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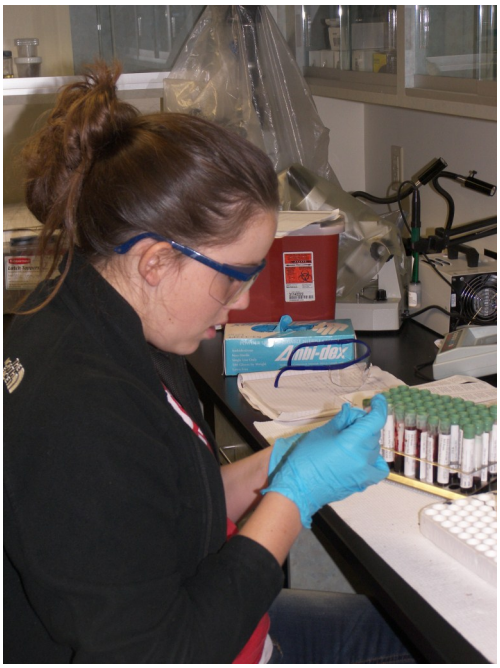
Monitoring and Education in the National Parks

By Ted Gostomski, Network Science Writer

This article is adapted from one that appeared in the June 2013 issue of the Midwest Region's e-newsletter, *Action in the Heartland: Answering the Call in the Midwest.*

> *"A sustained commitment is needed to strengthen the educational role of the Park Service, including the creation of new partnerships with the formal education community."*
>
> National Parks Second Century Commission Report

The National Park System has a lot to offer in terms of science education. The trick is to recognize the opportunities for engaging students (of all ages) and then making that engagement memorable. The National Parks Second Century Commission Report recommends this[1], and the National Park Service *Call To Action* (C2A) does as well[2]. Through Action items such as "Next Generation Stewards," "Live and Learn," and "Scholarly Pursuits," the NPS is encouraging students of all ages to become involved with research and monitoring in the national parks.



Sophie Howk prepares eaglet blood samples for analysis.

The Inventory and Monitoring program's long-term monitoring projects offer excellent opportunities for teachers and their students to take classroom lectures and apply them to real-life study in the parks. The Great Lakes Network has been working with a local high school science teacher to do just that in the Apostle Islands.

Bayfield High School science teacher Rick Erickson has a long-standing interest in teaching practical applications of chemistry, especially as it relates to the local environment. So he jumped on the chance to participate in a 2008 workshop on "Linking Research and Education" organized by the NPS Great Lakes Research and Education Center. While there, Erickson worked with Bill Route from the Great Lakes Network office and resource management and interpretation staff from Apostle Islands National Lakeshore to develop a classroom lesson plan based on the Network's monitoring of contaminants in bald eagles nesting in the Apostle Islands. Erickson wasted no time in working the lesson plan into his classes.

"I like students to see the connections between classroom science and the real world," says Erickson. "With this lesson plan, they learn about practical applications of chemistry and develop good research skills, but they also provide real data towards ongoing monitoring in the Apostle Islands."

Erickson encourages his students to develop their own independent research projects, and the I&M Network provides them with monitoring data to get them started. Erickson works with each student to develop their hypotheses and study design.

(Continued on page 2)

Monitoring, Education, and the National Parks

(Continued from page 1)

He teaches them proper laboratory techniques and methods of analysis and works with them through the summer to collect additional data as needed. How far the students take these projects is up to them. Since 2010, three students whose research projects grew out of Network monitoring data have presented their studies at national-level junior science competitions, earning scholarships for college along the way (*see table*).

Bayfield High School student research projects based on long-term monitoring at Apostle Islands National Lakeshore.

Year	Student	Study
2010	Emma Dalzell	An Investigation of Dissolved Organic Carbon in Water Samples Near Apostle Islands Eagle Nest Sites
2011	Sophie Howk	The Relationship Between Stable Isotope Ratios of Carbon and Nitrogen and Contaminants in Apostle Islands' Bald Eagles
2012	Ellie Hoopman	Stable Isotope Analysis of Apostle Islands' Fish
2013	Emily Hoopman	Stable Isotope Analysis of the Lower Food Web in the Apostle Islands

In 2013, Erickson met Dr. Toben Lafrancois, an Adjunct Assistant Professor at Northland College in Ashland, WI, who has similarly engaged students in monitoring on the St. Croix and Namekagon rivers. Discovering their shared interest, Rick and Toben began working together to develop a project related to Dr. Lafrancois's investigation of stable isotopes in the base level of the aquatic food web (namely, plankton). The stability of these isotopes allows them to be used as a sort of tracking device up through the food chain, perhaps allowing us to determine how contaminants move through the system. High school senior Emily Hoopman is collecting plankton samples from lagoons on Outer, Stockton, and Madeline islands, and from Lake Superior near those islands. She is having the plankton analyzed for stable carbon and nitrogen isotope ratios and will compare those ratios between near-shore and deeper-water samples as well as lagoon vs. open water samples. The results of this work are important for understanding patterns of contaminant accumulation in this fraction of the food web.

Emily Hoopman collects water samples from Lake Superior near Outer Island (APIS). Plankton are filtered out of these samples and used to study contaminants in the base of the aquatic food chain.

"When you get students involved in the science and actively participating in the fieldwork, you open up a whole new audience, extending the value of your work into future generations," says Dr. Lafrancois. "If done right, you are creating immediate opportunities—like scholarships, providing training in a particular skill set, encouraging creative and intelligent inquiry, and most importantly setting in motion a lifelong engagement with our national parks."

