1888 MBL Biological Discovery in Woods Hole

The Ecosystems Center ANNUAL REPORT 2011

The Ecosystems Center
MBL
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Cover photo: A soil slump related to the thawing of permafrost in the Noatak National Preserve in the Brooks Range, Alaska. The feature is approximately 250 meters wide and about 400 meters long. The sediment discharged from the bottom of the slump reduced water clarity for several kilometers downstream. (Lisle Snyder)

The Ecosystems Center was founded in 1975 as a year-round research center of the MBL. Its 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 scientists work together on projects, and collaborate with investigators from other centers at the MBL and from other institutions, combining expertise from a wide range of disciplines. Together, they conduct research around the world:

• At Toolik Lake on the North Slope of Alaska and at Palmer Station in Antarctica, scientists on the Long Term Ecological Research (LTER) projects study the effects of climate change on polar ecosystems.

• At the Plum Island Ecosystem LTER site in northern Massachusetts, on Martha's Vineyard, at Waquoit Bay on Cape Cod, and in the mangrove swamps of Panama, scientists investigate the links among climate and land-use change, urban development, and the hydrology and ecology of watersheds, estuaries and coastal zones.

• In tropical Brazil and at the Harvard Forest LTER site in central Massachusetts, scientists study the effects of land-use change in temperate and tropical forest ecosystems.

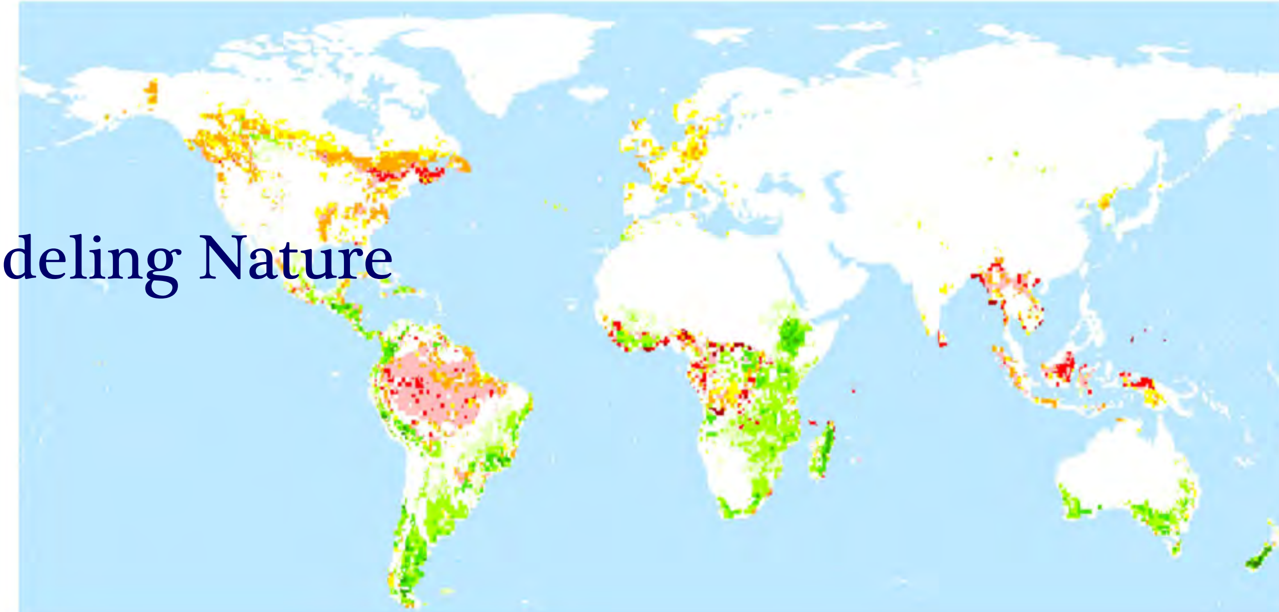
Sam Kelsey crosses the flooded Plum Island marsh during a very high tide. (Inke Forbrich)

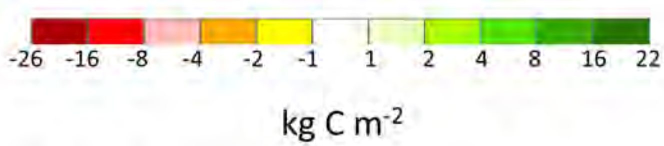
• In the deep Sargasso Sea, researchers continuously measure particle fluxes, examining the transfer of material from the surface to the deep ocean.

• In our laboratories in Woods Hole, scientists analyze thousands of samples generated in field sites around the world and conduct experiments on microbial systems, roots, soils and sediments to understand the ecological processes governing global biogeochemical cycling of carbon, nutrients and greenhouse gases. Scientists use sophisticated computer models to ask questions about effects of future changes in climate, land use, carbon dioxide, ozone, water and nutrients on vegetation productivity, carbon storage and nutrient cycling. Center researchers collaborate with social and atmospheric scientists at MIT to investigate ecological responses to various scenarios of economic and energy development.

For more information, see Ecosystems Center Research Projects.

Modeling Nature





Above: The Terrestrial Ecosystem Model projects that an aggressive global program to produce biofuels, liquid fuels from biomass, will lead to a loss of carbon from some ecosystems (shown as negative values) and a gain of carbon in others (shown as positive values). The largest carbon losses occur when massive forests (e.g., tropical forests in the western Amazon) are cleared to grow biofuels crops.

Above right: Microbial microcosms are being used by Ecosystems and Bay Paul Centers researchers to model the flow of energy through complex bacterial communities

Far right: Striped bass are implanted with an acoustic tag so that they can be followed as they migrate along the coast.

Each of the feature articles in this year's annual report describes a model of nature. Everything scientists do depends on some sort of a model of what they work on, even if it isn't apparent at first glance. An experiment is a simplified model of some aspect of nature. Dependence on models extends into everyday life too. Imagine you're in New England on a cold blustery day packing for your winter vacation in Florida. What do you take? Mostly clothes for the beach of course, but what do you wear to the airport, and then on the way back home? Your plan for packing includes some prediction, unconscious or otherwise, of what weather you'll experience on your trip. Your model of the trip might be good or bad, and will be evaluated by comparison to your observations along the way. Every video game is a model of the world we live in (or think we do).

Ecosystems Center scientists use a wide range of models in their work to represent some part of the world around us. Linda Deegan describes the use of a model organism, the striped bass, to study the role of animal migration in linking distant ecosystems. Animal, plant and microbial models are selected because they have special characteristics that suit them to laboratory study or some other aspect that makes them easy to use. White mice, *E. coli* bacteria and zebrafish are other model organisms used by scientists as windows into the workings of the natural world. MBL is famous for using marine models such as squid and horseshoe crabs.

$$\frac{dN_1}{dt} = r_1 N_1 - k_1 N_1 N_2$$

$$\frac{dN_2}{dt} = k_2 N_1 N$$

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$= k_2 N_1 N_2 - d_2 N_2$

$\frac{dN_1}{dt} = r_1 N_1$

Joe Vallino and Chris Algar use another sort of model in the lab to investigate the microbial process of denitrification, the conversion of fixed nitrogen compounds back to nitrogen gas, a major link in the global nitrogen cycle. They have a physical model of marine sediment, the thin disk model, composed of a network of filter disks with microbial assemblages and flowing seawater connecting the disks. These simplified versions of the complex structure of sediment, nutrients and microbes facilitate their measurements of the denitrification process, allowing them to control external factors such as temperature, light and oxygen.

Mostly what scientists, and increasingly the informed public, think of when they use the term model, is a numerical or simulation model of a natural system, whether it's the weather system, the global carbon cycle or a metabolic pathway. Ed Rastetter pioneered the development of multiple-element models of nutrient cycling, and describes their application to predicting the effects of thermokarst scars in the Arctic as the climate warms. Numerical models are built up of mathematical equations representing or simulating natural processes. The best way to get answers about what would happen if there were changes in natural processes, such as climate change, would be to do an experiment and manipulate nature—a very difficult task indeed. But with computers, we can ask very sophisticated "what if" questions stretching decades and centuries into the future (or the past). Ecosystems Center scientists developed the first global scale model of terrestrial ecosystems, the Terrestrial Ecosystem Model (TEM). TEM is being used today to project the effects of large-scale conversion of tropical forests to agricultural fields, and other important drivers of global change on the climate, the world economy and the water cycle.

Models of all types lie at the heart of science. As our dependence on them to make predictions and guide policy formation grows, it's important for us to understand and be able to evaluate their limitations and biases. Climate models are a lightning rod used by special interests to push their views. As scientists we have a responsibility to help the public understand their uses and misuses.

