North Central Research Station News.....

Winter 2001/2002

Growing Under the Influence: New Findings About Atmospheric Pollutants and Northern Forests

In the News.....

◀ *Jud Isebrands inspects trees growing in the presence of elevated CO_2 and ground level ozone at Rhinelander's FACE facility. Detrimental effects include altered photosynthesis, early leaf fall, weakened defenses, and reduced soil nitrogen.*

If forest science wasn't in the briefing packet of the average politician before the mid-1990s, it's likely to be there now. With the preponderance of evidence pointing to climate change, worries about deforestation have shifted to hopes that reforestation or afforestation may help sequester carbon dioxide (CO_2), a greenhouse gas that contributes to global warming. Participants in the Kyoto Protocol—a multinational agreement to reduce greenhouse gas emission by an average of 5.2 percent (1990 baseline) between 2008-2012—are grappling to find the appropriate role of forests in the modern carbon cycle.

At issue is whether countries should be allowed to use forests as carbon 'sinks' that can offset part of an industry's emissions. It's a charged political question, but it hints at a broader scientific inquiry that interests NC researchers: Will trees continue to be effective carbon sinks as the atmospheric levels of carbon dioxide and other pollutants continue to rise?

The traditional answer is that carbon dioxide acts as a growth stimulant, helping to ensure its own sequestration by encouraging faster growth of plants. But that's a rather simplistic view,

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according to Jud Isebrands, NC's project leader and Co-Principal Investigator of NC's and Michigan Technological University's Aspen FACE (Free-Air Carbon dioxide Enrichment) project in Rhinelander, Wisconsin. Carbon dioxide is not the only atmospheric component that will increase in concentration in the coming decades. "Very few people are conducting multi-factorial studies that include air pollution in the equation," he said.

That's where the Aspen FACE experiment comes in. In the world's largest open-air site, twelve 90-foot diameter rings of gas-emitter tubes deliver a steady stream of CO_2 and ozone to freely growing aspen, birch, and sugar maple trees. The tubes are calibrated to deliver the same levels of CO_2 and ozone that are expected to be prevelant in 2100.

The FACE team (see below) chose to study ozone because it is increasing in concentration throughout the Eastern United States and the world, and its effects on forests have not been studied as well as other pollutants. Now that results are in from the first 4 years of study, the importance of including this particular pollutant is obvious. While the team prepares these sobering findings for submission to scientific journals, we offer you a first look.

Ozone Offsets the Growth-Stimulating Effect of CO_2

Due to pollutants such as ozone, the carbon sequestration picture is not as tidy as we once imagined. The following findings should be of interest to landowners, governments, and groups that are either designing or taking advantage of incentive programs to sequester carbon in northern forests.

1. *Fundamental Biochemistry is Being Altered*—"What we're starting to see in the fourth year is that the effects of ozone are offsetting the effects of elevated carbon dioxide that people have been talking about [the increase in plant growth]," Isebrands said. "It seems that ozone is not only damaging the photosynthesis apparatus in the leaf, which drives the plant's growth, but is also altering the fundamental biochemistry of the plant." These detrimental effects on a tree's physiology counteract the growth-enhancing effect of carbon dioxide alone.

2. *Premature Leaf Fall*—"The other very serious finding is that trees are losing their leaves prematurely under the future climate scenario—about a month earlier than they should," Isebrands said. "That's when the tree should be putting reserves in place for the stem and roots. Losing its leaves means losing 1 month of food and energy needed to make it through the winter and to prepare for the next spring's bud break. Over a long period of time, the tree will probably decline in vigor."

Bill Mattson

Trees growing in high-CO_2 environments had nearly twice as many aphid colonies per plant than those in low-CO_2 environments.

3. *Reduced Soil Nitrogen*—The nitrogen content of the soil seems to be decreasing, which will likely be a further blow to forest productivity, because trees rely on nitrogen to sustain themselves. "You can fertilize crops, but with 600 million acres of forests in the U.S., it's unlikely that anybody is going fertilize all of them," said Isebrands.

