INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

3rd Quarter 2003 | The IMPROVE Newsletter | Volume 12 / Number 3

Monitoring update

Feature Article: Taking stock of night sky visibility, Page 4

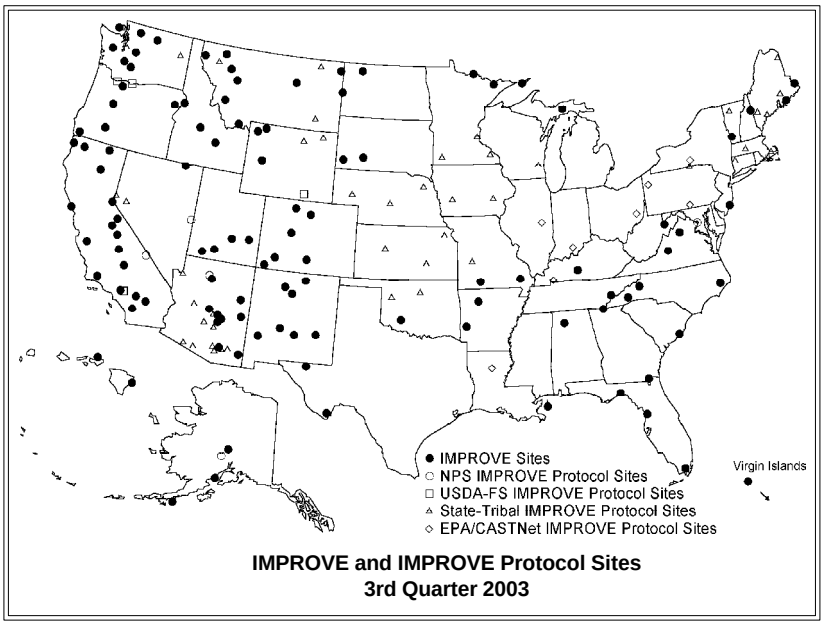
Network operation status

The IMPROVE aerosol monitoring network consisted of 110 aerosol samplers during 3rd Quarter 2003 (July, August, and September). Additional instrumentation that operates according to IMPROVE protocol in support of the program included:

- 54 aerosol samplers
- 21 transmissometers
- 44 nephelometers
- 13 film or digital camera systems
- 37 Web camera systems
- 3 interpretive displays

Federal land managers, states, tribes, and other agencies operate supporting instrumentation at monitoring sites as presented in the map below. Preliminary data collection statistics for the quarter are:

- Aerosol (channel A only) 94% collection
- Aerosol (all modules) 92% completeness
- Optical (transmissometer) 93% collection
- Optical (nephelometer) 94% collection
- Scene (photographic) 97% collection



IMPROVE and IMPROVE Protocol Sites
3rd Quarter 2003

One aerosol sampler was installed during 3rd Quarter 2003 for the Omaha Tribe, in northeast Nebraska. It will operate according to IMPROVE Protocol. The site will also receive a nephelometer and meteorological station in October. A nephelometer was installed at National-Capital Central, DC, to complement the Web camera installed this past spring.

Big Bend National Park has operated two transmissometers, side-by-side for 4 years. The first instrument, installed in 1988, was deactiviated in August per the National Park Service. The 4-year comparison test indicated that the second instrument has a better sight path, and will remain active.

High-resolution Web camera systems were installed at North Cascades, Mount Rainier, and Olympic National Parks, WA; and at Purchase Knob, in Great Smoky Mountains National Park, NC/TN. The Purchase Knob system is the second system to be installed in Great Smoky Mountains National Park. The camera system is collocated with existing air quality and meteorological instrumentation at the site. Purchase Knob and surrounding land were donated and added to the park in 2001.

