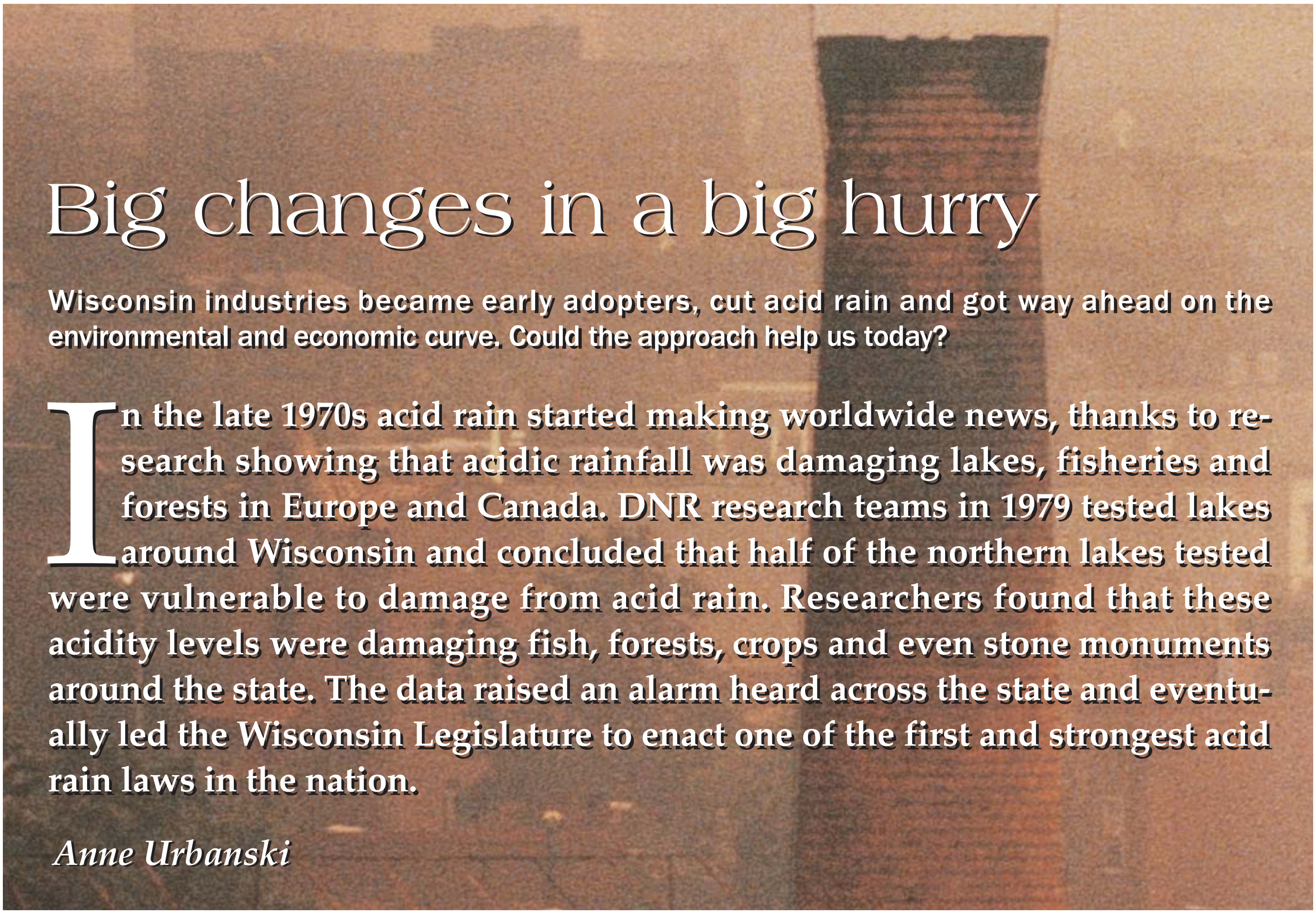
Creating the right atmosphere

APPROACHES THAT STAVED OFF ACID RAIN SET THE STAGE TO TACKLE TODAY'S AIR CHALLENGES.



ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

Big changes in a big hurry

Wisconsin industries became early adopters, cut acid rain and got way ahead on the environmental and economic curve. Could the approach help us today?

In the late 1970s acid rain started making worldwide news, thanks to research showing that acidic rainfall was damaging lakes, fisheries and forests in Europe and Canada. DNR research teams in 1979 tested lakes around Wisconsin and concluded that half of the northern lakes tested were vulnerable to damage from acid rain. Researchers found that these acidity levels were damaging fish, forests, crops and even stone monuments around the state. The data raised an alarm heard across the state and eventually led the Wisconsin Legislature to enact one of the first and strongest acid rain laws in the nation.

Anne Urbanski

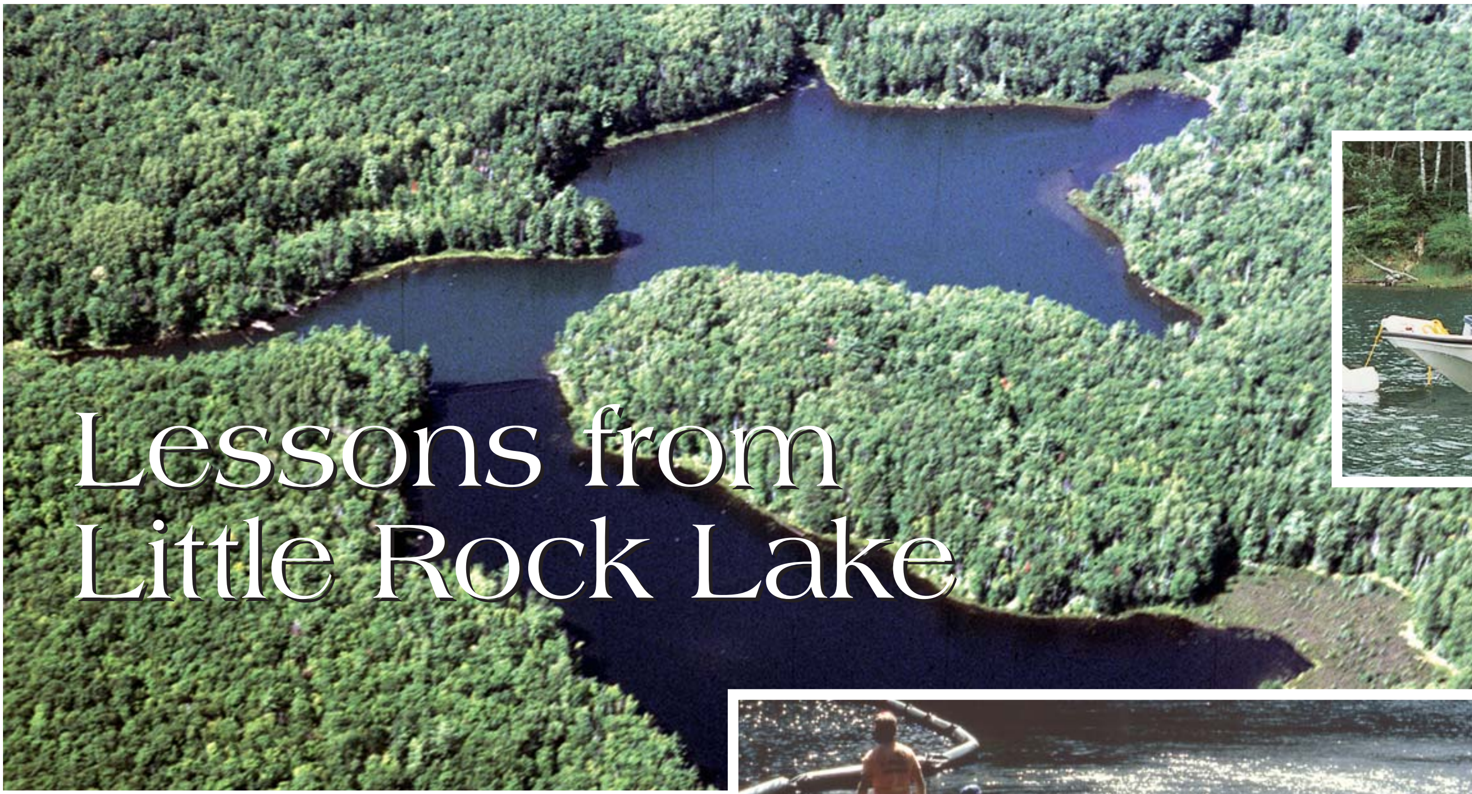
Acid rain is caused primarily by emissions of sulfur dioxide and nitrogen oxides. Sulfur dioxide emissions come mostly from coal-fired power plants and pulp and paper mills. Nitrogen oxide emissions come mostly from coal-fired power plants, factories, motor vehicles and home furnaces. While in the air, sulfur dioxide and nitrogen oxides react with oxygen and moisture to form sulfuric acid, nitric acid and nitrous acid, which return to the land as precipitation through rain, snow or fog.