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The FACE Partnership

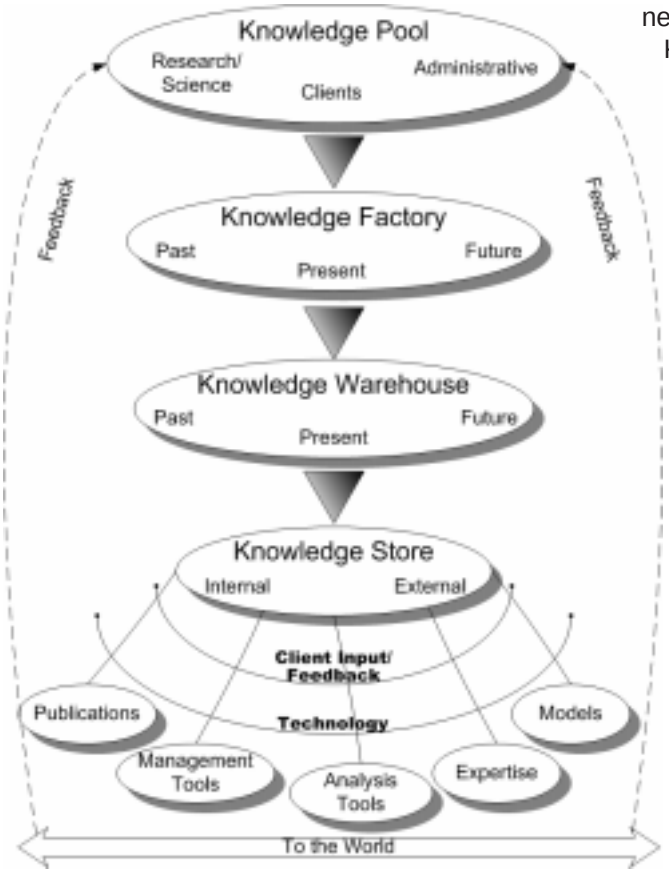
The Aspen FACE experiment works because of its many partners. The research team includes cooperating scientists from North Central, Michigan Technological University; U.S. Department of Energy; Argonne National Laboratory; Brookhaven National Laboratory; the universities of Michigan, Wisconsin, and Minnesota-Duluth; and Mississippi State University. International scientists from Finland, Canada, Estonia, Italy, Slovakia, and Great Britain are also participating. Funding comes from an equally complex network, including North Central, the Forest Service's Northern Global Change Program, U.S. Department of Energy, National Science Foundation, National Council of Air and Stream Improvement, Michigan Technological University, Canadian Forest Service, Finnish Academy of Science, and the University of Wisconsin Foundation.

E-Knowledge: A New Way to Store, Use, and Share Research Results

Fiscal Year 2002 is the kickoff year for new ideas, philosophies, and practices related to information management and program delivery at the North Central Research Station, according to Dave Shriner, North Central Assistant Director.

For more than 75 years, Station scientists have worked to better understand the forests, waters, wildlife, climate, and communities of people in the Midwest. What they've learned—a vast reservoir of information—exists in many forms including published papers in journals and symposia volumes, reports, bulletins, software, CDs, maps, and long-term data sets. "We're living in an age of information but it's not always easy to find what you need. We're trying to design a way to help our clients find what they need, when they need it, in a form that's right for them," Shriner said.

The Station vision is to provide a "Web portal" through which clients can search NC databases, run software, download documents, and chat with scientists. Over the past year several steps have been taken to move from vision to reality. In January 2001, a small, select group of Station scientists and administrators convened to think strategically about what NC products would look like and how these products would be delivered to Station clients. Then, in May 2001, a 3-day meeting of Station leadership further refined the conceptual framework for information management and program delivery. Shriner and others are currently drafting a white-paper describing North Central's new information delivery initiative, and protocols are being developed for archiving important Station data sets. By the end of September 2002, a new chief information officer/knowledge manager should be on board, and we'll begin to more fully stock the shelves of the Knowledge Store (see graphic).