— Hugh Ducklow

$$\frac{dN_2}{dt} = k_2 N_1 N_2 - d_2 N_2$$

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Biotic Teleconnectivity: Patterns and Consequences of the Migration of Striped Bass

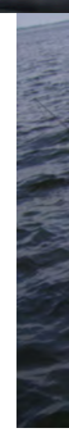
Cristina Kennedy, former Ecosystems Center research assistant and current University of Massachusetts graduate student, and University of Masschusetts professor Martha Mather release a tagged bass in the University of Massachusetts Amherst Adopt-a-Bass acoustic tagging program in Plum Island Sound. Once the fish are tagged, receivers, or "acoustic arrays," along the Atlantic coast pick up their movements. For $30, people are invited to name their adopted fish and receive updates on its behavior, while contributing to research on an important fishery stock. Ms. Kennedy said the majority of adopters were avid recreational fishermen with a connection to Plum Island Sound. She also noted that recreational striped bass fishermen are generally "impressed and surprised" by the fact that individual striped bass return to Plum Island the following year.

Long-distance animal migration has fascinated scientists and the general public for generations. Migration between geographically distinct areas, what we call biotic teleconnectivity, is an adaptive response that allows animals to take advantage of variation across ecosystems in the availability of breeding habitat or food. Migration is essential to the survival of many birds, mammals and fish. Understanding the nature of migration is a pressing conservation concern as globally many animal migrations have disappeared or are threatened by human activities.

The lack of understanding about why fish migrate here and not there in the ocean has limited our ability to reap the benefits of management using marine-protected areas. Species that use a small number of habitats and follow predictable routes may be more susceptible to human disruptions, but ironically, may be easier to manage by protecting small key areas than species whose migrations are spread over a large area. Thus, understanding whether a migratory organism uses small or large areas for migration is important for long-term conservation.

Ecosystems Center scientists and their colleagues at the Plum Island Ecosystem Long-Term Ecological Research (PIE LTER) site have found that striped bass are an exemplary marine organism to study because they migrate south to north to maximize growth and survivorship, similar to the well-known spring migration of songbirds.

Schoolie striped bass, so called because at two to five years of age they are the equivalent of teenaged fish and travel in schools because they are small, spend the winter in southern estuaries, predominately Delaware Bay, Chesapeake Bay and the Hudson River. Each spring these fish move northward, concentrating in estuaries from New England to Nova Scotia to feed on small fish and invertebrates. How much these schoolie bass can grow in the summer is important because increased growth of teenage bass can increase survival into adults. Research at PIE LTER offers new insights into these patterns and provides guidance to scientists as they develop policies for managing coastal fisheries.



To understand the biotic teleconnectivity of striped bass, Ecosystems Center scientist Linda Deegan, along with her colleague, Martha Mather, and students from the University of Massachusetts Amherst are pioneering the use of a new acoustic fish tagging technology.

Schoolie striped bass in Plum Island, Massachusetts, are implanted with tags and then followed for the next year. The team cooperates with the Atlantic Cooperative Telemetry (ACT) network, researchers who work with acoustic tags to understand the coastal migrations of fish species.

Deegan, Mather and their group have discovered two remarkable findings that suggest a previously unsuspected geographic connectivity between wintering and summering estuaries by schoolie striped bass. Their results show that striped bass that had wintered in Delaware Bay, then traveled hundreds of miles along the coast, became summer residents in Plum Island Sound. Approximately 60% of the Plum Island summer resident striped bass overwintered in Delaware Bay, despite the fact that Delaware Bay produces less than 5% of the migratory stock. Even more unexpected was the finding that 75% of these bass returned to Plum Island repeatedly over several years.

These findings contradict the common assumption that striped bass stair-step their way up then back down the coast, foraging briefly in a series of random estuaries, and using different estuaries every year, until they decide to turn around and head back home for the winter.

The team also found that once at their summer home, individual bass develop very specific locations where they feed repeatedly, with the same striped bass occupying the same locations, tide after tide. Individual striped bass clustered into two groups of fish: those that preferred to feed in shallow rivers adjacent to saltmarshes, and those that preferred the deeper water of the open bay. These results cast doubt on the conventional wisdom that although striped bass, in general, may be found in predictable locations, it is a different bass every tide. Within those broad locations, individual striped bass often feed in focused areas, spending most of their time feeding in an area smaller than an acre within a much larger area.

The finding of distinct, small foraging areas for individual striped bass suggests that bass behaviorally adjust their realized ecosystem to maximize growth. Fish that repeatedly migrate to Plum Island may grow faster because by returning to the same location within the estuary they learn to become more efficient predators. A smaller realized ecosystem may result in a stronger feeding intensity that can control the abundance of small fish and invertebrates on which striped bass feed. This may increase their importance as predators in estuaries.

The strong biotic teleconnectivity between far-away locations suggests that local environmental conditions in one estuary may have profound effects in estuaries thousands of miles away. Environmental conditions in Delaware Bay that determine the number of schoolie fish that migrate north may influence the productivity of the Plum Island Sound estuary.

These cutting-edge tagging technologies, along with our cumulative understanding of the role of migratory fish in ecosystem functions and processes, will help to form sound policies on managing coastal fisheries.

—Linda Deegan

Will Increase in Permafrost Thaw Stimulate CO_2 Release?

This thermokarst in the form of a thaw slump in the foothills of Alaska's Brooks Range adds enough sediment to a stream to greatly reduce the clarity of the water. (Lisle Snyder)

Much of the Arctic is underlain by permafrost, which includes permanently frozen ice, soils, organic material and rocks. The ice cements together this material and provides firm footing not only for man-made structures like buildings, roads, and pipelines, but also for the landscape itself. If the ice is present as blocks or ice wedges and the permafrost thaws, the land surface may collapse and form a depression called a thermokarst. If a thermokarst develops on a hillside, as shown in the photo above, the entire surface can detach and slide downslope leaving a scar of freshly churned earth stripped of vegetation and a mound of amalgamated plants, peat, and mineral soil at the base of the hill.

The soil exposed in such scars — and the associated carbon and nutrients — might have been frozen for thousands or even millions of years and therefore stored away, or sequestered, from the active cycling of elements through the overlying tundra vegetation and soils. These newly exposed elements then become available to plants and microbes with several potential consequences. First, the previously sequestered carbon might be respired by soil microbes, releasing CO_2 into the atmosphere. Second, the freshly exposed nutrients might fertilize plant growth, thereby stimulating photosynthesis and the removal of CO_2 from the atmosphere. Third, the carbon and nutrients might be washed off the hillslope by rainwater and melting snow and alter the ecology of lakes and streams downslope.

Over the last 10,000 to 15,000 years, the broad-scale effects of these thermokarst scars has probably been small because they have been relatively rare and cover only a small fraction of the landscape. However, as the climate warms, the occurrence of thermokarst is expected to rise and large areas of hilly terrain in the Arctic might be affected. If the warming is severe enough, increased formation of thermokarsts is likely to have a significant impact on the Arctic carbon budget and the ecology of the region. Exactly what those effects will be is the subject of intensive current research.

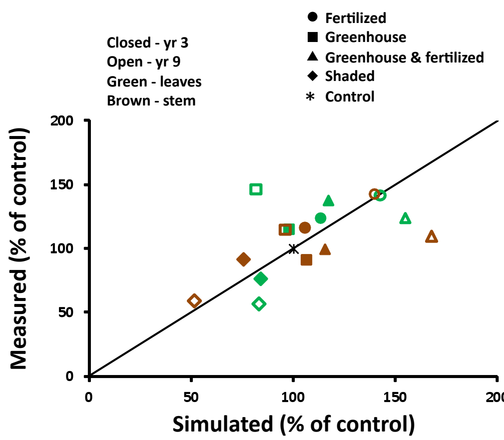


Figure 1: Comparison of leaf and stem biomass simulated with the MEL model to data from years 3 and 9 of a fertilizer, greenhouse, and shading experiment.

Another type of thermokarst is called a gully, shown here on a small stream feeding into the Toolik River. Running water has melted large blocks of ice in the soil, causing the collapse of the stream bank. (Photo courtesy of Alex Huryn)

Ecosystems Center scientist Ed Rastetter is part of a large team of scientists from several universities and laboratories studying the changing characteristics and frequency of thermokarst formation on the North Slope of Alaska. Along with Andrea Pearce of the University of Vermont, Rastetter has been modeling the recovery of vegetation and soils in thermokarst scars. The model simulates the cycles of carbon, nitrogen, phosphorus and water in tundra ecosystems.