Wisconsin's acid rain law aimed to reverse the damage resulting from acid rain by aggressively limiting emissions of nitrogen oxides beginning in 1991 and sulfur dioxide beginning in 1993. The law passed in April 1986 and these goals were met:

- Reduced acid rain and kept the pH of precipitation more neutral (at least 4.7) across Wisconsin.
- Created standards for nitrogen oxide and sulfur dioxide emissions from different sources.
- Required the state's five major electric utilities to reduce their sulfur dioxide emissions to 50 percent of 1980 levels by 1993.
- Capped annual emissions from the state's five major electric utilities at 250,000 tons of sulfur dioxide beginning in 1993, and 135,000 tons of nitrogen oxides beginning in 1991.
- Kept sulfur dioxide emissions from all large sources in Wisconsin below 75,000 tons per year.
- Reduced average sulfur dioxide emissions to 1.5 pounds per million BTUs of heat produced by plants owned by Wisconsin companies.

In just a few years, compliance with the state law brought noticeable improvements to Wisconsin's air and waters. By 1990 sulfur dioxide emissions from electric utilities had already fallen 46 percent. By 1992 these companies projected they would easily meet the law's mandates. During the subsequent 20 years, these changes at electric utilities helped reduce sulfur dioxide emissions by two-thirds compared to 1980 levels and improved the pH range to 4.78 in southeastern lakes and 5.29 in northwestern lakes.

Anne Urbanski communicates about emerging air issues, public health and policy for DNR's Air Management program.



Lessons from Little Rock Lake

COURTESY OF CARL WATRAS

CARL WATRAS

In a 1983 experiment, researchers divided Little Rock Lake in Vilas County with a plastic barrier (RIGHT) and acidified the bottom lobe of the lake to simulate how acid rain might change lake chemistry and biology. The research showed that small seepage lakes in northern Wisconsin are very susceptible to damage as acidic rainfall and snowmelt alter water clarity, algae growth, fish growth rates, and cause more subtle changes to aquatic food chains and water chemistry. When acidic conditions were neutralized six years later, the lake slowly returned to its natural state. Continuous research for more than 25 years has studied how acid rain changes lakes and how conditions abate when acid precipitation is reduced.

An acid rain experiment on a small Wisconsin lake almost 25 years ago continues to teach us about consequences of air pollution, energy use and growth.

Carl Watras and Ken Morrison

Northern Wisconsin's pristine waters are valued for providing recreational enjoyment for people and critical habitat for wild species. For example, the Northern Highland/American Legion State Forest (NHAL) in Vilas, Oneida and Iron counties has more than 900 lakes and 300 miles of streams within the 225,000-acre forest. Many of these lakes are protected from the pressures development can bring, but they are still subject to other environmental stresses. About 25 years ago consequences from the long-range drifting of atmospheric pollutants raised concerns about acid rain, soon followed by concerns about mercury deposition and climate change.

The Little Rock Lake experiment attracted international interest. Here Swedish scientists joined Wisconsin colleagues in examining how airborne mercury pollution settles in lakes and more readily moves into food chains as lakes acidify.

CARL WATRAS

Long-term research on one NHAL lake continues to provide insight into the consequences of atmospheric pollution. Research on Little Rock Lake began in 1983, three years before Wisconsin's landmark legislation on acid rain was signed into law by then-Governor Tony Earl. The research has continued for 24 years, providing the longest record of environmental responses to acid rain, mercury rain and climate change for any lake in the world. We'd like to share some of the lessons learned from this research that suggest ways to preserve the quality of our northern waters.

A simple yet revealing experiment

Little Rock Lake is a small, clear-water lake that sustains a warmwater fishery of yellow perch and largemouth bass. It is located in Vilas County about three miles southwest of the UW Trout Lake Research Station. Like most Vilas County lakes, Little Rock is a seepage lake, where no streams enter or drain the waterway. More than 98 percent of the lake's water comes from rainfall and snowmelt, so Little Rock is highly sensitive to atmospheric pollutants. Its shape also makes it an ideal water to study and simulate how such lakes respond to acid rain: The 45-acre lake naturally forms two lobes with a narrows between the two segments.

The original experimental design was simple but elegant. The two lobes were divided by stretching a flexible, impermeable barrier across the narrows. The plastic dividing curtain had floats on the top and was anchored on the bottom to form an effective barrier. Initially, the divided basins were monitored to ensure that the barrier itself had no effect on water quality or aquatic communities. Then one basin would be gradually acidified using small doses of sulfuric acid to simulate increasing acidic deposition. The other basin (the reference basin) remained untreated as a reference to measure the variable effects of weather.

Water quality, plankton, bottom-dwelling organisms, fish, and the natural biological, geological and chemical cycles would be monitored continuously in both basins as the treated basin was gradually acidified. The experimental effects were then compared to conditions in other lakes where acid rain impacts were suspected. The acidification phase of the experiment was planned to run for six years, after which acidification would stop. Then recovery of the treated basin would be monitored to determine whether lakes would return to their natural state if acid rain abated.

Scientists and students involved in the experiment had to make difficult career decisions. Final results would not be known for at least a decade, and the interim results were highly uncertain. But these concerns were quickly assuaged after the first two years of acid addition, because adding even very small amounts of acid brought about substantial changes to lake chemistry and biology. The lake was much more sensitive to acid rain than anyone had suspected.

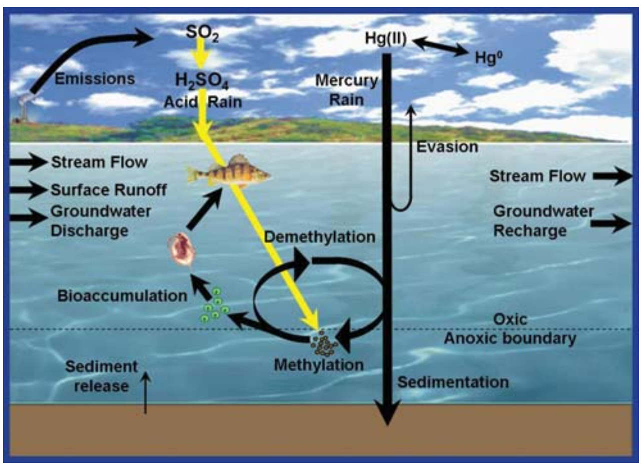
Among the more obvious responses was increased water clarity, consistent with observations by scientists in the northeastern U.S., Canada and Sweden who had reported that where acid rain fell, lakes that had previously supported healthy fisheries became clear and fishless. The scientists suspected acid rain might be the culprit. In Little Rock Lake, clearer water allowed dense green algae growth on the lake bottom. Acidification also slowed fish growth rates. By the end of the acidification, largemouth bass were unable to reproduce successfully; eggs were laid, but they failed to hatch. The bass population got older and, on average, the fish got bigger because no young bass were being added to the population. This result was also consistent with observations in other regions where acid deposition was high. For a while, fishing was very good, and then the fish disappeared altogether.