Future installations in the network include an IMPROVE aerosol sampler, scheduled to be installed in Kobuk Valley National Park this fall. The park is above the Arctic Circle, in northwest Alaska. Also, the USDA Forest Service has selected a location on Mitkof Island in the Tongass National Forest, AK, for an IMPROVE aerosol sampler. The site is about 15 miles south of Petersburg and about halfway between the south-central Alaskan IMPROVE sites and the Pacific Northwest sites. This will be the first air quality sampler of any type in the Alaskan Region of the Forest Service. Installation will occur in Fall 2003. Planning for an IMPROVE sampler in the San Juan Basin of southwest Colorado has also begun.

Monitoring update continued on page 2....

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://views.vista.cira. colostate.edu.* Aerosol data are available through March 2003. Transmissometer data are available through December 2001 and nephelometer data are available through June 2003.

Photographic slides and digital images are archived but are not routinely analyzed or reported. Complete photographic archives and slide spectrums (if completed) are available at Air Resource Specialists, Inc. Slide spectrums are also available on the IMPROVE Web site, under *Data*. Near real-time digital images from National Park Service Web camera sites can be viewed at *http://www2.nature.nps.gov/ard/cams/index.htm*. USDA Forest Service camera images from IMPROVE sites can be viewed at *http://www. fsvisimages.com.*

Standard Operating Procedures and Technical Instructions have been developed for High-Resolution Digital Image Acquisition Systems (HRDC). These, and other operating procedures are available on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/publications/IMPROVE/SOPs.htm.*

Monitoring update *continued on page 3....*

Visibility news

IMPROVE display acknowledges partnerships

The Aspen Skiing Company and its employee non-profit, Environment Foundation, constructed and placed an exterior sign acknowledging the IMPROVE Program and the local and national partnerships which support it, on top of Aspen Mountain last September.

Site operation here is shared by the Aspen Ranger District, the Aspen Wilderness Workshop (an advocacy group working to protect wilderness within the White River National Forest) and the Aspen Skiing Company. Like the national program, this local partnership leverages funding and personnel to cooperatively operate the site; site operator costs here are about half of what most USDA Forest Service IMPROVE sites cost to maintain.

The display was developed by the Cooperative Institute for Research in the Atmosphere's Dave Richie and Graphic Illustrator Jeff Lemke, and will be visible to nearly 400,000 visitors each year.

The IMPROVE sign atop Aspen Mountain explains air quality monitoring in the White River National Forest, in Colorado.

The IMPROVE sampler (site WHRI1) can be seen in the cylindrical structure to the right of and behind the sign, in the photograph above. A complete, four-module IMPROVE aerosol sampler was installed in the forest in September 1999.

For more information contact Dave Richie at the USDA-Forest Service. Telephone: 970/925-7604. Fax: 970/925-7604. E-mail: richie@cira.colostate.edu.

Visibility news *continued on page 7....*

Monitoring update *continued from page 2 ....*

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 operating the IMPROVE and IMPROVE Protocol networks. Sites that achieved 100% data collection for 3rd Quarter 2003 are:

Aerosol

Acadia
Addison Pinnacle
Arendtsville
Badlands
Bandelier
Big Bend
Blue Mounds
Bondville
Breton
Cabinet Mountains
Cadiz
Cape Cod
Chiricahua
Cloud Peak
Columbia Gorge East
Connecticut Hill
Crater Lake
Death Valley
El Dorado Springs
Ellis
Grand Canyon
Great Basin
Great Gulf
Great Sand Dunes
Haleakala
Hercules-Glades
Hillside
Isle Royale
James River
Kalmiopsis
Lassen Volcanic
Lava Beds
Livonia
Lostwood
Lye Brook
Mammoth Cave
Mingo
MK Goddard
Mohawk Mountain
Moosehorn
Mount Baldy
Mount Hood
Okefenokee
Old Town
Olympic
Pasayten
Petrified Forest
Phoenix
Point Reyes
Presque Isle
Proctor Research Center
Quaker City
Queen Valley
Redwood
Rocky Mountain
Saguaro
Saguaro West
St. Marks
Seattle
Seney
Shining Rock
Simeonof
Snoqualmie Pass
Starkey
Tallgrass
Three Sisters
Trapper Creek-Denali
Washington DC
Weminuche
White River
Wind Cave
Zion