Student projects like these demonstrate the benefits of using "Parks for Science" and how Network monitoring can lead to more specific research. Even more important are the opportunities Rick Erickson and Toben Lafrancois offer students to gain skills and knowledge that will last a lifetime. ●

[1] www.npca.org/protecting-our-parks/policy-legislation/second-century-commission/

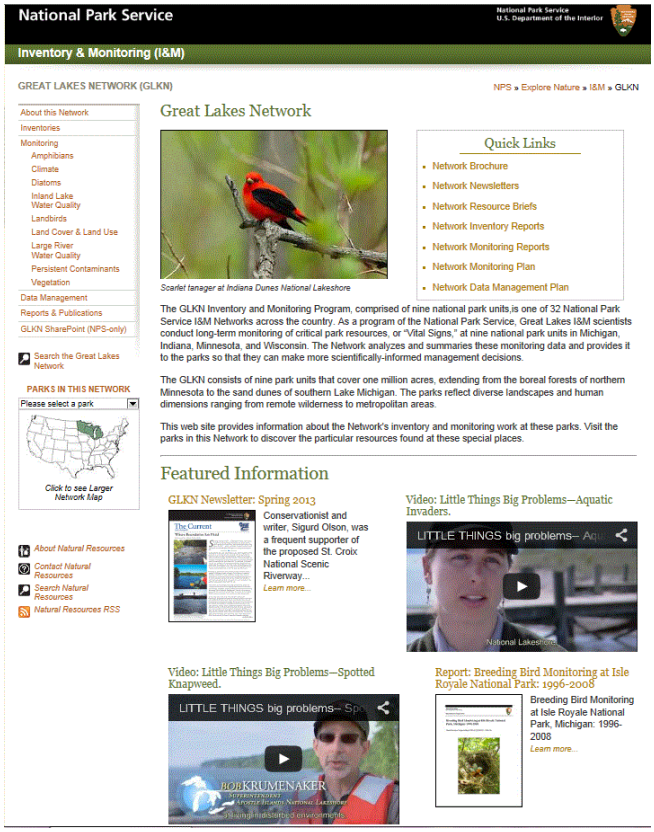
[2] www.nps.gov/calltoaction/

In September, Rick Erickson was chosen as the **2013 Wisconsin High School Teacher of the Year** (http://www.dpi.wi.gov/files/eis/pdf/dpinr2013_106c.pdf; http://www.wdio.com/article/stories/s3164531.shtml). **Congratulations, Rick!**

Updates and Changes

The data management team in Fort Collins announced updates to the NPSpecies database that took effect this summer. Overall these changes were designed to make NPSpecies easier to use, more responsive to changes in park species lists, and more informative.
https://irma.nps.gov/App/Portal/Home

The Network unveiled a new look to its website in August, part of a Service-wide re-working of all the I&M websites (*image at right*). Highlights include a "Featured Information" section and an easy-to-navigate publications page. Coming soon – individual pages for each Network park.
http://science.nature.nps.gov/im/units/glkn/



Our monitoring of contaminants in fish is evolving to become a volunteer-based program that engages park staff and the public to collect dragonfly larvae. This is due in part to the cost of analyzing the large amount of fish tissues that are collected each year. It is also because we have learned from the past six years of monitoring that dragonfly larvae can serve as a reasonable predictor of mercury levels, one of the most pervasive contaminants in park lakes and rivers. For more information, see the Resource Brief "Using Larval Dragonflies to Monitor Mercury" on our website. Click on "Persistent Contaminant Monitoring Briefs."
http://science.nature.nps.gov/im/units/glkn/publications.cfm ●

Staff Insider

Bill Route, Network Coordinator

Bill Route has a BS in wildlife resources from the University of Idaho and an MS in vertebrate ecology from Michigan Technological University. His affiliation with the NPS began at VOYA, where he held positions as volunteer, biological technician, graduate student, contractor, and term employee before becoming a permanent employee. He then worked at parks in Alaska and New Mexico before leaving the NPS to be biologist and curator at the International Wolf Center in Ely, Minnesota, and to work as a private contractor. While working as a contractor, Bill became the Network's first coordinator in 1999 and was later hired for the position. In addition to his administrative duties, Bill runs the Network's contaminants monitoring program, spending many weeks in May and June visiting eagle nests to collect blood and feather samples from nestlings at APIS, SACN, and MISS. ●

2013 Field Season Summary

As the information gathered by our long-term monitoring programs begins to accumulate in the databases, we are reaching a point where we can begin doing some meaningful analyses. Thus, with this 10th issue of *The Current*, we have replaced the large format center-spread with an extended version of the field summaries, some of which include analysis and interpretation of monitoring data. ●

Amphibians

The Network began amphibian monitoring in five parks this year, using pre-programmed digital song meters ("frog loggers") placed at pre-selected sites to record frog and toad calls. This is an efficient method in that monitoring staff do not need to visit sites in the evening. However, we did encounter a number of issues resulting in lost data, including premature shut-off, battery failure, theft, and animal damage. We are investigating and seeking solutions to these problems. Despite the difficulties, acceptable recordings were collected from 31 sites across the five parks.