Another early response was increased mercury contamination in fish in the treated area. Mercury investigations were not included in the original design, but supplementary studies showed that mercury concentrations in perch from the treated basin were higher than in perch from the reference basin. This finding led to a comprehensive study of mercury cycling in Little Rock Lake and to potential links between acid rain and mercury contamination in Wisconsin lakes.

The mercury studies required new sampling and analytical methods. Concentrations of mercury and methylmercury (the chemical form that accumulates in aquatic food webs) were too low to be detected by conventional techniques. Sample contamination was a major problem. Scientists needed to wear special "clean" suits that were free of lint and dust in the field and lab. All containers and reagents needed to be scrupulously free of mercury. Highly sensitive analytical techniques needed to be developed as well. It took several years to make these advances, but by the late 1980s the fundamental aspects of the aquatic mercury cycle had been worked out — the first time for any pristine lake in North America.

We learned that rainfall is the principal source of mercury to northern Wisconsin lakes and their watersheds. After entering lake water, atmospheric mercury escapes back to the atmosphere as a gas, becomes buried in sediments, or is converted to methylmercury by certain bacteria. Methylmercury is passed up the food chain where it poses health risks to animals that eat fish, including humans. Along the chain from water to fish, the concentration of methylmercury can increase 10 million-fold. This phenomenon is called biomagnification, and methylmercury is one of the few toxic substances known to biomagnify in nature.

When sulfuric acid was added to the treated basin, it stimulated the growth of methylating bacteria that inhabit the bottom waters of the lake. These sulfate-reducing bacteria inadvertently produce methylmercury as a by-product of their growth. So during acidification, methylmercury production increased. As the lake de-acidified, these bacteria also declined and methylmercury production decreased again. The fish tipped back and forth between being more contaminated and less contaminated as conditions changed over the course of a few years.



COURTESY OF CARL WATRAS

Over years, the research sorted out and explained complicated interactions as bacteria reduced acids and converted mercury into a form that moved up food chains. Water chemistry, bacteria, insect life, plant life, fish and physical conditions continue to be monitored to look for long-term lessons from acid rain, other contaminants and, perhaps, climate change.

As the treated basin recovered, scientists unexpectedly observed that methylmercury levels declined in the reference basin too. Researchers discovered the reference basin was responding to the effects of cleaner air, as both mercury and acid rain levels have declined substantially over the past 10 to 25 years. The decline in mercury may be due to less commercial and industrial use of mercury in products such as paint, batteries and electrical switches.

Same lake, different dilemma

Regional reductions in acid rain and mercury rain lowered mercury levels in the water and fish of Little Rock Lake as well as across the board in other northern lakes. However, there is new evidence that the unexpected declines may have suddenly reversed in Little Rock Lake for another unanticipated reason. In the year 2000, scientists were surprised by data that hinted that the lake was becoming more acidic again. The concentration of sulfate in both basins was rising, pH was falling, and the concentration of methylmercury was rising too. Notably, the reversals were occurring despite continued declines in acid rain and mercury rain.

Further monitoring suggests that climate change may be driving the re-acidification of Little Rock Lake and, perhaps, other lakes in the region. Climate change is predicted to have several environmental consequences in northern Wisconsin. In addition to warmer average temperatures, seasonal precipitation patterns may shift, with more precipitation coming in the winter and less in the summer. Less rain in summer, paired with increased evaporation caused by warmer temperatures, could trigger more severe summer droughts and lower water levels in northern Wisconsin lakes.

The reversals observed in Little Rock Lake coincided with an extended period of low water in NHAL lakes. Water levels began to decline in 1998 and remain very low. Studies in Canada document what might be called an "acid drought effect" — a phenomenon whereby sulfate that had been reduced by bacteria is re-oxidized when shallow sediments are exposed to air during drought. Following heavy rain or spring melt, sulfuric acid is regenerated and washes back into the lake. In Little Rock Lake, re-acidification and an increase in methylmercury began about 1999 — one year after the onset of drought conditions.

Future effects of climate change and other human activity remain uncertain for the NHAL lakes. To document these changes, Little Rock Lake has been designated as one of three "sentinel lakes" in the region that will be monitored quarterly to compare their behavior to changes in weather and atmospheric deposition over five- to ten-year periods.

In addition to climatic change, there is growing concern that acid rain and mercury rain levels may increase relatively soon. To meet the anticipated demand for electric power, roughly 150 new coal-burning power plants may be constructed in the United States over the next decade. Several coal-burning facilities are either under construction or planned for Wisconsin and many more in neighboring states. Although new power plants generally employ cleaner technologies than older plants, a net increase in the emission of greenhouse gases, sulfur dioxide and mercury is likely unless older power plants are retired or upgraded.

Research results from Little Rock Lake illustrate that freshwater ecosystems can respond to environmental changes in unexpected but explainable ways. They show that one key to understanding environmental change is long-term monitoring. In the coming years, Wisconsin DNR scientists and their colleagues will continue following the status of Little Rock Lake and the other sentinel lakes of northern Wisconsin.

Carl Watras and Ken Morrison are lake researchers with DNR's Science Bureau and the UW-Madison Center for Limnology at the Trout Lake Research Station in Boulder Junction.

ACKNOWLEDGEMENTS: Research on Little Rock Lake has been supported by funds from the U.S. EPA, U.S. National Science Foundation, the Electric Power Research Institute, the Lake Superior Basin Trust, the Potawatomi Community of Forest County, and the Wisconsin Department of Natural Resources. These acid rain experiments were jointly conceived by DNR scientists and the UW-Madison Center for Limnology. They reached out to researchers from other UW campuses, the University of Minnesota and the U.S. Geological Survey to form the primary research team. Over the ensuing 24 years, hundreds of students and scientists from around the world have participated in studies on the lake.

Instructive for the future

DEAN TVEDT

Particle emissions from an industry in the 1970s. Historically, smokestack emissions, particularly from coal burning to generate electricity throughout northeastern states, contributed to acid precipitation across a wide region. Leadership from the utilities association, the Public Service Commission and the Department of Natural Resources directed research, studied the problem and developed an action plan to reduce acid rain in Wisconsin. The work was financed through small surcharges on utility customers. Could that model work now to address air contaminants like fine particles shown above or carbon dioxide emissions that contribute to changing climate?

Can Wisconsin's approach to tackling a borderless environmental problem in the '70s be applied to the needs of a new century?

Jon Heinrich

As the debate on climate change continues to rage, it's worthwhile to revisit a problem that was the global warming of its era. In the 1970s, the presence of "acid rain" and its effect on surface waters was a matter much disputed and even denied in some quarters, particularly in Washington, D.C.

Studies initiated by the Wisconsin DNR at the time indicated rainfall in the state was highly acidic, and that lakes in northern Wisconsin were changing in response to the increased acidity. Wisconsin began a program of requiring meaningful reductions in smokestack emissions from electric utilities and industries more than four years ahead of the federal 1990 Clean Air Act amendments to control acid deposition. Wisconsin's willingness to learn and to act made the state an acknowledged national leader in emerging air quality issues back in the '70s and '80s.

