Shenandoah National Park
National Park Service
U.S. Department of the Interior

Resource Management

Exciting Lichen Discoveries

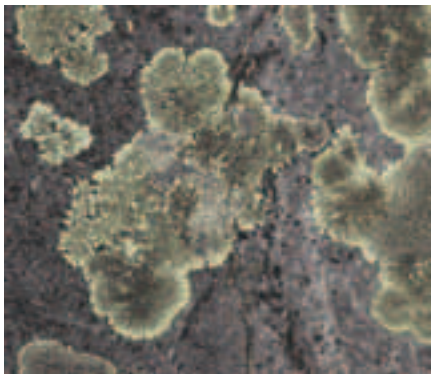
By Nicholas Fisichelli

Lichens are an often overlooked, but very common group of organisms growing on numerous surfaces throughout the park including tree branches and trunks, buildings, Skyline Drive's rock walls, and cliff faces. As part of the Rock Outcrop Management Project, lichens were collected and identified from four high elevation rocky areas: Hawksbill Mountain, Crescent Rock, Old Rag Mountain, and Blackrock Summit. These sites were selected because they include each of three major rock types found in the park, greenstone (metabasalt), granite, and quartzite (siliciclastic). Park staff, Virginia Department of Conservation and Recreation scientists and several volunteers collected over 350 specimens of lichens from these sites. The specimens were then sorted and sent out to three lichenologists for identification.

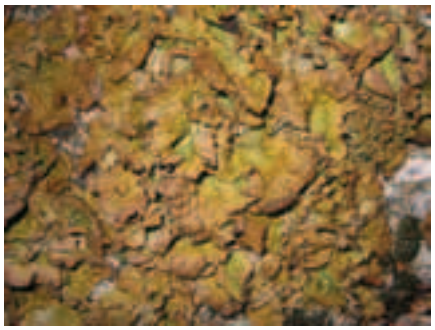
Lichens are unique life forms in that they are actually made up of two separate species functioning as one organism. They are the product of a symbiotic relationship between a fungus and a photobiont, either a green alga or cyano-bacterium. Within this relationship, the fungus provides the physical structure and ability to take in substances from the environment while the photobiont produces and provides energy through photosynthesis. Lichenologist Trevor Goward described lichens as "fungi that have discovered agriculture." Lichens come in many sizes, shape, and color and exhibit three primary growth forms, crustose, foliose, and fruticose. Crustose lichens form thin crusts and adhere very tightly to the substrate, usually tree bark or rocky surfaces; foliose species are typically flattened and somewhat leafy in nature with distinguishable upper and lower surfaces; and fruticose species, which do not have distinguishable upper and lower surfaces, are more three-dimensional in form, and grow either erect or pendent from the substrate.

The scientific community's knowledge of lichen species and their ranges, especially in the Appalachian Mountains, is limited due to a lack of comprehensive research. This particular survey produced many significant findings to contribute to this field of science. The preliminary results from the collection show that a total of 95 species were identified with potentially 6 new species to science, one species new to the eastern U.S., and 8 species new to Virginia. Many of these lichens are typically found growing in more northern, boreal locations. Virginia is considerably disjunct from their normal range; however the unique high elevation outcrops in the park provide small pieces of suitable habitat with a more northern clime.

The information collected through this study has helped facilitate a better understanding of the lichen species present in the park and their habitat requirements. The Virginia Division of Natural Heritage is currently working



The crustose golden moonglow lichen, *Dimelaena oreina*, produces a remarkable pattern on this quartzite rock. Photo by Gary P. Fleming.



This rock is covered by the leafy, foliose growth form of the blackened toadskin lichen, *Lasallia pensylvanica*. Photo by Nicholas Fisichelli, NPS.

This fruticose rock beard lichen, *Usnea halei*, grows directly on rocks in many areas of the park. Photo by Nicholas Fisichelli, NPS.

on updating the state and global rarity ratings for several species based in large part on this study. It is now known that several state rare and a few globally rare lichen species inhabit high elevation rock outcrops in Shenandoah National Park. In addition, two new natural community types dominated by lichens have been proposed for entry into the National Vegetation Classification System.

Lichens species are also very important because they are excellent indicators of ecosystem health. Many species have known tolerance levels for ozone pollution, smog, acid precipitation, and other forms of anthropogenic and natural disturbances. The suite of lichen species present in an area can inform scientists on the relative health and integrity of the ecosystem. Thus it is important to document lichen community composition in the park and look at changes in these communities over time. Lichens can function as the terrestrial ecosystem "canary in the coal mine" if we just pay attention to them.

Nicholas Fisichelli is Lead Biological Science Technician.

2005 Ozone Season

By Liz Garcia

Ground-level ozone is a clear and colorless gas formed by nitrogen oxides (NOx) and volatile organic compounds (VOCs). Ozone is a component of smog, which can develop during clear warm weather and is associated with high pressure systems. Ozone can be hazardous for human health as well as damage vegetation. Concentrations of ozone tend to be greater at higher elevations like Big Meadows versus lower elevations in the Shenandoah Valley.

At Shenandoah National Park, we monitor ground-level ozone using the National Ambient Air Quality Standards (NAAQS) set forth by the U.S. Environmental Protection Agency (EPA). These standards regulate ground-level ozone and sulfur dioxide and define the national targets for acceptable concentrations of each pollutant.

The NAAQS for ozone is 0.08 ppm over an 8-hour period. An exceedance of the standard occurs when the 8-hour ozone concentration is greater than or equal to 85 ppb. An exceedance is not the same as a violation. A violation occurs when the 3-year average of the forth highest daily maximum 8-hour average ozone concentration equals or exceeds 85 ppb.

The year 2005 is only the third time since ozone monitoring was started in 1983 that there was not an exceedance! The other two years that there was not an ozone exceedance were in 1985 and in 1989. The recent decrease in ozone production is partially due to the NOx emission controls that were put in place on several large point sources in the Midwest and portions of the South in 1999, reducing the production of NOx, therefore reducing the creation of ozone. Changes in industry and the weather have also kept ozone production lower in recent years.

The 1st highest ozone level was 81 ppb, under the NAAQS by 3 ppb. The 1st highest ozone level had fallen from 87 ppb in 2004 to 81ppb.NAAQS standards for the 2nd year in a row. The 4th highest ozone level was also 81 ppb, which helped keep the 3-year average of 80 ppb out of violation of the NAAQS standards for the 2nd year in a row.

