The Ecosystems Center Report 2010
Cover photo: A barrier beach along the Pacific coast of Panama. The natural environment for the Coconut Palm is the high tide mark of the beach. (Photo: Ivan Valiela)

This page: Green Cabin Lake, Alaska (Photo: Cameron MacKenzie)
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 to answer a variety of scientific questions:

In both the Arctic and Antarctica, Ecosystems Center scientists in the Toolik Lake and Palmer Long Term Ecological Research (LTER) Projects study the effects of climate change on polar ecosystems. Will increased permafrost thaw make more nutrients available to plants? If these nutrients flow into streams and lakes, how will they affect aquatic food webs? In Siberia, center scientists show how increased freshwater discharge from the arctic rivers may affect ocean circulation and climate. In the coastal ecosystem along the west Antarctic Peninsula, sea ice duration has declined by 80 days in response to climate warming since 1975, leading to large-scale declines in plant and animal populations and other changes in the marine ecosystem.

In New England and around the world, scientists from the Ecosystems Center and their colleagues and students investigate the links among climate and land-use change, urban development, and the hydrology and ecology of watersheds, estuaries and coastal zones. Researchers at the Plum Island Ecosystem LTER site in northern Massachusetts ask how urban development affects the flow of nutrients and organic matter into New England estuaries. In Boston Harbor, researchers measure the transfer of nitrogen from the sediments to the water column to find out how long it will take the harbor to recover from decades of sewage addition. On Martha’s Vineyard, researchers restore coastal sandplain ecosystems with controlled burning or mechanical clearing. Will these changes restore diversity in plant and animal species? In mangrove estuaries of Panama, Ecosystems Center scientists study how watershed deforestation affects water flow from land into the mangroves and how mangrove removal alters the function of tropical coastal ecosystems.

The center’s scientists study the effects of land-use change in temperate and tropical forest ecosystems. In tropical Brazil, scientists investigate how the clearing of tropical forests in the western Amazon affects the release of greenhouse gases such as carbon dioxide and nitrous oxide. How will nutrient and organic matter flows in streams, rivers and watersheds change as Brazil converts more forest into pasture for soybean agriculture? Ecosystems Center scientists are beginning to team with social scientists and economists to explore how large-scale changes in the global economy affect tropical forest ecosystems and how these changes in turn affect climate and the global socioeconomic system. At the Harvard Forest LTER in central Massachusetts, 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?

In our laboratories in Woods Hole, Ecosystems Center 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.

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.
Everything – every plant, animal and microbe on the planet – releases its waste products into the surrounding environment. The wastes are the byproducts of life: carbon dioxide from animal respiration, nitrogen compounds like ammonium and urea, and organic wastes from defecation and death. Oxygen is a waste product from plant photosynthesis. Many plants and microbes even produce toxic waste by releasing antimetabolites to conduct biological warfare against their competitors. The release and subsequent breakdown and recycling of all this waste is part of the gigantic machinery of nutrient cycling that keeps life going. Without these cycles of release, decomposition and re-use of nutrients and organic matter, life would grind to a halt, starved of nutrition. The cycling and re-use of waste products is an essential service performed by healthy ecosystems to maintain a sustainable planetary biosphere.
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Like all other organisms, humans have released their wastes into the environment throughout their history as a species. When populations were small and dispersed, surrounding ecosystems could assimilate the wastes. As populations grew and people concentrated in cities, waste accumulation began to exceed ecosystem capacity to break it down and recycle it. History is replete with evidence of civilizations that had to move or collapse after they had fouled their environments.

Following the Industrial Revolution, when exploitation of fossil energy stores and agricultural development enabled explosive population growth, the human ability to produce waste began to overwhelm the natural biogeochemical cycles of the entire planet. The increase of CO₂ in the atmosphere and the growth of oxygen-depleted dead zones in the oceans are two indications of how waste production has gotten out of hand.

Most of our wastes are released to ground waters, rivers, estuaries or coastal zones of the ocean. The end result is eutrophication, the enrichment of receiving waters with nutrients and organic matter that cause excess plant growth and consume oxygen in the water. Although the problem has exploded to global proportions, its effects begin at the local level. Even a small town like Falmouth, Massachusetts (home of the Ecosystems Center) produces more waste nitrogen than the local waters of Cape Cod and Buzzards Bay can handle. Now Falmouth is exploring options to increase treatment of wastewater to remove nitrogen. There are also alternative technologies like permeable nutrient barriers and composting toilets available now that might help to achieve reduction in nutrient loads at lower cost than a strictly traditional engineering solution to the problem.

