Smithsonian Environmental Research Center

Summer 2006

SERC

On the CO_2 Trail

Exploring rising carbon dioxide

Building Reefs | Blue Crab Project Update | 1st Rhode River Wade-In

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During a visit to SERC Doreen Bickel (standing-left) and Jessica Pinkey (standing-right) of the Chaney Foundation receive a demonstration of field work by student volunteer Katie Bentley in the Forest Ecology Lab. The Chaney Family Foundation generously supports our Open House. (Also pictured: Tuck Hines and Susan Jiacinto)

Midgett Parker, SERC Advisory Board member and Chairman of the Chesapeake Bay Trust, speaks to visitors at Open House during a celebration to mark the launching of Friends of SERC and our new membership in the Gateway's Network.

Cover photo: Bert Drake in the field site he established in 1986 to study impacts of rising carbon dioxide on plants (story page 4).

Eye on Education . . .

On a warm sunny day in early May, the R.V. Patricia Campbell sidled up to the SERC dock and began spewing many tons of oyster shell into the water. The shells will form the base for the education department's oyster reef.

Oyster populations have declined dramatically in the Chesapeake Bay, but they play a very important ecological role. Oysters filter the water, aiding in water quality, and the reefs created by generations of oyster shells provide habitat for other organisms and protection from shoreline erosion in shallower waters. Scientists and conservationists are working to help restore oysters to the Bay and to teach people about their important ecological role in the Chesapeake.

SERC's new oyster reef will serve both causes. As a demonstration reef, it will be a place where school children and visitors can learn about oysters and visit a living, functioning oyster reef. Researchers will also make use of the reef by conducting small-scale studies on oyster reef ecology that will complement and add to the research being done in the field.

The next step will be to place shells with small live oysters, known as spat, on the reef. As the spat grow into adult oysters, they will forming a living oyster reef.

Last year, SERC began working with the Rhode River, West River, and South River (RhoWeSo) Oyster Restoration Consortium to build experimental oyster reefs and study oysters both in the field and the lab.

As members of the RhoWeSo Consortium, The Chesapeake Bay Foundation delivered the oyster shells, and Discovery Village will provide some of the spat. SERC will also settle spat from larvae received from Horn Point hatchery at the University of Maryland.

Planting Questions

by Kimbra Cutlip

With rapid climate change and the continuing increase in atmospheric carbon dioxide no one can say with any certainty what the future world will look like...

Could the temperate zones of North America come to resemble tropical forests? Will crop production increase as plants grow more vigorously in high carbon dioxide (CO_2)? Will opportunistic invasive plants gobble up more real estate in new territories, wiping out native organisms and reducing biodiversity?

While these answers remain elusive, a few things are certain: CO_2 is rising, largely from the burning of fossil fuel; global temperature is rising dramatically; and the response of plants to these changes is going to play a significant role in how the world fares.

Our lack of understanding about how all the world's plants will respond to rising CO_2 and the complex interactions within ecosystems leaves a lot of room for debate about what's to come. Some would say that plants can take up extra CO_2 and thereby buffer us from the ill effects of rapid increases. Others would prefer not to focus on the ability of plants to take up excess CO_2 for fear it will weaken the case for reducing CO_2 emissions.

Bert Drake, who has been running the world's longest continuous field study on plant response to rising CO_2, says both sides are missing the point. "The fact that plants may provide an enormous sink for excess carbon gives us hope that we may learn to use the biosphere to help us mitigate the impacts of rising CO_2." He said, "But we don't know nearly enough about which plants can take up the most CO_2 and the fate of the CO_2 they absorb."

"Different plants have different capabilities to take up excess carbon," he said, "but we don't know why, and just because plants can take up increased carbon, doesn't mean they always do." When they do, the consequences are not always as we would like, as a recent widely publicized study illustrated when it announced that poison ivy outpaced many other plants and became more toxic to humans when exposed to increased CO_2.

The very concept that increased CO_2 would stimulate plants to grow and take up more carbon indefinitely was discounted just 20 years ago when Drake began his field study. Most scientists believed plants exposed to increased atmospheric CO_2 would increase CO_2 uptake and grow rapidly at first, but that the response would level off as they acclimated to the new conditions. In fact, they found that for the first five years, plant response to a high CO_2 environment remained constant. They anticipated that it would begin to decline as time went on.