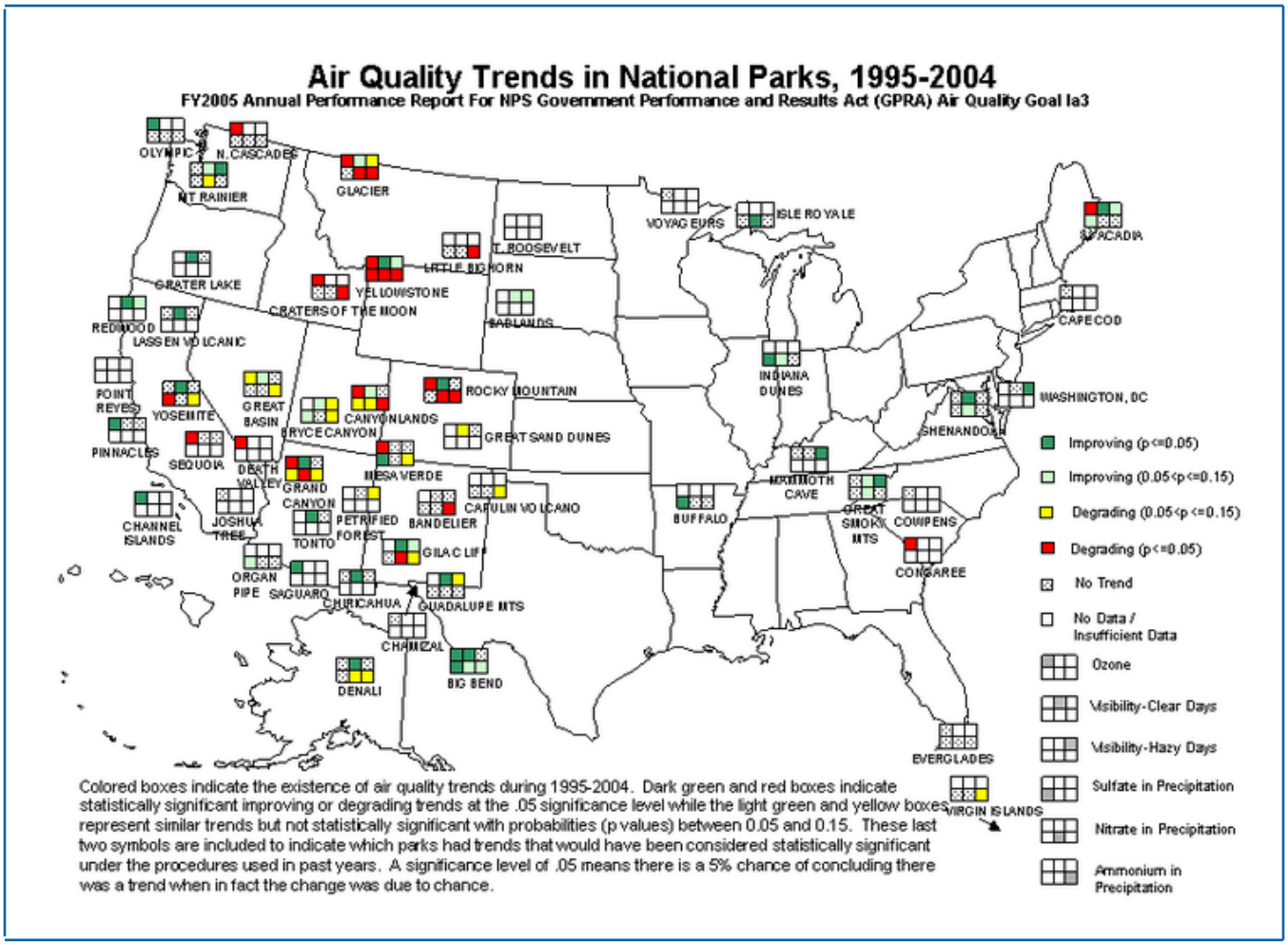
Help keep Shenandoah National Park violation free by doing your part to reduce NOx and VOCs emissions. NOx emissions trends can relate to the trends in ozone production. The main emitters of NOx from man-made combustion process are from industries, power plants, and automobiles. VOCs are emitted from vehicles and industries. Do your part by reducing automobile use, car pool or walk when possible. Also when driving reduce time spent with engine idling. Turn off the engine while talking or waiting to pick up others. This not only saves gas but reduces the amount of NOx and VOCs emissions that are produced. Be sure to check and keep tire pressure maintained. When refueling a vehicle, don't top off the tank and try to fill the gas tank after dusk especially when ozone levels are expected to be high. If you use household, workshop or garden chemicals, use them in a way to keep evaporation to a minimum during poor air quality days. All the little things you do to help add up, especially if everyone pitches in a little.

Liz Garcia is a Physical Science Technician.

Year	Number of Ozone Exceedances	1st Highest Ozone Concentration
1994	2	90 ppb
1995	7	93 ppb
1996	1	87 ppb
1997	6	95 ppb
1998	22	110 ppb
1999	15	101 ppb
2000	1	93 ppb
2001	8	95 ppb
2002	6	101 ppb
2003	6	104 ppb
2004	1	87 ppb
2005	0	81 ppb

3-year Average	4th Highest Ozone Concentration
2003-2005	80 ppb
2002-2004	82 ppb
2001-2003	87 ppb *
2000-2002	85 ppb *
1999-2001	87 ppb *
1998-2000	93 ppb *
1997-1999	96 ppb *
1996-1998	92 ppb *
1995-1997	85 ppb *
1994-1996	83 ppb
1993-1995	84 ppb
1992-1994	81 ppb

*indicates a violation



Ambient Weather Data Summary for Shenandoah National Park at Big Meadows Air Quality Station

Shenandoah National Park - Big Meadows	2000	2001	2002	2003	2004	2005
Ozone Exceedance (>=85ppb)	1	8	6	6	1	0
1st Highest, 8-hour Ozone Concentration (ppb)	93	95	101	104	87	81
4th Highest, 8-hour Ozone Concentration (ppb)	80	90	86	86	75	81
Sulfur Dioxide, Annual Arithmetic Mean (ppb)	2.5	2.3	2	2	2	2
Average Wind Speed (Scalar)	2.9	2.6	2.7	2.7	2.5	2.5
Average Ambient Temperature (°C)	7.6	8.8	9.6	7.5	8.2	8.2
Maximum Ambient Temperature (°C)	25.2	25.7	27.8	25.6	25.6	27.3
Minimum Ambient Temperature (°C)	-18.1	-14.2	-15.2	-20.1	-21.4	-20.1
Average Relative Humidity (%)	66	71	73	76	73	74
Maximum Relative Humidity (%)	100	100	100	100	100	100
Minimum Relative Humidity (%)	8	10	5	12	4	8
Accumulated Precipitation (mm)	1040.9	965.5	1128.3	1736	1455.1	1407.4
Accumulated Precipitation (inches)	40.98	38.01	44.42	68.34	57.29	55.41
National Atmospheric Deposition Program – National Trends Network*						
Calcium ion concentration as Ca^{2+} (kg/ha)	0.64	0.77	0.69	0.87	0.91	0.8
Magnesium ion concentration as MG^{2+} (kg/ha)	0.122	0.123	0.125	0.174	0.202	0.229
Potassium ion concentration as K	0.133	0.145	0.137	0.349	0.219	0.201
Sodium ion concentration as Na^{+} (kg/ha)	0.542	0.504	0.569	0.872	1.18	1.604
Ammonium ion concentration as NH_4^{+} (kg/ha)	2.24	2.72	2.95	3.29	3.64	2.76
Nitrate ion concentration as NO_3^{-} (kg/ha)	9.44	9.96	10.64	11.6	10.4	8.89
Inorganic nitrogen wet deposition from nitrate and ammonium as N (kg/ha)	3.87	4.36	4.69	5.18	5.18	4.16
Chloride ion concentration as Cl^{-} (kg/ha)	1.12	1.1	1.14	1.82	2.29	3.02
Sulfate ion concentration as SO_4^{2-} (kg/ha)	13.98	15.39	17.12	19.04	18.51	16.15
Hydrogen ion concentration as pH (in lab)	4.62	4.61	4.59	4.74	4.72	4.69

* The National Atmospheric Deposition Program – National Trends Network (NTN) monitors the chemistry of precipitation for geographical and temporal long-term trends at over 250 sites nationwide. Shenandoah National Park has been collecting samples for the NTN since 1981. *By Liz Garcia – Physical Science Technician*

Predicting Acid Deposition Impacts on Natural Resources

By Gordon Olson

After several years of effort, staff at the Environmental Sciences Department, University of Virginia completed a report that outlines the anticipated impacts of acid deposition on Shenandoah's natural resources. Major elements of this project had direct ties to the larger Assessment of Air Quality and Air Quality Related Values project, completed, in part by the University of Virginia. This project is, however, an extension of that effort and provides greater detail in terms of forecasting impacts on a watershed-by-watershed basis.

The following is an excerpt of the entire Executive Summary from the report that resulted from this project. It provides an excellent summary of the project and resulting information:

The goal of the Acid Impacts Project has been to develop an assessment of the extent of possible adverse effects of acidic deposition on resources in Shenandoah National Park (SHEN). The assessment approach utilized maps of the park highlighting *areas of concern* with respect to adverse effects on aquatic and terrestrial systems. The maps were constructed to display past, present, and future areas of concern in response to changing levels of acidic deposition.

Four categories of concern were adopted for soil and surface water conditions in SHEN: 1) *Low Concern*; 2) *Moderate Concern*; 3) *Elevated Concern*; and 4) *Acute Concern.* While the same category names were used for maps of adverse effects on both surface water and soils, the biological effects for each category are specific to either aquatic or terrestrial ecosystems.