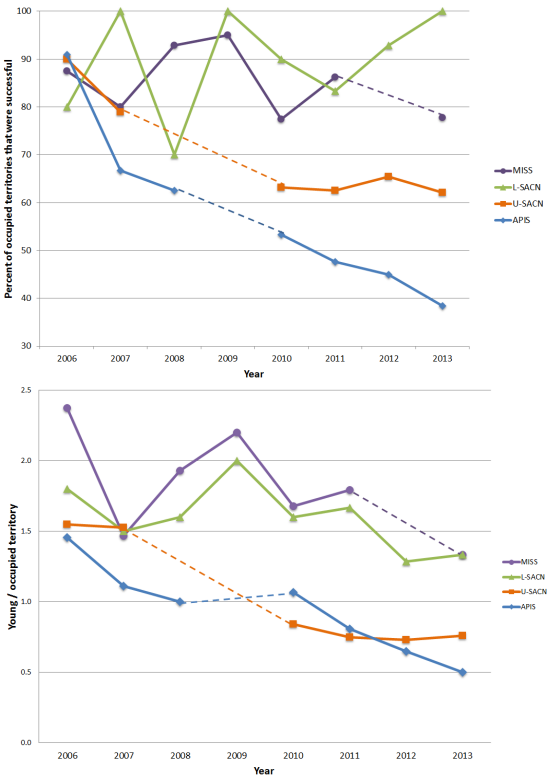
Bioaccumulative Contaminants

There was no data collection for either the bald eagle or fish segments of this program in 2013, except for assessments of eagle nest occupancy and productivity. Analysis of the fish and dragonfly larvae data from the previous six years continues at the University of Wisconsin–La Crosse.

Trends in bald eagle productivity

An important aspect of monitoring contaminants in bald eagles is conducting annual surveys to determine nest occupancy and productivity. These surveys help us locate active nests and they provide an assessment of the eagle population's health.

Surveys show that both nest success and productivity have declined since 2006 at the three parks where we are monitoring (MISS, SACN, APIS). The exception is the lower St. Croix River (L-SACN) where nest success increased the last two years (*see graphs*). An eagle population is considered healthy when 50% or more of the occupied territories are successful and they produce an average of at least one young per nest. APIS has been below the nest success threshold in each of the past three years, and the upper SACN (U-SACN) has been below the productivity threshold for four years. So what's up?



Percent of occupied territories that were successful (top) and the number of young per occupied territory (bottom) for bald eagles at APIS, SACN (above St Croix Falls=U-SACN; below St Croix Falls=L-SACN), and MISS. Dotted lines span years when surveys were not conducted. Data from the WDNR (APIS, SACN) and from Network surveys (MISS).

The Wisconsin Department of Natural Resources (WDNR) has conducted occupancy and productivity surveys across the state for over 40 years. They find that Wisconsin's eagle population continues to grow, and, similarly, our surveys at MISS show an increasing number of nesting pairs. However, northern areas, particularly near Lake Superior, are less productive compared to other areas. Northern Wisconsin lakes produce fewer fish that eagles need to feed and raise their young. In fact, occupancy and productivity rates at APIS and on the U-SACN may have been over-estimated prior to 2010. In 2010 the WDNR changed observers for surveys conducted in the northern areas, and that change resulted in a slightly different interpretation of what constitutes an "occupied" territory. We believe part of the population decline at APIS and U-SACN after 2009 can be attributed to this change in observers. Weather also plays a part. Northern regions are prone to severe weather just when adults are incubating eggs or caring for young. For

Acronym Decoder

APIS
Apostle Islands National Lakeshore (Wisconsin)

GLKN
Great Lakes Inventory and Monitoring Network

example, in 2013 an unusually cold spring with heavy snows hit much of northern Wisconsin, and some nests likely failed due to abandonment and chilled eggs. The exact causes of nest failure are difficult to determine, but we have tested these declines against contaminant levels and find no indication that contaminants have been the cause.

Another possibility is that occupancy and productivity are declining in response to a nearly saturated population. Bald eagle numbers have increased dramatically across the upper Midwest, and there are indications that some areas may be approaching a habitat threshold. The literature states that average territory size for a nesting pair of eagles is about 1 km^2 (0.3 mi^2). Assuming a nest is at the center of a territory, nests should be no closer than 0.6 miles from one another. Yet, along the Mississippi and lower St. Croix rivers, we are finding nests as close as 600 meters (0.3 miles) from one another.

Mercury bioaccumulation in larval dragonflies

Since 2008 we have monitored bioaccumulative contaminants in GLKN index lakes, streams, and wetlands at INDU, GRPO, ISRO, PIRO, SLBE, and VOYA by collecting water, surficial sediments, seston, dragonfly larvae, prey fish and predatory fish. Dragonfly larvae were identified to species and gender, then measured and freeze-dried. Individual larvae were analyzed whole for total and methylmercury concentrations. We compared these concentrations to those in the water and the fish from each water body.

Clubtail dragonfly species (Family Gomphidae) were collected most frequently in the four park units where inland lakes were sampled (ISRO, PIRO, SLBE, and VOYA), and represented 38% of all dragonfly individuals collected during the 2008–2012 surveys. Ten species of clubtail were collected across 17 lakes. Four species occurred in six or more water bodies and were collected in high numbers. One species, *Gomphus spicatus*, also known as the "Dusky Clubtail," was found in 13 of the water bodies. *Gomphus spicatus* is known to be common throughout the northeastern United States and is found northward into Ontario, Quebec, and the Maritime Provinces. This widespread species appears to be a strong candidate for use as a sentinel organism across much of this region. Methylmercury concentration in *Gomphus spicatus* did track ambient concentrations of total mercury measured in unfiltered water across water bodies and was a reasonable predictor of average mercury concentration in coexisting predatory fish (*Figure 1*).