North Central's Knowledge Enterprise: *The Knowledge Pool represents the domains of knowledge and expertise available for problem solving. The Knowledge Factory symbolizes the process by which the NC research enterprise generates information and knowledge; management provides policy, vision, and direction; and scientists bring their expertise and the scientific method to bear on the problem or question. The Knowledge Warehouse is the repository of Station knowledge, and the Knowledge Store is the way we distribute a variety of knowledge products (labeled) to clients.*

One-Stop Shopping

Analogous to a large department store, the NC Knowledge Store will be a virtual place where clients can obtain the information and services they need. The shelves of the Knowledge Store will be stocked with the text, data, maps, models, and images emerging from NC research efforts. It will serve as a storehouse for the Station's forms, study plans, and reports. Self-help sections will allow customers to receive training, use tutorials, ask an expert, and relate interactively with NC data and models. Continually updated with new information from the Knowledge Warehouse, the Knowledge Store will provide easy access to the Station's tremendous legacy of long-term research information about the region. Products in the Knowledge Store will also be available at a national site showcasing products from all Forest Service Research Stations (see next article).

"We are committed to helping those working to solve natural resource problems by providing information that is clear, accessible, and customized," said Linda Donoghue, North Central Station Director. "It all comes back to service." North Central's efforts to redesign and improve information management and program delivery are a sure sign of this commitment.

Contributed by Sue Barro

Libraries in the Internet Age

With all the information now available on the Internet, aren't libraries becoming obsolete?

Far from it. According to a recent survey conducted for the Urban Libraries Council by the State University of New York at Buffalo School of Information Studies, 75 percent of adults use both libraries *and* the Internet to get information and reading material. In fact, survey respondents actually rated libraries *higher* than the Internet for ease of use, low cost, helpfulness of the librarians, and protection of user privacy.

One could even argue that libraries are being rediscovered because of the Web. Anyone who tries to "sip from the firehose" of 2 billion Internet homepages knows the speed with which information is proliferating. How do you access, organize, and validate this continuous stream of information? How do you know you've found the definitive word on a subject, given that search engines access only a portion of the Web, and that the entire Web contains only a small portion of the world's information (e.g., 8 percent of all journals and a smaller fraction of books)?

As "what we know" multiplies, the ability to navigate and critically assess information has become a fundamental skill—a new kind of literacy. Making critical judgments, including when a book may be a better resource than a computer, is exactly what librarians do: they help people to find, use, and evaluate information effectively and efficiently.

Whitewater Library Guides

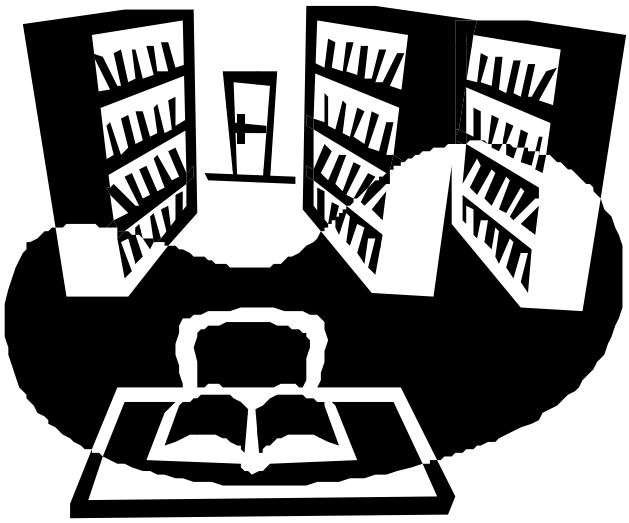
At the ready to assist Forest Service staff in maneuvering through today's information tsunami are the seven libraries of the Forest Service Library Network (FSLN). Each library serves a specific region or clientele. The INFO-NC Library, for example, serves the North Central, Pacific Northwest, and Southern Stations; and Regions 6 and 9.