Concern for Adverse Effects of Acid Deposition on Aquatic Ecosystems in Shenandoah National Park:
The categories of concern for surface water conditions are based on stream water Acid Neutralizing Capacity (ANC) and include a number of observed effects for a number of aquatic organisms in SHEN.

Low Concern. (Average ANC greater than 100 ueq/L). Reproducing brook trout populations expected where habitat is suitable. Fish species richness probably unaffected. Diversity and/or evenness of aquatic macroinvertebrate communities unaffected. Number of families and/or number of individuals of aquatic insects unaffected.

Moderate Concern. (Average ANC in the range 50–100 ueq/L). Reproducing brook trout populations expected where where habitat is suitable. Fish species richness much reduced. Diversity and/or evenness of aquatic macroinvertebrate communities begin to decline. Number of families and/or number of individuals of aquatic insects begin to decline.

Elevated Concern. (Average ANC in the range 0–50 ueq/L). Brook trout populations sensitive and variable, lethal and sub-lethal effects possible. Fish species richness much reduced. Diversity and/or evenness of macroinvertebrate communities decline markedly. Number of families of aquatic insects declines markedly. Number of individuals in most aquatic insect families declines markedly. Number of individuals of acidophilic aquatic insect families increases sharply.

Acute Concern. (Average ANC less than 0 ueq/L). Lethal effects on brook trout populations probable. Complete extirpation of fish populations expected (species richness equal zero). Extremely low diversity and/or evenness of aquatic macroinvertebrate communities. Extremely reduced number of families of aquatic insects. Extremely reduced numbers of individuals of most aquatic insect families. Large numbers of individuals of acidophilic aquatic insect families.

Concern for Adverse Effects of Acid Deposition on Terrestrial Ecosystems in Shenandoah National Park:
The categories of concern for soils are somewhat problematic in that direct observations of adverse effects of acidification are lacking in SHEN for terrestrial organisms. Nonetheless, there exist strong correlations between soil base saturation (BS) and measures of base cation availability for both forests and streams in SHEN. Because the relationships for effects of soil acidification are weaker than for surface waters, the expected effects for each category are less specific than for surface waters, but nonetheless represent best current knowledge.

Low Concern. (Average soil BS greater than 20%). No effects. Base cation availability for forests and surface waters not affected.

Moderate Concern. (Average soil BS in the range 10–20%). Moderate effects probable. Base cation availability for forests reduced and forest growth probably slowed. Base cation availability for surface waters reduced and moderate effects on aquatic biota expected (lowered stream water ANC).

Elevated Concern. (Average soil BS in the range 5–10%). Moderate effects certain and severe effects probable. Base cation availability for forests greatly reduced with resultant risk of mortality from various stresses (particularly if the base saturation was previously above 10% during the life of the tree). Base cation availability for surface waters greatly reduced producing sharp declines in stream water ANC (particularly during storm events) and resultant moderate to severe effects on stream water biota.

Acute Concern. (Average soil BS less than 5%). Severe effects certain. High risk of forest mortality from various stresses including direct acidification effects on roots and seedlings. Surface water ANC's are likely to be in the range of severe biological effects (certainly episodically and perhaps chronically).

Conclusions

Although baseline, pre-industrial resource conditions are not well known in Shenandoah National Park, the analysis here suggests that ranges of both soil and stream conditions that would occur in SHEN *in the absence of acid deposition impacts* would not include any areas of "acute concern" or "elevated concern." However, the historical mapping exercise also suggests that large areas of SHEN, especially in the southern district, may have always been of "moderate concern" reflecting the inherent sensitivity of the siliciclastic bedrock that dominates the southern district.

Simulation and mapping of watershed *responses to historical changes in acidic deposition* (from pre-industrial to current) suggest that large areas of SHEN have suffered deterioration of both soil and stream conditions. The changes in soil condition have been relatively modest up to the present time, with small areas in the southern district of SHEN moving from "moderate concern" (the historical baseline) to "elevated concern" as a result of leaching of base cations from the soils in these areas. Deterioration in stream conditions has been more severe than for soil conditions, with large areas in the southern district and some smaller areas in the central and northern districts moving from "moderate concern" to "elevated concern." Neither soil nor stream conditions have shown any improvement from 1980 to the present in response to the decline in acidic deposition over the last 25 years.

Simulation and mapping of watershed *responses to predicted future changes in acidic deposition* (from current through several decades into the future) relied upon a comparative approach. Several scenarios of possible future acid deposition were developed for this report following U.S. Environmental Protection Agency (EPA) methods for preparation of emissions inventory inputs into air quality modeling for policy analysis and rule making purposes. These alternate scenarios were based on existing emission control regulations and several proposed alternatives.

With respect to *future soil conditions,* the assessment suggests that the responses of soil conditions to changes in acid deposition are relatively slow. In the short term (by year 2020), neither improvement nor further deterioration is likely to be observed in soil condition regardless of the future deposition scenario considered. However, by the year 2100 it becomes clear that constant deposition at 1990 levels would produce worsening soil conditions in SHEN with the development of areas of "acute concern" in the southern district. Perhaps more importantly, while the two scenarios of reduced future deposition did not produce worsening soil conditions, neither did they indicate any improvement in soil condition even in the long term. It is possible that emission control activities (and therefore emissions reductions) currently being considered in the policy arena would all be insufficient to reverse the soil acidification that has occurred in SHEN and start soil conditions on a path to recovery to pre-industrial conditions.

With respect to *future stream conditions*, the assessment suggests that the responses of stream conditions are relatively more rapid than those of soils. In the short term (by year 2020), while constant deposition at 1990 levels would likely produce further deterioration in stream condition, the two scenarios of future deposition reductions do nothing to reverse the deterioration of stream condition that has occurred in SHEN. In the long term (by year 2100), the effects of the two deposition reduction scenarios begin to diverge. The moderate deposition reduction scenario still produces no improvement in stream conditions relative to current conditions. The largest deposition reduction scenario, by contrast, produces modest improvements in stream conditions by 2100. It is important to note, however, that even the relatively large deposition reductions of this scenario do not result in a return of stream conditions in SHEN to the pre-industrial state. It is unlikely that the pre-industrial state for streams in SHEN can be reached until deposition reductions sufficient to stop the soil acidification (discussed above) in SHEN are achieved.

Gordon Olson is Natural Resource Branch Chief.

Park Climate Summary Completed

By Gordon Olson

During the past several years, park staff members have been working with the Virginia State Climatologist's Office on the compilation of climate data and development of a brief report that describes the climate of Shenandoah National Park. This effort was completed in 2006.

The first major element of this project was the assembly of climate data from sources in and around the park. This was a substantial undertaking as it involved using or considering no fewer than 16 separate data sources. The project required development of a database that could house, in a single location, data from these sources. Data from eight of the sources was incorporated into the database and the database was designed such that data from the other eight sources could eventually be brought into the system. Development of the database revealed many issues and concerns. Issues were related to a lack of quality control, inadequate archiving mechanisms, focus on objectives other than time-series reconstructions and analysis, as well as inadequate geographic representation of the park. Despite these problems, this project was a major step in the right direction by gathering much of the available data and organizing it and by pointing out future needs.

The second major element of this project was the preparation of a concise document that summarizes what is known about climatic conditions at Shenandoah. This document provides a fundamental understanding of the park's weather by describing precipitation, temperature, relative humidity, cloudiness, winds, sunrise/sunset and solar radiation, and the growing season. In addition to presenting data for these topical areas, the report also describes regional patterns and influences that drive these weather conditions. This information should prove useful as park staff prepares public information, planning documents, and as researchers prepare proposals for scientific investigations.

It should be noted that the Climate Summary is not an attempt to analyze existing data to point to whether or not global climate change is being manifest at Shenandoah National Park. This was not the purpose of this project and is left as an area of interest for future investigation.

Gordon Olson is Natural Resources Branch Chief.

Natural Resource Assessment

During the past several years, park staff members have been working with Dr. Carolyn Mahan, Pennsylvania State University, on the preparation of a document known as the Natural Resource Assessment. Late in 2006, this document was completed. It represents a significant step forward in the protection of Shenandoah's natural resources and joins a suite of other documents that have been recently completed and that provide an overview of the condition of park resources.