Clubtail dragonflies are less common in small streams and in wetlands, which are the types of water bodies sampled at GRPO and INDU, respectively. In these ecosystems, dragonfly species in the families Corduliidae (the "emeralds"), Libellulidae (the "skimmers"), and Aeshnidae (the "darners") proved to be good sentinel organisms. Mean methylmercury concentrations for individuals from these three families were substantially greater at GRPO than at INDU (*Figure 2*). This finding was somewhat surprising given that GRPO, located on the north shore of Lake Superior, is relatively far from industrial emissions of mercury, whereas INDU is located near the coal-powered steel mills of northern Indiana and Illinois.

These findings suggest that larval dragonflies can be cost-effective alternatives to fish as sentinel organisms for monitoring mercury contamination in freshwater ecosystems. A new study being conducted by

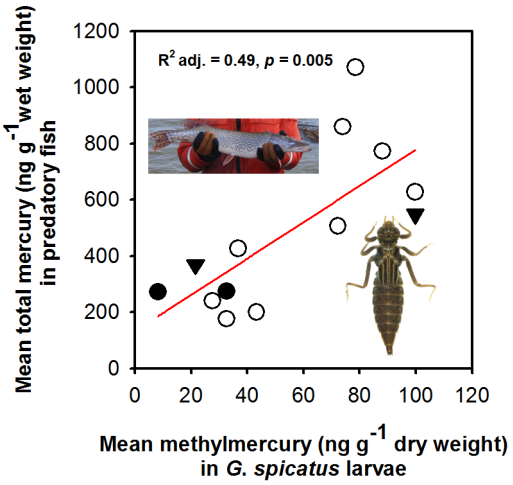


Figure 1. Linear regression between mean concentrations of total mercury in axial muscle of three predatory game fishes and the mean concentration of methylmercury in coexisting larval *Gomphus spicatus* in 11 lakes. Open circles= northern pike, closed circles= largemouth bass, and inverted triangles= smallmouth bass. More than one species of predatory game fish were analyzed In two of the lakes. Nanograms per gram (ng g-1) is equivalent to parts per billion.

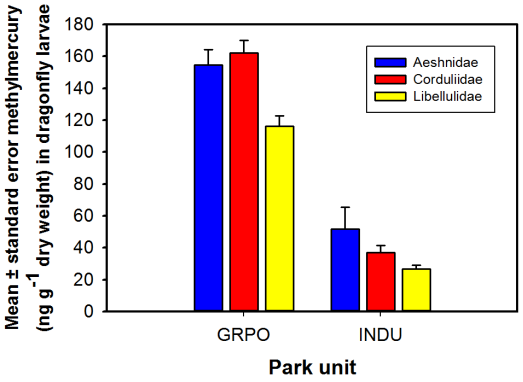


Figure 2. Mean ± standard error (SE) of whole-body methylmercury concentrations for larval dragonflies in three families (Aeshnidae, Corduliidae, and Libellulidae) collected from water bodies in GRPO and INDU. Nanograms per gram (ng g^{-1}) is equivalent to parts per billion.

(Continued on page 6)

2013 Field Season Summary

(Continued from page 5)

NPS Air Resources Division in cooperation with the University of Maine is using dragonflies as biosentinels and citizen-science partnerships to evaluate risk factors associated with mercury contamination in national park units across the country. Engaging citizen-scientists in the collection of dragonfly larvae for mercury research can help visitors learn "about the connection of all living things, the influence humans have upon natural systems, and how environmentally-responsible decisions can protect our parks and the planet" (National Park Service. 2011. *A Call To Action*. Available online at www.nps.gov/calltoaction/).

Landbirds

This was a challenging year for landbird surveys, as long-time surveyors at four parks (ISRO, SACN, SLBE, and VOYA) hung up their binoculars in one way or another. Other difficulties prevented surveys from being conducted at APIS and MISS, but data collection is expected to resume at both parks in 2014.

Grand Portage National Monument

Debbie Petersen returned to conduct surveys at GRPO this year, assisted by GRPO museum technician Stephen Veit. Excluding birds that could not be identified during the counts, there were 43 species observed this year. An average of 53 species have been observed each year since 2006. According to Petersen, higher than average species numbers were documented in the years when the first surveys were conducted before 10 June. "I am concerned that species that are documented before June 10 may be migrants," she writes. "The Minnesota Breeding Bird Atlas parameters list 10 June to 10 July as the 'safe dates' for collecting breeding bird data in the Grand Portage area."

Indiana Dunes National Lakeshore

Surveys were conducted at all 50 points by long-time observer Ralph Grundel (USGS). He recorded 329 birds of 52 species.

Isle Royale National Park

Despite losing Alex Egan, the park's tenured bird observer and biological technician since 1998, the park was able to complete all eight transects. A great deal of thanks goes to volunteers David and Sarah Fehringer, who completed six of the transects over a 10-day period. Long-time volunteers, Candy and Rolf Peterson, completed the other two transects, which they have done since surveys began in 1994. Preliminary results indicate a total of 52 species and 1,002 individuals were recorded during this year's point counts. These numbers are below the 17-year (1996-2011) averages of 57 species and 1,457 individuals.

