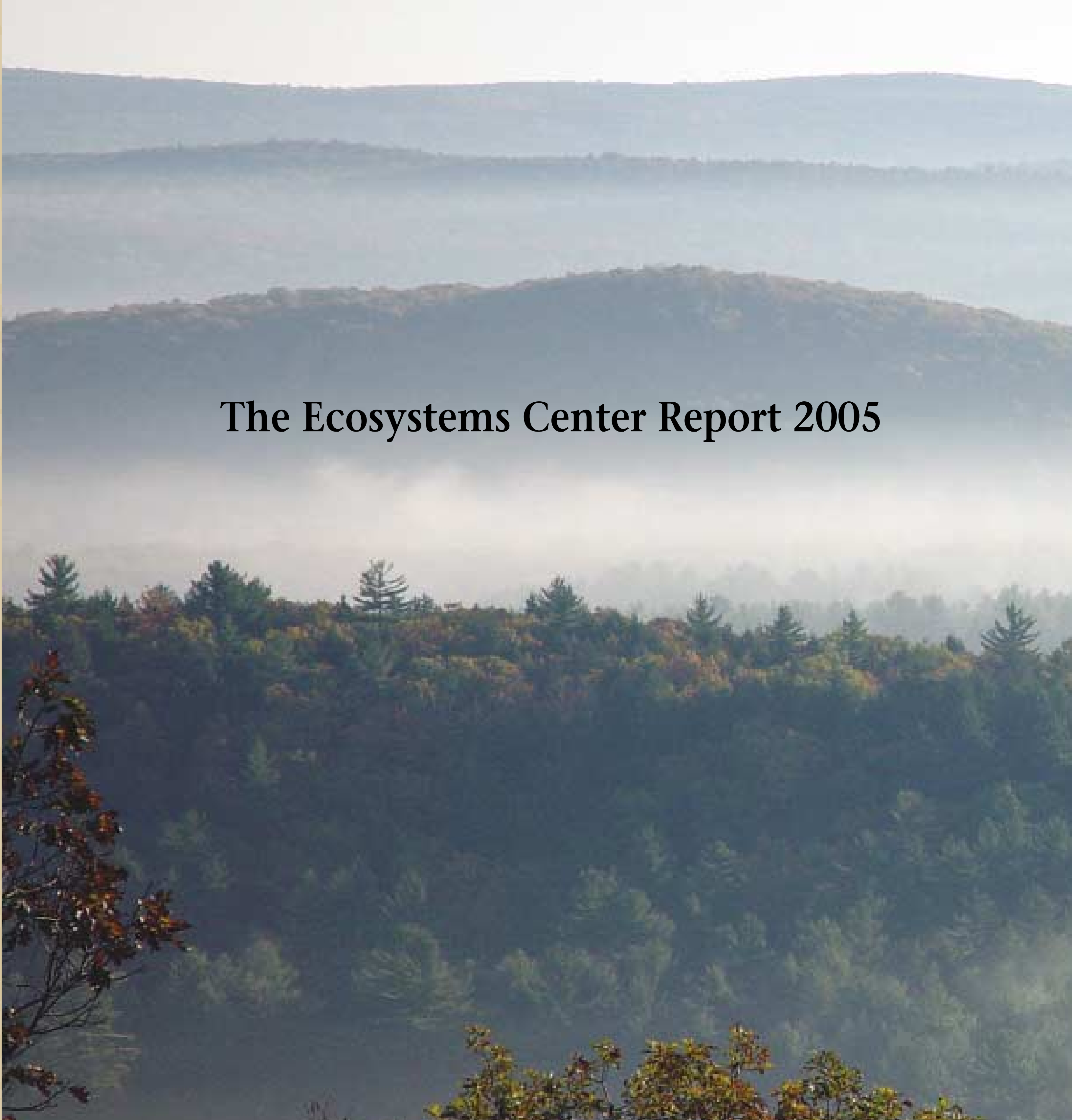
MBL | Biological Discovery in Woods Hole

The Ecosystems Center Report 2005



The MBL founded the Ecosystems Center as a year-round research program in 1975. The center's mission is to investigate the structure and functioning of ecological systems, predict their response to changing environmental conditions, apply the resulting knowledge to the preservation and management of natural resources, and educate both future scientists and concerned citizens.

Ecosystems Center researchers add low levels of fertilizer to the incoming tide in creeks in the Plum Island Estuary in northern Massachusetts. They are examining the response of the surrounding salt marsh to increased levels of nutrients caused by land-use change. (Photo: Christian Picard)

The Ecosystems Center operates as a collegial association of scientists under the leadership of John Hobbie and Jerry Melillo. Center scientists work together on projects, as well as with investigators from other MBL centers and other institutions, combining expertise from a wide range of disciplines. Together they conduct research to answer a variety of scientific questions:

At the **Arctic Long-Term Ecological Research (LTER)** project on Alaska's North Slope, Ecosystems Center scientists study the effects of warmer temperatures on Arctic ecosystems. Will increased permafrost thaw make more nutrients available to plants? If these nutrients flow into streams and lakes, how will they affect the aquatic food web?

At the **Plum Island Ecosystem LTER** site in northern Massachusetts, researchers ask how urban development affects the flow of nutrients and organic matter into New England estuaries. How will they alter the food web and plant growth in salt marshes? What happens to the production of commercially valuable fish as a result?

In **Brazil**, scientists investigate how the clearing of tropical forests in the western Amazon changes greenhouse gases such as carbon dioxide and nitrous oxide released into the atmosphere. What will the effect be on global climate? How will change in temperature and atmospheric gas concentrations affect the productivity of forests? What effect does the clearing of forest for pasture have on tropical streams ecosystems?

In **Boston Harbor**, researchers measure the transfer of nitrogen from the sediments to the water column. How long will it take the harbor to recover from decades of sewage addition?

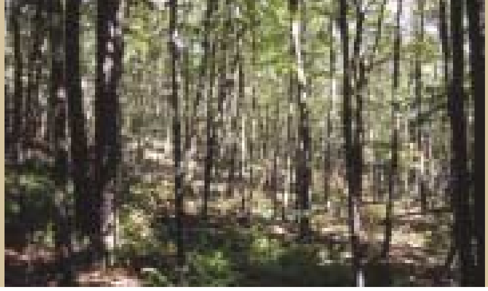
In the **Arctic rivers of Eurasia**, center scientists have conducted research that shows increased freshwater discharge to the Arctic Ocean. If ocean circulation is affected, how might the climate in western Europe and eastern North America change?