They first calibrated the model to a long-term tundra experiment maintained by Ecosystems Center scientist Gus Shaver at the Arctic Long-Term Ecological Research site (Fig. 1). To understand the mechanisms underlying tundra responses to climate change, Shaver has been manipulating tundra plots by adding nitrogen and phosphorus fertilizer, enclosing them in greenhouses, or covering them with shade cloth. The recovery of vegetation and soils in thermokarst scars will involve many of the same processes that regulate the response to climate change.

Rastetter and Pearce ran several simulations with the calibrated model (Fig. 2). All the simulations started with 90% of the plant biomass removed by the thermokarst disturbance. To capture the variation in soil conditions in thermokarst scars, the simulations started with soil organic matter ranging from 25 to 125% of the amount in undisturbed tundra. The amount of soil organic matter left in the scar is important because over 95% of the nutrients in a tundra ecosystem are tied up in the soil. As this organic matter decomposes, it serves as a slow-release fertilizer providing nutrients to the recovering vegetation. Consequently, plant biomass in the model recovers faster with more soil organic matter left in the scar. Nevertheless, nutrients are lost from the recovering thermokarst scar for about 40 years after the disturbance because the plants cannot take up nutrients fast enough to keep up with the nutrient release from decomposing organic matter. In addition, except with 125% of the undisturbed soil organic matter left in the scar, the amount of carbon stored in the simulated ecosystem after 100 years is less than that in the undisturbed tundra.

Regardless of the initial amount of soil organic matter left in the scar, both plant biomass and soil organic matter in all the simulations will eventually converge on the amounts in the undisturbed tundra, but may require thousands of years to do so. The reason for the long recovery time is that the ecosystems have to recover all the nutrients lost during the initial disturbance plus any subsequent losses. In arctic regions, the rate of supply of these nutrients through rainfall, dust and weathering of rocks is very slow.

The general pattern of recovery predicted by the model agrees with observations in the field, but the timing is off. Michelle Mack from the University of Florida, another member of the thermokarst study team, has been measuring the characteristics of thermokarst scars of different ages. Her results indicate that the scars recover about twice as fast as predicted by the model.

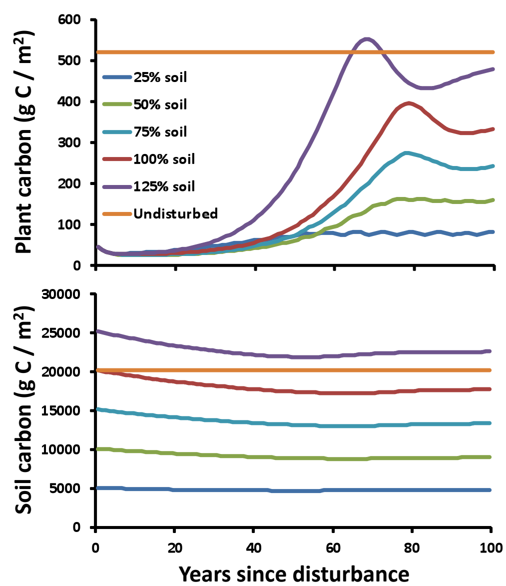
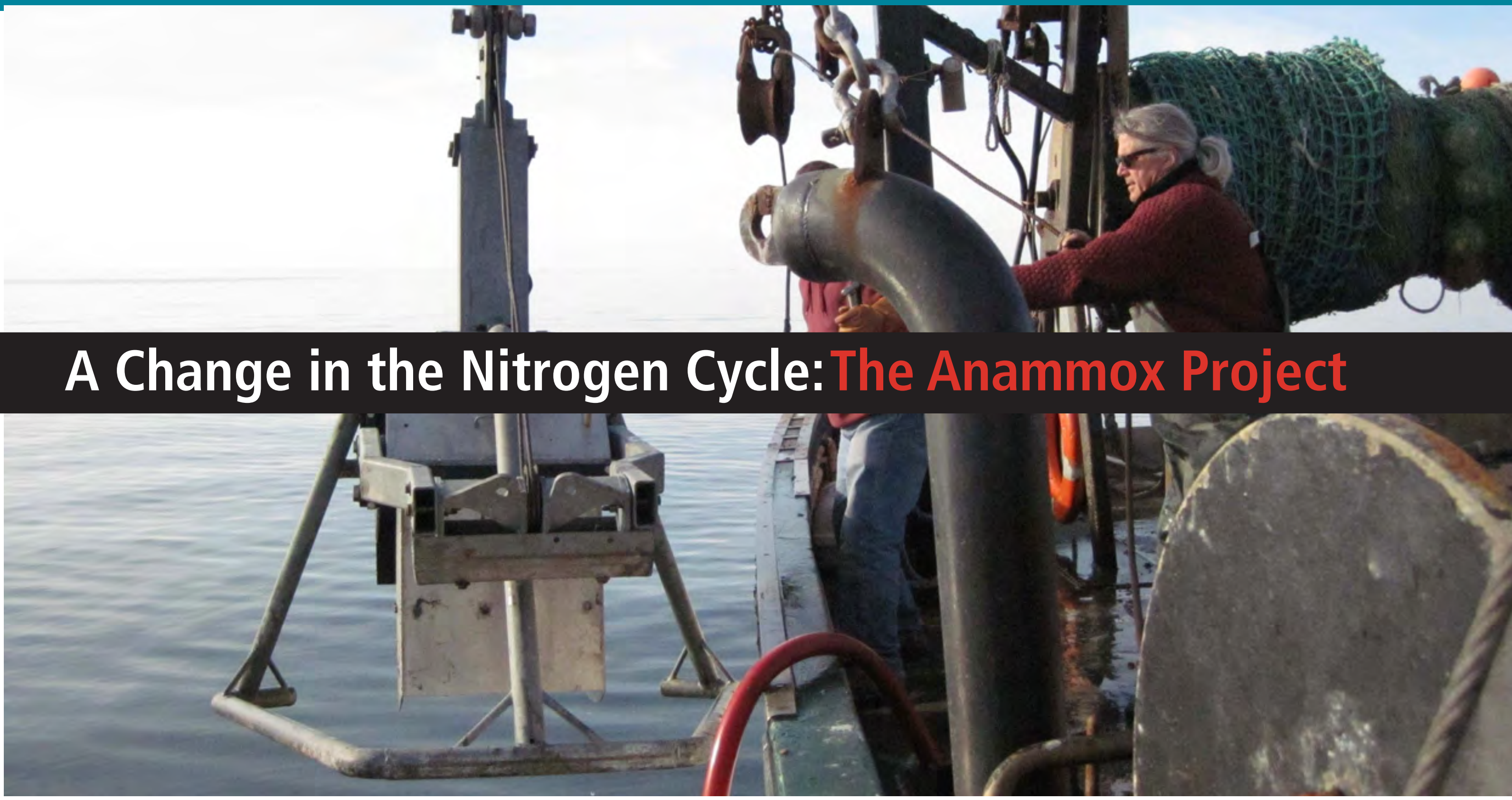


Figure 2: Simulated changes in tundra carbon stocks during recovery from a thermokarst disturbance. Colors indicate the percent of the pre-disturbance of soil organic matter left on the simulated plot.

These results suggest that nutrients accumulate faster in the field than in the model. A future objective of the study is to find out if these nutrients are coming from the surrounding tundra or from the previously frozen soil churned up by the thermokarst disturbance. The answer to this question is vital to understanding if thermokarst disturbances will result in a large release of CO_2 to the atmosphere or if tundra plants and soils can recover quickly enough to mitigate the effects of climate warming on tundra ecosystems.

— Ed Rastetter

A Change in the Nitrogen Cycle: The Anammox Project

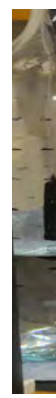


Stephen Granger from the University of Rhode Island deploys a box corer from the F/V *Virginia Marise* to collect sediments for study. (Jeremy Rich)

From bacteria to whales, from algae to redwood trees, the nitrogen cycle is critically important for all life on Earth. Nitrogen is an essential element in proteins that form the basis of all structure and function in biology.

The atmosphere is by far the largest reservoir for nitrogen, where it exists in an extremely stable form as dinitrogen gas (N_2). Until 1913, only bacteria and lightning converted stable N_2 gas into a chemical form accessible by life, namely ammonium. Likewise, only bacteria are capable of converting biologically active nitrogen into N_2 gas in a process known as denitrification. In its simplest form, the nitrogen cycle consists of these two basic processes, nitrogen fixation that conveys nitrogen to the biosphere, and denitrification that returns biologically active nitrogen to the atmosphere. For millions of years this global biogeochemical cycle has been in approximate balance.