Furthermore, the Assessment suggests relative condition of various categories of park resources and proposes 'desired future conditions' of those resources. This information is important to resource managers in making ongoing decisions about management programs and activities.

The Assessment joins a series of other recently completed reports that provide insight into resource conditions. These include the *Assessment of Air Quality and Related Values in Shenandoah National Park* (2003), the *Water Resources Scoping Report* (2004), the *Geologic Resource Evaluation* (2005), and the *Climate Summary, Shenandoah National Park* (2006). Availability of these documents provides much greater access by park staff and the public to an understanding of park natural resources and their condition than has ever been available before. They summarize voluminous and, sometimes, highly technical information.

It is anticipated that this document and the others cited above will serve park staff for many years to come in efforts to protect park resources.

Gordon Olson is Natural Resources Branch Chief.

Current Hemlock Woolly Adelgid Suppression Strategies and Hemlock Status

By Rolf Gubler

Background

The exotic insect hemlock woolly adelgid (*Adelges tsugae*) was first discovered in the park in 1988. Hemlock woolly adelgid (HWA) are aphid-like insects that attach to the underside of eastern hemlock (*Tsuga canadensis*) needles and feed on the starch of hemlock trees. Without treatment, HWA infestation generally leads to crown decline and hemlock mortality within 5-6 years. Hemlock crown health monitoring began in 1991 and showed progressive hemlock crown decline in many park areas throughout the mid 1990s. HWA suppression began in 1996 and continues currently. As of 2006, HWA infestations have caused approximately 85% mortality or impending mortality in the park's hemlocks. Over the last 11 years, several droughts are believed to have accelerated HWA-related hemlock mortality throughout the park (e.g. two droughts between 2000 and 2002, plus several warm springs were probable causes of the previously healthy Limberlost old-growth stand for having quickly succumbed to the HWA during 2001-2003). Because parkwide control of HWA is neither operationally nor economically feasible, the park's main goal is to preserve a portion of the park hemlocks for future recovery or restoration.

Left: Injecting imidacloprid into the soil, using the Kioritz system, to suppress HWA.

Current HWA Suppression Methods

In 2005, park staff began using a systemic pesticide with a new soil injection method to suppress HWA in vehicle-inaccessible areas. This approach uses the pesticide imidacloprid (MeritR 75 WP) delivered via soil injection (Kioritz™ System). With this novel approach, we have gained greater operational efficiency and treatment longevity by only having to treat hemlocks every two years. Applied properly, this soil injection method targets the affected hemlock with no physical impacts to the tree. Additionally, this new soil treatment has allowed staff to reach previously untreated hemlocks in vehicle-inaccessible areas such as Stony Man, Thornton Hollow, Frazier Hollow, and Hawksbill. In 2006, this system became the primary means of HWA suppression in the park. In 2006, park staff continued to use insecticidal soap (M-pedeR) applications via a hydrosprayer one-two times a year to specific developed area trees. These areas included portions of the Limberlost Area, Skyland Area, Old Rag Fire Road, Big Meadows Area, and along portions of Skyline Drive. This method is currently being phased out and these areas will be mainly switched over to soil injection treatments in 2007.

HWA Suppression Totals in 2006

In 2006, HWA Suppression took place on 157 acres throughout the park (primarily the portion of Central District between Skyland and Big Meadows). Imidacloprid soil injections were made on 97 acres (550 trees). These injections are made every other year. M-PedeR insecticidal soap was applied on 60 acres (or 510 trees) that were treated one-two times during the year. In general, hemlock crown health remained stable in 2006 in treated areas. Moisture conditions were sufficient throughout the growing season and drought was not a crown health decline factor.

Future Outlook

The long-term prognosis for eastern hemlock survival in Shenandoah is uncertain. At this point, there are no large contiguous blocks of hemlocks left in the park. There are a few isolated healthy hemlocks that have not yet been infested. Currently, most treated hemlocks are holding their own (meaning hemlock crown health has stabilized) in the absence of droughts (e.g. Skyland, Stony Man). Park staff will continue treating hemlocks in existing areas and expand our imidacloprid soil injec-

tion treatments in remote areas in future years. There are still scattered healthy hemlocks that we have not been able to treat due to remoteness. Those hemlocks will be identified and soil-injected as time and funding allow. Unfortunately, our U.S. Forest Service HWA Suppression Funding was severely cut back in 2006 (>50% reduction). This has hampered our ability to maintain the same level of HWA suppression as in previous years. However, Natural Resources staff will continue to treat as many hemlocks as fiscally possible. We are committed to preserving a lasting remnant of Shenandoah's hemlocks for future recovery.

Rolf Gubler is a Resource Management Biologist.

Did You Know…
that the systemic pesticide imidacloprid is actually a synthetic nicotine (chloro-nicotinyl) and is an effective pesticide against sucking insects? Besides aphids/adelgids, it is used to treat rice hoppers, thrips, whiteflies, termites, turf insects, soil insects and some beetles. It is most commonly used on rice, cereal, corn, potatoes, vegetables, sugar beets, fruit, cotton, and hops. The chemical works by interfering with the transmission of stimuli in the insect's nervous system. It is effective on contact and via digestion.

Backcountry Camping Info on Park Website

By Melissa Rudacille and Alan Williams

Shenandoah National Park welcomes visitors to explore the backcountry: those areas beyond Skyline Drive, the visitor centers, campgrounds and lodges. At the same time, the park realizes that even careful visitors will impact the park's resources. Backcountry and wilderness management seeks to reduce these impacts to an acceptable level which allows the most freedom for the visitor tempered with the least impact for the natural and cultural resources the park is mandated to protect. Therefore a key component of backcountry management is visitor education.

While research shows that education is most effective with face-to-face contact, this contact is not always possible when someone begins planning a backpacking trip at SNP. To provide useful information on backcountry trip planning, as well as an introduction to Leave No Trace principles, SNP introduced a backcountry camping component onto its website: www.nps.gov/shen. At the right is the site index. Throughout the web pages there are many links to other useful information such as bear safety, how to purchase topographic maps, and camping on the nearby National Forest.

As you can see, at right, under "Planning Your Trip", specific trip itineraries are available through the new website. SNP offers great freedom in choosing a place to backcountry camp, but some campers find this freedom overwhelming and prefer to have more guidance. Since there has been little information on specific backcountry camping options, visitors tend to congregate on the relatively few trails that they know about. While certain trails receive an excessive number of campers looking for a place to pitch their tent, other delightful trails see very few campers. Therefore we have created nearly 100 trip plans that include information on where to park, suggested trail routes, and where to look for places to camp, for a wide variety of areas throughout the park. A searchable database was created by the staff to generate the standardized trip plans. In the future interactive search tools will be made available to the public to find trips that suit their needs.

In order for campers to find this information they first must review the basic information on the website about planning for a backcountry camping trip in Shenandoah. Then they follow links appropriate for their experience

Backcountry Camping Index
on Shenandoah National Park Website

- Backcountry and Wilderness Camping (general information and explanations)
  - Preparing for your Backcountry Camping Trip (gateway to SNP-specific information)
    - Obtaining a Backcountry Camping Permit
      - Permit Worksheet (PDF)
      - Map of Permit Stations
    - Planning Your Trip
      - Trip Planning Worksheet (PDF)
      - Skill Level Worksheet (PDF)
      - Possible Trip Plans(specific itineraries)
        - Beginner Trips
        - Intermediate Trips
        - Advanced Trips
        - Horse Trips
        - Appalachian Trail Trips
        - Group Trips
    - Backcountry Camping Regulations
      - Backcountry Brochure (PDF)
    - Backcountry Safety and Travel Tips
    - Water Sources
    - Downloads

One Night Strenuous Beginner Trips			
Miles	**Trip Title**	**Description**	**Entry**
5.4	Big Run Loop and Big Run Portal	Simple, flexible trip in a wilderness valley with excellent camping and fishing	81.2
6.7	Elkwallow and Jeremys Run	Popular wilderness valley, excellent camping and fishing (open for harvest)	22.2
6.8	Big Run Loop and AT Circuit	Wilderness valley, excellent camping and fishing	81.2
8	Whiteoak Canyon and Cedar Run, short option	Popular waterfall circuit, beautiful, but avoid on weekends	45.6
9.1	Hannah, Hot-Short and Catlett	Cascading streams, swimming holes, homesites	35.1
9.5	Riprap and Wildcat	Popular circuit with good views, cascades, excellent swimming hole	90
10	Brown Mountain and Rocky Mountain Run	Excellent camping and fishing, great views and swimming holes in this wilderness area	76.9
11.6	Corbin Mtn and Nicholson Hollow, 1 night	Wilderness area, cascades, homesites and swimming holes	38.4
12.5	Jeremy's Run Basic Circuit Trips	Popular wilderness valley, excellent camping and fishing (open for harvest)	24.1

level, type of trip, and number of nights, until they get a page listing some trip options. For example, above is a table for One Night trips appropriate for Strenuous Beginner Trips. When the camper clicks on one of these trips, a PDF of that specific trip uploads.