That's where most studies would have ended. Unlike medical studies, in which patients are often followed for decades before a given treatment is even considered usable, for most environmental studies three to five years is considered long-term. Drake had the foresight and the funding from the Department of Energy, however, to keep going. To everyone's surprise, the plants' ability to continue to take up excess CO_2 increased as the study went on for the next 15 years.

Ten years ago, Drake opened another study site in a scrub oak system in Florida to address the same issues with different plants in a different environment—one dependant on fire. Between the two sites about 100 scientific papers have been written, some of them among the most quoted papers in the field. They've addressed a number of fundamental questions, and according to Drake, what we now know is this: The key environmental factors affecting plant response to high atmospheric CO_2 are: rainfall, which impacts water availability and salinity, sea-level rise, which results in flooding, and availability of nitrogen.

While plant growth has varied throughout the study as these elements have fluctuated with respect to one another, the overall trend has been that plant growth is higher in

the study sites with more CO_2 than in those without. "Over the long term, increased CO_2 releases the plant from stressors such as lack of water or nitrogen or too much salt," Drake said.

For Drake, the last two decades of research have revealed an important message if we as a society are willing to invest the time and money to understand it. Just as poison ivy seems to have a super-charged ability to take up CO_2, scientists suspect that other plants, particularly some invasive species, may share this trait. Phragmites for instance is a highly invasive wetland grass that is reducing biodiversity in marshes and impacting wetlands around the country from Washington in the Pacific North west to North Carolina in the South east. Drake and his colleagues are now planning experiments to find out if Phragmites may be a super-responder to CO_2. If it is, then we can expect it to continue to spread as CO_2 rises in the years ahead.

"That's one of the negative outcomes of not understanding all of this well," Drake said. "But what if we could turn this story on it's head," he continued, "What if we said 'well, if this plant really responds to CO_2, let's start growing it. Let's dedicate some land to growing it and harvesting it and burning it instead of coal to generate electricity.' Is it conceivable, would it work out? I don't know." Drake points to the use of switchgrass in special stoves in Canada and the increasing popularity of pellet stoves in the U.S. to replace fossil fuels.

The importance of such a resource is not just that it's renewable and reduces our dependence on non-renewable sources, but it can produce a zero net gain–or near zero net gain–in atmospheric CO_2. Instead of releasing the carbon that's locked up in fossil fuels such as coal and oil, a plant-based renewable energy program has the potential to simply cycle carbon--releasing the same amount of carbon that the current crop of energy plants is taking up.

For Drake, it's just one idea of many that may help turn a story of a liability into an opportunity. He is among a growing body of researchers becoming increasingly interested in finding out how we can use plants to store more carbon and to provide a viable alternative to fossil fuels. The potential for plants to store excess carbon and provide renewable energy may be all around us, but we don't know which plants do it best, under what conditions, or why. "We've got to know the rules that plants have evolved for taking up extra carbon," he said, "and we don't. We don't understand it well enough to predict which plants are best for our purposes."

With the 20-year anniversary of his study site at SERC and his widely referenced contributions to the field, Drake is taking the opportunity to speak out around the country about climate change and about the potential for using plants to help solve the problem. "We need to know more," he said, "we don't know enough, but with continued research, perhaps we can find out."

Bert Drake and Engineer Gary Paresta at the CO_2 Field site where Drake has been collecting data for 20 years.

Going Underground

As the CO_2 field experiment at SERC enters its third decade, biogeochemist Pat Megonigal prepares to take the operation underground.

Although 20 years of research has shown that elevated CO_2 stimulates marsh plants to grow and take up additional carbon, no one knows exactly where the extra carbon goes. It's unknown whether it is stored in the marsh, in the soil for instance, or if it's somehow leaving the ecosystem and cycling back into the atmosphere. Megonigal's earlier studies suggest that the soil isn't growing any denser with carbon, but the marsh is rising. Perhaps the excess carbon introduced to the study sites is going into the soil to produce peat and raising soil elevation.

In a major new undertaking, Megonigal and his team are placing 20 new chambers on the site and outfitting the plots with surface elevation tables, extremely sensitive instruments that can measure the rise in soil surface level. Over the next few years, Megonigal will be monitoring the elevation of the marsh and trying to understand below-ground processes that accumulate and cycle carbon in the marsh ecosystem.