Invention of the Haber-Bosch process in 1913 enabled industry to fix large quantities of dinitrogen gas into ammonium (i.e., fertilizer) by an energy intensive process that relies heavily on fossil fuels. Today, industrial processes fix more dinitrogen gas than nature, largely for fertilizer production. While we have more than doubled the flow of dinitrogen into the biosphere, we have little understanding of where the additional nitrogen goes or how much is returned to the atmosphere. Even more surprising is that we still lack a basic understanding of the microbial processes that return nitrogen to the atmosphere. Until the early 1990s, scientists believed that the only bacterial reaction that returned nitrogen to the atmosphere was denitrification, in which bacteria use nitrate (another form of biologically active nitrogen) in place of oxygen to produce energy for growth and produce dinitrogen as a waste product. In the 1990s, another type of bacteria was discovered that could convert ammonium plus nitrite into dinitrogen gas, in a process now called anammox (short for anaerobic ammonium oxidation). Anammox bacteria have some peculiar characteristics. For instance, they fix carbon dioxide into sugars for growth like plants. An intermediate chemical in the anammox reaction is hydrazine, which is dangerously unstable and used in industry for rocket fuel. Discovery of the anammox bacteria reveals new potential pathways in which the nitrogen cycle can operate, and a great deal of research is currently being conducted to understand how the new anammox pathway may operate in nature.

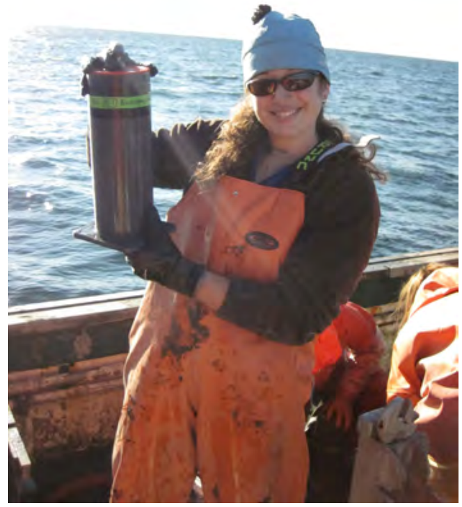


In a National Science Foundation-sponsored project, scientists from the Ecosystems Center and Brown University are looking at how environmental conditions influence bacteria that control classic denitrification versus the new anammox pathway. Using a combination of field, laboratory and modeling approaches, Ecosystems Center senior scientists Joe Vallino and Anne Giblin are collaborating with Brown assistant professor Jeremy Rich, postdoctoral scientists Chris Algar of the Ecosystems Center and Amber Hardison of Brown, and Ecosystems Center senior research assistant Jane Tucker.

Both denitrification and anammox only occur under anaerobic conditions — environments lacking oxygen — such as in marine and freshwater sediments and in the ocean in areas referred to as oxygen minimum zones like the "dead zones" in the Gulf of Mexico. Rich and Giblin have been able to measure the potential rate of anammox reactions by using a novel technique that relies on subtle atomic mass differences between two different stable isotopes of nitrogen (Nitrogen-14 and N-15). By adding heavy isotopes of nitrogen to a sediment sample, Giblin and Rich can determine the potential rates of denitrification and anammox by measuring the atomic mass of the dinitrogen produced by microbial communities using mass spectrometry.

Chris Algar's thin-disk experiments for testing model predictions of anammox versus denitrification activity. (Chris Algar)

Depending on how the nitrogen isotopes get paired, which depends on the activity of the anammox reaction, the mass of dinitrogen can be 28, 29 or 30 atomic mass units. Using this isotope pairing technique, Rich, Giblin and Hardison have found that the rates of anammox and denitrification can vary between different environmental samples. For instance, anammox rates have been found to be higher in marine sediments collected near Block Island than in Narragansett Bay.



Brown-MBL graduate student Lindsay Brin holds up a sediment core, which will be brought back to the lab for study. (Courtesy Rich Laboratory)

Why does denitrification dominate in some areas, while anammox dominates in others? That is a core question of the MBL-Brown Anammox research project. One hypothesis is that the availability of organic carbon may determine which reaction dominates. Because anammox bacteria can grow autotrophically (that is, like plants that can use carbon dioxide as their source of carbon), they may have an advantage over denitrifiers that require organic carbon compounds like sugars for growth. To study how the availability of resources such as nitrate, ammonium and organic carbon influence the activity of anammox versus denitrification, Joe Vallino and Chris Algar have developed a mathematical model that describes how anammox and denitrifying bacteria grow. The model, based on thermodynamics, examines how much energy bacteria can extract from the anammox versus denitrification reactions.

By changing environmental conditions in the model, they show that the anammox reaction should dominate when both organic carbon and nitrate concentrations are low.

To test the model, Algar designed a series of "thin-disk" experiments to examine metabolic switching between anammox and denitrification. While experiments are still on-going, Algar and Jane Tucker have detected different rates of anammox activity in the thin-disk experiments using the isotope pairing technique. Results from the field measurements, laboratory experiments and modeling will allow the group to better understand how marine environments will respond to excess nitrogen inputs that ultimately derive from fertilizer production. More research will be needed to determine if the bacteria responsible for returning fixed nitrogen to the atmosphere will be able to match the increased nitrogen inputs, thereby maintaining the global balance of the nitrogen cycle.

— Joe Vallino

Above: JoHanna Burton, SES student from Ripon College, hunts for snails and small crustaceans among the grass in the salt marshes of the Plum Island Estuary, Massachusetts, in November. (David Samuel Johnson)

Left: SES student Elisabeth Ward of Brown University measures tree diameter for her independent project. (Jehane Samaha)

The Semester in Environmental Science (SES) marked its 15th anniversary in 2011 with the largest class ever. Twenty-three students from 17 colleges and universities enrolled in the 15-week semester to learn fundamental theory and methods of ecosystems research.

These students learn from their own data as much as from lectures and readings offered by the Ecosystems Center faculty. During core courses, students sample a variety of freshwater, estuarine and terrestrial sites where they measure ecosystem process and structure, including species composition and biomass of plants, animals and microbes; physical factors such as light, salinity, soil characteristics, and functions such as photosynthesis, respiration, nutrient cycling. SES students use many of the same basic approaches to understanding ecosystem function as our research staff employs at field sites across the globe. From the data collected, they are able to build a coherent picture of how these diverse ecosystems work. In addition to core courses, the students complete an elective in either mathematical modeling of ecosystems or microbial methods in ecology. During the last six weeks of the program, after the formal course work ends, students pursue independent research projects and present their findings at a public symposium held in December.

Fifty-seven colleges participating in the MBL Consortium in Environmental Science have approved SES for credit. Amherst College was added to the consortium this year. Students from non-affiliated colleges and universities may receive credit through Brown University.

In 2011, Davis Educational Foundation gave SES $264,000 in grants for laboratory and field equipment.

Enthusiastic SES Alumni Return to MBL

Carrie Harris (Bates '11, SES'09) was back at the MBL as the aquatic teaching assistant for the program in fall 2011. When the semester ended, she transitioned from that job to Research Assistant for Ivan Valiela at the Ecosystems Center working on a project that focuses on deforested watersheds in Panama. "It's great how once you're in Woods Hole, neat opportunities seem to crop up. In January, I'm traveling to the Liquid Jungle Lab on the island of Canales de Tierra off the Pacific coast of the Veraguas province of Panama for two weeks of field work. I use the skills taught in SES on a daily basis and am grateful to have been part of the course, as a student and teaching assistant, as it has prepared me so well for future scientific endeavors!"

From left, SES alumni who worked at Ecosystems Center in 2011: Melanie Hayn, Stef Strebel, Melissa Campbell, Carrie Harris, Chelsea Baldino, Laura van der Pol, Sam Kelsey.

Melissa Campbell (Clark '11, SES '10) served as SES recruiter for fall 2011. "SES was the best decision I made as an environmental science undergrad. My enthusiasm for SES has made it easy for me to sell the program as the SES recruiter this past fall!" Melissa's future plans include working as research assistant at the Harvard Forest Long-Term Ecological Research site in Petersham, Massachusetts.

Chelsea Baldino (Northwestern University '11, SES '09) is a research assistant working on climate change research for Jerry Melillo. For most of the year, she maintains three soil-warming experiments and collects samples at Harvard Forest in Petersham, Massachusetts. In the winter she returns to Woods Hole to analyze data and run samples in the lab at the Ecosystems Center. "SES helped prepare me for this position; it was a great way for me to get my feet wet and fingernails dirty doing undergraduate research in ecology and really complimented my curriculum at Northwestern."