Pictured Rocks National Lakeshore

Scott Hickman was contracted to conduct surveys at PIRO for the third consecutive year. Winter and cold temperatures lingered longer than average, which delayed bird migration. Consequently, the surveys were started a week later than normal because birds were still migrating through on the normal start date. Though vocalizations associated with nesting started late, they diminished sharply by the middle of June. Despite the abnormal year, 772 birds of 72 different species were detected this year. An eastern whip-poor-will heard at one point was a new species for the PIRO surveys.

Yellow-headed blackbird. *Photo by Dave Menke / U.S. Fish and Wildlife Service.*

Sleeping Bear Dunes National Lakeshore

Volunteer Mick Seymour took over survey responsibilities from Alice Van Zoeren this year. He recorded 880 birds among 79 species in 2013, including two prairie warblers.

St. Croix National Scenic Riverway

Recently-retired SACN biologist Robin Maercklein returned as a volunteer to do this year's surveys with assistance from SACN staff. Robin reported that, "Blackpoll warblers are rarely found on the survey, but we found one on the lower Namekagon River. Also, just downstream from the confluence of the Apple and St. Croix rivers, yellow-headed blackbirds and marsh wrens have been

known to nest in "Rice Lake" (a.k.a. the Wisconsin DNR's St. Croix Island Wildlife Area). However, as the area has seen high water during the surveys in the past few years, both species had disappeared. I am happy to report that with the return of normal water levels, both have species returned to this area."

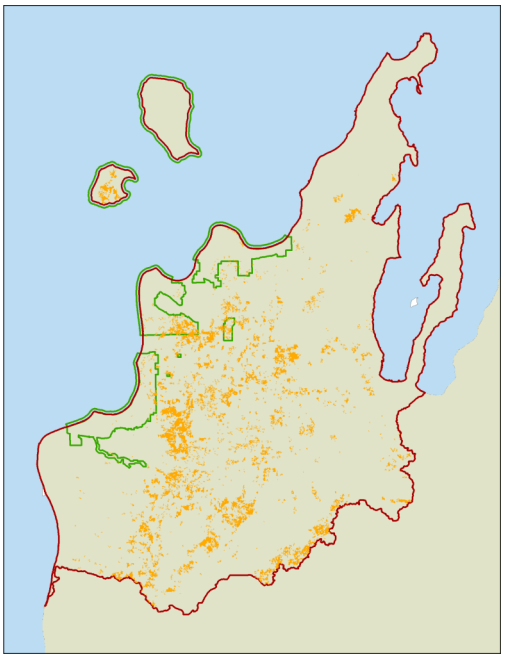
Voyageurs National Park

Long-time observer, Lee Grim, retired from the breeding bird survey this year and passed the binoculars to Sarah Malick and Lisa Maas. Despite a few challenges locating points for the first time, Sarah and Lisa were able to survey the majority of historic points, recording 741 birds representing 51 species. The greatest identification challenge this year was a powerful squawk emanating from about 100 meters from one point. After the survey, we traced this unusual vocalization to its source, and discovered it came from a treed raccoon!

Land Cover/Land Use

We analyzed land cover change at PIRO and SLBE this year. These two parks protect significant portions of shoreline along lakes Superior and Michigan, respectively. We mapped and analyzed land cover disturbance within and adjacent to both parks, encompassing 235,000 hectares (580,000 acres) at each park, for a total of 470,000 hectares (1.1 million acres).

PIRO is rather unique in that nearly 60% of the park land is not owned by the park. Instead, it is largely state and industrial forest land. Consequently, forest harvest is a significant disturbance agent within the park boundary. Very little development is occurring, even outside the park. On the other hand, there is a great deal of agricultural land around SLBE (mostly fruit orchards and berry production), and, to a lesser degree, privately-owned woodlots. As a result, only a small amount of forest harvest occurred around SLBE during the analysis period, and those harvests were typically in smaller, isolated patches. An extensive defoliation event occurred in 2009 and 2010 due to a gypsy moth outbreak (*see map*), and that was by far the largest disturbance in the region.



Extent of defoliation (shown in orange) caused by gypsy moths in and around Sleeping Bear Dunes, Michigan, in 2009 and 2010. Defoliation on South Manitou Island occurred in 2006. Park boundary is shown in green. The total analysis area is shown in red.

The GRPO trail inventory and condition assessment is now complete, and all trail assets have been geo-located using GPS. This information will feed directly into the park's Facility Management Software System (FMSS) database to assist with directing where maintenance is needed.

The Network funded an air photo project at INDU this past spring. The imagery is high resolution (0.15 m, or 6 inches), and preliminary products appear to be very good quality. High resolution elevation data was also collected as part of this project, using LiDAR (Light Detection and Ranging). This is an exciting addition to the air photos, and will provide a 1 m resolution product with vertical accuracy around 15 cm.

Vegetation

The vegetation monitoring crew spent the summer at SACN, resampling the 35 plots established there in 2007 and installing another 15 plots. Collectively, the 50 plots will be critical for understanding forest response following the arrival of emerald ash borer, a non-native beetle. Emerald ash borer (EAB) was found in May of 2009 in St. Paul, Minnesota, approximately 13 miles west of the riverway, near its southern boundary. In the summer of 2013, EAB was found in Superior, Wisconsin,

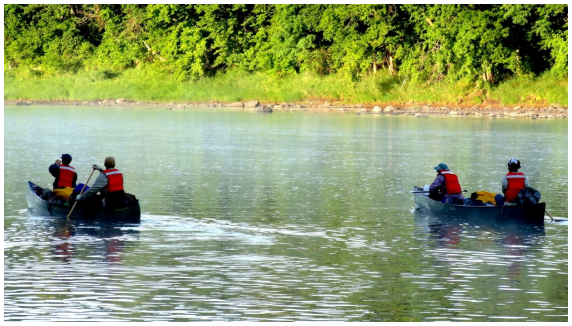
(Continued on page 8)

2013 Field Season Summary

(Continued from page 7)

approximately 35 miles from the riverway's northern boundary. EAB kills all ash species, and there is no known resistance. Because black ash is abundant throughout the riverway, Network data collected this year and in 2007 will provide valuable, pre-borer reference conditions.