Field Notes:

A Juvenile crab awaits tagging. Photo: Alicia Young-Williams

Scaling Up

Over the last four years, it has become a summer tradition for members of the SERC staff to gather en masse at the wet lab and, in assembly-line fashion, manually inject thousands of 20mm (3/4-inch) baby blue crabs with brightly colored dye and a tiny micro-wire before their release into the wild. This year, the biggest year yet for the Crab Lab, may well signal a shift in technology and an end to tradition as the blue crab enhancement project ramps up in scale. The injected tags allow the researchers to identify hatchery-reared crabs as they follow the crab populations in their study coves along the western shores of the upper Chesapeake Bay.

By following their little charges after release, the researchers have learned important information about how and where to release hatchery crabs to improve their survival. So far, they've more than doubled the population of blue crabs in their test coves, and they've seen their crabs grow to maturity and mate in the wild. The next step will be to determine if the same patterns hold true in other regions of the Bay, and if it's logistically and economically feasible to conduct this kind of stock enhancement with numbers large enough to increase the breeding population and help the struggling blue crab population recover in the Chesapeake Bay.

In the four years between May of 2002 and fall of 2005, they released about 91,000 hatchery-reared juvenile blue crabs in batches of between 1,500 and 10,000 crabs. This year, they've already released more than half that many and expect to reach that number by the end of the season. The tagging activity around the wet lab during releases is frenetic to say the least. But now that they are hoping to ramp up to release between 30,000 and 50,000 crabs at a time, the manual tagging parties may be coming to an end.

"When hatchery production reaches this level, traditional tagging will be time prohibitive, and genetic tagging will be required to follow released cohorts through time," said researcher Eric Johnson.

The juvenile crabs come from wild-caught mated females which are held at the University of Maryland Center of Marine Biotechnology until they become egg-bearing and hatch their larvae. By tracing the genetic signature of the mother through mitochondrial DNA (which remains exactly the same from mother to offspring), researchers will be able to identify both their hatchery crabs and crabs descended from any females they release that enter the breeding population.

So now, instead of processing thousands of crabs before release, the researchers need only take a little blood, or one of the legs from the crabs they catch on follow-up visits and send it to the lab for identification. Following the crabs through their DNA could begin as early as next season.

Reef Research

Before being planted on the reef, an oyster shell with live spat growing on it is prepared by Lori Davias.

By the end of this field season, more than 10,000 oysters will be placed on constructed reefs in the Rhode River. Under the close watch of Denise Breitburg and her staff in the Marine and Estuarine Ecology Lab, the oysters are expected to reveal new information about the transmission of Dermo and resistance to this devastating oyster disease.

Once plentiful enough to filter a volume of water equal to the Chesapeake Bay every week, oysters contribute dramatically to the health of the Bay ecosystem. Oyster reefs provide habitat for fish, shrimp, crabs, and other marine animals, and just two decades ago they represented the most economically productive fishery in the Bay.

Since then, overfishing, loss of habitat, pollution and disease have ravaged the population and today's oysters represent no more than 1% of historic levels.

As Maryland and Virginia struggle with the question of how to restore oyster populations, the Army Corps of Engineers and their federal and state partners are preparing an environmental impact statement evaluating the risks and benefits of their options.

Some believe that the native oyster population is so depressed that the only hope lies in the introduction of a non-native species *Crassostrea ariakensis* or the "Asian Oyster" which seems to grow faster and is more resistant to Dermo than natives. Others feel that not enough has been done to try to restore native populations. Options for the Bay states include introduction of reproductive Asian oysters, aquaculture of sterile Asian oysters, more vigorous efforts to restore native populations, and stricter limits on oyster harvests.

Breitburg is actively involved in the scientific discussions and has led some of the Chesapeake Bay Program's Scientific and Technical Advisory Committee meetings to address these issues. Through her field work she hopes to improve our understanding of vulnerability of both species of oysters to Dermo and the risks and benefits of introducing *C. ariakensis* into the Bay.