Transmissometer

Chiricahua
Yosemite

Nephelometer

Big Bend
Grand Canyon (Hance)
Mammoth Cave
Mount Rainier
Quaker City

Photographic

Bryce Canyon
Grand Canyon
Red Rock Lakes

Operators of distinction

The Aroostook Band of the Micmac Tribe in Presque Isle, Maine, has operated an IMPROVE aerosol sampler since March 2001. The operators there see to it that they achieve and maintain good data collection. The current site operator at Presque Isle, Dave Macek, even performs site visits while on vacation, to ensure the aerosol filters are changed according to schedule.

Dave is an environmental specialist for the tribe. He has many responsibilities in their air program, and will soon be working full-time for the program. Along with the aerosol sampler, the Presque Isle site is equipped with a meteorological station, and plans are in the works to add continuous monitors for all criteria pollutants. In cooperation with NESCAUM, the tribe also plans to place real-time data on the CAMNET Web site. Dave hopes this project, made possible by a grant from the Environmental Protection Agency, will be completed by late Spring 2004. The air monitoring and public education project will also use the collected data to generate alerts for poor air quality days.

Dave graduated from the University of Maine with a B.S. degree in environmental studies, and a concentration in geology. He moved to Maine 10 years ago, and is in his fifth year with the Micmac Tribe. Originally from Kansas, Dave moved around a bit, to Illinois, Missouri, and Montana, before settling in Maine. His wife and six children watch him work on his passion, a new home built by his hands. “The stone and timber frame house occupies every spare minute I have,” said Dave. “I have been collecting stones for two years now, and my goal is to have the house completed in eight more years. All the construction is by hand, the old-fashioned way. I buy logs and turn them into timber for the framework of the house.”

Dave Macek operates and maintains the IMPROVE monitoring shelter at Presque Isle, Maine. The sampler was installed in March 2001, and the tribe is currently seeking to expand its air monitoring program.

Feature article

Taking stock of night sky visibility

(by Chad Moore, National Park Service Night Sky Team)

Introduction

The expanded Clean Air Act of 1977 embraces the preservation of visibility. It acknowledges that in addition to the chemical properties of the atmosphere and human health needs, preserving the air's natural transparency is important. While much attention has been paid toward daytime horizontal visibility, there is comparatively little focus on the nighttime visibility upwards. The rate at which nighttime visibility is being lost is astonishing, and dark starry night skies are becoming an "endangered" resource.