Here at the Ecosystems Center we specialize in taking an integrated, multifaceted ecosystem-level approach to understanding the Earth’s biogeochemical cycles, including the nitrogen cycle. We’re investigating how we can enhance natural ecosystem services to help us do the job, for example, by using the upper reaches of tidal creeks as natural wastewater treatment systems. Towns like Falmouth are ecosystems with their own particular ecological organization and functioning and we should apply our knowledge to come up with cost-effective, sustainable solutions to waste treatment.

We just need to find the best way to clean up after ourselves.

— Hugh Ducklow

Left to right: Algal bloom in Waquoit Bay was a result of excessive nitrogen loading from nearby homes. (Photo: Ken Foreman); Experimental permeable nutrient barriers show promise in removing nitrogen. (Photo: Ken Foreman); Falmouth’s current sewage treatment facility. (Photo: Debbie Scanlon)
The large-scale, widespread deforestation of terrestrial watersheds is arguably the major human-driven agent of ecological change in tropical latitudes. Deforestation on land can alter transport of water, nutrients, and sediment toward coastal ecosystems. The effects of shifts in watershed land cover, however, may interact with other changing major global forces that also alter delivery of water and nutrients to coastal waters. One tropical setting where such interactions are playing out is the Pacific coast of Panama, where deforestation is rampant, and where a powerful La Niña phase of the El Niño-Southern Oscillation during 2010, the most pronounced in many decades, fostered heavy rains that led to unusually severe floods in Colombia, Venezuela, and Panama. A measure of the unusual conditions was the closing in early December of the Panama Canal, the first time in its history, due to record flooding of the watershed that supplies water to the locks.

In spite of the overwhelming accumulation of evidence of human impacts on environments world-wide, there is still some controversy over the reality of the causes and consequences of global atmospheric changes, and demand for evidence of what might be the result. Ecosystems Center research being done at the Pacific coast of Panama site will furnish concrete evidence of what can take place as increased globally driven atmospheric change, interacting with deforestation of the terrestrial watersheds, exert their influence on land and marine ecosystems in the tropics.
Land-Sea Interactions in a Tropical Setting: Role of Watershed Deforestation, Climate Change, and Upwelling

To assess effects of watershed deforestation on coastal mangroves and reefs, Ivan Valiela, Anne Giblin, and colleagues from U.S. Geological Survey, Woods Hole Research Center, and Woods Hole Oceanographic Institution took advantage of two unusual circumstances on the Pacific coast of Panama. First, they identified a series of watersheds where deforestation ranged from nil to nearly complete. Second, the research team worked and lived at the Liquid Jungle Laboratory (LJL), a research and residential facility that offered an ideal base of operation.

The team measured hydrological transport of nutrients, water, and sediments down to receiving mangrove estuaries and adjacent reefs, and assessed biological and biogeochemical consequences. Results so far suggest that tropical watersheds, at least in this region, have substantial abilities to capture and retain rain-derived nutrients, as long as vegetative cover (whether forests or pastures) is present on the watershed surface, and as long as there is sufficient rainfall. The degree of forest cover determines the mix and concentrations of nutrients that manage to course through the gauntlet of nutrient-interceptors on watersheds. Groundwater plays a large role, moving freshwater and whatever nutrients escape through the vegetation, soil, and aquifers and move toward coastal ecosystems.

In addition to deforestation on watersheds, other forces powerfully interact with the human-derived terrestrial influences. The Eastern Pacific is subject to large scale climate-driven forces known as El Niño-Southern Oscillation (ENSO), large scale shifts in weather that govern the degree to which nutrient-rich, colder deep ocean water is upwelled near shore. For example, red mangroves proliferate in areas where nutrients are more frequently delivered by upwelling.

More generally, global warming has increased the amount of water vapor in the atmosphere, and changes in ENSO affect rainfall patterns over much of the Earth. Since 2009, ENSO entered a strong La Niña phase, which usually brings a combination of upwelled deep water near-shore and increased rain to the region. Local people in Panama reported that they saw the sun on only two days during October and November. There were widespread reports of catastrophic floods though northern South America and Panama. During 2010, La Niña prompted a large-magnitude, large-scale clash between countering terrestrial and marine influences, a situation that has altered conditions in the entire region.