Backcountry managers hope these trip plans will influence visitor use without additional regulations and closures. For example, very few areas in SNP are currently closed to backcountry camping, but as some areas receive an unacceptable level of damage, additional closures could be necessary. The trip plan for an area of concern asks campers to use caution when visiting these areas, perhaps choosing to stay on a weekday night rather than a weekend. At the same time, visitors will now have the information that they need to camp in some other areas of the park that currently receive little use.

SNP will continue to inventory and monitor both new and existing campsites, and hopefully will be able to use the website to influence camping patterns as impacts emerge. If monitoring shows excessive impact in a specific area, those trip plans can be modified. Backcountry managers anticipate two benefits to this approach. One, park employees and volunteers at visitor contact stations will have ready access to information which may change the trips they recommend to visitors. Secondly, visitors accessing the website will have information, and hopefully most of them will choose to avoid problem areas as recommended. If resource impacts grow in the following two years, additional research will be required to determine why and what might be done. Even if impacts decrease (as we hope), a social survey to determine visitor perceptions and reactions may provide helpful data in refining this new management tool to better serve the needs of both the resource and the park visitor.

Check: http://www.nps.gov/shen/bc/ for more information.

Melissa Rudacille is a Trail Laborer and Alan Williams is a Natural Resources Data Manager.

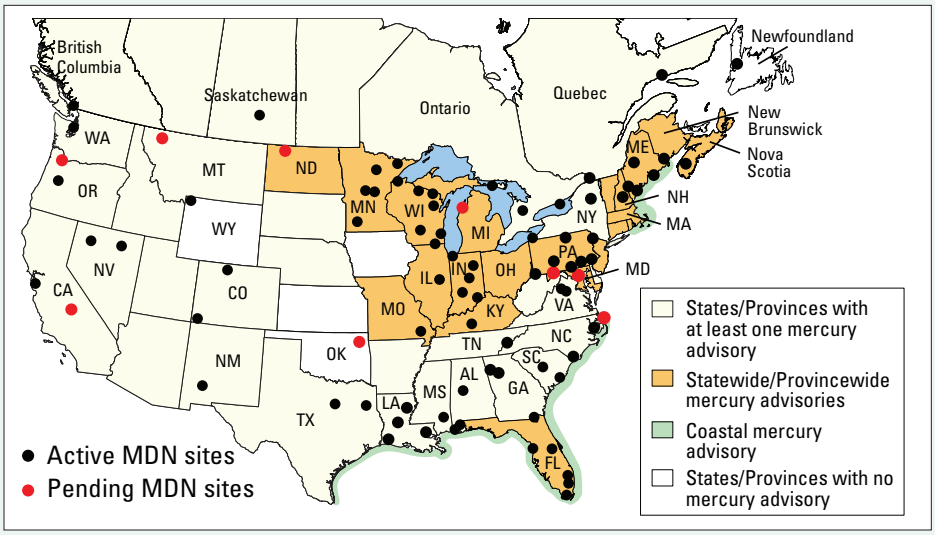
USGS
science for a changing world

Expanding the Mercury Deposition Network in Virginia and the U.S. Mid-Atlantic Region

Mercury in the Environment

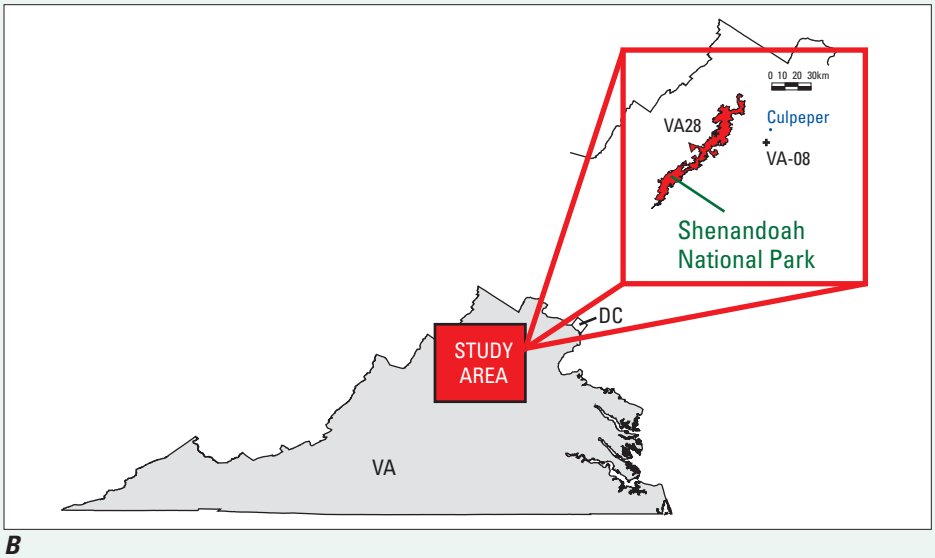
Mercury is a toxic metal having known detrimental health effects on the central nervous system. Mercury in the environment is derived from natural sources (such as volcanic eruptions) and from human activities (such as combustion of fossil fuels, metal processing, and some mining activities). Mercury added to the atmosphere by these sources may circulate globally or may be deposited locally, depending on its chemical form. Levels of mercury present in the air and in precipitation (rain and snow) generally do not pose a direct threat to humans; however, mercury derived from the atmosphere is thought to be a primary source of mercury in fish. Fish consumption is the main avenue for human exposure to mercury in the United States, and fish consumption advisories for mercury now account for more than three-quarters of all State fish consumption advisories (fig. 1).

Monitoring atmospheric mercury deposition provides estimates of the amount of mercury added to lakes, rivers, estuaries, and wetlands. In an aquatic environment, a portion of the mercury may be converted by bacteria to organic forms (for example, methylmercury) that can be taken up by organisms.



A

Figure 1*A*. Map showing distribution of operating Mercury Deposition Network (MDN) stations, pending sites, and fish consumption advisories as of 2003. Prior to 2003, there were no operating MDN sites in Delaware, Maryland, Virginia, or West Virginia. Map compiled by National Atmospheric Deposition Program - Mercury Deposition Network (http://nadp.sws.uiuc.edu/mdn), with data from U.S. Environmental Protection Agency National Listing of Fish and Wildlife Advisories (http://oaspub.epa.gov/nlfwa/nlfwa.bld_qry?p_type=advmap&p_loc=on).



B

Figure 1*B*. Location map showing the sites of MDN stations in northern Virginia. Stations VA–08, near Culpeper (latitude 38.42; longitude –78.10), and VA–28, at Big Meadows (latitude 38.52; longitude –78.44), are about 100 and 130 kilometers southwest of Washington, D.C., respectively.

Figure 2. Views of MDN sites VA–08 , Culpeper (top), and VA–28, Shenandoah National Park-Big Meadows (bottom). Each station consists of a recording rain gauge (cylinders) and a precipitation collector (boxes). Mercury sample is collected through a glass funnel exposed when a moisture sensor activates the lid covering the sample chimneys at the left side of the collector. Top photograph by Allan Kolker, USGS; bottom photograph from National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu/sites/siteinfo.asp?net=MDN&id=VA28).