On **Martha's Vineyard**, researchers restore coastal sandplain ecosystems with either controlled burning or mechanical clearing. How much will beneficial processes such as groundwater recharge and nitrogen retention increase in restored ecosystems? Will it restore diversity in plant and animal species?

At the **Harvard Forest LTER** project in central Massachusetts and at the **Abisko Scientific Research Station in Sweden**, scientists use soil-warming experiments to assess how forests would respond to climate warming. How much carbon might be released as temperatures increase? How will warming change the types of trees in forests of the future? Will changes in nitrogen cycling affect carbon storage in plants?

Computer models at the center are also used to ask questions about effects of future changes in climate, carbon dioxide and ozone on vegetation productivity and carbon storage world-wide. A project with social and atmospheric scientists at MIT investigates ecological responses to various scenarios of economic and energy development.

Ecosystems and Society



(Photo: Paul Steudler)

Earth's mosaic of ecosystems provides materials and processes that sustain all life on this planet. When functioning naturally, these ecosystems—forests, grasslands, wetlands, streams, estuaries, and oceans—deliver benefits called "ecosystem services."

Some of these services are very familiar to us, such as providing food and timber that are essential for our survival and key elements of the global economy. Equally important, but certainly less well recognized, are the array of services delivered by ecosystems that do not have easily assigned monetary values, but that make our lives possible. These include the purification of air and water, the decomposition of wastes, the recycling of nutrients on land and in the oceans, the pollination of crops, and the regulation of climate.

In West Falmouth, Massachusetts, nitrogen from the town's municipal sewage treatment plant is leaching into the harbor. The additional nitrogen results in a decrease in eel grass beds, which leads to algae overgrowth on the water's surface, odor, fish kills, and the disappearance of shellfish. (Photo: Tom Kleindinst)

As the world's human population grows and the consumption of all kinds of materials increases, ecosystems are being degraded and their capacity to deliver crucial services is being compromised. This "quiet crisis" is largely hidden from view, but the consequences of this degradation are potentially catastrophic for human beings and many other forms of life on Earth.

The work of scientists at the MBL's Ecosystems Center is providing a scientific foundation for managing the planet in ways that will maximize the capacity of ecosystems to serve their life-support function. In Brazil, for example, center researchers study how forest clearing impacts water quality and fish habitats and offer possible solutions. In New England coastal areas, where bacteria from urban and agricultural runoff contaminates 30-40% of shellfish nurseries, scientists document the ways that humans are altering these systems and suggest environmentally sound alternatives for managing the coastal zone.

This report contains more examples of how MBL Ecosystems Center researchers respond to this "quiet crisis" in the delivery of ecosystems services and what more they believe needs to be accomplished.

Melt-water streams along the edge of the Greenland Ice Sheet. The rate of melting has increased measurably in recent decades. (Photo: John Hobbie)

Global Climate Change

Human actions are causing the Earth's climate to change. The burning of fossil fuels and clearing of forests for agriculture are releasing carbon dioxide into the atmosphere, where it is accumulating and adding to the natural greenhouse effect.

Long-term observations confirm that our climate is changing rapidly. Over the twentieth century, the average annual temperature in the United States rose by almost 1°F (0.6°C) and precipitation increased nationally by 5–10%, mostly due to increases in heavy downpours. Over this century, climate change is expected to accelerate as we add more and more carbon dioxide and other greenhouse gases to the atmosphere.

Without major initiatives to reduce continued growth of world greenhouse gas emissions, estimates are that U.S. temperatures will rise by at least 5–9°F (3–5°C) in the next 100 years. This rise is likely to be associated with more extreme precipitation and faster water evaporation, leading to greater frequency of both very wet and very dry conditions. These changes are already affecting ecosystems, and the effects are expected to be even greater with more rapid climate change in the future.

Through controlled laboratory and field experiments, MBL Ecosystems Center scientists are documenting the consequences of climate change, adding to our understanding of how climate affects fundamental ecosystem processes, such as plant photosynthesis and decay of organic material by microbes. Ecosystems Center scientists are also developing simulation models to predict possible climate changes in the future and to help managers make correct choices.

The snout of this northern glacier has retreated several hundred meters since 1951. (Photo: Debbie Scanlon)

Abrupt Climate Change: Will Increased Fresh Water Have a Chilling Effect on Europe and North America?

One of the many consequences of global warming is the freshening of the North Atlantic and Arctic Oceans, which could have a chilling effect—sudden climate cooling—on residents of the United Kingdom, Germany, Sweden, Norway, and eastern North America.

Fresh water from melting glaciers and icecaps, increased high latitude precipitation, and river runoff reduces ocean salinity. This decrease in salinity could lead to a slowdown or cessation of the thermohaline circulation—the giant ocean conveyor system the size of 50 Amazon Rivers—that warms the climates of these northern countries.

In recent articles in *Science* magazine and the *United Nations Environmental Programme Geo Year Book* (2004/5), Ecosystems Center senior scientist Bruce Peterson and colleagues have examined the causes and magnitude of the problem. The rise in global temperatures has increased the evaporation of water from subtropical oceans, increasing their salinity. For example, in the past 40 years, scientists have observed a 5-10% increase in evaporation in the subtropical Atlantic Ocean. The increased moisture from the subtropical evaporation condenses in the atmosphere at higher latitudes, leading to an increase in precipitation of about 6-12% in the past century. This in turn has changed the flow of fresh water from Russian rivers to the Arctic Ocean. Peterson and his research team have discovered that this flow has increased 7% since the late 1930s.

Additionally, during the past half century, arctic glaciers have melted and sea ice has shrunk and thinned, adding still more fresh water to the Arctic and North Atlantic Oceans. Recently glaciers of the Greenland Ice Sheet have increased their rate of flow to the sea, and the ice sheet is melting at an increased rate. Peterson's latest paper documents that the sources of increasing freshwater input presently consist of river flow (11%), precipitation on the ocean (40%), sea ice attrition (44%), and glacier melt (5%).

But that's just one piece of the puzzle. "To obtain a clearer outlook of what might happen," says Peterson, "requires improved understanding of ocean and ice sheet physics, improved climate simulations through computer modeling, and a more precise estimate of future global warming."