"What makes the network critical to the success of the Forest Service is our skill in selecting, acquiring, organizing, and disseminating relevant information," explains Carol Ayer, director of the Rocky Mountain Research Station Library and head of the FSLN. "Forest Service libraries are an important link between Research, the National Forest System, and State & Private Forestry in providing access to the best available scientific and technical information."

New Portals to FS Information

Eager to link knowledge generators and users, the FSLN has been integral in two national projects, the Digital Desktop Library Initiative and the One-Stop Shopping Project. The Digital Desktop Initiative, sponsored by the USDA National Agricultural Library in cooperation with FSLN and other USDA libraries, will provide cost-effective, online access to books, journals, and other reference materials. The goal is a desktop library that you surf to, rather than drive to, and if you're a staff member of the participating agencies, you can visit any time, 24 hours a day.

For customers outside the agency, the One-Stop-Shopping Project will provide access to all Research Station publications in one site—a first step towards a national version of NC's Knowledge Store. No more surfing from Station to Station to find what you want. A major component of this project is the FSLN database that includes, among its 175,000 records, more than 60,000 publications written, sponsored, or produced by Forest Service research, with more than 3,000 hot links to full-text.



Who Needs Libraries?

While the Internet may have changed the way librarians work, it has not changed their importance. Librarians are masters of making things findable, and their ability to provide this service to their customers makes them indispensable. As Forest Service libraries evolve in the 21st century, they will continue to meet their customers' individualized needs with personalized, timely, and high quality information services—something you simply won't get from a firehose.

Contributed by Laura Hutchinson

Learning About Trees fro m the Roots Up

The most interesting part of a forest, says Kurt Pregitzer, is the part you can't see. Pregitzer, project leader at NC's Ecosystem Processes unit in Houghton, Michigan, studies forest productivity and its relationship to carbon and nutrient cycles. And that leads him below the majestic trunks and soaring canopy, beneath the tangled undergrowth of the forest floor, and into the soil and the root systems, where roots and mycorrhizal fungi make up an intricate water-absorbing and nutrient-acquiring network.

This underground ecosystem plays a key—if little studied—role in the carbon cycle. "Below-ground functions, although vital, are difficult to directly observe," Pregitzer said. "If we want to measure the growth of a tree above ground, we measure its diameter, its height, or we estimate the number of leaves, but we have historically had problems trying to understand how root systems function."

A Look Below

His latest project, still in the planning stages, aims to change all that. The research rhizotron will be a far more ambitious version of current root-observation systems, which consist of small plastic tubes inserted into the soil at an angle. A miniature video camera threaded through the tube allows direct observation. Fancier rhizotrons are glass-walled viewing facilities. Pregitzer's version will be more like a fully equipped, rhizosphere laboratory, "something like an ocean-going research vessel that studies the intricate interrelationships in the soil instead of the sea."

"Think of it as a sophisticated basement with windows, high resolution video cameras, sensors sampling soil solution and the soil atmosphere (gases), with the ability to remove the windows and sample roots and soil microbes," said Pregitzer. "We'll access a patch of forest right behind the building….drawing gas samples directly into the lab, making observations of rhizospheric activity using high magnification video cameras, and coupling those observations with changes in the activity of microorganisms." The lab could also allow researchers to follow the fate of stable isotopes, thus tracking carbon and nutrients as they pass through the tree and its roots.

Felix Ponder, Jr., a research soil scientist at the North Central facility in Jefferson City, Missouri, says he would be interested in using the research rhizotron in his study of how tree root systems react to soil compaction. He has found that in rocky soils, compaction—caused by logging trucks, for example—can actually cause some species of trees to grow more rapidly. "I'd be interested in seeing how those roots access the compacted soil to get at the moisture." The research rhizotron could also help solve a mystery about the phosphorus content of the soil. Although it is low, repeated testing has shown that the trees are getting enough phosphorus anyway. "I'd like to know the mechanism by which the phosphorus becomes available and how the tree takes it up," Ponder said. "Is it the tree root affecting the rhizosphere, or are there just more roots to access more soil?"