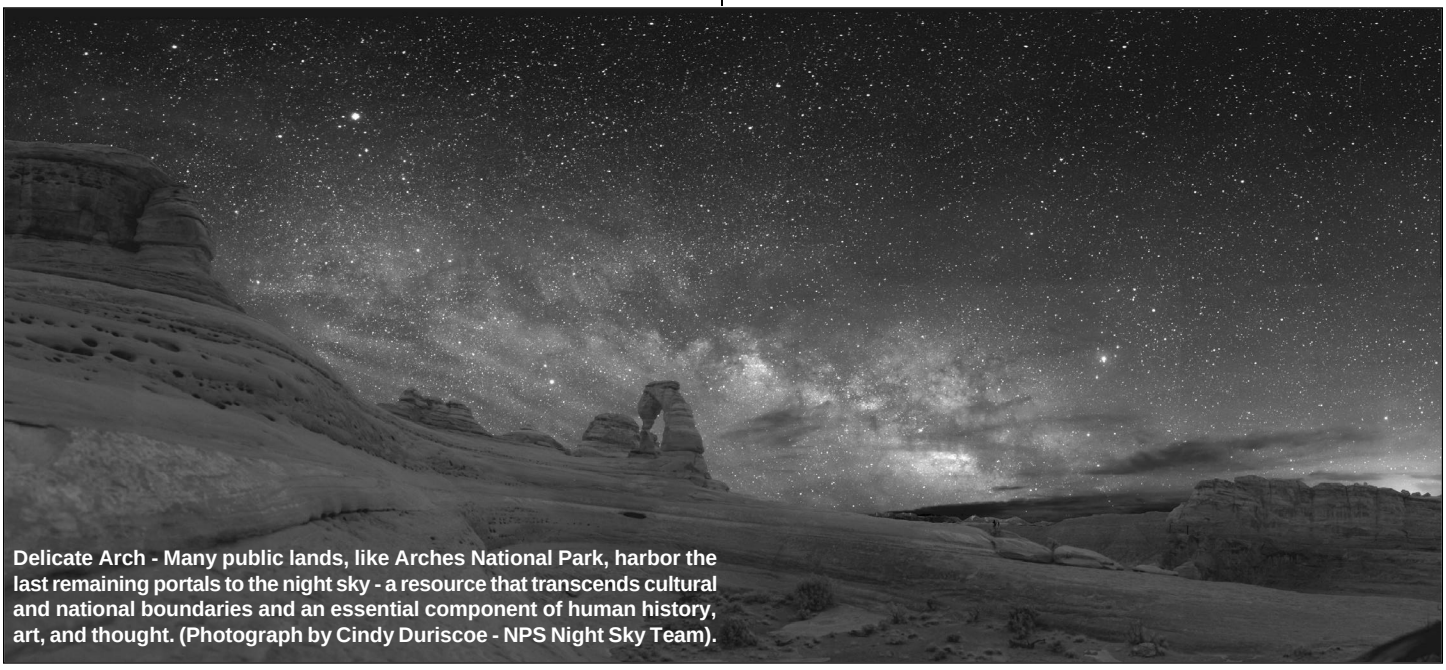
Like carbon dioxide in the atmosphere, light is a native element; however, its abundance and distribution should be tied to a regular cycle. Too much visible light is becoming known as "light pollution." A large proportion of visible light from outdoor lamps is often directed sideways or upwards. These errant photons are then scattered throughout the lower atmosphere or reflected off clouds in a somewhat predictable fashion[1]. In effect, the "space" between the stars becomes less and less black to the ground-based observer. The number of visible stars is reduced by loss of contrast, as well as the resplendent features of the night that were once so familiar to humanity.

In this country, the use of outdoor lighting increased sharply in the 1950s, and has been increasing at a rate faster than population growth. This trans-boundary pollutant is pervasive, reaching to the most remote national parks and national forests in the lower 48 states. Because light from large cities can travel 200 miles, the remaining visual harbors of dark sky are dwindling. Unless the projected track for the future is changed, this will be the last generation that has access to truly dark skies in the contiguous United States. Computer models based on military satellite imagery of the earth at night project that by 2025, the remaining dark areas in the Western United States will be lost[2].

Already, two-thirds of Americans lack the ability to see the Milky Way from their own backyard[2]. As the public loses the experience of a starry sky at their homes, they are increasingly seeking it out in their protected lands and wilderness areas. Yet, only a handful of federal or state land managers have any information whatsoever on the quality of their night skies, and no personnel dedicated to this issue. Dark night skies are an Air Quality Related Value, a wilderness resource, a cultural resource, and an important element in the ecological landscape.