As scientists work to fully grasp how the freshening of our oceans will ultimately affect our climate, there are ways to avoid the worst-case scenario.

"The scientific evidence suggests that minimizing the buildup of carbon dioxide in the atmosphere would lower the projected temperature increase," Peterson says, "which would slow the acceleration of the hydrological cycle and reduce the chance of disruption of the North Atlantic thermohaline circulation."

"Complete stoppage of the North Atlantic conveyor circulation is more likely to happen if we are careless and allow fossil fuel use to increase further and continue at a high rate," according to Peterson. "It is less likely to happen if we develop international agreements to limit greenhouse gas emissions, which would mean a better chance of maintaining a stable climate in the North Atlantic region and elsewhere."

Globalization and the Environment

The globalization of the world's economy—the strengthening of economic connections among regions and among nations—is not only reshaping international relations, but it now drives the transformation of many of the largest regions of natural ecosystems left on earth. Much of this change occurs in the tropics, where forests and savannas are being cleared for pastures and mechanized agriculture to supply a growing demand in developed nations.

These changes are nowhere more evident than in Brazil, where large areas of both Amazon forest and the unique Brazilian savanna, or "cerrado," are being converted to produce beef and soybeans, largely for export. Between 14,000 and 27,000 square kilometers of new Amazon forest have been cleared every year since 1996. The Amazon cattle herd grew from 15 million to 33 million during this time. Amazon soybean production increased even more sharply, from 0.1 to 1.8 million tons per year.

Soybeans (top) and cattle are two of Brazil's largest exports. (Photos: Chris Neill)

In a global economy, adoption of strict environmental controls—such as on forest cutting—in countries like the United States threatens to shift those activities to other parts of the world. The world demand for meat and protein now makes production of beef and soybeans highly profitable in the Amazon. Soy export from Brazil to China climbed from zero in 1996 to 7 million tons in 2005. A European Union (EU) ban on feeding of animal protein to livestock imposed in 2001 created a demand for protein in animal feed that is now being filled by soy meal. Half of the EU's imported soybeans now come from Brazil. At the same time, the Amazon cattle herd expanded at 30% per year from 2002 to 2004 following the eradication of foot-and-mouth disease over large Amazon ranching regions. This led to the opening of markets for the export of Amazonian beef. Brazil became the world's largest beef exporter in 2004, with 38% of exports bound for the European Union.

These dramatic changes in Brazil have created ecological challenges. The science conducted by MBL Ecosystems Center researchers is vital to laying a foundation for environmental protection in this new globalized world.

In Brazil, areas of forest one to two times the size of Connecticut (14,000-27,000 km^2) are cleared annually for agricultural use. (Photo: Chris Neill)

The Changing Face of Brazil: Forest Clearing Effects and Possible Solutions

Few trees offer relief from the relentless sun that turns an early dry-season morning from warm to hot in an expansive Amazon cattle pasture. A small stream traversing this open landscape makes its sluggish way through a sea of grass. Not far away, however, a patch of Amazon forest offers a welcome respite from the heat. The stream flowing there is open and clear.

Researchers from the MBL's Ecosystems Center are working to understand how the conversion of large areas of forest to pasture is altering freshwater ecosystems. They strive to develop information to guide the inevitable changes that globalization is bringing to the Brazilian Amazon.

Christopher Neill, Linda Deegan, and their colleagues from the University of São Paulo study how deforestation for cattle pasture alters the chemistry and habitat in small streams. They find that pasture streams have such low levels of dissolved oxygen that they support almost no fish—in stark contrast to forest streams that support a diverse assemblage of fish. The ingrowth of grass into pasture streams plays a key role in this transformation. Grasses crowd the channel and produce organic material that consumes oxygen from stream waters when it decays. But the ingrowth of grass can be prevented if a buffer zone of native forest is allowed to remain—or regrow, in the cases of already-cleared land—adjacent to stream banks.

Low levels of oxygen, caused by organic matter from grasses in this pasture stream, limit fish population. (Photo: Chris Neill)

On lands that already have been cleared, Neill and his Ecosystems Center colleagues Jerry Melillo and Paul Steudler work, together with Carlos Cerri at the University of São Paulo, to study how conversion of forest and savanna to pasture and soybean farms changes soil fertility and the emissions of the greenhouse gases carbon dioxide and nitrous oxide to the atmosphere. They also study how the increasing use of fertilizer influences these emissions—and how fertilizer management might be improved to reduce emissions.

"While this globalization of trade in Amazonian agricultural products will undoubtedly lead to further forest clearing, it also presents opportunities for conservation," Neill notes. "Concern in European nations that beef and soybean imports not promote Amazon deforestation can pressure producers to comply with Brazil's existing environmental laws that require 80% of forests and riparian forest buffers of 30 to 500 meters (depending on stream size) on private farms to be left uncut as forest reserves. Though this has been difficult to enforce in the past, enforcement could be encouraged if banks and other financial institutions make compliance with environmental laws and use of environmental 'best practices' requirements for securing loans," he adds.

To better protect this rapidly changing area, Ecosystems Center scientists try to answer several questions. How wide does a forest buffer along streams need to be to preserve water quality and habitat for fishes? What timing and amounts of fertilizer applications will supply crop needs but minimize greenhouse gas emissions? This information is critical to developing regulations and guidelines that will protect the environment and that can be justified to ranchers, farmers, and increasingly savvy consumers around the world. It is the information needed to seize the opportunity to shape globalization as a force for Amazon conservation.

Managing the Coastal Zone

Some of the most beautiful, productive, and diverse ecosystems lie in the coastal zone at the interface of land and sea. These include estuaries, coastal forests and wetlands, and seagrass beds. These ecosystems provide a range of goods and services for our society, from fisheries and mariculture to recreation, storm protection, and habitat for a wide diversity of plants and animals.

Top: In salt marshes, such as this one in Plum Island Sound Estuary in Massachusetts, an increase in "ponding" is an early sign of salt marsh degradation. (Photo: Chuck Hopkinson)

Bottom: The Ipswich River in northeastern Massachusetts dries up in years of low precipitation. Water is exported to households outside the watershed and towns within the watershed export wastewater to regional sewage facilities. These water diversions have increased 40% since 1930. (Photo: Ipswich River Watershed Association)

Today the coastal zone is facing unprecedented pressure from increased population growth and associated human activity. Coastal watersheds within 30 miles of the ocean support more than 50% of the world's population, and this percentage is expected to increase dramatically in the coming decades.