Wisconsin acts with Act 296

Lack of action at the federal level compelled the DNR air program to document the acid rain problem in the upper Great Lakes and take action to address it. While the Reagan administration stood firm against taking any initiative on acid rain, Wisconsin established the Acid Deposition Research Council to direct basic research. Findings showed lakes in northern Wisconsin had been adversely affected by acid rain. Despite this evidence, there was still resistance to adopting state requirements to reduce smokestack emissions.

The decision of a blue ribbon panel appointed by Governor Tony Earl broke the deadlock. The panel, whose members included DNR Secretary C.D. Besadny, William Keepers of the Wisconsin Utilities Association, and Mary Lou Munts, Chair of the Public Service Commission, concluded that Wisconsin electric utilities were contributing to the acid rain problem in Wisconsin and that state action was appropriate. The decision was a major victory in the national fight to get action started at a federal level because it showed that acid rain

BRUCE RODGER

ROBERT QUEEN

Some of the acid rain test equipment was already available, like the sulfur dioxide analyzer to the left and simple rain gauges. Other tools were invented to match the need. Buckets with automatic lids that shifted as the weather changed caught samples of rainfall, dust and particles for analysis.

was also a problem in areas beyond the northeast United States and Canada. On April 22, 1986 Governor Earl signed into law 1985 Wisconsin Act 296 — the "acid rain law."

Wisconsin's acid rain law set targets, goals and timetables for reductions in emissions of sulfur dioxide and nitrogen oxides. It provided funding for research and studies to identify economical means of achieving emission reductions. When the federal Clean Air Act was amended in 1990 it contained emission trading and capping provisions similar to those pioneered in Wisconsin Act 296.

As a result of the state law and the subsequent federal requirements, we've achieved the primary goal of reducing the acidity of rainfall in the state. Rain has a normal acidity of pH 5.0 to pH 6.0. In the early '80s, rainfall ranged from pH 4.4 in southeastern Wisconsin to pH 4.8 in northwestern Wisconsin. In 2005, rainfall ranged from pH 4.8 in the southeast to pH 5.3 in the northwest. The reduction in sulfur dioxide emissions by major electric utilities has certainly contributed to this improvement. Sulfur dioxide emissions from coal-fired power plants operated by the major utilities in Wisconsin have been reduced 67 percent below 1980 levels, from 506,954 tons to 168,633 tons in 2005.

We were successful thanks to public support, cooperation among key stakeholders, and the willingness of government to invest in the research necessary to determine the extent of an environmental problem and its likely causes. Although a definitive causal relationship was not established, it was clear that the coal burned by industry and the electric utilities was the principal contributor to acid deposition in the state. Armed with that knowledge, it made sense to take prompt action rather than wait for federal regulation to catch up with the facts. Wisconsin's proactive stance had economic as well as environmental benefits: Because our electric utilities had already begun to reduce their emissions, they were in a good position to take advantage of the national emission trading program established in the 1990 amendments to the Clean Air Act.

National paralysis

There was little movement nationally on acid rain during the time Wisconsin was developing requirements to address acid deposition. Industry argued that natural factors rather than fossil fuel combustion caused acid rain, and insisted that natural sources of sulfur dioxide and nitrogen oxides were a significant part of the acid rain problem. Those opposed to reducing emissions from coal combustion portrayed acid rain as a natural phenomenon that had always existed. Industries argued that no action should be taken because no one could pinpoint the sources of acid rain or trace lake acidification back to emissions from specific stacks. The U.S. Environmental Protection Agency (EPA) supported this view by concluding that it was not possible to distinguish between the amount of acidification that was manmade and the amount that was caused naturally. Those opposed to action had a litany of arguments that were modified over time, passing from *"There may be a problem, but it has always been there"* to *"We don't know what causes the problem"* to *"We don't know how to act"* and finally *"Even if we acted, it would not help."*

The energy crisis of the '70s was still fresh in our minds in the early '80s and contributed to the national inertia on acid rain. With a nation dependent on foreign oil supplies, the Carter administration initiated actions such as converting power plants

Acid or alkali?

Chemists use a pH test to determine a solution's relative acidity or alkalinity. This test measures the concentration of hydrogen ions in the solution, and ranks the solution's acidity/alkalinity on a scale from 0 to 14. A pH value of 1 is very acidic (like battery acid), while a pH value of 14 is very alkaline (like lye). A pH value of 7 is neutral, like distilled water. The pH scale is logarithmic, which means that pH 6 is 10 times more acid than pH 7, and pH 5 is 100 times more acid than pH 7.

ROBERT QUEEN

Technology was developed to collect water and air samples that were analyzed for tiny amounts of mercury and other diffuse pollutants that traveled long distances before settling out of the wind and clouds.

from cleaner burning fuel oil to coal. The memory of the "oil shocks" slowed down the speed at which the federal government required emission reductions from coal-fired power plants.

During the debate on acid rain, EPA damaged its credibility and politicized its role. The agency did not reflect the opinions of a majority of the scientific community, which had called for reducing sulfur dioxide and nitrogen oxide emissions from coal-fired power plants. A 1981 National Academy of Sciences report recommended a 50 percent reduction in the acidity of rainfall and snowmelt in the northeastern U.S. to protect lakes and forests. "Scientific uncertainty" was the official EPA explanation for the lack of federal response. Kathleen Bennett, EPA's air pollution control chief, stated that "scientific uncertainties in the causes and effects of acid rain demand that we proceed cautiously and avoid premature action."

In 1982, Bennett appeared at a Senate Energy Committee hearing and stated "There is no good measure of when acidity in rain should be considered detrimental…hence at this point; there is no clear reference for developing a remedial program." In 1984 the Reagan administration called for more research before regulation, even after the negative effects of acid rain were widely conceded and the National Academy of Sciences concluded that acid rain could be addressed effectively through sulfur dioxide emission reductions from coal-burning power plants in the eastern U.S.

Eventually EPA and the U.S. Congress did act, by including a comprehensive national program to reduce the emissions that cause acid rain in the 1990 amendments to the Clean Air Act. Adopting a nationwide approach to address acid rain was a watershed event for air quality management in the U.S. For the first time, those responsible for emissions in upwind states that caused problems in downwind states were required to clean up the air we all share.

What worked well

Wisconsin's actions to address acid rain were based on research supported and conducted in-state. The undoing of the scientific approach on a national level did not hinder Wisconsin from addressing a serious environmental issue, even though we understood that our action alone would not entirely eliminate acid rain from falling in our lakes.

The members of the blue ribbon panel representing industry, ratepayers and the environment accepted the responsibility to develop recommendations to resolve the issues. These leaders showed a commitment to solving the problem. The Department of Natural Resources agreed to do the research that would answer questions; the panel agreed to let the science dictate what steps should be taken; and government financed the research through small payments from every residential energy user.

It's a model we can use to confront the difficult air quality problems we face today. When the acid rain debate was undertaken in Wisconsin and the rest of the nation, the issue of the long-range transport of air pollutants across state and national borders was just emerging. Now other serious pollution transport issues like mercury contamination, ground-level ozone and fine particulates, and the very large elephant in the room — "climate change " — must be tackled.

The questions we faced then apply to the issues we face now: Who is responsible? Who should bear the costs? What role should Wisconsin play in addressing regional, national and global air quality issues? Reflecting on what worked with acid rain years ago will help Wisconsin deal with the air quality issues we face now and in the future.

Jon Heinrich recently retired after 33 years with DNR's Air Management program. Heinrich supervised the development of many air quality programs, including efforts to contain ozone, sulfur dioxide, hazardous substances and mercury emissions.