During December, at the end of an unusually rainy wet season along the Pacific coast of Panama, there was a pronounced freshening in estuaries and coastal waters. The flow of rainwater, moving from land to sea, and massive amounts of rain falling directly on the sea, nearly completely overwhelmed the expected upwelling and its effects. Estuaries became more like freshwater rivers, near-shore salinity fell to a third its usual values, and reduced salinity was recorded as far offshore as 6 km and as deep as 50 m.

The remarkable rainfall led to a fresher upper layer on the marine water column; this lighter fresher layer prevented upwelling of deeper, saltier and nutrient-rich seawater. Rain also added considerable nutrients to the normally nutrient-poor upper layers of seawater. These developments could have substantially altered near-shore ecosystems. We are assessing the interaction effects of impaired upwelling and freshened upper layers. This research will define the resulting course of events, identify the degree to which land-sea couplings and interactions have been affected, and discern the relative importance of global- and human-driven land and marine agents of environmental change in these tropical regions.

— Ivan Valiela
Undergraduate Education: An Integral Component of Ecosystems Center for 35 Years

Since its founding in 1975, the Ecosystems Center has offered many educational opportunities to undergraduate students. A four-week course in ecosystems and resource management, led by then-director George Woodwell, was offered in January from 1975 to 1981. The popular class was attended by Linda Deegan, now senior scientist at the center, and many others who are now active ecologists.

Since then, almost 200 undergraduates have participated in the Research Experience for Undergraduates (REU) program of the National Science Foundation. These students have conducted their own research projects with Ecosystems Scientists at our four Long-Term Ecological Research sites in the Arctic and Antarctica, and Plum Island Sound and Harvard Forest, in Massachusetts. Ecosystems scientists also served as mentors for REU students studying marshes and estuaries under a program run by Ivan Valiela, then at Boston University.

More recently, opportunities for undergraduates have expanded with the Woods Hole Partnership in Education Program (PEP). The PEP program was launched by a consortium of Woods Hole scientific institutions, including the MBL, and is committed to increasing diversity in the science community. In the past two years, Ecosystems Center scientists have hosted college juniors and seniors for PEP internships.

In 1997, the Ecosystems Center initiated the Semester in Environmental Science Program (SES), an influential program that has been successful in training the next generation of ecologists. The program is offered during the fall semester. Undergraduates pursue an intensive 15-week curriculum in lecture and field-based ecosystem science followed by independent research. Many SES graduates have gone on to conduct research at the Ecosystems Center or at the center’s remote field sites. During the summer of 2010, four alumni participated in research at the Arctic LTER site at Toolik Lake, Alaska. To date at least 19 SES alums have spent a summer at Toolik as undergraduate interns, research assistants or graduate students.

Marshall Moore, SES ’09 and Brown ’11, summarizes his experience at the Toolik LTER site in the article that follows. Located 140 miles north of the Arctic Circle on the North Slope of Alaska, the camp provides a rare and extraordinary experience for researchers, both in terms of living in an unspoiled natural setting and in participating in cutting-edge scientific research on Arctic ecosystems and climate change.
I begin to wonder if this trip will ever end. As a summer research assistant at the Arctic Long Term Ecological Research project at Toolik Lake in Alaska, I have traveled for two days to reach the remote field site, and it seems like the Haul Road from Fairbanks is endless. Finally, after 12 hours of travel, we reach our destination on the North Slope of Alaska, 140 miles above the Arctic Circle.

I quickly find that research on the frontiers of climate change means living in a community of friendly, amazing people, who can throw together a great string band after dinner that will play bluegrass classics to your heart’s content. Those same people can also play a mean game of soccer with goals constructed from PVC pipes, duct tape, and fishing net during the “Toolik Cup.” It means, while helicoptering back from field work, seeing the broad shoulders of a moose crossing the rushing turquoise blue waters of the Itkillik river in the summertime. It means jumping into a lake which, aside from a meter-wide strip against the shore, is completely iced over. It means 75 degrees and sunny on the fourth of July and snow on the fifth. Of course, research on the frontiers of climate change also means killing a dozen mosquitoes by simply closing your field notebook, and then deciphering those notes through the red blotches on the (thankfully) waterproof pages.