This intensity of human use is threatening the environmental integrity and sustainability of coastal zone ecosystems and the services they provide. The changes begin in the river basins, where decreasing forests and increasing houses lead to more nutrients from sewage and less retention of nitrogen from acid rains. In some areas intensive agriculture, such as hog and chicken farms, also increases nutrients in river waters. The freshwater input to rivers and coastal waters changes, too, as groundwater wells are heavily pumped and river flow reduced. In the estuaries and salt marshes increased algal growth follows increased levels of nutrients running off from land. The result is a cascade of changes in plants and animals, starting with plants. For example, in New England green clouds of algae replace eelgrass and then scallops disappear. As if this eutrophication were not enough, coastal shellfish and finfish of all types are being over-harvested. The U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration estimate that more than 30% of our estuaries show signs of degradation or impairment.

Scientists at the MBL's Ecosystems Center are helping to deal with these environmental challenges by setting out scientifically sound alternatives for managing the coastal zone. Future scenarios and predictions are based on their studies of how ecosystems are linked to each other and the ecological consequences of human-induced changes on land and water ecosystems.

Chuck Hopkinson of MBL and Jim Morris of the University of South Carolina set up an experiment to measure plant growth at various water levels at the Plum Island Ecosystem Long-Term Ecological Research site in Massachusetts. (Photo: Karen Sundberg)

A New Approach to Assessing Ecological Trade-offs

As coastal communities grow, they increasingly face ecological trade-offs. The town dam provides power and opportunities for recreation, but it destroys fisheries, such as herring, and promotes the loss of coastal wetlands. The sewer system is the cheapest method of waste disposal, but the excess nitrogen it produces causes algal blooms and destroys the clam beds.

Each management option has its positive and negative aspects, so how do town managers evaluate these trade-offs and reach management decisions? MBL Ecosystems Center scientist Chuck Hopkinson was one of the authors of a paper in *BioScience* about an approach, based on ecosystem services, for assessing these trade-offs and making ecological management decisions that incorporate economic values.

As Hopkinson and his colleagues wrote, "The tragic consequences of Hurricane Katrina on the Gulf Coast have highlighted the importance of addressing ecosystem services—such as the storm protection that wetlands provide—in management decisions involving coastal settlement and infrastructure policies."

Hopkinson is the lead principal investigator on the Plum Island Ecosystem Long-Term Ecological Research project in northeastern Massachusetts. In this ever more suburbanized area, two watersheds from 26 towns drain into Plum Island Sound. One of the major ecological issues facing these communities is the change in the delivery of water, nutrients, and sediments to the coastal zone. Water is exported—sold—from the watersheds for consumption by people living in communities outside the watershed, sewage is diverted for disposal outside the watershed, and the result is that river channels dry up during summers with low precipitation. And as a result of river damming and the abandonment of agriculture, the export of sediments—important for maintaining coastal wetlands and a productive shellfishery—decreases. How do town managers provide an adequate water supply while maintaining river flow, preserving open space, and maintaining the clam fishery?

Using the ecosystems services-based approach, scientists would compare the effects of two management options: business as usual, and "replumbing" the sewer and stormwater systems. The replumbing alternative means that water would not be exported outside the watershed, resulting in increased river flow. Sewer systems would be replumbed, reducing cross-boundary flows of water. Results of the replumbing would mean an improvement of water-supply services and fish habitat, as well as better buffering of uplands against coastal storms and sea-level rise.

Town managers, conservation commission members, and other community leaders would then evaluate changes in the ecosystem services that would be affected by the two options. In the example of the water supply service, options could be evaluated using replacement costs for alternative supply sources. To assess flood and storm protection values of the two management options, managers would look at hydrologic models showing how an increase in wetlands could moderate storm surges and protect property, and the cost savings resulting from less property damage.

With values placed on each of the primary ecosystems services, which range from water supply to aesthetics to food production, the town managers would score the two options. For some towns, beautiful vistas and a healthy clam crop would mean more than revenue from selling water. Others might choose differently.

"This is a brand-new approach," Hopkinson says, "but one that has the advantage of fairly evaluating trade-offs in management decisions. We are hopeful that managers will give it a try."

Semester in Environmental Science

Searching for the best strategy to restore threatened sandplain grasslands, Allegheny College student Laura Nagel spent long hours on Martha's Vineyard island, collecting soil and adding carbon—in the form of sugar and sawdust—to her samples in the laboratory.

Jeff Walker of Cornell University, meanwhile, spent many days on West Falmouth Harbor collecting water samples and deploying and retrieving an instrument package that recorded oxygen, light, temperature, and other water-quality parameters at 20-minute intervals. His goal was to study the effects of nitrogen pollution from the town's wastewater treatment plant on the harbor.

SES students collect samples in West Falmouth Harbor for their independent projects. Nicole Travis (top) of Brown University nets small fish, mummichogs, for her experiment on how human-induced habitat changes affect predator-prey relationships. Jeff Walker of Cornell University deploys an instrument that measures water quality. (Photos: Tom Kleindinst)

Laura's and Jeff's efforts were part of their independent Semester in Environmental Science projects. Laura's project centered on the sandplain grasslands that occur on the dry, sandy soils of Martha's Vineyard. These grasslands are a globally endangered community, supporting many rare plants. The Nature Conservancy (TNC) aims to restore sandplain grasslands on old agricultural lands, but high amounts of nitrogen in agricultural soils make restoration difficult, because the nitrogen favors non-native plants at the expense of desired native ones. Laura tested how addition of sources of carbon—sugar and wood chips—in the laboratory could reduce soil nitrogen and promote growth of native species. Laura's results were compelling. Even small additions of both these kinds of carbon reduced soil nitrogen and reduced the growth of non-native grasses.

Jeff's study measured the total metabolism of the West Falmouth Harbor ecosystem. He used the data he collected to build a mathematical model that predicted what the total system production would be over an annual cycle, and compared this to other ecosystems that have experienced a range of nitrogen loadings. These data will give scientists an idea of how harbor metabolism may change as the plume of nitrogen-rich wastewater from the town sewage treatment plant reaches the harbor.