Levels of methylmercury in the tissues of organisms increase upward in the food chain; that is, there are higher concentrations at increasingly higher levels in the chain. This bioaccumulation poses a potential hazard to humans and long-lived wildlife.

The Mercury Deposition Network

The Mercury Deposition Network (MDN) of the National Atmospheric Deposition Program (NADP) was started in the mid-1990s to meet the need for information on rates of mercury deposition from precipitation in North America (information on the NADP is available on the Web at http://nadp.sws.uiuc.edu). The goal of the MDN is to develop a national database of weekly mercury data to determine spatial and seasonal trends in mercury wet deposition (that is, mercury deposited from the atmosphere via rain, sleet, and snow). Mercury deposition under dry conditions, which accounts for a portion of the mercury deposited from the atmosphere, is not measured by the MDN. Most MDN stations are in the eastern third of the United States, where predicted levels of mercury deposition are greatest due to prevailing weather conditions and the number of coal-fired power-generating stations, a significant source of atmospheric mercury, in the Midwest, the mid-Atlantic States, and the Southeast.

The MDN in the U.S. Mid-Atlantic Region

In autumn 2002, two MDN stations began operation in Virginia (fig. 1), helping to fill a significant gap in the network in the mid-Atlantic region. Station VA–08, located southwest of Culpeper, Va., at an elevation of 163 meters, is operated jointly by the U.S. Geological Survey and George Mason University (fig. 2). Station VA–28, located at Big Meadows in Shenandoah National Park, at an elevation of 1,074 meters, is operated by the National Park Service. These sites greatly improve MDN coverage immediately west of the Washington, D.C., metropolitan area. The proximity of the Culpeper and Big Meadows sites

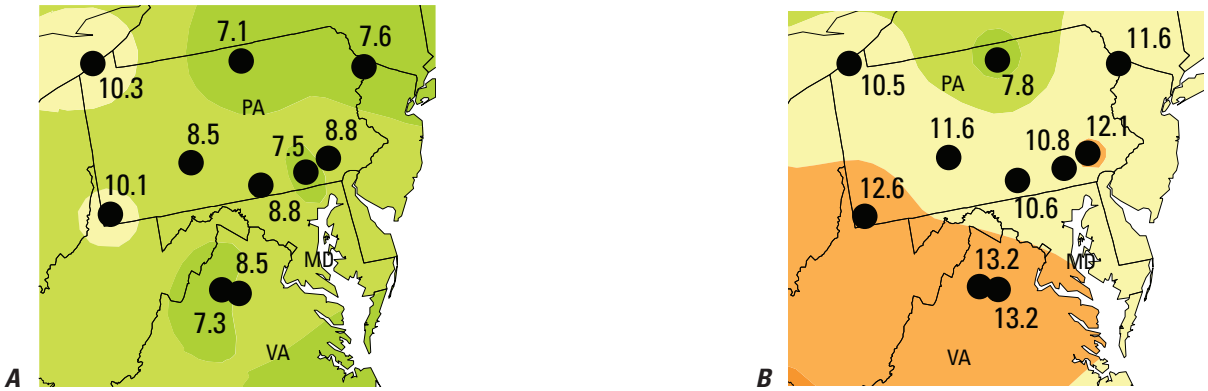


Figure 3. MDN results for 2003 for U.S. mid-Atlantic stations (black dots), including two stations in Virginia. *A*, Average yearly mercury concentration, weighted by volume, in nanograms per liter (1 nanogram equals 10^{-9} grams). *B*, Total mercury deposition for the year, in micrograms per square meter. Each site also showed seasonal variation in mercury concentrations, with the highest values occurring in the summer months. Variation in total mercury deposition mainly reflects differences in precipitation for the year. Color bands indicate contoured 2003 results. Maps from National Atmospheric Deposition Program - Mercury Deposition Network (http://nadp.sws.uiuc.edu/mdn/).

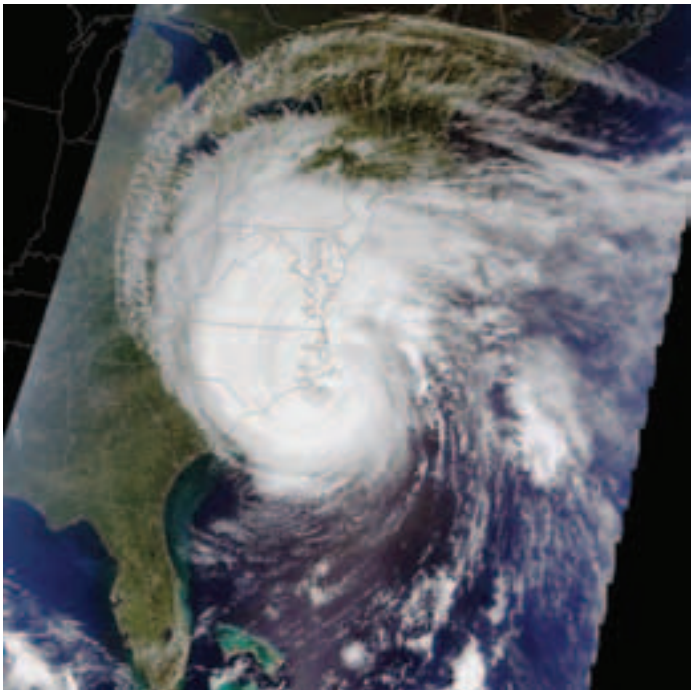


Figure 4. Satellite view of Hurricane Isabel, September 18, 2003, 11:50 a.m. From NASA Terra satellite, **http://science.nasa.**gov/headlines/y2003/18sep_isabel.htm.

to each other (31 kilometers) is among the closest in the MDN, allowing comparisons of local mercury deposition at different elevations. Station VA–28 is also used to monitor potential mercury exposure by wildlife in Shenandoah National Park.

Annual MDN results for 2003 (fig. 3) showed a gradual southward increase in mercury deposition across the mid-Atlantic region. These results are consistent with the high levels of mercury deposition that occur in the southeastern States. A longer period of observation, however, is needed to assess nationwide patterns and differences among MDN sites in the region.

Most MDN sites also show seasonal variations, with increases in mercury concentration and total deposition in the warm weather months. For the year 2003, mercury concentrations were higher at Culpeper (lower elevation) than at Big Meadows (higher elevation). Because precipitation was greater at Big Meadows, however, total mercury deposition at both sites was nearly the same. Additional yearly results will soon be available as data for 2004 and for three new MDN stations in Virginia and Maryland—VA–98 (Harcum; lower Chesapeake Bay), MD–08 (Piney Reservoir; Garrett County, western Maryland), and MD–99 (Beltsville; suburban Washington, D.C.)—are finalized.

Generally, weekly MDN samples cannot be linked to specific weather events. For samples taken the week ending September 22, 2003, however, most mid-Atlantic MDN sites showed unusually low mercury concentrations. These samples consisted predominantly of precipitation from Hurricane Isabel, which came ashore along the North Carolina coast and followed a path northward through the region (figs. 4, 5). Mercury concentrations in precipitation from Hurricane Isabel were much below average for that time of year (fig. 6), consistent with the depletion of mercury from the atmosphere by the heavy rain and the origin of the storm far from anthropogenic mercury sources.