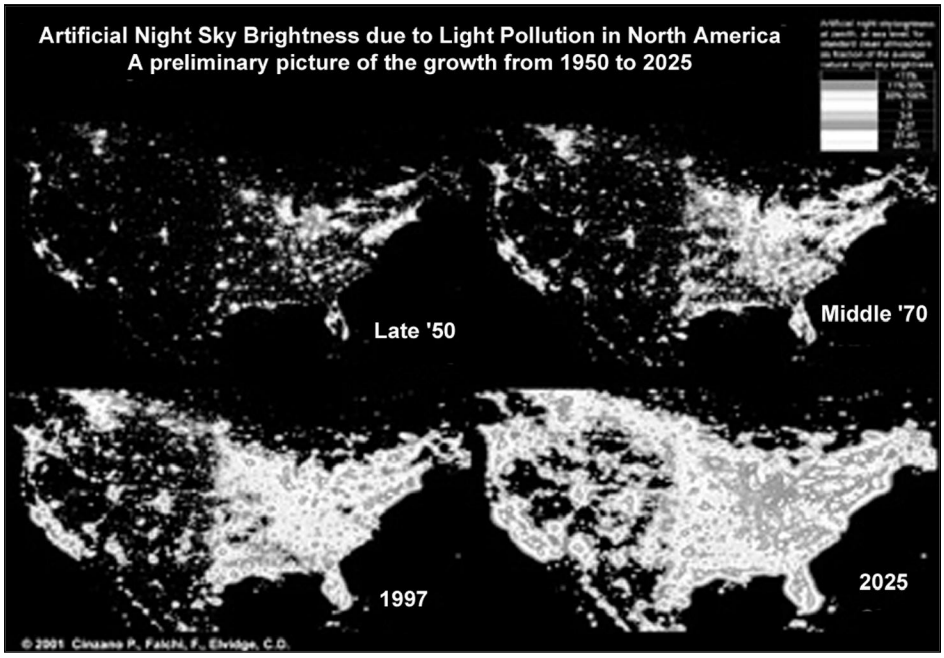
Ecosystem impacts

Altering the nocturnal lightscape is as fundamental for many biota as altering the air that they breathe. For the entire history of life on this planet there has been a predictable day and night cycle, yet other environmental parameters have changed radically. While the atmosphere 3 billion years ago had little resemblance to today's, the daily and lunar cycles marked out the same pattern as they do now. A large proportion of the animal kingdom is nocturnal, as darkness serves as a shelter element. Perhaps it is the diurnal nature of humans that has blinded us to the subtle yet profound environmental change of light pollution, or perhaps it is the limitation of our eyes or the dominant urban culture that has left this problem unaddressed for so long.



Delicate Arch - Many public lands, like Arches National Park, harbor the last remaining portals to the night sky - a resource that transcends cultural and national boundaries and an essential component of human history, art, and thought. (Photograph by Cindy Duriscoe - NPS Night Sky Team).

Although the research on light disruption only touches on a few species, a pattern is clearly evident. Artificial light disrupts interspecies interactions such as predation, foraging, and competition for food. Altered light levels also disrupt reproduction, communication, and perhaps most strikingly navigation[3]. Disorientation by nesting sea turtles has been well documented, but similar dramatic effects are observed with migrating birds striking lit buildings, lighthouses, and radio towers[4]. Light levels as small as 0.1 lux have been shown to alter zooplankton migration in the marine water column, as well as macroinvertabrate foraging patterns in ponds[5]. This is roughly equivalent to illumination levels expected with suburban light pollution. In some cases, the impact of elevated light levels are acute and direct, but more often they are chronic stresses in the environment which reduce specie fitness and overall ecosystem resilience.



Computer models have projected the rapid growth in light pollution in the coming years[2].

The process of biochemical disruption by light has been recently identified in humans as well as animals. Remarkably small light levels can trigger retinal cells that set circadian rhythm response in the brainstem of mammals. This leads to a cascade of neuroendocrine changes, including adrenaline, progesterone, and other key hormone production[6]. Current research in human health now focuses on links between altered light cycles and increased cancer risk.

Project history and methods

The National Park Service funded a small pilot project in 1999 to develop a method for measuring the brightness of the night sky. In 2002 the NPS Night Sky Team was further funded to collect inventories of the night sky at 30+ NPS units and provide technical assistance nationwide. Although park managers have become increasingly concerned about light pollution, they have lacked the tools to measure and communicate the problem until now.