"I've not seen another program that offers such rigorous scientific training. Those students seriously considering a career in ecosystem or aquatic ecology will find that they will be very well served by the SES experience."

— visiting professor Howard Drossman, Colorado College

Both students' projects are typical of the challenging field and lab work tackled by undergraduates in the SES program during the five-week independent research phase of the semester. And the results from these activities are also typical of SES students. Laura won the MBL Associates award for excellence in her project work presented during the final course symposium. Jeff's project served as the basis of his senior thesis at Cornell, and his data will be used in a National Science Foundation-funded Ecosystems Center research project aimed at understanding the response of West Falmouth Harbor to nitrogen pollution.

The goal of SES is to help train the next generation of environmental leaders, according to program director Ken Foreman. Not simply a program in marine biology or terrestrial ecology, SES integrates and contrasts ecosystems structure and processes across the landscape. Students learn to think critically about scientific information and environmental issues by analyzing and interpreting data they collect in a diverse array of ecosystems on Cape Cod. Students aspiring to become policy makers and environmental advocates leave SES equipped to understand complex scientific issues.

In addition to their independent research, students spend about 20 hours a week in the field and lab during core courses in terrestrial and aquatic ecosystems science that introduce them to local field sites including freshwater ponds, coastal bays, and an experimental forest that is irrigated with treated wastewater from Falmouth's municipal wastewater treatment facility. Students also complete a science-writing seminar and an elective such as Mathematical Modeling of Ecosystems and Microbial Methods in Ecology. During the last five weeks of the program, SES students chose a topic for independent research, such as Laura's or Jeff's, and work with a mentor from the Ecosystems Center staff to produce a paper and an oral presentation at the semester's end.

SES students at work in the lab: Karie Harrold of Middlebury College and Rowan Spivery of Harvard University (above); Craig McGowan of Brown University (left) (Photos: Tom Kleindinst)

Students at the 62 colleges that are members of the MBL Consortium in Environmental Science are guaranteed credit at their home institutions for successfully completing the SES program. Brown University also offers credit to students from non-affiliated institutions, further extending the reach of the program.

Other Educational Programs

The Ecosystems Center is actively involved in education in a variety of ways. In addition to teaching in the Semester in Environmental Science Program, center scientists serve as adjunct professors and advisors in the Brown-MBL Graduate Program, members of doctoral committees, and mentors for postdoctoral scientists and undergraduate interns. The center staff also takes part in a range of community outreach activities to increase public understanding of science.

Top: Reporters in the MBL's Science Journalism Program survey the view of the Sagavanirktok River from Slope Mountain, looking south toward Alaska's Brooks Range. (Photo: John Hobbie)

Undergraduate Internships

With funding from the National Science Foundation (NSF) and other groups, the Ecosystems Center has offered many college students the opportunity to undertake summer projects at research sites. In 2005, 15 undergraduates conducted research projects through NSF's Research Experience for Undergraduate program, the National Oceanic and Atmospheric Administration's Coastal Internship program, the Woods Hole Marine Science Consortium, or independently. Their projects ranged from the study of sediment nitrification rates in nearby West Falmouth Harbor to research on the effects of deforestation in the Brazilian province of Rondônia to the study of effects of phosphate fertilization on Arctic streams.

Middle: Andrew Gaylord, undergraduate intern from the University of Massachusetts Amherst in Maureen Conte's lab, prepares samples. (Photo: JC Weber)

Brown-MBL Graduate Program in Biological and Environmental Sciences

Bottom: (left to right) Seeta Sistla, Marselle Alexander-Ozinskas, and Gillian Galford of the Brown-MBL program. (Photo: Bethany Bradley)

Three Ph.D. students are working with Ecosystems Center scientists in the MBL's graduate program with Brown University: Gillian Galford (Washington University 2004) is studying regional and global consequences of the expansion of mechanized agriculture in the Brazilian Amazon with Jerry Melillo of the Ecosystems Center and Jack Mustard of Brown. Marselle Alexander-Ozinskas (Bates College 2005) is conducting research on the effects of topography, landscape age, and climate change on biogeochemical nitrogen cycling in the arctic and other arid ecosystems with Gus Shaver of the center and Osvaldo Sala of Brown. Seeta Sistla (Swarthmore College 2004) works with Melillo and Sala on estimating the contribution of root respiration to total soil CO_2 flux to the atmosphere in a temperate forest ecosystem.

Barrow (Alaska) High School students Krista and Donna Frantz check a tundra warming experiment at Arctic Schoolyard LTER site in Barrow. (Photo: Leslie Pierce)

Schoolyard Long-Term Ecological Research Projects

The two MBL-based Long-Term Ecological Research (LTER) projects again in 2005 received supplemental funding from NSF to promote educational activities near their sites. The Arctic Schoolyard LTER is based at Barrow, Alaska, and designed for students, mostly native Inupiat Eskimos, their teachers and local residents. It consists of "Schoolyard Saturday," a weekly series of lectures and field demonstrations by visiting scientists, and two field activities. One field experiment measures the effects of climate warming on tundra vegetation; the second experiment measures changes in lake water chemistry.

Undergraduate interns Christina Bethoney of the University of Massachusetts Amherst and Carter Thurman of Sewanee University install a fish-exclusion net at Plum Island Sound estuary in Massachusetts. (Photo: Christian Picard)

Another schoolyard program, the Plum Island Ecosystem Schoolyard LTER, is conducted in cooperation with the Massachusetts Audubon Society's Salt Marsh Science Project, and provides ongoing professional development for teachers in the greater Boston area. In 2005, through another component of the Plum Island Schoolyard program, middle and high school students from the region continued their long-term monitoring of salt marshes for vegetation, invasive species, salinity levels, and salt marsh fish.

Science Journalism Program

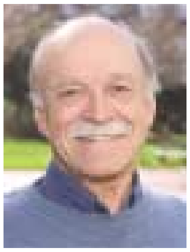
The Ecosystems Center participates each year in the MBL's Science Journalism Program. Journalists attend a hands-on training course in ecology with lectures and laboratory work in Woods Hole in June, directed by John Hobbie and taught by Chris Neill and Ken Foreman. In 2005, as in past years, five of the journalists traveled to the Arctic LTER site at Toolik Lake, Alaska, where they participated in field work and lab analysis, attended lectures by researchers, and interviewed scientists. Although publishing an article about the Toolik Lake research is not a requirement of the fellowship, numerous stories about the research being conducted there have been inspired by these interactions. Last year's Alaska fellows were James Bruggers, *The Courier-Journal*; Hannah Hoag, freelance writer from Quebec; Kristan Hutchison, *The Antarctic Sun*; Mike Stark, *The Billings Gazette;* and Jeff Tollefson, *Congressional Quarterly*.