I am excited to use the knowledge I gained during the Semester in Environmental Science at the MBL but today, on my first day of work at Toolik, I am still new to the research team and still learning from my mentor, Gus Shaver. Today, we need to take a stack of two-by-eight boards to the experimental plots that Gus started in 1979—almost a decade before I was born. These plots simulate different potential alterations to the tundra in this changing world: a greenhouse plot simulates extreme warming, a fertilized plot simulates increased nutrient availability, and a fenced plot simulates the loss of caribou from the system. The plots seem to go on forever, with no limit to the number of treatments or replicates. We load the boards up into a canoe and slide them across the white ice covering the lake. The boards are needed to make a boardwalk for a new instrument we will install this year. Gus, a bearded scientist with a rough appearance that disguises his warm blue eyes and ever-present smile, is excited to build the platform for the instrument.

“The thrilling thing about being a scientist,” he says, “is that you get to be so many things. We get to be carpenters right now, when we bring the instrument out we will be electricians, and when the lake thaws we will drive boats!”

Of course, doing fieldwork at this site comes with its own challenges. At the end of my first week at Toolik, I fly out to a remote field site via helicopter with Adrian Rocha, a post-doctoral scientist with Gus’s team.

Our research plot within the massive burn scar from tundra fires has instruments set up to measure photosynthetic carbon fluxes, surrounded by a thin white fence. Adrian explains that this fence—a bear fence—was just put up because last year a bear attacked the instruments and caused the researchers to lose the data from the end of the summer.

“But don’t worry too much,” he says, “bears haven’t come around while we have been out here before...”

That’s just life on the frontiers of climate change.

— Marshall Moore (SES ‘09, Brown University ‘11)
established a funding mechanism to scale up the African Green Revolution to substantially increase nitrogen applications in Sub-Saharan Africa.

However, the increased nitrogen (N) loading in Africa has both positive and negative consequences that influence the whole world. On the negative side, the dramatic increase in nitrogen loading in Africa will result in 1) increases in nitrogen leaching into surface and subsurface waters; 2) increases in nitrous oxide (N₂O) production, a powerful greenhouse gas that contributes to global warming and climate change; and 3) increases in nitrogen oxide (NOₓ) production, a pollutant that increases tropospheric ozone in the lower atmosphere and a component of smog that impacts human health. In addition, the increase in nitrogen content of soils will also change the carbon cycle, which in turn impacts climate change.

To improve agricultural yields without compromising the natural environment and public health, it is crucial to promote the sustainability of agriculture and agroecosystems. Sustainable agricultural practices include increased nitrogen-use efficiency, more reliance on organic nutrient sources and nitrogen-fixing plants (such as legumes), using multiple cropping systems, and increasing irrigation and water management systems.

To guide the African Green Revolution toward sustainability without compromising global ecosystems and human welfare, there is an emergent need to improve the understanding of the impacts of increasing nitrogen loading in Africa on the global carbon and nitrogen cycles. The accompanying article explains the use of cutting-edge technologies to help develop policies as Africa moves toward sustainable agricultural practices.
Developing New Technology to Measure Greenhouse Gases

Ecosystems Center scientist Jim Tang and his group are pioneering the coupling of new technologies to develop an automated system to continuously measure the emissions of the greenhouse gases carbon dioxide, methane, and nitrous oxide from land ecosystems. Greenhouse gases trap infrared radiation in the atmosphere, causing global warming and climate change. The in situ measurement technique for carbon dioxide fluxes has been available for a few decades, but in situ measurements of methane and nitrous oxide became available only recently.

Tang’s group is developing an automated system based on infrared and laser-based analyzers to measure the three greenhouse gases simultaneously at both the landscape scale (~1 hectare, or 10,000 square meters) and on small plots (<1 square meter) with automated incubation chambers. Currently these systems are deployed in an agricultural field located in South Deerfield, Massachusetts, an agricultural research station of the University of Massachusetts and at the Harvard Forest in Petersham, Massachusetts.

The preliminary results from Tang and his collaborators indicate that nitrogen fertilization at a rate of 200 kilograms per hectare or more will significantly increase nitrous oxide fluxes, up to five times above the baseline values. The response of nitrous oxide fluxes to nitrogen fertilization could last up to a week after a single fertilization.

Jim Tang and Jerry Melillo, distinguished scientist at the Ecosystems Center, and their collaborators at Columbia University and Brown University, are planning to deploy these measurement systems in Sub-Saharan Africa. They will analyze the results using process-based simulation models to explore the environmental impacts of the new African “Green Revolution” on the global nitrogen and carbon cycles. This activity will also be linked to the new Partnerships for International Research and Education program, a joint Brown-Columbia-MBL program funded by the National Science Foundation and headed up by senior scientist Chris Neill, which will involve graduate students in assessing the environmental and social consequences of Africa’s New Green Revolution.