Several plots showed evidence of the 2011 tornado and severe wind event, though only four plots were severely impacted. Blowdown was apparent in one of the new plots (established in 2013), just outside of Danbury. In three other plots (two new plots, and one revisit), salvage logging created clear-cut-like conditions.



The vegetation monitoring crews set off for a day of sampling along the St Croix River. *Photo courtesy of Joseph W. Johnson.*

We located four exciting species in our plots during the 2013 sampling season. Marsh horsetail (*Equisetum palustre*), a special concern species in Wisconsin, was found in six plots on the Wisconsin side of the riverway, while prickly current (*Ribes oxycanthoides*), a threatened species in Wisconsin, was found in a plot near Cable. We also located American ginseng (*Panax quinquefolius*), and we documented staff trees (*Staphylea trifolia*) in Pine County, Minnesota. This likely represents a county record and the most northerly distribution of this tree in the State of Minnesota. A sample of this population will be collected during flowering in May of 2014 and sent to the Bell Museum at the University of Minnesota to confirm its identification.

Water Quality—Large Rivers

This year's monitoring at MISS and SACN was led by SACN Biological Technician Michelle Prosser, with assistance from staff at both parks. This work was previously led by the Network's Rivers Aquatic Ecologist David VanderMeulen, but his position was vacated in February when he assumed the Network's aquatics program manager position after Joan Elias retired.

Seven out of eight planned monitoring rounds were completed at SACN. Sampling in October did not occur due to the federal government shutdown. This year we joined an ongoing project to sample and assess surface waters in the parks for pesticides, pharmaceuticals, personal care products, and waste water indicators. This project is a collaborative effort among the Environmental Protection Agency (EPA), NPS Water Resources Division, and six other NPS I&M Networks. In 2013, we collected water from four Mississippi River sites and one groundwater spring site (Coldwater Spring) once per month in April, June, and November. The EPA will test the samples for approximately 270 different chemicals, and we will begin to work with our USGS colleagues this winter to assess the data and report on the results.

We made a few adjustments to our monitoring effort at SACN this year: *Monitoring was suspended* at the mouth of the Snake River, a tributary to the St. Croix, and on the St. Croix River above the dam in St. Croix Falls, Wisconsin. We did this to reduce duplicity, as these sites are being monitored by the MPCA and the WDNR. We *added monitoring sites* on the St. Croix River at the Highway 70 Bridge near Grantsburg, Wisconsin, and on the Namekagon River at the Namekagon Trail Bridge, approximately 4.5 river miles upstream of the confluence with the upper St. Croix River. The new site on the St. Croix will fill a gap between two other Network sites and give us the ability to assess baseline water quality conditions of the St. Croix River just above the confluence of a tributary that experienced excessive sedimentation caused by a spill from a sand mine in 2012. The new site near the terminus of the Namekagon River will integrate all upstream conditions for this major tributary to the St. Croix. (3) We *added a supplemental monitoring site* near the mouth of the Clam River, another major tributary to the St. Croix. In recent years excessive amounts of algae have been observed in the Clam River, and we are working to understand the extent of the problem.

Water Quality—Inland Lakes

We conducted three rounds of sampling on 32 lakes at APIS, INDU, ISRO, PIRO, SLBE, and VOYA. Vertical arrays of temperature loggers collected data year-round from one lake each at ISRO, PIRO, SLBE (new in 2013), and VOYA. Data from

these arrays are providing important information on available fish habitat and thermal structure of the lakes as it is related to weather and climate. We continued a collaborative project with USGS to sample 16 lakes and four Lake Michigan beach sites for cyanobacteria toxins (see the ISRO, PIRO, and SLBE sections for more details).

Apostle Islands National Lakeshore

This was a year of change for water quality monitoring at APIS, as we continued to work at Outer Island lagoon but suspended sampling at Little Sand Bay, Michigan Island, and Stockton Island lagoons. The latter three lagoons are periodically flushed by Lake Superior, confounding our understanding of current water quality conditions and making interpretation of long-term water quality trends problematic. Three rounds of monitoring were completed at Outer lagoon by David VanderMeulen and Ted Gostomski, with some extra help from Midwest Region Aquatic Ecologist Brenda Moraska Lafrancois. We collected sediment from Outer lagoon in what normally would be an off-year for diatom monitoring at the park.

Indiana Dunes National Lakeshore

As with APIS, we made some changes at INDU this year by dropping monitoring at Long Lake and designating Middle Lagoon as an index lake. By the end of 2012, the water levels in Long Lake receded to the point where what remains is essentially a wetland and no longer a lake. Josh Dickey completed all three sampling rounds at Middle Lagoon, with assistance from other park staff. Going forward we will continue to monitor at Middle Lagoon and to provide technical assistance for other aquatic monitoring efforts.