This team developed a monitoring system with assistance from the non-profit International Dark-Sky Association and astronomers at the US Naval Observatory- Flagstaff, AZ. It is based around a CCD camera (essentially a research grade digital camera). The camera is thermoelectrically cooled and optimized for high sensitivity and minimal noise. The CCD chip itself is 1 square centimeter in area with a 512 x 512 pixel array. When coupled with a rectilinear wide angle Nikon lens, it produces a 16 x 16 degree field of the sky. Because of the high sensitivity, the camera is able to record very faint light in a 10-second exposure. Spectral sensitivity is limited to the green wavelengths by a "Johnson V" filter, a common astronomical standard. This roughly corresponds to the human eye's nighttime visual response.

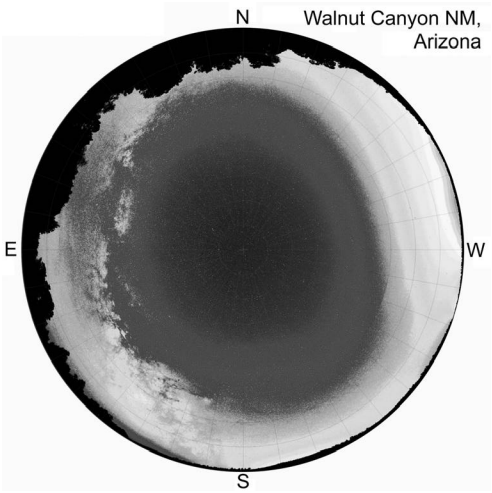
Recently, we have developed an automated sampling routine that mates a commercially available telescope mount with the CCD camera, both of which are commanded by a laptop computer. This system automatically points the camera and captures 108 images of the entire sky. Post-processing will later merge all the individual image tiles into a seamless polar projection of the celestial hemisphere. Brightness values are conveniently keyed to astronomical magnitudes. Atmospheric extinction values can be gleaned from these images by using stars of known and constant brightness. The attenuation of the starlight through the atmosphere reveals the optical depth of the air, and from this we derive an instrument constant. The final product has a precision of about ±10%, which is adequate given that light pollution levels typically vary 1 or 2 orders of magnitude in all but the darkest sites.

Preliminary data

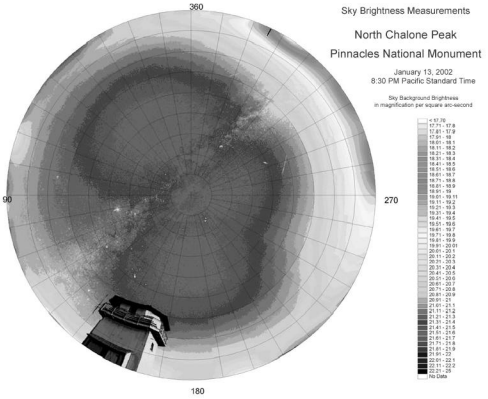
Currently, we have collected baseline data at 18 NPS units. Data collection is limited by weather, the 10-day window around a new moon, and available equipment sets. From these images, light pollution sources can be immediately identified by comparing a direction on the captured images with a map and protractor. The aggregate brightness of a source can be determined, as well as its deviation from expected natural values.

Existing data demonstrate the connection between nighttime visibility and air pollution, as poor air quality generally results in degraded nighttime visibility. Haze exasperates light pollution, particularly from nearby sources. Urban sky glow waxes and wanes with the changes in atmospheric extinction; because of this we generally try to capture data when conditions are in the cleanest 20th percentile to control for atmospheric conditions.

Data show that even remote NPS units have measurable and visible traces of light pollution on the horizon and only a handful of sites have unaltered skies straight overhead. Parks we have sampled appear to be more degraded than what computer models predict[2]. Few in the public may realize this now, since their night sky experience may be jaded by even brighter urban settings, however, the opportunity to experience a truly natural sky could potentially end in the coming decades. This measurement system can be equally useful in gauging progress. The image from Walnut Canyon National Monument below, demonstrates the improvement that can be made with properly controlled outdoor lights. The advanced lighting codes in Flagstaff, AZ, 12 miles distant, result in a much smaller light pollution component than is theoretically expected.



Walnut Canyon - Efforts to retrofit outdoor lights and apply a strict code to new installations has resulted in less light pollution to nearby Walnut Canyon than would be expected so near the small city of Flagstaff, AZ.