These cutting-edge technologies, along with our cumulative understanding of ecosystem functions and processes over long-term studies, will help to inform sound policies for agricultural intensification in Sub-Saharan Africa.

—Jim Tang
The Semester in Environmental Science at the MBL is currently the only academic year educational program available for undergraduates at a research institution in Woods Hole. It offers instruction in the interdisciplinary fields of biogeochemistry and global change ecology and is team-taught by the scientific staff at the Ecosystems Center. During the 15-week semester, students learn fundamental theory and methods of ecosystems research. In 2010, there were 16 students from Allegheny College, Brown University, Carleton College, Clark University, Clarkson University, Connecticut College, Haverford College, Hamilton College, Lafayette College, Middlebury College, Northwestern University, Oberlin College and Wheaton College.

These students learned from their own data as much as from lectures and readings offered by the Ecosystems Center faculty. During core courses, students sampled a variety of freshwater, estuarine and terrestrial sites where they measured ecosystem structure, including species composition and biomass of plants, animals, and microbes; physical factors such as light, salinity and soil characteristics, and functions such as photosynthesis, respiration, and nutrient cycling. SES students employ many of the same basic approaches to understanding ecosystem structure and 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 coursework ends, students pursue independent research projects and present their findings at a public symposium held in December.

To help provide all students with equal access to the program, we offered $37,156 in financial assistance this year. This scholarship aid was derived from two major sources: gifts from individual donors and endowment income from the Osterhout/Sears and Speck funds dedicated for undergraduate financial aid at the MBL.

During 2010, the SES also successfully completed a major challenge grant for endowment, raising a total of $750,000 over three years. Together with existing endowment this brought the value of the SES endowment to $1.18 million at the close of 2010, nearly a threefold increase from the value in December 2008.

SES students David Dodge and Austin Ritter, both of Middlebury College, in the Rowley River near Plum Island Sound after collecting samples for their independent research projects on salt marsh eutrophication. (Photo: David Johnson)
Over the past 14 years, more than 200 students have completed the Semester in Environmental Science program. About three-quarters of these students eventually go on to receive advanced training in fields such as environmental science, public health, policy or engineering. SES alumni are also involved in the increasingly important field of alternative energy and biofuels.

Three former SES students who are actively involved in research on alternative energy and biofuels are Beth Bernhardt, Nicole Travis and Toby Ahrens.

Beth Bernhardt (SES ’03, Lawrence ’05) is working as an analytical chemist for Cellana, LLC, a company based in Hawaii developing of algal-derived biofuels and bioproducts. She is part of the “lipid team” extracting, analyzing and characterizing algal lipids at Cellana. This is critically important since Cellana’s mission is to use “the most productive plants on earth – marine microalgae – to produce lipid-based feedstocks for biofuels while simultaneously reducing industrial emissions of carbon dioxide.” Beth reports “this has been a great opportunity to put my education to work towards the important goal of developing an environmentally friendly and sustainable source of fuel. It’s a really exciting field!”

Nicole Travis (SES ’05, Brown ’07) works as a research assistant in the Photosynthesis Research department at Aurora Algae Inc. “Aurora attracted me because it was working at the forefront of green energy technology, trying to create biofuels from unicellular algae at a commercial scale,” says Nicole. “The idea of harnessing the power of photosynthesis and basically farming these oil-rich algae strains seems like a viable solution to some of the world’s energy needs. It was a perfect combination of my academic interests in marine biology and my desire to be a guardian of the environment. On site in Australia, I help monitor growth and productivity in our acre-sized ponds. In the California lab, I am working to find new proprietary strains of algae that will utilize light in the most efficient way possible for biomass production and lipid accumulation. I use techniques I learned while in SES every day!”

Toby Ahrens (SES ’97, Connecticut College ’99), is senior scientist at BioProcess Algae. Prior to BioProcess, he worked as a scientist for one of the pioneers in the recent surge in interest in algae-to-biofuels, GreenFuel Technologies in Cambridge, Massachusetts. He received a Ph.D. in Biogeochemistry and a Master’s degree in Engineering, both from Stanford. “I am a proud graduate of the first SES semester (Fall ’97). SES was an incredible introduction to research science and provided a broad foundation that has served me well in my terrestrial work at Stanford and my recent transition back to the aquatic side,” says Toby.