Lasting benefits from the way Wisconsin addressed acid rain

- ❍ Dramatically reduced sulfur dioxide and nitrogen oxide emissions while reducing rainfall acidity.
- ❍ Increased the credibility of using Wisconsin-specific research to drive regulations.
- ❍ Showed a willingness to invest in research to determine the extent of air pollution problems.
- ❍ Recognized that air pollution does not have borders and that local emissions contribute to regional air pollution.
- ❍ Increased support for regional solutions to air quality problems.
- ❍ Set cleanup targets, then provided flexibility to meet those goals.
- ❍ Spurred interest in voluntary programs and "green" solutions by business partners.
- ❍ Showed the benefits of convening a balanced panel of business, environmental and legislative leaders committed to resolving an environmental/health problem.
- ❍ Fostered a partnership with weather service professionals on air quality and health reporting.
- ❍ Brought together the Lake Michigan Air Directors Consortium (LADCO) — Illinois, Wisconsin, Indiana and Michigan — to work together for over 27 years; and added Ohio to regional air quality efforts starting in 2004.
- ❍ Proved the economic benefits of taking state action ahead of the federal government that allows us to tailor solutions to Wisconsin businesses and industries.

— *Anne Bogar, DNR Air Management*

Air apparent

DNR PHOTO

Images captured on an automated haze camera or "haze cam" in Milwaukee show that we are still challenged to reduce air pollution that can travel long distances over wide regions. The combination of pollution and weather conditions contribute to ozone, haze and fine particles that cause health concerns prompting air quality watches and warnings some days.

DNR PHOTO

Forecasting air issues

Natasha Kassulke

Recent scientific evidence suggests efforts 30 years ago are not enough to protect public health and the environment, and the acid rain story is far from over.

A report by the Intergovernmental Panel on Climate Change (IPCC), "Impacts, Adaptation and Vulnerability," emphasizes that global warming is already having worldwide effects and predicts regional impacts if temperatures continue to rise.

According to IPCC findings, for each degree of global warming, the earth will experience more wildfires, coral bleaching, flooding and storm damage. A rise of more than five degrees Fahrenheit in average temperatures would result in water shortages for up to 3.2 billion people, 20 percent of the global population would be directly affected by flooding, and three to eight times more heat waves would occur in some cities.

Key findings of a Wisconsin Public Interest Research Group Foundation report, "An Unfamiliar State, How Global Warming Could Change Natural Wisconsin," concluded:

- The Great Lakes would likely be smaller, shallower and less able to sustain healthy populations of aquatic life.
- Wisconsin habitats of several key tree species — balsam fir, paper birch, white spruce, jack pine and red pine — would likely be reduced.
- Popular winter pastimes such as ice fishing and snowmobiling would have much shorter seasons.
- Hunting and fishing opportunities might change as populations of several game birds shift northward and coldwater fish, such as brook and brown trout, lose habitat.
- Drought and heat stress would reduce cattle vigor and dairy herd milk production.

"Climate change impacts are already occurring in Wisconsin," says Dr. John Magnuson, UW Madison Emeritus Professor of Zoology and Limnology. Reduced ice cover on lakes is a visible signal of warming especially during the last 35 years. Increases in runoff and associated algal growth and shoreland flooding from extreme rain events over the last hundred years are expected to continue increasing through this century.

There is broad scientific consensus that carbon dioxide and greenhouse gas emissions in the United States must be reduced at least 15 to 20 percent by 2020 and 80 percent by 2050 to prevent the worst impacts of global warming. While Congress considers action, some states have already established emission reduction plans. California enacted the nation's first statewide cap on global warming pollution. Wisconsin has joined over 30 states to form a national registry to track greenhouse gas emissions. Some states are also turning to alternative biofuels produced from ethanol, switchgrass and woody biomass.

The state's "bioeconomy" includes a Declaration of Energy Independence that sets three broad goals:

- To generate 25 percent of our electricity and 25 percent of our transportation fuel from renewable fuels by 2025.
- To capture 10 percent of the market share to produce renewable energy sources.
- To become a national leader in research that makes alternative energies more available and affordable.

Mercury reductions

"Controlling mercury emissions is vital in protecting Wisconsin's environment and public health," says Al Shea, DNR Air and Waste Division administrator.

Citizen interest in controlling mercury remains high. The federal government adopted mercury rules for electric utilities that warrant changes to Wisconsin's existing rules. The nature of those changes remains controversial. The federal rules would reduce mercury about 70 percent by 2018 — not really more stringent than Wisconsin's existing mercury rule. Industrial and electric utility groups strongly favor adopting federal rules without change. "I believe that they have a legal and political commitment for that," says Kevin Kessler, DNR air management bureau director.

Environmental groups, on the other hand, petitioned the Department of Natural Resources earlier this year to reduce mercury emissions by 90 percent by 2012 and to reject the federal "cap and trade" program that would allow electric utilities to buy credits from other utilities instead of making the reductions at their own plants.

Health concerns also result from home-grown air pollution. Wastes in burn barrels and smoke from outdoor wood furnaces often do not burn hot enough to destroy a mix of pollutants in the smoky emissions. The acrid smoke raises possible health issues throughout the neighborhoods and countryside near such burning. Sparks from trash burning in open barrels can also cause wildfires. Some communities restrict or ban open burning within their jurisdictions.

JONATHAN STONE

Stay tuned. The economic, political, environmental and public health stakes regarding Wisconsin's mercury rules are high. Mercury emissions remain an issue needing the same type of scientific and political consensus that was reached on acid rain in the 1980s.

Other contaminants

Unfortunately, mercury is just one air contaminant challenge facing the state. The EPA adopted a new health-based standard last year for fine particulate matter, which several of our most populous counties don't currently meet. Official designations of these non-attainment areas and new regulations to address particulate matter are forthcoming.

Wisconsin and our neighboring states have made great strides on ozone during the past two decades. In fact, in June 2007, Wisconsin asked the EPA to designate eight counties as having reached attainment status for ozone. At the same time, new studies have found that ozone presents a greater health hazard than was previously recognized. Under court order, the EPA will issue more stringent ozone standards that will likely put some of our counties back in non-attainment and require more emissions controls.

The federal Clean Air Act also requires states to reduce haze and improve visibility. Reasonable progress toward that goal will be submitted to the EPA in late 2007.

Educating about options

Education continues to be an important goal to instill air pollution awareness, Kessler says. Communication strategies include school programs like "Easy Breathers" and "Air Defenders" as well as messages for adults that encourage using mass transit when commuting. Environmentally responsible driving also can cut exhaust emissions, reduce fuel use and save money.

Open burning of home garbage remains a concern and this low-temperature burning at ground level remains the number one dioxin threat to aquatic organisms. Burning solid waste materials such as treated wood, plastic, household garbage and most other trash is prohibited statewide; local ordinances may be more stringent.

Outdoor wood-fired boilers and furnaces are also becoming more popular and causing local air concerns. Wood smoke causes particle pollution and emits toxics at the low burning temperatures in these boilers. DNR has neither the authority nor funding to address the problem. As a result, this air pollution issue is largely handled by local governments. Some communities have enacted ordinances that prohibit or control burning and wood boilers within their jurisdictions.

Future resources

The air pollution challenges are greater than ever, but will the funding that is needed to continue and build on these efforts keep pace? The picture is not bright according to Kessler.

"Reductions in state and federal funding for our state air pollution program are compounded by the constraints in how we use our funding," Kessler says. "We don't have the discretion to address DNR's highest priorities and it's critical to work with our stakeholders to resolve funding issues."

Monitoring equipment that is aging is used to continue baseline sampling and identify problems early on. The Department of Natural Resources has had to reduce the number of air quality monitors and hasn't been able to replace obsolete equipment. People demand information online and in real-time. Operating within funding constraints, the state's air program continues to consolidate sites, increase automation, eliminate redundancies, upgrade to higher sensitivity monitors for reactive nitrogen and carbon monoxide, and enhance the air toxics monitoring network. But it's not cheap.