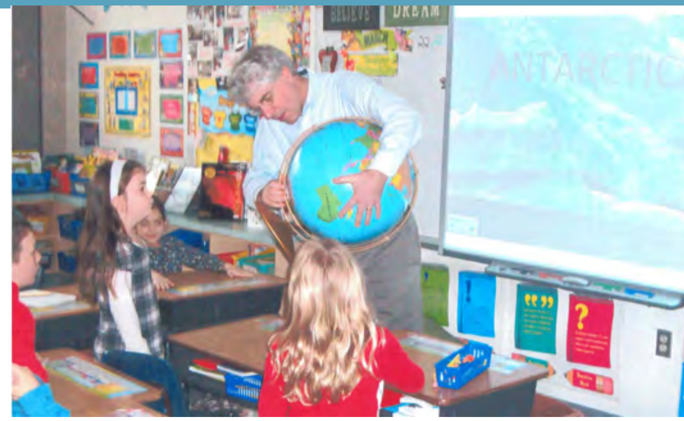
Melanie Hayn (Cornell '04, SES '03) For the past seven years, Melanie has been working at the Ecosystems Center putting her SES skills to use on a National Science Foundation-funded project that studies the changes in biogeochemical cycling in West Falmouth Harbor resulting from increased nitrogen loading caused by the nearby wastewater treatment plant. "At the same time, I have been able to pursue a Master's of Science in Natural Resources at Cornell based on my work at the Center – so it's really been the best of both worlds, work and study."

Sam Kelsey (Dickinson '98, SES '97) has been a research assistant at the Ecosystems Center for 14 years and has analyzed sediment and water biogeochemistry at sites all over the world, from the arctic lakes of Alaska to the temperate coast of Massachusetts to the mangrove swamps of Panama. "Who would have thought that playing in the mud as a kid could turn into a career as an adult? Yet somehow, that is exactly what happened to me. And while my toys have become considerably more complex, my enthusiasm remains the same. SES was largely responsible for setting me on my current career path, as it introduced me to the more technical aspects of the scientific method."

Stef Strebel (Franklin and Marshall '10, SES '08) returned to SES the fall after graduation to serve as teaching assistant. After that, "the experience I gained as an SES teaching assistant after I graduated earned me jobs all over the world," she said. "I chased pelicans and loons in the Gulf of Mexico as a field biologist evaluating the damage caused by the Deepwater Horizon spill, and was a crew leader for safe-grouse habitat assessment with the Bureau of Land Management in Nevada." In Fall 2011, she was back at SES as teaching assistant.

Laura van der Pol (Wellesley '07, SES '06) was an ensign in the Coast Guard for the first three years after college, piloting a 20-foot buoy tender up and down the East Coast. She then returned to the Ecosystems Center in the summer of 2011 to assist with collecting data at burn sites at the Arctic LTER site on the North Slope of Alaska near Toolik Lake. She returned to the Ecosystems Center in the fall as the dorm resident teaching assistant in SES. "I will return to Alaska and Toolik Lake next summer. The adventure continues! Disney World may have the copyright on 'the place where dreams come true,' but Woods Hole needs no gimmicks to earn such a title."

The Ecosystems Center is actively involved in education in a variety of ways. In addition to running the Semester in Environmental Science program for college undergraduates, center scientists serve as 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.



Right: Christopher Neill talks to second graders at the Stonehurst Elementary School in Dobbs Ferry, NY, about research in Antarctica.

Science and Community Outreach

Every year, scientists and research assistants volunteer to mentor junior high school students and judge system-wide science fairs. In 2011, Melanie Hayn, Jim Tang, Suzanne Thomas, Sam Kelsey and JC Weber met with students, helping them to develop their science project ideas and organize their approach and methods. Jim Tang, Ken Foreman and Melanie Hayn advised high school students who went on to win top prizes in Falmouth and regional science fairs. Projects such as the mentoring program are organized by the Woods Hole Science and Technology Educational Partnership (WHSTEP). Ecosystems staff members JC Weber, Debbie Scanlon and Kate Morkeski serve on WHSTEP's board and act as liaisons to respond to requests from teachers and students and to provide outreach events, such as a tour of the Ecosystems Center for junior high school teachers, and family science nights.

Left: Sandwich High School student Kenna Garrison and Falmouth High student Jessica Freedman worked with Maureen Conte and JC Weber. (JC Weber)

Right: Kate Morkeski judged the Falmouth school system's science fair. (Debbie Scanlon)

Many center staff members also judge community and state science fairs, including Kate Morkeski, Lindsay Scott, Marshall Otter, JC Weber, Suzanne Thomas, Jim Tang and Hap Garritt.

Ecosystems Center staff members play an active role in town activities, serving on both non-profit private groups and Falmouth committees and as town meeting members. Hugh Ducklow and Matthew Erickson provide nutrient analyses for the Baywatchers Program of the Coalition for Buzzards Bay. Hugh, Maureen Conte and JC Weber serve as volunteers in the program, carrying out weekly observations on water quality at nearby sites around the Bay. Chris Neill writes a monthly column on the environment for *The Falmouth Enterprise*.

Alanna Yazzie of San Juan College was an REU at Harvard Forest LTER. Her research project was "Mechanisms underlining the response to soil-warming: The microbial component." (Lindsay Scott)

Research Experience for Undergraduates and Other Internships

With funding from the National Science Foundation and other groups, the Ecosystems Center has given many college students the opportunity to pursue research projects in the lab and at field sites. In 2011, their projects ranged from looking at algal biomass in salt marshes at the Plum Island estuary to studying particulates in the deep Sargasso Sea.

Jim Tang also mentored Tuskegee University student Lakiah Clark, a summer intern in the Partnership Education Program (PEP), a consortium of Woods Hole scientific institutions that includes MBL, NOAA National Marine Fisheries Service, Sea Education Association, U. S. Geological Survey, Woods Hole Oceanographic Institution and Woods Hole Research Center. The goal is to increase diversity in the science community.

Schoolyard LTER

Plum Island Ecosystem's Long Term Ecological Research (LTER) Schoolyard Program collaborates with both the Massachusetts Audubon Society and the Governor's Academy in Byfield, Massachusetts. Mass Audubon implemented a science education program for grades 5-12 called the Salt Marsh Science Project (SMS), in which students monitor vegetation transects and measure porewater salinities to relate them to vegetation patterns. SMS serves an average of 1,000 students and 35 teachers from 10 schools per year. Now in its 16th year, the SMS has long-term data from numerous sites in the Great Marsh region. Teachers at Governor's Academy have set up science modules for high school students that involve student monitoring of ribbed mussels and intertidal marsh plant distribution.

The Arctic Schoolyard LTER program focuses on the community of Barrow, Alaska, the closest large town to the LTER site at Toolik Lake. The activities include two main components: field work that replicates some of Arctic LTER experimental and monitoring activities such as measuring the effects of climate warming on tundra vegetation and measuring changes in lake water chemistry, and a weekly lecture series, called "Schoolyard Saturday," on a wide range of scientific topics. The Barrow Arctic Science Consortium has supplemented these Schoolyard activities with additional funds and actively manages both the in-school activities and the public lectures. This year, Eve Kendrick, a teacher in the Tuscaloosa, Alabama school system, and a participant in the National Science Foundation's Research Experience for Teachers program, gave a talk in the "Saturday Schoolyard" lecture series in Barrow.

The Palmer Station, Antarctica, LTER program partners with state-wide and international organizations, educational professionals, kindergarten to grade 12 educators, and formal and informal science programs to promote ocean literacy and improve public awareness and understanding of polar ocean science along the western Antarctic peninsula. The Palmer Schoolyard LTER draws upon site research to offer learning opportunities for those interested in professional development through our Research Experience for Teachers program, helping educators create better instructional materials and more dynamic learning experiences for their students in classrooms, libraries, museums and informal learning centers.

Eve Kendrick, a teacher in the Tuscaloosa, Alabama, school system and participant in the NSF's Research Experience for Teachers, at the Arctic Long-Term Ecological Research site at Toolik, Alaska. (Mike Kendrick)

Students collected vegetation and salinity data from local salt marshes as part of PIE LTER Schoolyard program. (Liz Duff)

Science Journalism Program

Ecosystems Center scientist Christopher Neill directed the environmental laboratory course of the 2011 MBL Logan Science Journalism Program, which was taught at the Plum Island Long Term Ecological Research (LTER) site in northeastern Massachusetts. Linda Deegan was a course instructor and Rich McHorney was course coordinator. Eight journalists participated: Vikki Valentine, National Public Radio; Claudio Angelo, *Folha de São Paulo*; Jennifer Smith, *Newsday*; Margot Roosevelt, *Los Angeles Times*; Asher Price, *Austin-American Statesman*; Sharon Oosthoek, Freelance; Steven Ashley, *Scientific American*; and Aleida Rueda Rodriguez, Radio Mexican Institute. Jennifer Smith and Margot Roosevelt also traveled to the Arctic LTER site on the North Slope of Alaska where they were able to team up with research scientists to work with them in the field and laboratory. To date, the MBL Logan Science Journalism Program has granted fellowships to nearly 300 journalists.

