.state.ar.us.

Operators of distinction

IMPROVE site operator Ron Mackie has been the operator at Pasayten Wilderness, WA, since the site was installed, and he wouldn't have it any other way.

Up near the Canadian border, the Pasayten Wilderness is home to an IMPROVE sampler and a Web camera system, sponsored by the USDA-Forest Service. When the Forest Service was locating the site, atop the Loup Loup Ski Area, Ron stepped up to operate the equipment. Changes in seasons mean changes in vehicles needed to reach the instrumentation. In the summer, Ron uses a 4-wheel drive vehicle to reach the site, but as winter approaches, a snowmobile or snowcat is needed. Servicing may take three to four hours a week.

Both the IMPROVE sampler and Web camera (*http://www.fsvisimages.com/pasa1/pasa1.html*) needed some special attention recently, and Ron spent hours troubleshooting both systems, replacing parts, and testing solutions. His mechanical skills allowed him to perform extensive troubleshooting, alleviating the need for an IMPROVE technician to visit the site. "I enjoy mechanical things," said Ron, "I enjoy maintaining the visibility instrumentation and making sure it operates as it should." Ron also likes a little diversification in his work. "I've been in the ski business since I was 15, and have been a logger, welder, and truck driver. Being a site operator adds to my skills and is interesting work." He takes a new task, learns as he goes, and asks questions until he understands it.

Ron and his wife Kim raised three boys, the youngest of which occasionally helps to service the monitoring instrumentation. In addition to his general management duties of the ski area (*http://www.skitheloup.com*) and owning a ski rental shop, Ron loves water sports including snorkeling and jet skiing, and 4-wheeling in the wilderness.

IMPROVE site operator Ron Mackie maintains the IMPROVE sampler and Webcamera atop the Loup Loup Ski Area, in the Pasayten Wilderness, Washington.

Outstanding sites

Data collection begins with those who operate, service, and maintain monitoring instrumentation. IMPROVE managers and contractors thank all site operators for their efforts in caring for IMPROVE and IMPROVE Protocol networks. Sites that achieved 100% data collection for 3rd Quarter 2005 are:

Aerosol (Channel A)

Badlands
Baltimore
Bandelier
Birmingham
Bondville
Brigantine
Cabinet Mountains
Cadiz
Canyonlands
Cape Cod
Cape Romain
Casco Bay
Cherokee
Columbia Gorge East
Columbia Gorge West
Crescent Lake
Dolly Sods
Douglas
Ellis
Fort Peck
Frostburg Reservoir
Gates of the Mountains
Glacier
Grand Canyon (Hance)
Great Basin
Great Smoky Mountains
Haleakala
Hoover
James River Face
Linville Gorge
Livonia
Lostwood
Mammoth Cave
MK Goddard
Monture
Moosehorn
Mount Baldy
New York
North Cascades
Northern Cheyenne
Okefenokee
Olympic
Petersburg
Phoenix
Pinnacles
Point Reyes
Presque Isle
Proctor Research Center
Quabbin Reservoir
Quaker City
Queen Valley
Redwood
Rocky Mountain
Sac & Fox
Saguaro
Salt Creek
Sequoia
Simeonof
Sycamore Canyon
Theodore Roosevelt
Three Sisters
Trapper Creek-Denali
Trinity
Tuxedni
UL Bend
Upper Buffalo
Viking Lake
Virgin Islands
Walker River
Wheeler Peak
White River
Wind Cave
Yosemite

Transmissometer

Bandelier
Big Bend
Great Basin
Guadalupe Mountains
San Gorgonio
Yosemite

Nephelometer

Dysart
Grand Canyon (Hance)
Grand Canyon (Indian Gardens)
Mammoth Cave
Mayville
Mammoth Cave
Phoenix
Queen Valley

Photographic

Cucamonga
Mount Zirkel
Red Rock Lakes

Sites that achieved at least 95% data collection for 3rd quarter 2005 are:

Aerosol (Channel A)

Acadia
Big Bend
Bliss
Boundary Waters
Bridgton
Caney Creek
Cedar Bluffs
Connecticut Hill
Crater Lake
Great River Bluffs
Hercules-Glades
Joshua Tree
Kalmiopsis
Lava Beds
Martha's Vineyard
Meadview
Medicine Lake
Nebraska
Omaha
St. Marks
San Gorgonio
Shenandoah
Sikes
Thunder Basin
Tonto
Weminuche

Transmissometer

Badlands
Bridger
Canyonlands
Thunder Basin
Grand Canyon (In-Canyon)

Nephelometer

Acadia
Big Bend
Bliss
Cedar Bluff
Children's Park
Chiricahua
Craycroft
Dolly Sods
Estrella
Great Smoky Mountains
Milwaukee
Mount Zirkel
National Capital
Organ Pipe
Petrified Forest
Seney
Shell Oil
Shenandoah
Sycamore Canyon
Thunder Basin
Tucson Central
Tucson Mountain
Upper Buffalo
Vehicle Emissions
Virgin Islands

Photographic

Agua Tibia North
Bryce Canyon
Gates of the Mountains
Grand Canyon
Monture
Wichita Mountains

Sites that achieved at least 90% data collection for 3rd quarter 2005 are:

Aerosol (Channel A)

Addison Pinnacle
Arendtsville
Atlanta
Bosque del Apache
Bridger
Bryce Canyon
Capitol Reef
Cloud Peak
Denali
El Dorado
Everglades
Flathead
Fresno
Ike's Backbone
Grand Canyon (Indian Gardens)
Isle Royale
Jarbidge
Kaiser
Lake Sugema
Lye Brook
Mohawk Mountain
Mount Hood
Mount Zirkel
Old Town
Organ Pipe
Petrified Forest
San Gabriel
San Pedro Parks
Sawtooth
Seattle
Shamrock Mine
Shining Rock
Sipsey
Snoqualmie Pass
Starkey
Swanquarter
Tallgrass
Voyageurs
Washington DC
Wichita Mountains
Zion Canyon

Transmissometer

Cloud Peak
Glacier
Rocky Mountain

Nephelometer

Sierra Ancha

Photographic

Bosque del Apache

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First Class Mail

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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