Isle Royale National Park

Rick Damstra completed all three sampling rounds, with assistance from Water Quality Technician Ryan Bart and park staff. In addition to the routine monitoring, they collected water samples for analysis of algal toxins on four index lakes and two non-index lakes during each sampling round. To-date, toxin levels have been below detection limits. Rick and Ryan also serviced temperature and depth loggers on two streams, conducted flow measurements on Washington Creek to contribute to USGS discharge calculations, and maintained a vertical array of temperature probes on Lake Richie for the fourth full season. Rick and Ryan also helped the park in supporting University of Maine researchers by deploying temperature arrays at additional lakes and serving as boat operators.

Network Lakes Ecologist Rick Damstra deploying a vertical array of temperature probes at Lake Richie, Isle Royale. *NPS photo.*

Pictured Rocks National Lakeshore

This was a year of transition in terms of staffing at PIRO, with the retirement of Lora Loope in February. Still, Leah Kainulainen and Ben Thierry ably completed all scheduled routine monitoring. They also collected water samples for analysis of algal toxins in four index lakes, collected field data from Little Beaver and Little Chapel lakes, and continued bathymetric mapping at Beaver, Chapel, and Miners lakes. In May and October, they downloaded data from and serviced the vertical array of temperature probes in Grand Sable Lake. Leah and Ben also began pilot-testing the Network's wadeable streams monitoring protocol on Miner's River by establishing a monitoring site, collecting macroinvertebrates, and deploying a multiprobe that will continuously collect data on water temperature, pH, specific conductivity, and dissolved oxygen.

Sleeping Bear Dunes National Lakeshore

Chris Otto, with the assistance of other park staff, completed all three rounds of monitoring at six index lakes. Water

2013 Field Season Summary

(Continued from page 9)

samples were also collected for analysis of algal toxins at the lakes and at four Lake Michigan beach sites. In June, a vertical array of temperature probes was deployed in Manitou Lake on North Manitou Island by Network Data Manager Mark Hart and Remote Sensing Specialist Al Kirschbaum. Year-round temperature monitoring will help us understand the timing of ice-out and ice formation on this lake. This additional monitoring, coupled with monitoring of several other vital signs (see 2013 Great Lakes Network Resource Brief "Monitoring North Manitou Island" at http://science.nature.nps.gov/im/units/glkn/publications.cfm), will allow us to connect the dots across multiple monitoring programs.

Voyageurs National Park

Jaime LeDuc completed all sampling, with assistance from park intern Ladd Corrin, other park staff, and volunteers. Special thanks to Ladd Corrin and Brandon Seitz (from Grand Portage National Monument), who, with very short notice, were able to take on additional fieldwork responsibilities in July when Jaime was injured. In May and October, Jaime downloaded data from and serviced the vertical array of temperature probes on Little Trout Lake. After some debate among Network, park, and USGS staff, we decided to continue monitoring mercury in five of the park's inland lakes. Park and USGS staff are completing a trend analysis of a decade's worth of mercury data from these lakes, which also draws on water quality and water level data collected as part of routine Network monitoring.

Diatoms

Analysis of diatom species composition is accomplished by collecting bottom sediment cores every three to five years from inland lakes and from areas of sediment deposition in river sites. The silica-based cell walls of diatom remains are well-preserved in bottom sediments and are easily identified (by expert algologists) to species. Diatoms serve as bioindicators of water quality, as the assemblage of species present reflects conditions in the lake or river.

Semiorbis hemicyclus, a rare diatom found in a sediment sample from Outer Island Lagoon at APIS. *Photo by Mark Edlund.*

In 2013 our collaborators at the St. Croix Watershed Research Station caught up on a backlog of previously collected samples by analyzing surface sediment collected in 2011 from APIS, INDU, MISS, and SACN, and in 2012 from ISRO. Findings from this and earlier diatom work at those parks were published as a NPS Natural Resource Technical Report. Diatom samples were collected at one site at APIS (Outer Island lagoon) in 2013 and sent to researchers at the University of Arkansas in an attempt to propagate the rare diatom species *Semiorbis hemicyclus* in a laboratory setting.

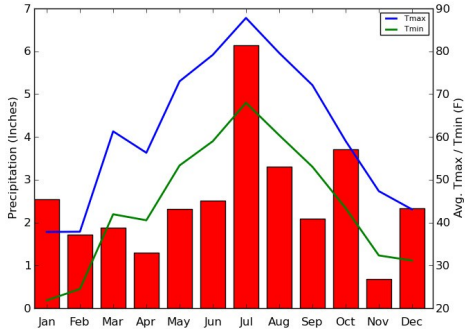
Weather and Climate

Climate Analyzer (www.climateanalyzer.org/glkn/map_html), an online data portal for GLKN priority weather stations, was used to create weather/climate resource briefs for APIS, INDU, and VOYA. Mike Tercek of the Sonoran Institute created the site and completed some basic analyses and interpretation of long-term temperature and precipitation data from the three parks (*see next page*). We now have station data for all the Network parks on that site, and we are working on making it publicly available.