Brown-MBL Graduate Program

Ecosystems Center scientists are advising these students in the Brown-MBL Graduate Program in Biological and Environmental Sciences.

Lindsay Brin examines how temperature influences pathways of nitrogen cycling in estuaries and mangroves. Her advisors are Anne Giblin from the Ecosystems Center and Jeremy Rich from Brown.

Sarah Corman studies how multiple stressors, including climate change, affect salt marshes and rocky shores of New England. Her advisors are Linda Deegan of the Ecosystems Center and Heather Leslie of Brown.

Will Daniels uses markers in sediments of Arctic lakes to study how lake nutrient cycling and productivity have responded to climate change during the last 12,000 years. He works with Anne Giblin of the Ecosystems Center and Jim Russell of Brown.

Shelby Riskin studies how the expansion of intensive soybean farming in the Brazilian Amazon affects stream hydrology and chemistry and the sustainability of phosphorus fertilizers. Her advisors are Christopher Neill from the Ecosystems Center and Stephen Porder from Brown.

Chelsea Nagy examines the long-term persistence and health of forested stream buffer zones along streams in the Amazon soybean region. She is advised by Christopher Neill from the Ecosystems Center and Stephen Porder from Brown.

Xi Yang uses remote sensing, field measurements and ecosystem models to test how changes to the timing of forest leaf emergence caused by climate change influence ecosystem carbon storage. He is advised by Jim Tang from the Ecosystems Center and Jack Mustard from Brown.

Three Brown-MBL students participated in an NSF Partnerships for International Research and Education (PIRE) project led by Christopher Neill.

Marc Mayes studies how climate, land-use practices and mineralogy affect soil carbon and nitrogen biogeochemistry in East Africa. His advisors are Jerry Melillo from the Ecosystems Center and Jack Mustard from Brown.

Maya Almaraz studies how intensification of agriculture in tropical Africa alters nitrogen cycling and the fate of nitrogen fertilizer. Her advisors are Christopher Neill from the Ecosystems Center and Stephen Porder from Brown.

Mengdi Cui uses emerging technologies to study greenhouse gas emissions from soils across temperate and tropical regions. Her advisors are Jim Tang from the Ecosystems Center and Meredith Hastings from Brown.

John Hobbie and former President Jimmy Carter shared the podium at a celebration of the 50th anniversary of the Arctic National Wildlife Refuge (ANWR), held at the National Conservation Training Center of the U.S. Fish and Wildlife Service in Shepherdstown, WV, in January. John's presentation on "Ecosystems research on the North Slope: Changes in ecological processes over the next century" included many photos from his doctoral research at Lake Peters, which is part of ANWR, during the late 1950s and 1960.

Zoe Cardon was the invited speaker in March at the Keystone Symposium in Breckenridge, CO, and again at a workshop in February at the American Academy of Microbiology colloquium in Dallas.

Joe Vallino was promoted to Senior Scientist in December.

Christopher Neill continues as Rosenthal Director of the Brown-MBL Partnership. He is president of the Falmouth Associations Concerned with Estuaries and Saltponds and a board member of Biodiversity Works and Coonamessett River Trust.

Linda Deegan was appointed to the Board of Trustees of the Massachusetts Chapter of The Nature Conservancy. She was also named to the Science and Engineering Special Team for 2010-2013. The group addresses issues related to the restoration of the Mississippi River delta in the Gulf of Mexico. Linda was also an invited member of the International Council for the Exploration of the Sea Study Group on designing marine protected area networks in a changing climate.

Hugh Ducklow was appointed to the U.S. Antarctic Program Blue Ribbon Panel by John Holdren of President Obama's Office of Science and Technology Policy and Subra Suresh, National Science Foundation director. The panel examines the status and capabilities of the U.S. Antarctic program in anticipation of the upcoming renegotiation of the Antarctic Treaty.

Jerry Melillo was named chairman of the National Climate Assessment Development and Advisory Committee. The announcement was made by Jane Lubchenco, undersecretary of commerce for oceans and atmosphere and administrator of the National Oceanic and Atmospheric Administration (NOAA). The committee will produce the next National Climate Assessment report for the United States.

In December, MBL employees and their families collected food and gifts for Cape Cod families that were distributed by the Housing Assistance Corporation of Hyannis. Sam Kelsey helped load the more than 400 pounds of food, 200 presents and $500 in grocery store gift cards that were donated for 20 families. The effort was led by the MBL Activities Committee. Kelly Holzworth and Melanie Hayn are committee members from the center.

Anne Giblin is on the Board of Directors of the Gulf of Maine Institute. She participated in the institute's Summer Institute by giving a lecture and leading a field trip.

Jim Tang is a co-chair of the National Ecological Observatory Network (NEON)'s Fundamental Instrument Unit (FIU) Technical Working Group for soils and a member of the LTER International Committee.

Gus Shaver is a member of the National Academy of Science Polar Research Board, the Department of Energy's Biological and Ecological Research Advisory Board, and a member of International Study of Arctic Change Scientific Steering Committee.

Ed Rastetter is subject editor for *Ecosystems*, and Gus Shaver serves on the journal's editorial board. **Ivan Valiela** is an editor of *Estuarine, Coastal and Shelf Science*. **Zoe Cardon** is a member of the editorial board of *Oecologia*.

In the News:

Zoe Cardon was interviewed by Austin, TX, radio station 91.7 KOOP on the topic of Earth stewardship during the Ecological Society of America Annual meeting in early August. She also organized Austin Night for Nature, featuring three local bands to benefit 20 local area environmental groups.

A report on *BBC News*, "Huge Arctic fire hints at new climate clue," covers research published in the July 28 issue of *Nature* on carbon loss and the 2007 fires on the Arctic tundra. Authors were **Gus Shaver** of the Ecosystems Center, lead author Michelle Mack of University of Florida and their colleagues at the Arctic Long Term Ecological Research site at Toolik Lake, Alaska. Mack, M.C., M. S. Bret-Harte, T. N. Hollingsworth, R. R. Jandt, E.A.G. Schuur, G.R. Shaver, and D. L. Verbyla. 2011. Carbon loss from an unprecedented Arctic tundra wildfire. *Nature* 475: 493-496.

Research at the TIDE project at Plum Island Sound, led by Ecosystems Center senior scientist **Linda Deegan**, was highlighted by the National Science Foundation on its Science, Engineering & Education Innovation webpage, "Human-Generated Nutrient Overloads Can Destroy Coastal Wetlands."

ENVIRONMENTAL PROTECTION AGENCY (EPA)

Integrated Assessment of Greenhouse Gases and Climate Impacts
Principal Investigators:
Jerry Melillo, David Kicklighter. ($375,000)

BROWN UNIVERSITY

Brown-MBL Partnership Linking Long- and Short-Term Controls on Terrestrial Phosphorus Cycling
Principal Investigator:
Zoe Cardon ($11,339)

The Impact of Agricultural Practices on Greenhouse Gas Emissions and Air Quality: A Case Study in New England
Principal Investigator:
Jianwu Tang ($24,279)

DEPARTMENT OF ENERGY (DOE)

Exploratory: Quantifying the Control of Plant Photosynthesis on Root Respiration by Measuring and Manipulating Photosynthate Transport Rates in the Tree Phloem
Principal Investigator:
Jianwu Tang ($149,805)

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

Carbon Management in Coastal Wetlands: Quantifying Carbon Storage and Greenhouse Gas Emissions by Tidal Wetlands to Support Development of a Greenhouse Gas Protocol and Economic Assessment
Principal Investigator:
Jianwu Tang ($378,125)

NATIONAL SCIENCE FOUNDATION (NSF)

IGERT: Reverse Ecology: Computational Integration of Genomes, Organisms and Environments
Principal Investigators:
Zoe Cardon, Hugh Ducklow, Anne Giblin, Edward Rastetter, Joseph Vallino ($28,281)

Arctic LTER: Climate Change and Changing Disturbance Regimes in Arctic Landscapes
Principal Investigator:
Gus Shaver ($5,956,500)