Science Outreach in the Community

In 2005, members of the Ecosystems Center staff judged community and state science fairs for students in kindergarten through grade 12, and mentored junior high school students as they researched their projects. The center also continued its participation in the Woods Hole Science and Technology Education Partnership, providing assistance to teachers and students in the local school systems.

Ecosystems Center staff members also serve on many town committees, including the Falmouth planning board and conservation commission, Falmouth Associations Concerned with Estuaries and Salt Ponds, the Association to Preserve Cape Cod, the Falmouth Coastal Resources working group, the Nutrient Management working group, and the Falmouth Ashumet Plume Nitrogen-Offset Committee.

Scientists at the Ecosystems Center



John E. Hobbie
Co-Director, Distinguished Scientist
Ph.D., Indiana University
As an aquatic ecologist, John tries to identify the factors controlling decomposition and productivity in aquatic ecosystems, especially the role that microbes play.

Jerry M. Melillo
Co-Director, Senior Scientist
Ph.D., Yale University
Jerry is interested in how human activities are altering the biogeochemistry of terrestrial ecosystems and especially how global changes are affecting the chemistry of the atmosphere and the overall climate system.

Linda A. Deegan
Senior Scientist
Ph.D., Louisiana State University
Linda is interested in the relationship between animal populations and ecosystems because animals can strongly influence community composition and ecosystem nutrient cycles and productivity.

Kenneth H. Foreman
Director of Semester in Environmental Science Program
Ph.D., Boston University
Ken's principal research area is the coastal zone. In recent years, he has been studying the effects of nutrient loading on benthic and water column communities and processes.

(Photos: Tom Kleindinst)

Anne E. Giblin
Senior Scientist
Ph.D., Boston University
Anne's major research focus is the cycling of elements in the environment, especially the biogeochemistry of iron, sulfur, nitrogen, and phosphorus in soils and sediments.

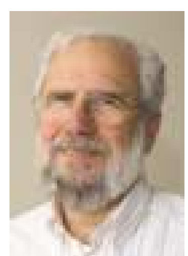
Charles S. Hopkinson
Senior Scientist
Ph.D., Louisiana State University
Chuck's work focuses on the coastal zone, examining the effects of climate change, land use change and sea level rise on estuaries and continental shelves and the ecosystem services they provide.

Christopher Neill
Associate Scientist
Ph.D., University of Massachusetts Amherst
Chris investigates how ecosystems cycle nutrients and organic matter and how changes in land use, such as deforestation in the tropics, alter the structure and biogeochemistry of ecosystems.

Bruce J. Peterson
Senior Scientist
Ph.D., Cornell University
Bruce focuses on understanding aquatic productivity and global change by studying the cycles of water, carbon, and nitrogen at the ecosystem and global levels.

Edward B. Rastetter
Senior Scientist
Ph.D., University of Virginia
Ed synthesizes field and laboratory data using simulation models to study how plants and microbes optimize their use of resources like carbon, nitrogen, light, and water, and how that optimization might influence the response of ecosystems to global change.

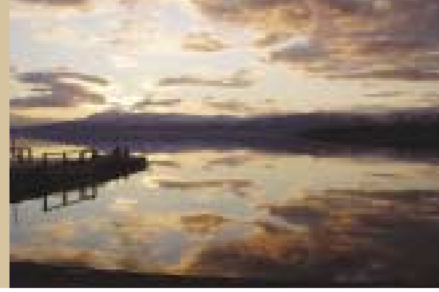
Gaius R. Shaver
Senior Scientist
Ph.D., Duke University
Gus's research is focused on the role of plants in ecosystem element cycles, especially in Alaskan tundra ecosystems, where low temperatures, low light intensities, low nutrient availability, and a short growing season all interact to limit plant growth



Paul A. Steudler
Senior Research Specialist
M.S., University of Oklahoma
Paul is interested in the responses of temperate and tropical forest and agricultural ecosystems to disturbances like hurricanes, nitrogen and sulfur additions, forest cutting and re-growth, and increased temperature.

Joseph J. Vallino
Associate Scientist
Ph.D., Massachusetts Institute of Technology
Joe's research employs thermodynamics to examine how microbial metabolic networks organize and evolve to utilize energy and resources in the environment.

News & Honors



Lake Torneträsk at the Abisko (Sweden) Scientific Research Station at midnight in summer. (Photo: Lorna Street)

Ecosystems Center scientists serve on national-level planning committees for science initiatives, on boards and as officers of scientific societies, and as conveners of professional conferences.

In 2005, Ecosystems Center co-director **John E. Hobbie** was honored by colleagues at both the MBL and the Estuarine Research Federation (ERF). John was named Distinguished Scientist at the MBL, a special recognition bestowed on an MBL scientist with outstanding scientific achievements and service to the scientific community. Only one other MBL scientist, Shinya Inoué, has ever held this designation.

John and Olivann Hobbie (Photo: Tom Kleindinst)

At the ERF biennial conference, John received the Odum Award for Lifetime Achievement. Named for ecological scientists Howard T. Odum, Eugene P. Odum, and William H. Odum III, the recognition is given to a scientist with a continuous record of important contributions to the understanding of estuaries.

"John Hobbie has been sustaining an impressive array of research and outreach activities for over 40 years and shows no signs of slacking his pace," according to the ERF committee.

John has published more than 150 research papers and edited several books. In 1975, he and Ralph Daley wrote "Direct counts of aquatic bacteria by a modified epifluorescence technique" in *Limnology and Oceanography*. The article has become one of the most cited papers in environmental science.

Also in 2005, the John E. Hobbie Scientific Research Endowment was established to mark John's career as a scientist and as co-director of the Ecosystems Center. The endowment will be used as a discretionary fund for Ecosystems Center scientists to explore emerging areas of ecology, fill gaps in support of existing programs, and further John's vision of collaboration and excellence in ecosystem science.