"Ironically, budgetary problems have arisen as a result of Wisconsin's air quality monitoring success," Kessler says. "Emissions are dropping yet our fees are tied to emission amounts, so success means we have less and less money to do regular local inspections and to monitor air quality. It's the price of success."

The last 30 years saw significant progress in air quality improvement, but the next 30 years will be equally important. The DNR's air management program will build on the acid rain partnership model and lessons that were learned.

"There are a lot of challenges, but also a lot of potential to make important and necessary changes in Wisconsin's air quality," Kessler says.

Natasha Kassulke is creative products manager for Wisconsin Natural Resources.

Looking for clear

A HOST OF APPROACHES OFFER PRACTICAL WAYS TO CLEAN UP THE AIR.

KRISTINA TEETER, AMERICAN LUNG ASSOCIATION OF THE UPPER MIDWEST

Medical clinics, local health advocates and family doctors are important partners in helping people understand the direct links between air pollutants and community health. Young and elderly patients whose lung tissue is more fragile, are especially susceptible to smaller amounts of air pollution.

Reach people close to home

Outreach through businesses, neighborhoods, health clinics and the airwaves keep people informed.

Anne Bogar

TV meteorologists, insurance company managers, allergists, computer programmers and social workers are just a few of an expanded network of partners conveying air quality information so the public can make informed choices to protect their health. While more than 3,000 substances have been measured in the air, we regulate about 500, and there are outdoor air quality standards for only six. We need the expertise and the contacts through all of our partners to share what we know and what we need to know about the health effects of air pollution. Today, our partners help clean the air in ways we could only imagine when we first started talking about acid rain a few decades ago.

Allergists, pulmunologists, family practice doctors, school-based clinics and school nurses are now all explaining the links between pollution and respiratory health. DNR educators work with the American Lung Association, Fight Asthma Milwaukee and the Partners for Clean Air Health Committee to develop and distribute information to over 275 clinics and doctors in southeast Wisconsin where pollution concerns are concentrated. We try to keep the message simple. Tear-off sheets similar to prescription pads share the gist of health information at medical office displays. Each clinic also gets cover letters, posters and pamphlets to share with patients in their native languages. Evaluation forms provide feedback aiming to refine the message for each community.

Working closely with the National Weather Service and broadcast meteorologists, the DNR issues air quality watches and advisories when air pollutant concentrations rise. "Watches" are issued when unhealthy levels of pollution that can affect those most sensitive (older adults, children and those with heart or lung disease) are predicted for the next day. During watches, individuals are encouraged to take actions to reduce emissions by limiting car trips, delaying grass cutting and docking their watercraft. "Advisories" are issued when air pollution concentrations reach or exceed unhealthy levels for sensitive groups. The Weather Service and forecasters increase public awareness and explain the link between weather and air quality. They show people how air pollution can move in large masses like storms and how air pollution has no borders, crossing community boundaries, city limits and vast expanses hundreds or thousands of miles away.

Businesses, government offices, schools, medical facilities and health organizations spread the word by sponsoring programs to discuss air quality health effects. Large employers in southeast Wisconsin were original members of the Wisconsin Partners for Clean Air and Ozone Action Days. Since 1995, the group has grown to more than 250 Wisconsin Partners who take voluntary actions to improve air quality. Many partners notify employees on air quality watch days and provide incentives to carpool, bus, walk or bike to work while reducing emissions at the worksite. In recent years, partners programs have expanded to Dane, Jefferson, Fond du Lac and Winnebago counties.

KRISTINA TEETER, AMERICAN LUNG ASSOCIATION OF THE UPPER MIDWEST

Physicians now test children starting at an early age to gauge lung capacity and susceptibility to air pollution. Simple tests like blowing a pinwheel can give early signals of a child's stamina for outdoor play.

In one of the longer running programs, DNR staff cooperate with the Sixteenth Street Health Clinic in Milwaukee to help people make the connection between respiratory illness and poor air quality. It's part of a larger environmental health project focusing on adults and children in the culturally diverse community on Milwaukee's south side, targeting Hispanics, Southeast Asians and African Americans.

To get the big picture of regional pollution, hazecams show current video of air visibility taken from rooftops and overviews at various panoramic locations. Hazy days are often caused by a mix of pollutants we can and cannot see. The hazecams update camera images every 15 minutes around the clock and are displayed with current air quality and meteorological data. The Midwest Hazecam network (www.mwhazecam.net) includes sites in Chicago, Ill.; Cincinnati, Ohio; Grand Portage and St. Paul, Minn.; Sault Ste. Marie and Seney Wildlife Refuge, Mich. and St. Louis, Mo. Funding for additional sites, including one in Milwaukee, was lost in the past year.

The acid rain control program developed more than 20 years ago helped forge the way to look for innovative solutions to air pollution problems. It emphasized relying on research and looking beyond our borders. The partners we work with today continue to pursue innovative ways to regulate air pollution and educate the public about air quality and their health. Our best solutions come from working together.

— Anne Bogar coordinates community outreach programs for DNR's air management program.

Give companies breathing room

Agree on goals and trust firms to innovate to reach them.

Mark McDermid

RICHARD EBERT, PCA

RICHARD EBERT, PCA

An environmental partnership gave Packaging Corporation of America incentive to reclaim resources from pulp waste. The firm now collects methane produced in an anaerobic digester and uses the gas to produce steam and heat. George Kleist, PCA wastewater system manager, holds digester residues used as a high quality soil amendment for vegetable gardens, lawns, embankments and gravel pit reclamation. PCA has a three-year waiting list of customers who want to use the residues.

Companies are finding that a little bit of flexibility, better understanding of their business needs, some community involvement and a little public recognition provide a potent combination that can profitably reduce environmental risks. They understand that managing costs while meeting environmental standards is just one more challenge in remaining competitive and profitable while protecting both corporate and community interests.

In a more typical approach, it can take years to set the standards that businesses and communities must meet to comply with environmental laws. It would be preferable to tap the business potential to respond quickly and develop innovative solutions. The Environmental Cooperation Pilot Program and Green Tier provide a legal framework to challenge businesses to look at a full range of environmental opportunities and take steps that all pioneers take by working on problems together in uncharted territory.

Packaging Corporation of America (PCA) provides a concrete example of environmental and business gains made possible by addressing environmental risks through flexible and creative approaches.

Back in 1998, PCA was required to collect and incinerate gaseous emissions from its pulp mill in Tomahawk. PCA research identified a different kind of pollution control system, an anaerobic digester that could economically reduce six times more pollution than was required by existing environmental regulations. Using flexibility provided under the law, PCA installed the new system at half the cost of the more conventional technology. It captured and treated 1.6 million pounds of pollution, more than five times the 300,000 pounds that would have been captured using traditional methods.

Further, PCA found that byproducts from their digester could be used for fuel and could replace virgin, purchased fuels. Consequently, PCA launched a $2.4 million project to collect biogas from the digester and use it to fire its on-site boiler to produce steam. The recovered biofuel produces the amount of energy equivalent to heating and cooling 2,250 homes. The program has reduced annual greenhouse gas emissions by 70,000 tons.

To put this into perspective, a $10 million biomass gasification plant currently planned for a pulp mill in British Columbia is forecast to reduce greenhouse gas emissions by 25,000 metric tons per year. So PCA is eliminating nearly three times more emissions for about a quarter of the cost of the Canadian project. PCA's closed loop system demonstrates that a flexible approach and technological innovation can enhance both environmental performance and company profitability.