For more information about the SES program, please go to the website, http://ecosystems.mbl.edu/SES
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.

Schoolyard LTER Program

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. Elizabeth Duff, education coordinator at Mass Audubon and Plum Island LTER, has been conducting a science education program for grades 5 to 12 called the Salt Marsh Science Project (SMS), in which students analyze marsh vegetation changes by measuring salinity, assessing tidal restrictions, and collecting other pertinent data. Ms. Duff was recently named Massachusetts Marine Educator of the Year. SMS serves an average of at least 1,000 students per year and 50 teachers from nine towns. Teachers at Governor’s Academy implement science modules for high school students using 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. In addition, each year several Arctic LTER scientists visit Barrow to lecture in the “Saturday Schoolyard” series and in the public schools.

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. The Palmer Schoolyard LTER draws upon site research to offer learning opportunities for those interested in professional development through its 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.

Logan Science Journalism Program

From the Arctic to Antarctica, journalists in the MBL Science Journalism Fellowship Program were able to view first-hand the effects of climate change in areas that are warming faster than anywhere else in the world. In June, 10 journalists, accompanied by Chris Neill and Rich McHorney from the Ecosystems Center, traveled to the Arctic LTER at Toolik Lake, Alaska. There, the journalists participated in a weeklong hands-on course, taught by Neill, focusing on key science questions in polar research. Following the course, the journalists teamed up with research scientists to work side-by-side with them in the field and laboratory. In November, three Polar Fellows spent a month with Chris Neill and other scientists studying the effects of climate change and ecosystem function at Palmer Station on the Antarctic Peninsula. For three weeks, the journalists worked closely with scientists at Palmer Station, receiving hands-on training in some of the methods of ecosystems science from Chris Neill. They also accompanied the three LTER teams in residence at Palmer as they studied microbial processes, phytoplankton ecology and penguin foraging and breeding.
Brown-MBL Graduate Program

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

Xi Yang is working with Jim Tang from the Ecosystems Center and Jack Mustard from Brown on the interdisciplinary research of remote sensing, terrestrial ecosystem ecology and climate change.

Shelby Hayhoe is studying the effects of land use change on biogeochemical cycling in tropical systems, focusing on agricultural conversion in the Amazon. Her advisors are Chris Neill from Ecosystems Center and Stephen Porder of Brown.

Lindsay Brin is working with Brown’s Jeremy Rich and the Ecosystems Center’s Anne Giblin to examine how temperature influences nitrogen pathways in estuaries and mangroves.

Sarah Corman is interested in the impact of multiple stressors, including climate change, on coastal marine ecosystems, particularly rocky shores and salt marshes. Her advisors are Linda Deegan of the Ecosystems Center and Heather Leslie of Brown.

Chelsea Nagy is co-advised by Stephen Porder of Brown and Chris Neill of the Ecosystems Center and is studying how land use change affects the structure and function, particularly nutrient cycling, of forest fragments in the Mata Atlantica and Amazon regions of Brazil.

Partnership in Education Program (PEP)

Ecosystems Center scientist Jim Tang mentored Victoria Morgan, a student at Cornell University, who was a participant in the Partnership in 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.

PEP is designed for college juniors and seniors who have had course work in oceanography or marine and/or environmental science, or some combination of biology, chemistry, geology and physics. Scientists from all institutions acted as mentors, hosting PEP students in their labs. The University of Maryland Eastern Shore, a historically black college, and the NOAA Living Marine Resources Cooperative Science Center helped design the course and arrange college credit for students.

Science Outreach

Members of the Ecosystems Center staff judge community and state science fairs and mentor students as they develop their projects. The center also continued its participation in the Woods Hole Science and Technology Education Partnership (WHSTEP), providing assistance to teachers and students in local school systems. Ecosystems Center staff members serve on many town committees, including the Falmouth Zoning Board, the Falmouth Coastal Resources working group, the Falmouth Solid Waste Advisory Committee, and the Falmouth Wastewater Technical Advisory Committee, as well as non-profit private groups such as the Falmouth Associations Concerned with Estuaries and Salt Ponds and the Association to Preserve Cape Cod. Hugh Ducklow’s lab provides analytical services to the Baywatchers Program of the Coalition for Buzzards Bay. Chris Neill writes a monthly column on environment for The Falmouth Enterprise.