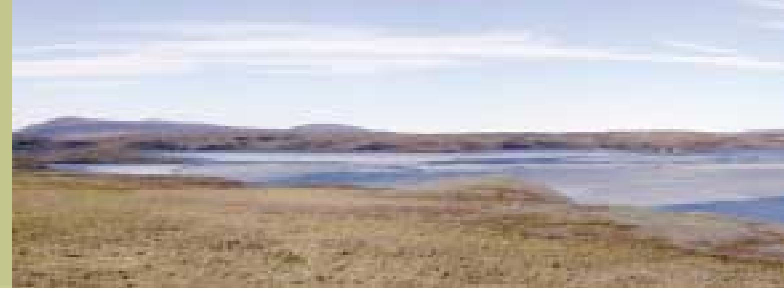
Other News

Jerry Melillo was president of the Ecological Society of America (ESA) in 2005, and **Gus Shaver** served as ESA's vice president for science. Jerry is also past president of the Scientific Committee for Problems of the Environment (SCOPE) and continues on its board. In 2005, Jerry was elected to membership in the American Philosophical Society, the nation's oldest scholarly society.

Linda Deegan is science co-chair of the Estuarine Research Federation's 2007 conference. **Ed Rastetter** organized a 2005 meeting of the National Ecological Observatory Network (NEON), while **Chris Neill** planned a joint meeting of scientists from the Nature Conservancy and the Ecosystems Center.

John Hobbie serves on the planning committee of NEON and on the executive board of the Long Term Ecological Research project. **Chuck Hopkinson** is on the steering committee for a National Center for Atmospheric Research effort on carbon budgets in coastal shelf water. **Gus Shaver** is on the steering committee of the Arctic Systems Science (ARCSS)'s Study of Environmental Arctic Change. **Jerry Melillo** is chairing the scientific task force advisory committee of the LTER network planning process and is a member of the NASA panel, *Next Set of Initiatives to Planet Earth*. **Bruce Peterson** is a member of the ARCSS board.

Publications 2005



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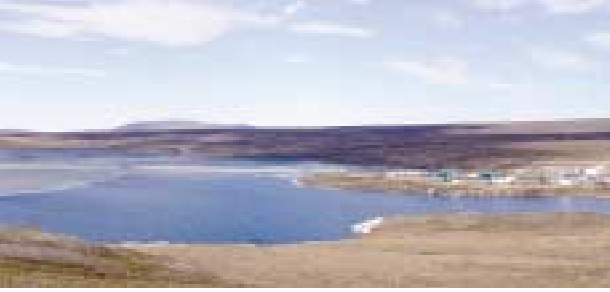

Toolik Lake, Alaska, site of the Arctic Long-Term Ecological Research Program. (Photo: Jim Laundre)

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Lael Rogan of the University of Alaska Fairbanks measures the extent of the thermokarst - the slumping of the stream bank caused by thawing permafrost - near the Arctic LTER on the North Slope of Alaska. (Photo: Adrian Green)

Suzanne Thomas prepares to add nitrogen solution to a northeastern Massachusetts stream, part of an experiment that studies the effects of excess nitrogen in aquatic environments. (Photo: Deanne Drake)

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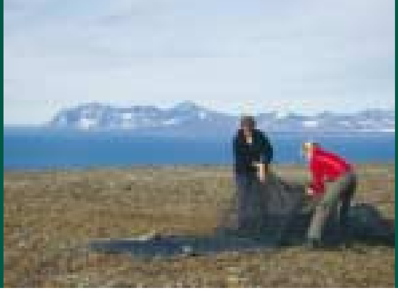
Seminars



Graduate students from Wageningen University, The Netherlands, work with MBL researchers in Svalbard, Norway, to measure the effect of light levels on carbon dioxide absorption by plants. (Photo: Lorna Street)

February

1 William Hagar, University of Massachusetts Boston, "Stable isotope analysis of food webs in acid sensitive ponds."

8 Richard Langan, University of New Hampshire, "Advances in offshore aquaculture in the northeast U.S.: The UNH Open Ocean Aquaculture Project."

March

1 Anthony Aufdenkampe, Stroud Water Research Center, "Isotopic constraints on organic and inorganic carbon cycling in the Amazon River system."

8 Scott Goetz, Woods Hole Research Center, "Land use change, loss of resource lands, and stream health in the mid-Atlantic region using satellite remote sensing."

15 Christie Haupert, MBL, "Size influences geomorphology and biogeochemistry in small Amazonian pasture streams."

22 Eric Davidson, Woods Hole Research Center, "Do phosphorous-limited mature lowland tropical forest sites become nitrogen-limited when converted to pastures and secondary forests?"

29 Martin Polz, Massachusetts Institute of Technology, "Microbial diversity: Can we see the forest for the (phylogenetic) trees?"

April

5 David Post, Yale University, "The long and short of food chain length."

12 James Kahn, Washington and Lee University, "Economic incentives for sustainable use of Amazonian rainforests."

19 Jeffrey Dukes, University of Massachusetts Boston, "Ancient roots and modern consequences of global environmental change."

26 Richard McHorney, MBL, "Ground water/surface water interactions and ecology of coastal plain ponds."

May

3 Melinda Smith, Yale University, "Dominant species and the functioning of ecosystems."

10 Ivan Valiela, Boston University Marine Program, "Land-estuary couplings: Land use, freshwater transport, estuarine responses."

17 W. Wyatt Oswald, Harvard Forest, "Edaphic controls on the response of arctic tundra to climate change: paleoecological evidence from the Toolik Lake area."

24 Robert Muth, University of Massachusetts Amherst, "A biosocial approach for environmental analysis and natural resource decision making."

September

13 Bruce Peterson, MBL, "Acceleration of the arctic and subarctic freshwater cycle."

16 Cynthia Rosenzweig★, NASA, Goddard Institute for Space Studies, "Assessing observed changes in natural and managed systems."

27 Jeremy Fisher, Brown Univeristy, "Climatic and anthropogenic influences on spatial patterns of green leaf phenology: New observations from LANDSAT data."

30 Jon Cole★, Institute for Ecosystem Studies, "What happens to terrestrial carbon when it enters aquatic ecosystems?"

October

4 David Foster, Harvard Forest, "Coastal lands through time: Insights from historical ecology to landscape conservation in southern New England."

11 John Fleeger, Louisiana State University, "Direct and indirect effects of toxicants and bioturbation on benthic producers and consumers."