Like Packaging Corporation of America, five other pioneers participating in Wisconsin's Environmental Cooperation Pilot Program have been outperforming the rest of the state in controlling greenhouse gases while addressing other significant environmental issues. Green Tier now provides a way for others to participate and offers even more tools to deliver environmental results with greater flexibility. Trade associations, organizations and companies alike have boldly stepped out of the comfortable confines of traditional regulatory approaches to explore their environmental and economic potential. Their strategies have saved thousands of hours of staff time, enabled bids to beat out national and international competitors, drawn work into the state and attracted new talent, all while addressing environmental issues in a comprehensive fashion.

— Mark McDermid directs DNR's Cooperative Environmental Assistance Bureau.

Consider international approaches to meet air quality challenges

Other countries show other ways to environmental innovations.

Lloyd and Patrick Eagan

We can learn from other countries' experiences even if they do not represent exact models for us to replicate. Leadership in environmental protection has been teeter-tottering among the U.S., Europe and Japan. In air quality protection for example, the United States led the world with the original Clean Air Act in the 1970s, but by 2000 Europe surpassed that lead, particularly in the areas of energy efficiency and climate change. Here are some observations from our opportunities to examine approaches to environmental protection in European countries and Japan.

In Germany, Wisconsin delegations toured power plants and learned about burgeoning growth of both air pollution control and renewable energy technology. During the late '90s, Germans passed a law requiring their utilities to slash nitrogen oxides emissions. The country reduced NOx emissions in four years, on time and under budget. How did this happen so fast? It appears that when the German public learned their forests were dying from nitrogen oxide emissions, the Green Party grew strong enough to win support for this key law. Also, the growth in windmills and renewable technology was seen as strategic, spurred in large part by regulation. German utilities were required to buy power from renewable energy producers even if it cost more than the current electrical rates. Establishing a guaranteed market for renewable energy created incentives for German entrepreneurs to develop new technologies to produce renewable energy.

Providing relevant and effective incentive systems to protect the environment will provide greater overall environmental benefits than regulations in the long run. Industries that discover how to sustain growth and decrease their environmental consequences are developing new sustainable economic models. The growth of the Danish wind industry provides a good example. Denmark, like Wisconsin, has none of its own fossil fuels. Danes took the oil crisis of the '70s very seriously and the country currently gets 20 percent of its energy from renewable resources, such as wind. Their experts on energy policy believe a goal of 100 percent renewable energy will be achievable. Danish energy cooperatives explored wind turbines to save money on energy production and spawned a profitable industry. Denmark has become the largest producer of wind turbines in the world and wind energy has become a key component of a sustainable Danish economy.

In the Netherlands, we learned a National Environmental Policy Plan (NEPP) now includes aggressive targets to control greenhouse gas emissions. The government proposed an industrial tax on carbon emissions. The paper industry responded that such a tax would put them at a competitive disadvantage, but agreed to support the government greenhouse gas targets by pledging to become the most energy-efficient paper industry in the world. The Dutch government entered into a covenant with the industry to seal the deal. By using contract law as an alternative approach to regulation, the Dutch met both environmental and economic targets.

Finally, using "eco-designed" products is another approach to environmental improvement. Examples include green buildings, more fuel efficient vehicles, and more energy-efficient light bulbs and appliances. In Japan, "eco fairs" draw thousands of visitors each year and display a large variety of ecologically designed products. So, in addition to traditional regulations, economic incentives, alternative legal tools and environmentally sensitive product design can contribute to a greener and cleaner future that is economically viable.

WOLFGANG HOFFMANN

ABOVE: Wisconsin delegations saw how wind power was developed, regulated and placed in Germany.

PATRICK EAGAN

RIGHT: A new way to get around? A prototype of a new kind of people mover on display at an eco fair in Japan.

— *Lloyd Eagan directs DNR's South Central Region and Professor Patrick Eagan directs the Department of Engineering Professional Development program at the University of Wisconsin-Madison.*

Like people, some plants are more sensitive to air pollution than others. Biomonitoring can make use of these unique features to supplement test results from air monitoring equipment.

RIGHT: Lichens absorb minute amounts of air pollutants over long periods of time.

ROBERT QUEEN

ROBERT QUEEN

ROBERT QUEEN

LEFT: Plants placed near air monitoring sites also react to air pollution.

ABOVE: Milkweed leaves develop this characteristic brown stippling when exposed to airborne ozone.

What can you learn from a plant?

Quite a lot if you ask the right questions.

Ed Jepsen

Change is a fact of life and we typically want to know if it will provide more benefits than stumbling blocks. Studying plants and animals in their native habitats provides one reliable measure of how mixtures of complex changes affect nature. And teasing out whether ecosystem change is related to acid rain, ozone, climate change or combinations of manmade and natural factors takes time.

For instance, acid rain was predicted to naturally fertilize some agricultural crops, but the adverse effects on lakes and forests in Europe, North America and Asia far outweighed those minor benefits. Fortunately, we in Wisconsin were spared the worst of these consequences by reducing emissions quickly, and the nation soon followed suit.

Long-term studies of organisms, called "biomonitoring," and examining complex processes such as energy and nutrient flow can help us estimate natural background conditions. These studies provide a meaningful baseline for assessing future changes. While certain effects may be obvious within months or a year, others may take many years or decades to unfold.

Biomonitoring is just one of the valuable tools used to assess long-term trends. Combined with laboratory studies to determine explicit cause-effect relationships, and computer modeling to project changes over time and space, scientists can test the direction and magnitude of ecosystem changes.

Some of the natural changes are more dramatic and some are more subtle. Drought, flooding, intense storms, and insect and disease outbreaks have more immediate consequences, but the way people change the landscape, the slow introduction of exotic organisms, and the gradual changes to air, land and water are harder to see. Our sustained investment in long-term biomonitoring and other environmental monitoring builds a database we need to sense changes that can develop over decades or longer.

Biomonitoring studies to track the effects of air pollution have been conducted in Wisconsin since the early 1980s. The federal North American Sugar Maple Project and the state-sponsored Forest Monitoring Network tracked the health of the forest tree (aspen) canopy. These studies indicated tree canopies were generally healthy and air pollution impacts, if any, were too subtle to be detected by the study methods used.

State-sponsored biomonitoring of milkweed and lichen to track air pollutants has been discontinued, but regional forest health assessments still occur annually on Forest Service Forest Inventory and Analysis (FIA) plots in Wisconsin.

How valuable is this data? Ozone biomonitoring data collected on the FIA plots since the early 1990s guided EPA scientists in reassessing ozone standards. Based on this field data and other evidence, the EPA recommended lower seasonal ozone exposures to protect our plant communities.

— Ed Jepsen is a plant pest and disease specialist with DNR's Bureau of Air Management in Madison.

Individual actions, community benefits

Cleaner air begins at home.

Elisabeth Olson

The next time you go on a rant about today's environmental challenges — climate change, acid rain, mercury, energy demand, regional air and water pollution — stop and take a look in a mirror. Examining and revising your individual behavior is equally as important as scrutinizing corporate, government and community uses of resources. Your behavior can significantly reduce pollution and environmental damage while conserving energy. Together, our collective behavior can encourage policy change within government at the local, regional and national levels and promote better environmental practices within corporations.

Below is a short list of actions you can take to reduce your contribution to poor air quality. Choose the ones that work for you and everyone will benefit! Saving energy conserves natural resources and reduces air pollution caused by producing and delivering that energy. What you do does make a difference. So do it — and we'll all breathe easier.