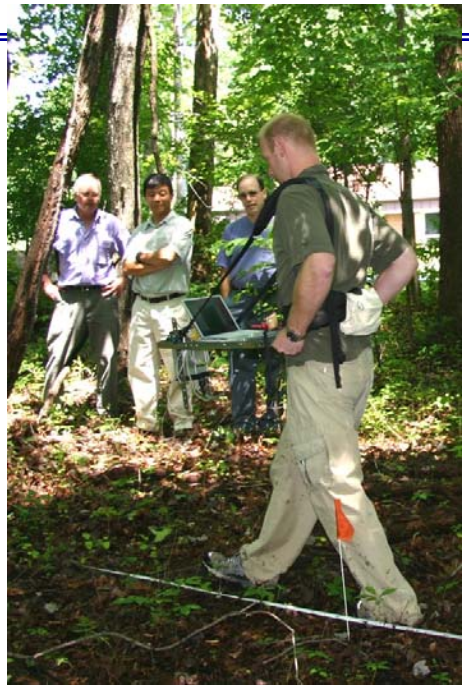
Tails of the Forest

A lot can be said about a person by the house they keep. Likewise, an awful lot can be learned about animals through studying their environment. That's why Forest Ecologist Jess Parker has been helping U.C. Santa Cruz primatologist, Nate Dominy, learn how to use his tools to study the forest.

Dominy believes that the structure of the forest has influenced not only the method primates and other animals use to get around, but the evolution of various physical characteristics. For example, South America is the only region of the world where primates have evolved a prehensile or grasping tail.

Correlating forest structure with a prehensile tail, Dominy said, "You would expect forests in South America to be characterized by vines that are fragile, so an animal needs to hold the tree crown that it's leaving and grab the one it's going to. Relying on fragile vines means needing to distribute weight more broadly." A prehensile tail would serve just this purpose.

In contrast, "The forests in South east Asia should be much more gappy, and the forest should be much taller in general," he said, "because animals there tend to jump or glide to move through the canopy." In Africa, where neither swinging with the aid of a tail nor gliding has arisen, Dominy expects something entirely different again.



Primatologist Nate Nominy tries out the Pedestrian Canopy Lidar in preparation for a trip to Africa as Jess Parker discusses its features with researchers from Florida who hope to use the system in mangroves.

"The density of vines in Africa is similar to that of South America, but the vines are much bigger and stronger and can support an animal's whole body weight," he said. "This may also describe why primates are much larger in Africa." According to Dominy, no one has been able to accurately test these theories because it requires a detailed, quantifiable picture of the inside of a forest. That's been nearly impossible to get until recently. "Jess Parker is a leader in this," Dominy said.

Over the past few years, Parker has been creating detailed images of the interior structure of forests in Asia and Latin America with a unique device he developed. Called the Pedestrian Canopy Lidar (PCL), it resembles a laptop strapped to a person's torso like a tray of peanuts or popcorn vendors wear to work the crowd at a ballgame. With it, a scientist walks through a forest rapidly capturing data about the height, size, shape and distance of its interior structures. "Think of it as sort of a CAT scan of the forest," Parker said.

"The nice thing about Jess's device is we can measure all of these factors, tree height, vine density, gappiness, in one go," Dominy said.

Dominy recently visited Parker at SERC to learn how to use the PCL for a trip to Congo and Cameroon. He intends to compare the data he gathers with data Parker has taken in Panama, Brazil, Borneo, and Australia. With the PCL's first journey to Africa, Dominy may gain a better insight into how and why primates there have evolved their various means of getting around the forest.

NexGen

Fostering the future of environmental science

Chuck Gallegos and Pat Neale sat on the Ph.D. committee for former SERC fellow Maria Tzortziou. Her work was funded by one of Gallegos' grants.

Postdoctoral Fellow Samantha Chapman was selected to participate in the National Science Foundation's Advance Faculty Horizons Workshop for women in science, technology, engineering and mathematical fields. The workshop was held in Baltimore.

Kathy Boomer was an invited attendee at "the 2006 Summer Institute: Uncertainty and Variability in Ecological Inference Forecasting and Decision Making. An Introduction to Modern Statistical Computation." The ten-day intensive workshop focused on hierarchical Bayesian inference and was sponsored by National Science Foundation and Duke University's Center on Global Change.

New Interns at SERC

The 2006 summer field season began with the assistance of 30 new interns from 26 universities including one intern from South Korea and one from Puerto Rico

Strength in Numbers

Geoffrey Parker received **$35,000** from University of California for Multi-site Integration of LIDAR and Hyperspectral Data for Improved Estimation of Carbon Stocks and Exchange.