Undergraduate Education

With funding from the National Science Foundation (NSF) and other groups, the Ecosystems Center has offered many college students the opportunity to undertake research projects in the lab and at field sites. In 2010, five undergraduates conducted research projects that ranged from an assessment of tundra streams at the Long Term Ecological Research (LTER) site at Toolik Lake, Alaska, to studying saltmarsh eutrophication at the Plum Island LTER to research on soil nitrogen dynamics in response to fire in the Cape Cod National Seashore.

Hugh serves on the National Academy of Sciences Polar Research Board Committee on Frontiers in Understanding Climate Change and Polar Ecosystems and the Long Term Ecological Research Network Executive Board. In 2010, he was also a member of the National Science Foundation Biological Oceanography Proposal Review Panel.

Chris Neill was promoted to Senior Scientist at the MBL and appointed Director of the Brown-MBL Partnership (see story at right). He also serves on the National Science Foundation’s Informal Science Education Panel.

Zoe Cardon is a member of the editorial board for the journal *Oecologia*, and served as president of the Physiological Ecology Section of the Ecological Society of America from 2009 to 2010.

Jerry Melillo was named Distinguished Scientist by the MBL, a title held by only three other scientists in the laboratory’s 123-year history.

Anne Giblin is a member of the board of directors of the Gulf of Maine Institute. She served on the Science Advisory Panel to the Environmental Protection Agency on nitrogen and phosphorus pollution in Florida coastal waters, and participated in the Coastal Estuarine Research Federation Strategic Planning Workshop.

Gus Shaver is a member of the Scientific Steering Group of the International Study of Arctic Change.

Joe Vallino was a panel member for the National Science Foundation’s Advancing Theory in Biology Panel Meeting for Emerging Frontiers Program.

Jim Tang serves as president of the Sino-Ecologists Association Overseas, and as a member of the LTER International Committee.

Linda Deegan is program director and chair of the steering committee for Comparative Analysis of Marine Ecosystem Organization (CAMEO).

Ivan Valiela is an editor of *Estuarine, Coastal and Shelf Science*.

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**News**

Chris Neill receives congratulations from Phyllis and Charles Rosenthal upon being named Rosenthal Director of the Brown-MBL Partnership. At left is Thomas Tisch, Brown Chancellor. (Photo: Hugh Ducklow)

Chris Neill Named Rosenthal Director of Brown-MBL Partnership

Ecosystems Center Senior Scientist **Christopher Neill** was named Rosenthal Director of the Brown-MBL Partnership. Neill’s directorship is sponsored by an endowment of more than $2 million established by MBL Trustee and Brown Trustee Emeritus Charles Rosenthal and his wife, Phyllis.

The expanded partnership will generate new joint research opportunities, strengthening graduate education, and enriching academic offerings across the two institutions. The partnership builds upon the joint Brown-MBL Ph.D. program launched in 2003.

In addition to Neill, four MBL scientists, including Jim Tang and Joe Vallino from the Ecosystems Center, were appointed to joint faculty appointments at Brown. They will teach advanced-level classes, advise graduate students, and spearhead joint research projects.

The expanded partnership will focus on three key scientific themes: ecosystems, environmental health, and microbiomes. While Brown and MBL researchers have collaborated on projects since the inception of the joint graduate program seven years ago, the new partnership aims to foster additional research collaborations among scientists at both institutions as well as to offer additional educational opportunities for students at all levels. A principal goal of the partnership is to introduce Brown graduate and undergraduate students to MBL scientists through enhanced course offerings and research opportunities in these targeted areas.
Research Grants Received

NATIONAL SCIENCE FOUNDATION:

PIRE: Land Use, Ecosystem Services and the Fate of Marginal Lands in a Globalized World. Principal Investigator: Christopher Neill ($193,423)

MSM Collaborative Research: Agricultural Expansion in the Brazilian Amazon and its Influence on the Water, Energy and Climate Cycles. Principal Investigator: Christopher Neill ($560,506)

Collaborative Research: Nutrient co-limitation in young and mature northern hardwood forests. Principal Investigator: Edward Rastetter ($180,926)

MRI-R2: Acquisition of Trace Gas Analytical Instrumentation for Ecosystem Analysis. (ARRA) Principal Investigator: Hugh Ducklow ($418,048)

IGERT: Reverse Ecology: Computational Integration of Genomes, Organisms and Environments. Principal Investigator: Zoe Cardon ($28,281)