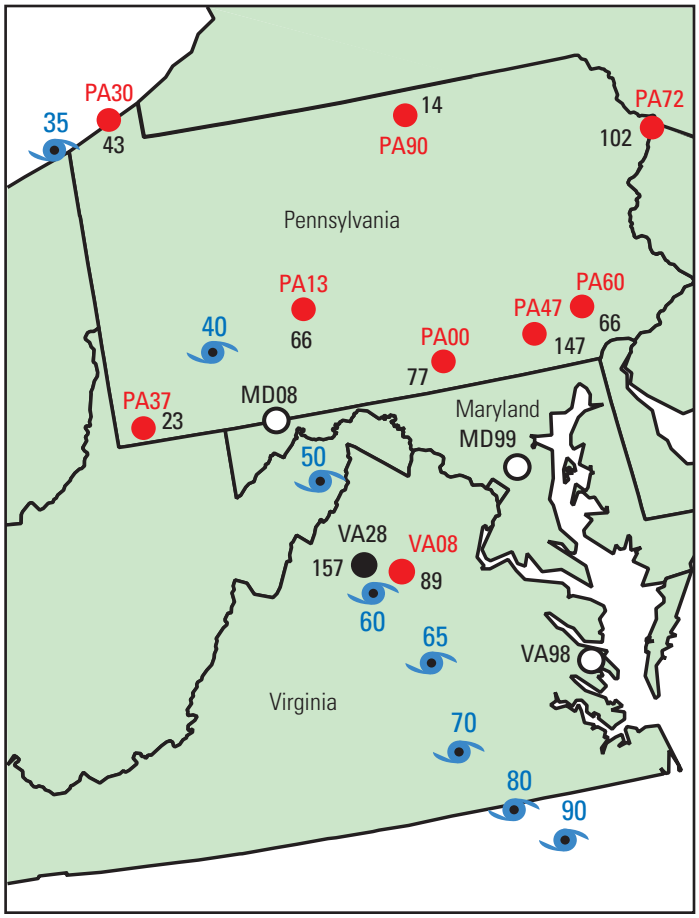


Figure 5. Map showing locations of U.S. mid-Atlantic MDN sites active in 2003 (solid symbols) and sites used to calculate average mercury concentrations (red symbols; see fig. 6 for concentration data) for the weeks leading up to and following Hurricane Isabel (September 18–19, 2003). Precipitation amounts (black numbers; in centimeters) are shown for the week ending September 23, 2003, as are the path (hurricane symbols) and wind speed (blue numbers; in mph) of the hurricane. Open symbols indicate MDN sites added after September 2003. Black symbol for MDN site VA–28 indicates that this site was excluded from the mercury concentration averages shown in figure 6 due to loss of power, which resulted in shutdown of the station during the hurricane. Storm track for Hurricane Isabel is plotted from information available at http://hurricane.csc.noaa.gov/hurricanes/. Modified from Kolker, Allan, Mose, D.G., and Spitzer, Shane, 2004, Filling a gap: MDN stations VA–08 (Culpeper) and VA–28 (Shenandoah National Park–Big Meadows) in Virginia [abs.]: National Atmospheric Deposition Program (NADP), 2004 Scientific Symposium, Halifax, Nova Scotia, Canada, 2004.

The Need for Measuring Mercury Deposition

Recent work (for example, see http://www.umanitoba.ca/institutes/fisheries/METAALICUS.html) suggests that new mercury added to the environment by atmospheric deposition is more prone to become methylmercury than mercury already present in sediments. It is therefore very important to quantify

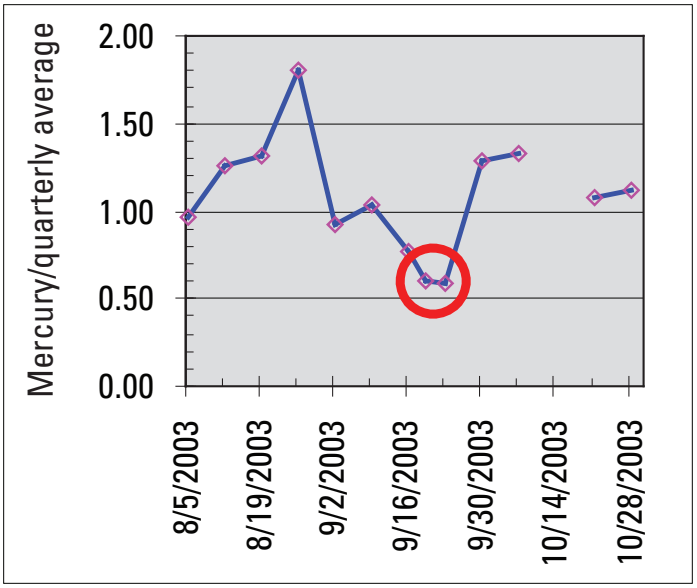


Figure 6. Mercury concentration averages of nine U.S. mid-Atlantic MDN stations affected by Hurricane Isabel, normalized to quarterly averages for the respective stations for the period shown. Plot shows a pronounced mercury concentration low for the first samples taken after the hurricane (red circle). Results for site VA–28 (Shenandoah National Park) are excluded due to site operation problems resulting from the hurricane. Modified from Kolker, Allan, Mose, D.G., and Spitzer, Shane, 2004, Filling a gap: MDN stations VA–08 (Culpeper) and VA–28 (Shenandoah National Park–Big Meadows) in Virginia [abs.]: National Atmospheric Deposition Program (NADP), 2004 Scientific Symposium, Halifax, Nova Scotia, Canada, 2004.

the amount of mercury deposited each year from atmospheric sources.

Currently, coal-fired powerplants are the largest industrial source of U.S. mercury emissions. The U.S. Environmental Protection Agency (USEPA) has approved a long-term plan to cap and reduce mercury emissions from coal-fired power-generating stations (see http://www.epa.gov/oar/mercuryrule/ for information on the USEPA Clear Air Mercury Rule). The MDN will be a primary tool for measuring the overall effectiveness of the new mercury rule. For example, the growth of the MDN has led to an increased ability to map regional patterns of mercury deposition. Documenting these patterns will help establish baseline mercury levels prior to the implementation of the USEPA plan.

The impact of the USEPA plan should be greatest in the eastern third of the United States, where the levels of mercury deposition are highest. A similar plan to limit emissions of sulfur dioxide resulted in a large decrease in deposition of sulfate (the main component of acid rain) in the East in the last decade.

Summary

The addition of new MDN stations in the mid-Atlantic region has greatly improved the ability to assess the impact of reduced mercury emissions from coal-fired powerplants in the region and in neighboring States. As the density of MDN stations increases, the network will also become more effective in defining local variations and improving yearly estimates of mercury deposited from the atmosphere to ecosystems in different regions.

By Allan Kolker,[1] Douglas G. Mose,[2] Shane Spitzer,[3] and Joseph A. East[1]

[1]U.S. Geological Survey, MS 956, National Center, Reston, VA 20192.

[2]George Mason University, Department of Chemistry, Fairfax, VA 22030.

[3]National Park Service, Shenandoah National Park, Luray, VA 22835.

For further information on Station VA–08, please contact

Allan Kolker
U.S. Geological Survey
956 National Center
Reston, VA 20192

Prof. Douglas G. Mose
Department of Chemistry
George Mason University
Fairfax, VA 22030

For further information on Station VA–28, please contact

Gordon Olson
Division of Natural and Cultural Resources
National Park Service
Shenandoah National Park
Luray, VA 22835-9036

Additional Resources

Shenandoah National Park Air Monitoring Program
http://www.nps.gov/shen/SHEN_IM/m_prog_air.htm

National Park Service, Center for Urban Ecology,
Air Resources Page
http://www.nps.gov/cue/programs/air/air_resources.htm