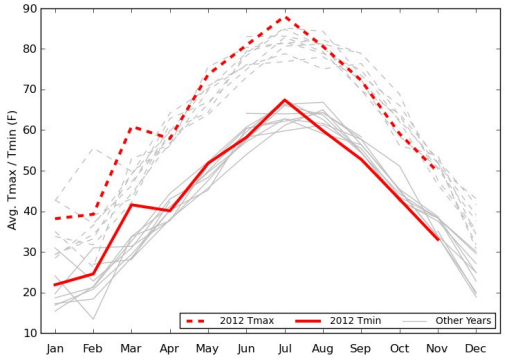
A new remote-access weather station (RAWS) was installed on North Manitou Island (SLBE) in 2012 and was put into operation this spring after repairing an electrical problem. ●

Visualizing Weather and Climate Trends

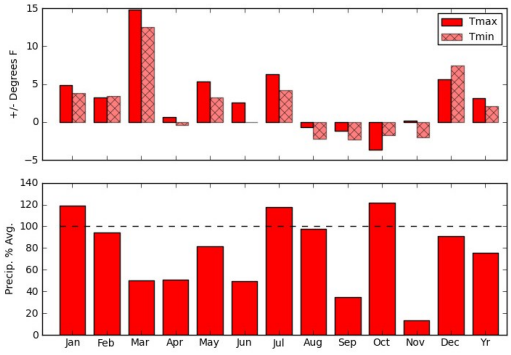
Long-term weather data provide another lens through which we can view our other monitoring programs—how, for example, songbirds may have started nesting early or been delayed, when ice-out occurred on lakes, or the timing of flower emergence. Below are some examples of the graphs that can be constructed on the Climate Analyzer web site using weather station data around Great Lakes Network parks. The data below are for Indiana Dunes National Lakeshore. For brief interpretation of the data, see the full Resource Brief on our website—http://science.nature.nps.gov/im/units/glkn/publications.cfm?tab=0&BriefClimate=open#BriefClimate. ●



Monthly temperature (Tmax and Tmin) and precipitation averages for the weather station INDU, 2012. Red bars show precipitation, blue line is Tmax, green line is Tmin.

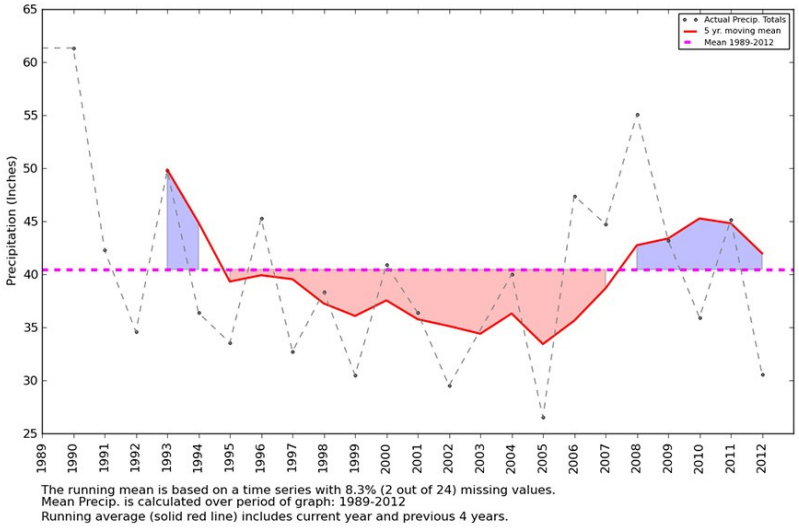


Monthly average Tmax (dashed lines) and Tmin (solid lines) for the automated weather station Bailly, IN (park headquarters). Red=2012, Gray=2003–2011.

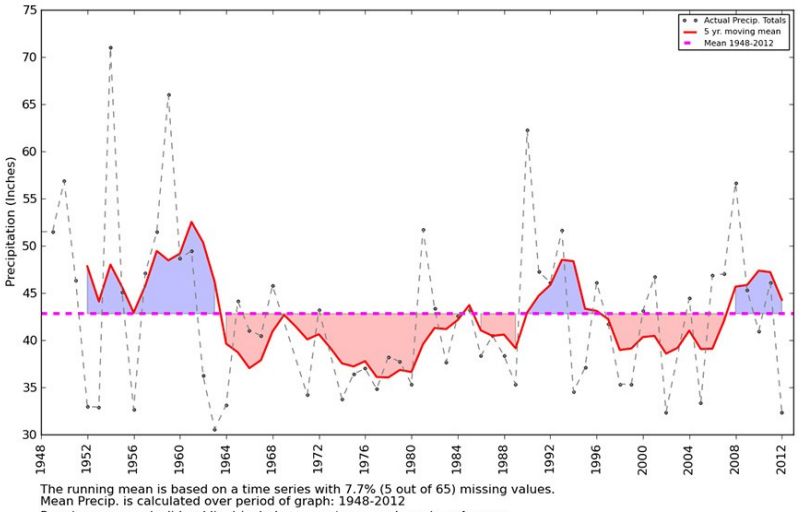


Monthly departures from the official 1981–2010 average normal temperatures at the LaPorte, IN, weather station in 2012. Tmax=average daily maximum temperature. Tmin=average daily minimum temperature. LaPorte is roughly 15 air miles from INDU.

www.climateanalyzer.org/glkn/map_html



Total annual precipitation at INDU, 1989–2012. Dashed red line indicates long-term average. Dots=actual precipitation totals. Solid red line=5-year moving average of annual precipitation.



Total annual precipitation at LaPorte, IN, 1948–2012. Dashed red line indicates long-term average. Dots=actual precipitation totals. Solid red line=5-year moving average of annual precipitation.

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Improving park management through greater reliance on scientific knowledge

Apostle Islands National Lakeshore
Grand Portage National Monument
Indiana Dunes National Lakeshore
Isle Royale National Park
Mississippi National River and Recreation Area
Pictured Rocks National Lakeshore
Sleeping Bear Dunes National Lakeshore
St. Croix National Scenic Riverway
Voyageurs National Park

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