EAGER: Differentiating heterotrophic and root respiration through concurrent measurement of CO₂ and O₂ fluxes in soils. Principal Investigator: Jianwu Tang ($149,211)

Plum Island Ecosystems Long Term Ecological Research. Principal Investigator: Anne Giblin ($1,880,000)

CDI-Type II: Collaborative Research: A Paradigm Shift in Ecosystem and Environmental Modeling: An Integrated Stochastic, Deterministic, and Machine Learning Approach Principal Investigator: Jerry Melillo ($199,996)

Arctic Long Term Ecological Research: Climate Change and Changing Disturbance Regimes in Arctic Landscapes. Principal Investigator: Gaius Shaver ($5,880,000)

THE NATURE CONSERVANCY:

Nitrogen Loads to Great South Bay: Phase 2, Assessment of Management Options. Principal Investigator: Ivan Valiela ($61,613)

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA):

Comparative Analysis of Marine Ecosystem Organization (CAMEO): Program Office Support and Steering Committee Meetings. Principal Investigator: Linda Deegan ($347,121)

Alternative Nitrogen Cycling Pathways: When does nitrate disappearance alleviate eutrophication? Principal Investigator: Anne Giblin ($62,000)

DEPARTMENT OF TRANSPORTATION (FAA):

Environmental cost-benefit analysis of alternative jet fuels (Project 28). Principal Investigator: Jerry Melillo ($250,000)

DEPARTMENT OF ENERGY:

Long-term Soil Warming and Carbon Cycle Feedbacks to the Climate System. Principal Investigator: Jerry Melillo ($508,000)

BEECH TREE TRUST:

Project on Naushon Vegetation. Principal Investigator: Christopher Neill ($10,000)

BROWN UNIVERSITY:

Phenological Shift in Facing Climate Change: Cross-Site Comparison Between Forests in the US and China. Principal Investigator: Jianwu Tang ($50,000)
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Dan White, Will Longo, Will Daniels and Marshall Moore were part of the team of Toolik Lake researchers who removed a polyethylene “curtain” from Lake N2 at the Arctic LTER site in Alaska. The curtain was installed in 1985 and the goal was to produce a divided lake to study the effects of increased nutrients in an Arctic lake due to climate change and increased land use. (Photo: Anne Giblin)
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.

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.

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.

Jerry M. Melillo  
Senior Scientist, Co-Director  
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.

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.

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.
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 airborne 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.

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

Postdoctoral Scientists

Christopher Algar  
Ph.D., Dalhousie University

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

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

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

Erin L. Kinney  
Ph.D., Boston University

Claire Lunch  
Ph.D., Stanford University

Suzanne Tank  
Ph.D., Simon Fraser University, Canada

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

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

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.
Research staff at Plum Island LTER cool off at the end of the day with a swim in the Rowley River. (Photo: Kate Morkeski)
Students

Graduate Students

Brown-MBL Graduate Students

Lindsay D. Brin  
B.A., Swarthmore College

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

Shelby Hayhoe  
B.A., Grinnell College

Rachel Chelsea Nagy  
M.S., Auburn University

Xi Yang  
M.E., Beijing Normal University

Visiting Graduate Student

Rita Oliveira Monteiro  
Ph.D. Candidate  
State University of New York ESF  
M.S., Université de Liége, Belgium

Consultants

Robert J. Golder  
John T. Finn  
David Silvennail

Visiting Scientists and Scholars

Soonmo An, Pusan National University, South Korea  
Brad Withrow-Robinson, Oregon State University

Staff who left in 2010

Sophia E. Fox, Aquatic Ecologist, National Park Service  
Mirko Lunau, Research Scientist, Alfred-Wegener Institut for Polar Research, Bremerhaven  
Rebecca L. Prosser, Public Health Career  
Chelsea L. Vario, Graduate School, Dartmouth College  
Margaret Waldran, Education Office, Northwestern University  
Sarah E. Wilkins, Graduate Studies
The annual operating budget of The Ecosystems Center for 2010 was $10,294,000. Approximately 80% of the income of the center comes 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 Program, as well as from institutional support for administration and income from the center’s institutional 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 2010 was $6,909,998. Income from these funds helps defray the costs of operations, writing proposals, consulting for government agencies and the center’s educational programs.

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Department of Transportation (DOT)
The Packard Foundation
The Nature Conservancy
Brown University
The Coalition for Buzzards Bay

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*Donations to Semester in Environmental Science