The Seasonal Cycle of Export Production in an Antarctic Coastal Marine Ecosystem
Principal Investigator:
Hugh Ducklow ($411,492)

A Regional Earth System Model of the Northeast Corridor: Analyzing 21st Century Climate and Environment
Principal Investigators:
Jerry Melillo, Bruce Peterson ($824,940)

Collaborative Research: MSB: The Role of Sulfur Oxidizing Bacteria in Salt Marsh C and N Cycling
Principal Investigators:
Zoe Cardon, Anne Giblin ($510,333)

Fire in Northern Alaska: Effect of a Changing Disturbance Regime on a Regional Macrosystem
Principal Investigators:
Gaius Shaver, Edward Rastetter, Adrian Rocha ($1,969,640)

Collaborative Research: Ecological Homogenization of Urban America
Principal Investigator:
Christopher Neill ($224,820)

Collaborative Research on Carbon, Water, and Energy Balance of the Arctic Landscape at Flagship Observatories
Principal Investigators: Gaius Shaver, Edward Rastetter ($1,676,468)

Publications 2011

Lindsay Scott and Rose Smith prepare soil samples that will be analyzed for extracellular enzyme activity relating to soil carbon turnover. (Alanna Yazzie)

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Ecosystems Center Publications Archive

Stream sampling at the Anaktuvuk burn site on the North Slope of Alaska. (Patrick Tobin)

JANUARY

11 Edward Brzostek, Boston University, "The response of amino acid cycling in soils to global change: Feedbacks on soil nitrogen availability."

18 James McClelland, University of Texas at Austin, "Nutrient and organic matter export from the North Slope of Alaska to the Beaufort Sea: Contemporary estimates, implications for coastal productivity, and potential changes in the future."

25 Jennifer Bowen, University of Massachusetts Boston "Combining molecular tools with experimental approaches to understand microbial community response to nitrogen fluxes in estuarine sediments."

FEBRUARY

22 Mike Sears, Bryn Mawr College, "Challenges for understanding the responses of organisms to climate change: Addressing thermal heterogeneity through space and time."

MARCH

8 (Joint MBL-WHOI seminar) Gijs Kuenen, Delft University "Anaerobic ammonium oxidation (Anammox): Microbiology, environmental role and application."

15 Mark Altabet, University of Massachusetts Dartmouth "Nitrogen loss biogeochemistry in the Peru-Chile oxygen minimum zone."

22 Karrie Radloff, Columbia University, "How arsenic mobility influences safe drinking water options in Bangladesh."

APRIL

5 Peter Groffman, Cary Institute of Ecosystem Studies "Denitrification in terrestrial ecosystems: A tale of misery and woe."

12 Jim Russell, Brown University "Climate impacts on the biogeochemistry of tropical African lakes: Tales from the sediment."

26 Laura Schreeg, University of Florida, "Solubility of leaf litter nutrients from 41 lowland tropical forest woody species."

MAY

10 Bethany Jenkins, University of Rhode Island, "Sifting through a sea of microbes: New players in the marine nitrogen cycle."

17 Neal Blair, Northwestern University, "The evolution of organic carbon from uplands to the ocean."

24 Paul Mann, Woods Hole Research Center, "Controls on the composition and lability of dissolved organic matter in Siberia's Kolyma River Basin."

SEPTEMBER

13 Hugh Ducklow, MBL Ecosystems Center, "Bacterial dynamics in Antarctic coastal waters: A long-term view."

16 *Scott Doney, Woods Hole Oceanographic Institution "Rising atmospheric CO_2 and ocean acidification."

20 James Casey, Washington and Lee University, "The economic value of marine biodiversity to recreational SCUBA divers in Barbados."

27 Jessica Mark Welch, MBL Bay Paul Center, "Visualizing microbial interactions in host-associated ecosystems."

30 *Edward DeLong, Massachusetts Institute of Technology, "Exploring marine microbial diversity, from genomes to biomes."

OCTOBER

11 Adrian Rocha, MBL Ecosystems Center, "Climatic and ecological insights and surprises from an unprecedented Arctic tundra wildfire."

14 *Bridget Emmett, Centre for Ecology and Hydrology, Environment Centre, Wales "How are soils changing and what are the impacts for ecosystem services?"

18 Felicia Keesing, Bard College "Biodiversity loss and infectious diseases: A recipe for risk?"

28 *Kevin McCann, University of Guelph, "Lake food web expansion and contraction: Nature flexes its muscles"

NOVEMBER

1 Trevor Keenan, Harvard University, "Understanding temporal trends in terrestrial carbon sequestration using model-data fusion techniques."

8 Mick Follows, Massachusetts Institute of Technology, "What regulates the habitat of nitrogen-fixing phytoplankton?"

18 *Robert Twilley, University of Louisiana at Lafayette, "Risks, reorganization and restoration of deltaic coasts as landscapes on the edge: Perspectives from the Mississippi River Delta"

22 Jeremy Rich, Brown University, "Resolving microbial processes in the nitrogen cycle: Anaerobic ammonium oxidation (Anammox) and denitrification in marine ecosystems."

29 Amanda Spivak, Woods Hole Oceanographic Institution, "Development of sediment organic matter in restored mangrove habitats: Insight from a 20-year chronosequence."

DECEMBER

6 Casey Kennedy, USDA-Agricultural Research Service "Nutrient discharge from cranberry bogs: A long-term monitoring approach for improving environmental water quality."

13 Ted Hart, University of Vermont, "Ecological and evolutionary impacts of altered trophic relationships under climate change in aquatic communities."

** SES Distinguished Scientist Seminar Series*

Hugh W. Ducklow
Senior Scientist, Director
Ph.D., Harvard University

Hugh is a biological oceanographer focusing on the roles of bacteria in the ocean carbon cycle. His research in Antarctica looks at the responses of the continental shelf sea ice zone ecosystem to rapid climate warming.

Zoe G. Cardon
Senior Scientist
Ph.D., Stanford University

Zoe's research focuses on microbial activity in soil around plant roots (the rhizosphere), including how water fluxes driven by plants affect resource availability, local conditions, and biogeochemistry in the rhizosphere.

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
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.

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.

Jerry M. Melillo
Distinguished 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.

Christopher Neill
Senior 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

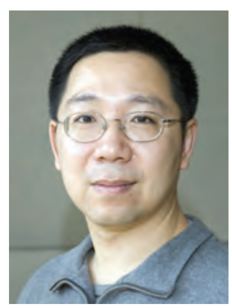
Bruce focuses on understanding aquatic productivity and global change by studying the cycles of water, carbon and nitrogen at the ecosystem and global levels.

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.



Jianwu (Jim) Tang
Assistant Scientist
Ph.D., University of California, Berkeley

Jim's research focuses on soil biogeochemistry and soil-plant interactions, particularly on carbon and nitrogen cycles through ecosystems processes.

Joseph J. Vallino
Senior 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.

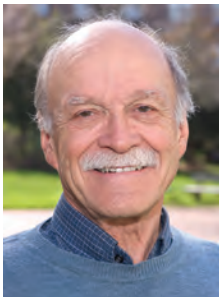
Senior Staff

Paul Colinvaux
Senior Research Scientist
Ph.D., Duke University

Paul studies past climates and vegetation from the Amazon to the Arctic through analysis of air-borne pollen trapped in lake sediments.

Paul A. Steudler
Senior Research Scholar
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 regrowth, and increased temperature.



John E. Hobbie
Senior Scholar
Ph.D., Indiana University

As an aquatic ecologist, John identifies the factors controlling decomposition and productivity in aquatic ecosystems, especially the role that microbes play.

Ivan Valiela
Senior Research Scientist
Ph.D., Cornell University

Ivan is interested in the coupling of land use on watersheds and coastal ecosystems in the larger context of global change.

Research Associates

David S. Johnson
Research Associate
Ph.D., Louisiana State University

David W. Kicklighter
Research Associate
M.S., University of Montana

Adrian V. Rocha
Research Associate
Ph.D., University of California, Irvine

Adjunct Scientists

Maureen H. Conte
Adjunct Scientist in Residence
Bermuda Biological Station for Research, Inc.
Ph.D., Columbia University

Maureen's research speciality is trace level molecular and isotopic organic geochemistry. Research focus areas include deep ocean particle flux and the organic geochemistry of biogenic aerosols.

Robert Howarth
Cornell University
Ph.D., Massachusetts Institute of Technology/ Woods Hole Oceanographic Institution

Bob's long-term interest is in environmental management and the effects of nutrients and pollutants on aquatic ecosystems. His scientific approach is through biogeochemistry, particularly nitrogen, phosphorus, and sulfur cycling and export from land to waters.