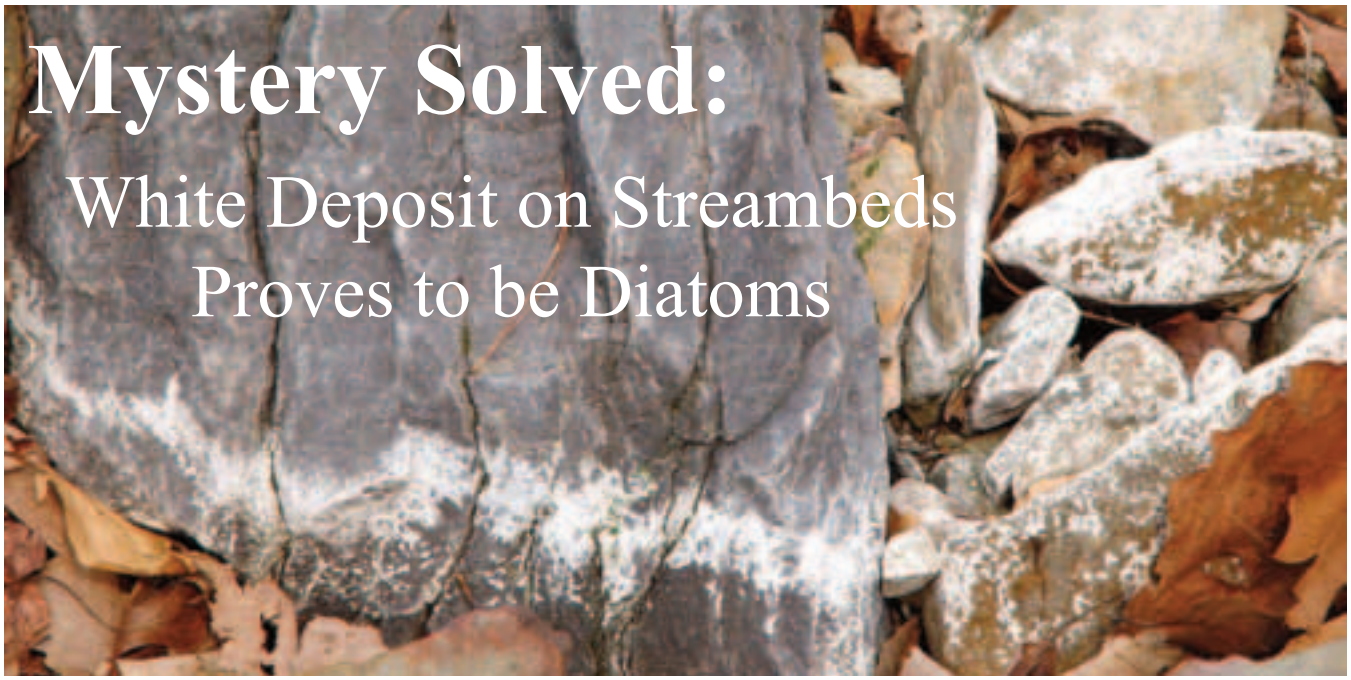
USGS Mercury Research
http://minerals.usgs.gov/mercury/

Fish and wildlife studies, methylation, and mercury in plants and/or organisms
http://co.water.usgs.gov/trace/

Mercury cycling in watersheds and aquatic ecosystems
http://toxics.usgs.gov/about.html

Mystery Solved:

White Deposit on Streambeds Proves to be Diatoms



By Rick Webb and Karen Rice

In the late winter and spring of 2006 an unusual white deposit was observed on rocks and margins of streambeds in a number of park streams. Inquiries were made to park staff and scientists studying water resources in the park as to what the deposit was and did it pose any type of risk. A number of explanations were proposed, but it was not until samples were collected and examined with a scanning electron microscope that the identity of the deposit was definitively determined.

The mystery deposit consists of diatoms.

Diatoms are single-celled, photosynthetic algae found in both marine and freshwater habitats, as well as in other damp environments. Diatoms are notable for their intricately structured cell walls, or frustules, which are made of silica. Although diatoms are microscopic, they are extremely abundant and an important part of the food web. It is estimated that diatoms are responsible for 20% to 25% of all organic carbon fixation on the planet. Although the silica cell walls of diatoms settle in large deposits on the ocean floor, deposits in freshwater streams such as those observed in the park generally do not occur.

So, why were there diatom deposits on park stream beds in the early spring of 2006? A couple of factors may have been involved.

One factor is that stream flows were unusually low for the season, leaving diatoms vulnerable to desiccation on dry streambeds. An increase in algal growth is often observed in park streams in the winter and early spring when the forest canopy is open and streams are exposed to sunlight. Later in the growing season algal growth diminishes as the canopy leafs-out and less sunlight reaches the streambeds. The spring of 2006 appears to have been unusual because water levels dropped during the period when algae were growing rapidly.

Supporting evidence for the low-flow explanation is provided by examination of the Palmer Drought Severity Index (PDSI), which is a measure of relative dryness based on temperature and rainfall information. During the first 15 weeks of 2006, the PDSI for the three western Virginia climate divisions that include the park changed from "Abnormally Moist" in January to "Abnormally Dry" in early April (SRCC, 2007).

Another possible factor is that diatom populations in park streams may be increasing. Trend analysis using

Above: A view of the white deposit. Samples were collected from the Big Run and Moormans River watersheds. A scanning electron microscope was used to determine the structure and composition of the material. Photo by Rick Webb.

Below: The white deposit observed on rocks in a dry streambed in the Big Run watershed. Photo by Rick Webb.

quarterly stream water composition data obtained through the Shenandoah Watershed Study (SWAS) indicates a statistically significant decrease in stream water concentrations of silica during 1988-2003. The median decrease in silica concentration in 14 SWAS study streams was about 7.5 µmol/L in this 15-year period. Grady et al. (2007) suggested that this decrease in dissolved silica in stream water occurred due to increased uptake by diatoms.

After examining a number of possible explanations for the change in stream water concentrations of silica, Grady et al. (2007) proposed that diatom numbers increased in response to increased nitrogen availability in stream water. During the early 1990s, a gypsy moth outbreak caused forest defoliation, which then caused increased nitrogen concentrations in stream water (Webb et al., 1995). If the increase in diatoms is related to the increase in nitrogen, silica concentrations in park streams should increase if nitrate concentrations return to pre-defoliation levels. SWAS continues to monitor park stream water chemistry to document such ecological changes.

Literature cited

Grady, A.E, T. M. Scanlon, and J.N. Galloway. 2007. Declines in dissolved silica concentrations in western Virginia streams (1988-2003): Gypsy moth defoliation stimulates diatoms?, Journal of Geophysical Research – Biogeosciences, 112, G01009, doi:10.1029/2006JG000251.

SRCC, 2007. Southeast Regional Climate Center, Drought and Agricultural Information (http://www.sercc.com/climateinfo/drought.html)

Webb, J. R., B. J. Cosby, F.A. Deviney, K. N. Eshleman, and J. N. Galloway. 1995. Change in the acid-base status of an Appalachian Mountain catchment following forest defoliation by the gypsy moth. Water, Air, and Soil Pollution, 85: 535-540.

Rick Webb is with the Department of Environmental Sciences at the University of Virginia. Karen Rice is with the Virginia Water Science Center of the U.S. Geological Survey. *The author wishes to thank Amy Grady, Nick Evans, Linda Blum, Kenneth Lawless, Chip Morgan, and Todd Scanlon for their help in developing the information in this article.*

Left: Scanning Electron Micrograph of streambed deposit showing diatom cell-wall structures. Additional analysis showed that the deposit was primarily silica. The sample was collected from the Big Run watershed in the spring of 2006. (Image provided by Dr. Kenneth Lawless, Department of Material Science and Engineering, University of Virginia).
Right: Scanning Electron Micrograph of streambed deposit collected from the North Fork of the Moormans River in the spring of 2006. (Image provided by Dr. Kenneth Lawless, Department of Material Science and Engineering, University of Virginia).

Leadership Changes

In August of 2006, Gary Somers, Chief of the Division of Natural and Cultural Resources here at Shenandoah announced that he would be transferring to Nez Perce National Historical Park in Idaho. Gary would be promoted to the Superintendency with this move.

Gary spent about seven and a half years working at Shenandoah. During his tenure here, he made several improvements to the resource management operation including restructuring the Division to have an integrated Natural Resource Branch, working to make all the Branches within the Division work more closely together and making compliance more user friendly and a process all in the park could understand. He was particularly proud of being successful in getting regional and national recognition for the great work the staff was doing. These included national awards for Reed Engle's work in cultural resource management and the work of many in the park, including Steve Bair, in wilderness stewardship. On a parkwide basis he helped make major strides in integrating the resource management staff and programs with other divisions and took on some of the "harder" issues in the park, particularly Old Rag parking, administrative roads and mowing. Finally, he worked tirelessly to improve relations between all of the Divisions within the park.

In February, 2007, it was announced that Gordon Olson, who had been serving as the Natural Resource Branch Chief, would be taking over as the new Division Chief.