Pinnacles- Although sought after by city dwellers weary of urban lights, the sky at Pinnacles National Monument has been frittered away be rapid development in the Silicon and Salinas Valleys. The single brightest light source is a state prison 12 miles from the park boundary.

Conclusion

The nighttime sky has been a constant in the human experience. It has inspired countless myth, religion, art, literature, and science from every culture around the globe. It is the ultimate common ground for humanity that has been tragically taken for granted. Some who recreate on public lands specifically seek out the night sky with telescopes or simply a warm blanket and their own eyes; but perhaps for everyone the night sky is an integral component of a natural experience.

The outlook for problem resolution is optimistic. Existing outdoor lights can be fitted with shields to direct all light downward. Most lighting manufacturers now provide an array of fixtures that are energy efficient, effective, and night sky friendly. With the ability to measure artificial night sky brightness, we have the tools to communicate the problem, articulate the cause, and monitor the restoration of the night sky.

Acknowledgements

The NPS Night Sky Team is supported by grants from the NPS Natural Resources Preservation Program. Technical advancement, data collection, and key input has been made possible by team members Dan Duriscoe- NPS, Angie Richman- NPS, Charlie Schelz- NPS, John Notar- NPS, Cindy Duriscoe, Chris Luginbuhl- US Naval Observatory, and the NPS Air Resources Division.

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[1]Garstang, R.H., 1986, Model for artificial night-sky illumination, *Publications of the Astronomical Society of the Pacific* 98, 364.

[2]Cinzano P. , F. Falchi, C.D. Elvidge, 2001, First World Atlas of the Artificial Night Sky Brightness, *Monthly Notices of the Royal Astronomical Society*, 328, 689-707.

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[4]Ogden L.J.E., 1996, Collision course: the hazards of lighted structures and windows to migrating birds, Toronto: World Wildlife Fund Canada and Fatal Light Awareness Program.

[5]Longcore, T., 2003, Personal Communication, Los Angeles: The Urban Wildlands Group and UCLA Institute of the Environment.

[6]Roberts, J., 2003, Circadian Rhythm and Human Health, *Ecology of the Night* Symposium, Muskoka, Ontario, Muskoka Heritage Foundation.

For more information contact Chad Moore at the National Park Service. Telephone: 831/389-4485, ext. 246. E-mail: chad_moore@nps.gov.

Visibility news *continued from page 2 ....*

Wyoming DEQ initiates visibility Web site

In June 2003, the Wyoming Department of Environmental Quality-Air Quality Division (AQD) launched the Wyoming Visibility Monitoring Network Web site as an integral part of programs to protect and improve visibility in Wyoming. The site, *http://www.wyvisnet.com*, features live images and current air quality conditions from three monitoring stations:

- Thunder Basin National Grasslands
- Cloud Peak Wilderness Area
- Campbell County

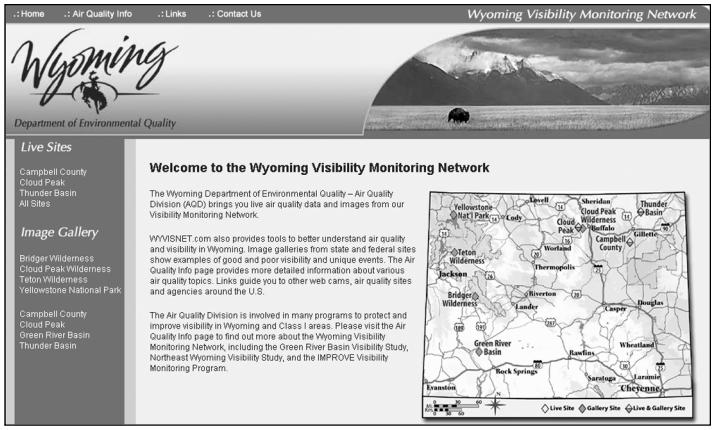
Digital images are updated every 15 minutes and near real-time air quality data provide current meteorological, air quality and visibility information.