Scientists and Staff

Postdoctoral Scientists

Christopher Algar
Ph.D., Dalhousie University, Canada

Nuria Fernandez Gonzalez
Ph.D., Universidad Autonoma de Madrid, Spain

Inke Forbrich
Ph.D., University of Greifswald, Germany

Claire Lunch
Ph.D., Stanford University

James Nelson
Ph.D., Florida State University

Marjan van de Weg
Ph.D., University of Edinburgh, Scotland

Stephanie Wilson
Ph.D., College of William and Mary

Staff

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B.A., Bates College

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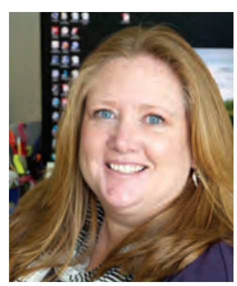
B.S., Cornell University



Kelly R. Holzworth
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University of San Diego

Miriam Johnston
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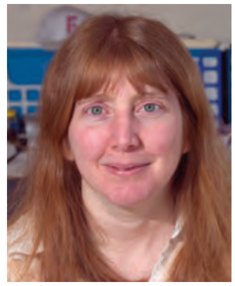
B.A., Middlebury College

Samuel W. Kelsey
Research Assistant
B.S., Dickinson College



Bonnie L. Kwiatkowski
Research Assistant
M.S., University of New Hampshire

James A. Laundre
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Research Assistant
M.S., Simon Fraser University, Canada

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M.S., University of Pennsylvania

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M.S., Virginia Polytechnic Institute and State University

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Ph.D., University of Cape Town, South Africa

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B.A., New York University

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B.A., Syracuse University

Lindsay Scott
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M.S., Ohio University

Mary Ann Seifert
Staff Coordinator
B.A., Alfred University

Stephanie Strebel
Research Assistant
B.A., Franklin and Marshall College

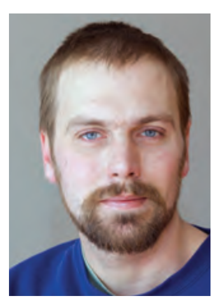
Suzanne M. Thomas
Research Assistant
M.S., University of Pennsylvania

Jane Tucker
Senior Research Assistant
M.S., University of North Carolina

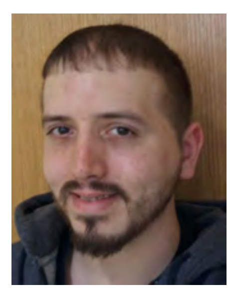
Laura van der Pol
Research Assistant
B.A., Wellesley College

J.C. Weber
Senior Research Assistant
M.S., University of Delaware

William Werner
Research Assistant
B.S., Beloit College



Daniel J. White
Research Assistant
M.S., State University of New York at Brockport



Erick Wolfinger
Laboratory Assistant
A.S., Cape Cod Community College

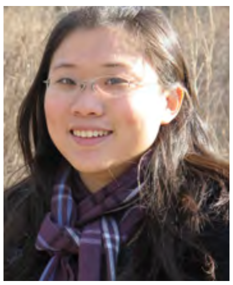
Students and others

Brown-MBL Graduate Students

Maya Almaraz
B.A./B.S., University of California, Berkeley

Lindsay D. Brin
B.A., Swarthmore College

Sarah S. Corman
M.S., University of Rhode Island



Mengdi Cui
B.S., Peking University

William Daniels
B.A., Lawrence University

Shelby Riskin
B.A., Grinnell College

Marc Mayes
M.S., University of Wisconsin, Madison

Rachel Chelsea Nagy
M.S., Auburn University

Xi Yang
M.E., Beijing Normal University

Staff who left in 2011

Sarah Butler, Research Assistant, University of Rhode Island
William Daniels, Graduate Student, Brown/MBL Program in Environmental Science
Skyler Hackley, Research Assistant, University of New Mexico
Erin Kinney, Postdoctoral Scientist, Texas A&M University, Galveston
David Koweek, Graduate Student, Stanford University
William Longo, Graduate Student, Brown University
Colin Millar, Research Assistant, High Quality Research Laboratory, Fort Collins
Stephanie Oleksyk, Research Assistant, Bilsa Biological Station, Ecuador
Verity Salmon, Graduate Student, University of Florida, Gainesville
Elissa Schuett, Research Assistant, University of Vermont
Rose Smith, Graduate Student, University of Maryland
Suzanne Tank, Assistant Professor, York University, Toronto

Visiting Scientists and Scholars

Soonmo An, Pusan National University, South Korea
James Casey, Washington and Lee University
Natalie Boelman, Lamont-Doherty Earth Observatory, Columbia University
Qianlai Zhuang, Purdue University

Summer Assistants

Alice Alpert, Field Assistant
Zena Cardman, Field Assistant
Robert Golder, Research Assistant
Christopher Haight, Field Assistant
Gregory Hill, Research Assistant
Sarah Laperriere, Research Assistant
Kathleen Woods, Research Assistant

NSF REU Students

Moussa Bakari, Lincoln University
Brittany Boyke, Louisiana State University
Julianna Brunini, Harvard University
Sophia Burke, University of New Hampshire
Leticia Delgado, Northern Arizona University
Christopher Hendrix, University of Texas, Arlington
Carolyn Judge, University of Connecticut
Eric Kretsch, University of Rhode Island
Katherine Laushman, Earlham College
Susanna Michael, Smith College
Benjamin Siranosian, Brown University
Camille Sogin, Dickinson College
Genna Waldvogel, University of Vermont
Alanna Yazzie, San Juan College

NSF Research Experience for Teachers (RET)

Eve Kendrick, Northside High School, Tuscaloosa County, AL

Undergraduate Interns

Katherine Dubois, Bowdoin College
Laura Kozma, University of Massachusetts Amherst
Michael Lerner, University of Michigan
Ujwala Ramakrishna, Mount Holyoke College

High School Students

Jessica Freedman, Falmouth High School
Kenna Garrison, Sandwich High School
Marius Karolinski, Falmouth Academy

Consultants

Francis P. Bowles
John T. Finn
Pamela Polloni
Christopher Sterpka

Sources of Support for Research and Education

The annual operating budget of The Ecosystems Center for 2011 was $10,570,000. Approximately 80% of the income of the center came from grants for basic research from government agencies, including the National Science Foundation, NASA, the Department of Energy and the Environmental Protection Agency. The other 20% comes from gifts and grants from private foundations, including support for the Semester in Environmental Science, 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 fund market value of the center's research and education endowments at the end of 2011 was $8,012,000. Income from these funds helps defray the costs of operations, writing proposals, consulting for government agencies and the center's educational programs.

2011 Supporters of the Ecosystems Center

Gifts from Individuals and Foundations

$100,000-$249,999
Davis Educational Foundation*
Harken Foundation*
The David and Lucile Packard Foundation
Patricia and Charles Robertson

$10,000-$99,999
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Margaret C. and Francis P. Bowles*
The Clowes Fund, Inc.*

$5,000-$9,999
Beech Tree Trust
Linda A. Deegan and Christopher Neill

$1,000-$4,999
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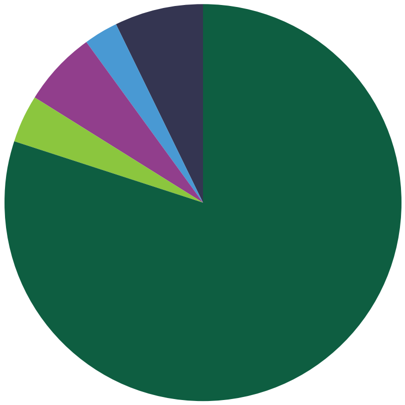
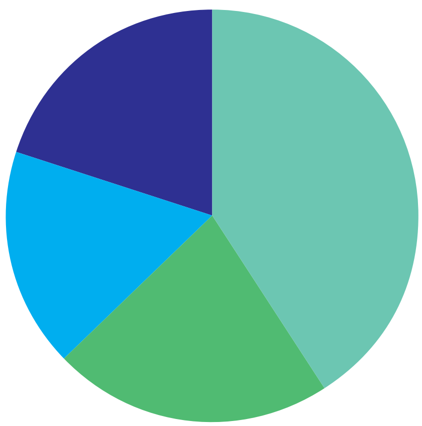
**Donations to Semester in Environmental Science*

Revenue



80% Government Grants
4% Non-government Grants
6% MBL
3% Investment Income and Reserves
7% Contributions and Tuition

Expenses



41% Personnel
22% Overhead
17% Operating
20% Subcontracts

The Ecosystems Center
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