Denise Breitburg received **$38,694** from Chesapeake Research Consortium for Supplemental Funding for Oyster Research at SERC.

Dennis Whigham received **$23,160** from Penn State/EPA for Understanding Ecological Thresholds in Aquatic Systems Through Retrospective Analysis.

Cindy Gilmour received **$143,007** from the State of Connecticut for The Importance of the Coastal Zone as a Source of Methylmercury to the Ocean.

Gregory Ruiz received **$179,639** from the U.S. Department of Homeland Security for Ballast Water Management and Delivery Patterns.

SIGHTINGS

Anson Hines represented SERC and spoke with reporters from The Washington Post, USA Today, NPR and the Associated Press during the press preview of the new National Museum of Natural History exhibit "Atmospheres." Hines was quoted by the A.P. story which appeared in multiple outlets around the country.

Hines was also interviewed in a program aired by Chinese Television in San Men, China, which featured his tour of crab aquaculture facilities in San Man, China.

SERC's blue crab enhancement project was featured in a National Public Radio story for the program "All Things Considered" on April 27. The story can be heard on NPR's web site www.npr.org.

The local NBC station in El Paso, TX, covered Bert Drake's visit to middle school children in which he described his work studying the impact of increased atmospheric carbon dioxide on plants.

The Washington Post featured an article titled "Get Your Feet Wet for Science's Sake" in the Weekend section the week of Open House.

Civil Science

SERC's first spring wade-in on the Rhode River was marked by the participation of former U.S. Senator Bernie Fowler, Maryland Department of the Environment Secretary Kendl P. Philbrick and Maryland Delegate Virginia P. Clagett. Co-sponsored by the West-Rhode Riverkeeper and held in conjunction with this year's Open House, the wade-in was a fitting celebration for the launching of Friends of SERC and the ribbon cutting that officially signified SERC's new membership in the Chesapeake Bay Gateways Network. Also participating in the initial wade-in were SERC Director Tuck Hines, SERC Advisory Board Board member Midgett Parker, River Keeper Bob Gallagher, and Ginger Ellis, Director of Environmental and Cultural Resources for Anne Arundel County. Following the official wade-in with Senator Fowler, members of the public were invited to wade-in and record their results.

Initiated by former Senator Fowler, wade-ins provide a fun and entertaining way for the public to learn about water quality and express their commitment to watershed protection and improving the Bay.

Wayne Coats attended an East Coast protozoology conference and gave an address as President of the International Society of Protistologists. The talk was titled "Microbial Controls of Chesapeake Bay Phytoplankton."

Denise Breitburg gave the keynote address for Research and Management of Eutrophication in Coastal Ecosystems: An International Symposium in Nyborg, Denmark. Her talk was titled "Low dissolved oxygen effects on fish and fisheries: When should we expect negative effects for mobile species?"

Jess Parker gave the talk "Some Effects of the Outer Canopy on the Forest Radiation Balance" at the annual meeting of the Wind River Canopy Crane Research Facility.

Chuck Gallegos presented the talk "Shallow Water Clarity Impairments" to the Chesapeake Bay Program Sediment Workgroup.

Gallegos also spoke at the "U.S. EPA STAR Global Aquatic Ecosystem Services and Multi-Stressor Progress Review Workshop" where SERC fellow **Xuyong Li** presented a poster.

Chela Zabin presented the talk, "Of Teens and Tubeworms: diversity in Hawaii's intertidal" at the Society for Conservation Biology, San Jose, CA.

Several SERC papers and posters were presented at the Joint Assembly of the American Geophysical Union held in Baltimore.

-Tom Jordan presented a paper entitled "Using stable isotopes of Nitrogen and Oxygen in nitrate as indicators of denitrification in agricultural watersheds." Co-authors were M. L. Fogel, A. D. Standbridge [former SERC intern], T. R. Fisher, and A. J. Sutton.

- **Kathy Boomer** and SERC alumnus **Matt Baker** organized and chaired a session of talks on the theme "Interactions Between Watershed Characteristics, Stream Dynamics, and Water Quality."