The Web site also provides tools to better understand air quality and visibility in Wyoming. Image galleries from state and federal monitoring sites show examples of good and poor visibility and unique events. The galleries featured are:

- Thunder Basin National Grasslands (AQD)
- Cloud Peak Wilderness Area (AQD)
- Green River Basin – 3 locations (AQD)
- Bridger Wilderness Area (USDA FS)
- Teton Wilderness Area (USDA FS)
- Cloud Peak Wilderness Area (USDA FS)
- Yellowstone National Park (USDI NPS)

In addition, the "Air Quality Info" page provides more detailed information about various air quality topics and the "Links" guide you to other webcams, air quality sites, and agencies around the U.S. Take a look at the site and forward it to anyone who has an interest in visibility in Wyoming.

For more information about the Web site or visibility program, contact Cara Casten with the WDEQ-AQD in Cheyenne. Telephone: 307/777-8684. E-mail: ccaste@state.wy.us.



IMPROVE 2004 calendar coming soon

The IMPROVE Program is sponsoring a calendar again this year. The 12-month, wall-sized calendar is being created by the Cooperative Institute for Research in the Atmosphere (CIRA), and will feature operators, monitoring sites, and other monitoring-related topics. The daily field portion of each month will contain notes to alert operators when filter changes should occur, and more. Julian days will also be added. CIRA expects to distribute the calendar to all IMPROVE site operators in December or January.

For more information contact Julie Winchester at CIRA. Telephone: 970/491-8443. Fax: 970/491-8598. E-mail: winchester@cira.colostate.edu.

Site operators -- you're not alone

This summer, Scott Copeland, a visibility data analyst with the USDA Forest Service, traveled to 11 IMPROVE sites from North Carolina to the North Cascades. He met with IMPROVE site operators from each of the 11 sites plus operators from 5 sites he didn't visit. At each site he held a brief training session highlighting the purpose and scope of the IMPROVE Program, and discussed some of the common operator pitfalls. (A Powerpoint presentation of this is available by e-mail). When possible, Scott met with the operators' supervisors to reinforce the need for continued support of the operators and their work. With luck, he'll continue these training trips in future years.

Scott was struck by two things throughout his travels. First was the dedication of the operators. Many of the sites in the network are quite remote, often at the top of mountains or ridge lines. In some cases, the sample change takes all day including travel to and from the site, and in inclement weather, access is sometimes impossible. Even under these demanding conditions, operators often perform to near perfection.

His second lingering impression was the size and scope of the human dimension of the network. There are about 160 sites in the network, most of which have backup operators. Many rely on interns and part-time work during certain seasons, and new operators are always being brought into the group. In any given year, there might be 500 people from the Virgin Islands to the Aleutian Islands keeping the blue boxes moving. Every Tuesday, rain or shine, roughly 200 operators, backups, and trainees make a trip from five minutes to five hours to get to their sites. If you're an IMPROVE operator, then on Tuesday you're really not alone.

For more information contact Scott Copeland at the USDA Forest Service. Telephone: 307/332-9737. E-mail: copeland@cira.colostate.edu.

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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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*** Please make a note of Marc Pitchford's new telephone and fax numbers.*

ASSOCIATE MEMBERS

Associate Membership in the IMPROVE Steering Committee is designed to foster additional IMPROVE-comparable visibility monitoring that will aid in understanding Class I area visibility, without upsetting the balance of organizational interests obtained by the steering committee participants. Associate Member representatives are:

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Government organizations interested in becoming Associate Members may contact any Steering Committee member for information.

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The IMPROVE Program was designed in response to the visibility provisions of the Clean Air Act of 1977, which affords visibility protection to 156 federal Class I areas. The program objectives are to provide data needed to: assess the impacts of new emission sources, identify existing human-made visibility impairments, and assess progress toward the national visibility goals as established by Congress.

To submit an article, to receive the IMPROVE Newsletter, or for address corrections, contact:

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