In the basement:

- Set the temperature of your water heater to no more than 120 degrees to save energy.
- Put an insulating blanket on your water heater to reduce heat loss if insulation is not built into the tank.
- Insulate hot water pipes to reduce heat loss, particularly those closest to the water heater and those passing through unheated areas.
- Take good care of your home heating/cooling plant: Replace furnace filters. Replace filters in air conditioners and heat pumps and clean the evaporators and coils. To ensure maximum operating efficiency, many people hire professional services to clean these parts, check insulation on the coils and lubricate pumps on a regular maintenance schedule.

Upstairs:

- Inspect your home's insulation. Add more if needed, first in the attic, then in the walls.
- Caulk and weather-strip doors and windows.
- Install a programmable thermostat to set back your temperature automatically at night and when you are not home.
- Turn your heat down by three degrees at a time in winter to find a temperature that is comfortable for you. Similarly, set air conditioning higher in summer to discover how little air conditioning you need to stay comfortable.
- Purchase clean energy where available. Many utilities now provide alternatives for their customers to buy units of energy from renewable sources.
- Purchase Energy Star rated appliances. See www.energystar.gov or call the ENERGY STAR Hotline at 1-888-STAR-YES (1-888-782-7937).
- Turn off lights, computers and appliances when not in use.
- Replace as many incandescent bulbs with compact florescent bulbs or even LED bulbs as possible. They save energy and last ten times longer!

Laundry:

- Do laundry during off-peak hours.
- Wait until you have enough dirty clothes to wash a full load.
- Discover when cold water washes work as well as warmer settings.
- Clean the dryer lint trap after each load so that the dryer runs as efficiently as possible.
- Dry laundry on a clothesline, if practical.
- Avoid wearing clothes that need dry cleaning, or use a wet cleaning service as an alternative.

On the go

- Take mass transit, share a ride, walk or carpool.
- Plan ahead! Combining errands into one trip reduces mileage and saves gas.
- Avoid rush hours and listen to the traffic report before you go. Congested conditions increase air pollution and expose drivers to unhealthy conditions.
- Tighten your gas cap until it seals tightly or clicks. You can lose up to 30 gallons of gas vapors a year by not tightening your gas cap.
- Avoid topping off the tank. Pumping in more gas after the pump shuts off releases gas fumes into the air and reduces the benefits of vapor recovery gas pumps.
- Refuel when it's cool. Refueling during cooler periods of the day or in the evening generates less air pollution.
- Drive the speed limit. Gas mileage decreases rapidly at speeds above 60 mph.
- Avoid jackrabbit driving! Unnecessary braking and acceleration decreases gas mileage.
- Use cruise control on the highway to save fuel by maintaining a steady speed.
- Use overdrive gears on the highway to decrease engine speed and improve fuel economy.
- Don't let your vehicle idle. Idling even for short periods wastes more fuel than restarting the engine.
- Dejunk the trunk! Extra cargo is extra weight. Your engine burns more gas and releases more emissions.
- Care for your car. Taking good care of your car can help reduce emissions. Regular oil changes and tune-ups improve your vehicle's performance, extend its life and save gas. Properly inflated tires improve gas mileage, reduce emissions, and help your tires last longer.
- Use those handy inside-the-windshield blockers when parked outside on a sunny day. It takes more energy to cool a hotter car.

Your ecological footprint

An ecological footprint is a tool to measure how much land and water area a human population requires to produce the resources it consumes and absorb its wastes under prevailing technology.

A 15-question quiz can help you gauge your consumption to national and international averages. The quiz will give you an idea of your ecological footprint relative to other people in the country. The quiz is not highly detailed, but will help you better understand yourself as a consumer, given your current environmental behaviors.

By measuring the ecological footprint of a population (an individual, a city, a nation, or all of humanity) we can assess and manage our ecological assets more carefully. Ecological footprints enable people to take personal and collective action to live within the means of one planet.

What's your "shoe size?" Visit www.myfootprint.org to find out.

Elisabeth Olson develops educational outreach programs on air quality for DNR's Bureau of Education and Information.

Get up on the air online

For more ideas of things to do to reduce climate change, educate yourself about the issue by visiting web resources listed below. Many good books and articles on climate change have been published over the past few years.

U.S. Environmental Protection Agency — EPA maintains an excellent website on climate change. It contains lots of information on climate change science, greenhouse gas emissions, state and federal policies, mitigation methods and lots more, including links to many other excellent climate change websites: www.epa.gov/climatechange/

United Nations Framework Convention on Climate Change — This website provides information related to the UN Framework Convention on Climate Change and the Kyoto Protocol: www.unfccc.int/2860.php

Intergovernmental Panel on Climate Change (IPCC) — This worldwide group of over 2,000 scientists is responsible for assessing the status of global climate change. They publish assessment reports every five years for the United Nations and the world community. The reports tend to be very technical, but they also publish summaries for policy makers and the general public: www.ipcc.ch/

National Oceanic and Atmospheric Administration — The NOAA website has a thorough discussion of weather and climate change for all audiences: www.education.noaa.gov/cclimate.html

British Broadcasting Corporation (BBC) — Information about science, impacts, adaptation, policies and more: www.bbc.co.uk/climate/

Union of Concerned Scientists — The Union of Concerned Scientists provides excellent information on climate change and on how it will likely affect the Great Lakes region and Wisconsin. To access the information on impacts on the Great Lakes and Wisconsin, go to: www.ucsusa.org/greatlakes/glchallengereport.html

Green power alternatives — To find out whether your electric utility offers customers the opportunity to purchase wind power, solar power or other green power, visit the U.S. Department of Energy's Energy Efficiency and Renewable Office, the Green Power Network: www.eere.energy.gov/greenpower/buying/index.shtml. Look for "Can I buy green power in my state?"

To learn about buying or leasing more energy efficient vehicles, visit www.epa.gov/greenvehicles. The site rates cars and trucks by air pollution scores, greenhouse gas emissions and fuel economy. The highest scoring vehicles earn a Smartway seal of approval as a good environmental performer.

To stay in touch with what's going on in the DNR Air Management program, subscribe to one or more of these e-mail lists at dnr.wi.gov/org/aw/air/newsletters

- **Air Health Advisory —** notifies you whenever DNR issues an Air Quality Watch or Air Quality Advisory anywhere in Wisconsin.
- **Air Matters —** notifies you when a new issue of our Air Matters newsletter is available online or the What's New section on the Air Management home page is updated.
- **Clean Air Act Task Force (CAATF) —** sends links to DNR web pages where you can find the latest information on CAATF activities.

DNR's air quality and health site — dnr.wi.gov/org/aw/air/health. Related links provide information about mercury in the air, acid rain in Wisconsin, nitrates and sulfur, health studies and open burning.

Technical papers about acid rain research at Little Rock Lake:

- Frost, T.M., J.M. Fischer, et al. (2006) "The experimental acidification of Little Rock Lake," Magnuson, J. J., T. K. Kratz, and B.J. Benson., Eds. Long-term Dynamics of Lakes in the Landscape, Oxford University Press.
- Watras, C. J., K. A. Morrison, et al. (2006). "The methylmercury cycle in Little Rock Lake during experimental acidification and recovery." Limnology and Oceanography 51(1): 257-270.

Resources for younger readers:

- **DNR's EEK! site:** dnr.wi.gov/eek/earth/air/index.htm
- **EEK's "You can make a difference" page:** dnr.wi.gov/eek/earth/makeadifference.htm
- **Exploratorium Museum in San Francisco has a neat site to view climate research data:** www.exploratorium.edu/climate/index.html
- **EPA Climate Change "Kids Site:"** www.epa.gov/climatechange/kids/index.html

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Listing compiled by Eric Mosher, DNR Bureau of Air Management

Produced by DNR Bureau of Air Management and DNR Bureau of Education and Information.

Project Coordinator: Elisabeth Olson

Graphic Design: Waldbillig & Besteman

PUBL-CE 7047