◀ *Traditional root study techniques (shown here) include sifting soil to recover the coarse roots. The rhizotron will permit researchers to study living roots without removing them from the soil.*

Testing the Testing Tools

Pregitzer also sees the facility as an important test-bed for new soil-sampling technologies. "Auto companies and the army have their proving grounds, and we hope to use the research rhizotron to test the tools of our trade," he said.

Reliable testing systems are crucial to the study of trees. "So often assumptions about root growth are made without direct testing, and they're not necessarily correct," said Pregitzer.

Pregitzer's research rhizotron could strengthen those assumptions, or tear them down and build new ones. With these new roots, the study of forest growth could be stronger than ever.

by James Kling

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4. *Weakened Defenses*—Finally, the stresses of ozone appear to be handicapping trees in their battle against insect pests and diseases. "It's pretty well known that when plants are stressed, insects are more attracted to them," said Isebrands. "The relationships are very complex, but at least in some cases, ozone has a cascading effect," says Bill Mattson, a research insect ecologist with the Ecophysiological Processes unit in Rhinelander. "Once the trees are adversely affected by ozone, an avalanche of bad things can happen," he said. After insects invade a tree under high ozone conditions, for example, woodpeckers may go in after them and exacerbate the wounds, leading to further infestations. The plant's defenses against disease may also be undermined. In the ozone-stressed trees, FACE collaborators found lower levels of chemicals that are known to protect plants against pathogens.

How What We Learn Can Help Our Clients

"I'm really glad to see they're doing this work," said Ed Jepsen, a plant pest and disease specialist with the Wisconsin Department of Natural Resources Bureau of Air Management. "There were a number of reports in the seventies and early eighties where they started to talk about carbon dioxide and its effect on trees. A lot of them were armchair hypotheses and hand-waving... . They were not un-insightful, but they weren't backed up by a lot of quantitative and qualitative research. This type of research will help us answer some of those questions."

"The project has the potential to influence forest management practices," said Alan Lucier, a senior vice president with the National Council for Air and Stream Improvement, an industry-funded group that serves as an environmental resource for the forestry industry. "If you discovered, for example, that the growth response of trees to elevated carbon dioxide and/or ozone is greatly affected by nutrition, you might need to manage nutrition effectively [using nitrogen-fixing plants in intensively managed forests, for instance] to capture that higher growth potential."

Overall, the project hints at a concern for forests facing rising pollutant levels, making a powerful statement for pollution control if the world's forests are to be counted on to reduce atmospheric levels of carbon dioxide.

In a sense, the FACE experiments are smaller versions of a greater, unwitting real-time experiment that is being carried out on the world's forests, plains, and oceans. The sooner such small-scale experiments reveal the ecological and biochemical responses to rising levels of carbon dioxide, ozone, and other pollutants, the sooner the world's countries will be able to respond to that other, larger experiment.

by James Kling

People on the Move

Congratulations!

Cassandra Asliem, **James Blehm**, **Gail Sindt**, *St. Paul*, **Donald Clark**, **Michael Downs**, *Manistique*, **William Dijak**, *Columbia*, **Amy Hanchen**, *East Lansing*, **Tamar Mannikko**, *L'Anse*, **Thad Rhodes**, *Salem*, **Jason Severe**, *Mt. Pleasant*, **Brian Wall**, *Harper's Ferry*, and **Adam Weise**, *Rhinelander*, were promoted.

Moving on. . .

Lisa Earle, *St. Paul*, transferred out.

Kent Bass, **Kevin Crane**, *Rhinelander*, **Brian Bergman**, *Manistique*, **Ronald Burns**, *West Lafayette*, **Kory Cease**, *Grand Rapids*, **Scott Douglass**, *St. Paul*, **Jeanette Irish**, *Mt. Pleasant*, **Matthew Logghe**, *Gaylord*, **Matthew Meade**,*Wakefield*, and **Thad Rhodes**, *Salem,* resigned.

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