14 William Mitsch★, Ohio State Univeristy, "Restoration of the Mississippi River Basin."

November

1 John Hayes, Woods Hole Oceanographic Institution, "Serols as biogeochemical indicators in surface sediments of the Ross Sea."

4 James Estes★, USGS and UC Santa Cruz, "From killer whales to kelp beds: Large predators and ocean food webs."

8 Michael Dorcas, Davidson College, "Amphibian and reptile conservation in the Carolinas: An epidemic of urbanization."

11 Andrew Rosenberg★, University of New Hampshire, "The ocean policy commission, fisheries and ecosystem based management."

15 Adam Schlosser, Massachusetts Institute of Technology, "The global impact of event-based precipitation change on estimated natural emissions of nitrous oxide."

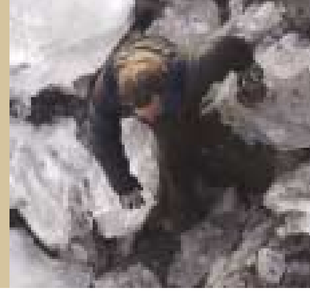
29 Jed Sparks, Cornell University, "Soil emissions of nitrogen trace gases in the Mojave Deset under elevated CO_2: Implications for regional tropospheric chemistry."

December

13 Scott Nixon, University of Rhode Island, "Nitrate removal by constructed subterranean wetlands."

★*SES Distinguished Scientist Seminar Series*

Staff



Hap Garritt pushes through ice to retrieve monitoring equipment on the Parker River in northeastern Massachusetts. (Photo: Emily Gaines)

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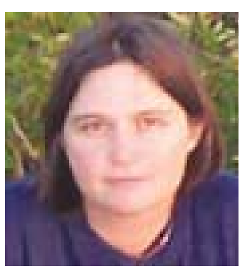

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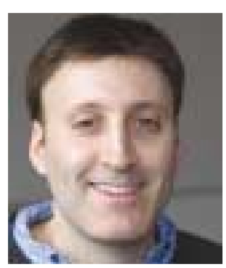

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At Harvard Forest LTER in Petersham, Massachusetts, Ecosystems Center scientists wrap trees in tubing connected to a chiller unit to inhibit the movement of carbon (in the form of sugars) in the canopy to the roots. They hope to separate root respiration from microbial respiration. (Photo: Seeta Sistla)

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Aimlee Laderman, Yale University
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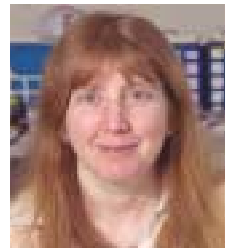

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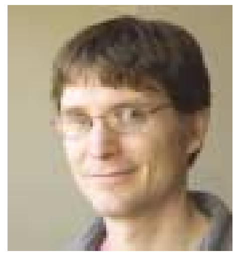

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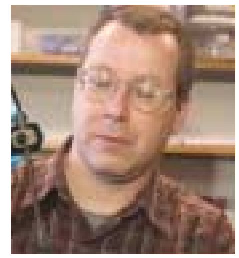

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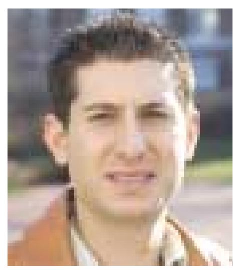

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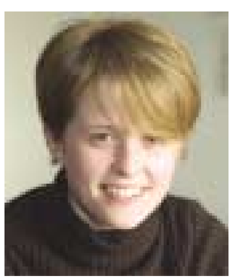

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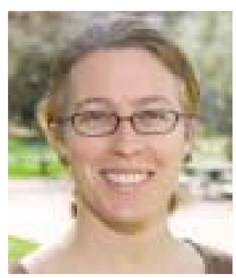

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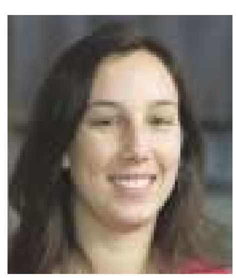

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Photos: Tom Kleindinst, Adrian Green, Sue Donovan, Martha Scanlon, Mac Lee, Jim Laundre, Paul Frankson, Chris Crockett, and Chad Norris

Sources of Support for Research and Education

Elizabeth Binkley, summer research assistant, and Chris Crockett run samples at Toolik Lake, Alaska, in an experiment designed to mimic nutrient loading that would result from climate warming. (Photo: Adrian Green)

The annual operating budget of The Ecosystems Center for 2005 was $8,600,000. Approximately 80% of the income of the center comes from grants for basic research from government agencies. The other 20% comes from gifts and grants from private foundations, including support for the Semester in Environmental Science program, as well as from institutional support for administration and income from the center's reserve and endowment funds.

These non-governmental funds provide flexibility for the development of new research projects, public policy activities, and educational programs.

The combined total value of the center's reserve fund and endowment at the end of 2005 was $5,600,000. Income from the reserve fund and endowment helps defray the costs of operations, writing proposals, consulting for government agencies and the center's seminar program.

The Ecosystems Center is grateful for the support it has received from the following corporations and foundations over the past five years:

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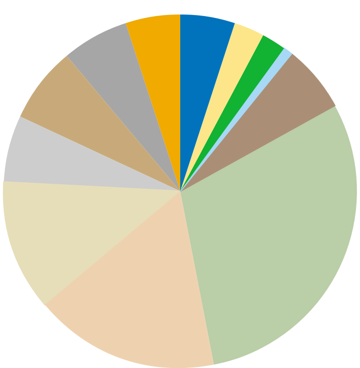

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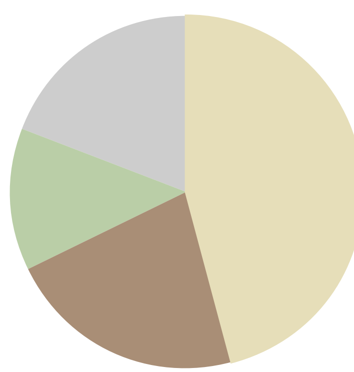

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Cover photo: View of Harvard Forest and Quabbin Reservoir lands in central Massachusetts. Ecosystems Center scientists carry out experiments on effects of environmental change as a part of the Harvard Forest Long-Term Ecological Research Project. (Photo: David Foster)