-**Tom Jordan, Kathy Boomer**, **Marc Russell**, **Xuyong Li** and **Don Weller** presented the following talks and posters: "Assessment of Modeling Tools for TMDL Development," "Net Anthropogenic Phosphorus Inputs in the Chesapeake Bay Region," "Effects of Watershed and Estuary Characteristics on the Abundance of Submerged Aquatic Vegetation in Chesapeake Bay Subestuaries," "Effects of Stream Map Resolution on Measures of Riparian Buffer Distribution and Nutrient Retention Potential," "Short-Term Weather Effects on Hydrochemical Patterns Across Two Fen Wetlands."

Scott Santagata, post-doctoral fellow in the invasions lab, presented his SERC research at Texas A&M in Galveston, and was invited to be a symposium speaker (Larval Sensory Biology) at the 7th Larval Conference at OIMB in Oregon. Santagata has started a collaboration with marine researchers in The Netherlands to conduct salinity tolerance experiments near Rotterdam in order to identify marine invertebrates likely to be spread among low salinity ports of the North Sea, Chesapeake Bay, and Great Lakes via ballast water.

Bert Drake gave a talk in Montreal at the MacDonald Campus of McGill University titled "Comment les plantes et les écosystèmes vont-ils répondre à l'augmentation de la concentration atmosphérique en CO_2 et aux changements climatiques."

Eric Johnson presented "Field Assessment of the Feasibility of Enhancing Blue Crab Stocks in Chesapeake Bay" at the World Aquaculture Society Meeting, Florence, Italy.

Cindy Gilmour presented "Mercury Methylation Among the Dissimilatory Iron-Reducing Bacteria"at the American Society for Microbiology Annual Meeting in Orlando, FL; and "Sulfur Contamination of the Everglades: Why Land and Water Managers Should Be Concerned" at the Greater Everglades Ecosystem Restoration Conference, also in Orlando, FL.

Tuck Hines presented multiple talks at the following universities in China: College of Aqua-Life Science and Technology, Shanghai Fisheries University, Shanghai; School of Life Science and Technology, Ningbo University, Ningbo; Xiamen University, Xiamen; South China Sea Institute of Oceanology, Chinese Academy of Sciences, Quangzhou; and Coastal Marine Laboratory, Marine and Coastal Environment Program, Hong Kong University of Science & Technology, Hong Kong. His talks focused on blue crab aquaculture and stock enhancement in Chesapeake Bay and on vectors, patterns of invasion, and management of invasive species in marine ecosystems of North America.

VISITORS

Pat Neale and Cristina Sobrino hosted John Beardall and Slobadonka Stojkovic from Monash University, Melbourne, Australia, for two weeks as part of a collaborative research project looking at effects of increased carbon dioxide and ultra violet radiation. (The work is supported by the Australian Research Council.)

Researchers from Syracuse University visited Cindy Gilmour's lab for a demonstration of mercury stable isotope methods by the Inductively Coupled Plasma Mass-Spectrometer (ICP-MS).

NEW PUBLICATIONS

Burdt, A.C., Galbraith, J.M. and Megonigal, J.P., 2006. Using CO_2 efflux rates to indicate below-ground growing seasons by land-use treatment. Wetlands Ecology and Management 14:133-145.

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Tzortziou M, Herman JR, Gallegos CL, Neale PJ, Subramaniam A, Harding LWJ, and Ahmad Z, 2006. Bio-optics of the Chesapeake Bay from measurements and radiative transfer closure. Estuarine Coastal and Shelf Science 68:348-362.

Hines, J., Megonigal, J.P., and Denno, R.F., 2006. Nutrient subsidies to belowground microbes impact aboveground food web interactions. Ecology 87:1542-1555.

McCormick, M.K., Whigham, D, F., Sloan, D., O'Malley, K., and Hodkinson, B., 2006. Orchid-fungus fidelity: a marriage meant to last? Ecology 87(4): 903-911.

Brooks, R.P., Wardrop, D.H., Thornton, K.W., Whigham, D., Hershner, C., Brinson, M.M., and Shortle, J.S., eds. 2006. Integration of ecological and socioeconomic indicators for estuaries and watersheds of the Atlantic Slope. Final Report to U.S. Environmental Protection Agency STAR Program, Agreement R-82868401, Washington, DC. Prepared by the Atlantic Slope Consortium, University Park, PA. 96 pp. + attachments (CD).

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Baker, M. E., Weller D.E., and Jordan, T.E., In press. Effects of stream map resolution on measures of riparian buffer distribution and nutrient retention potential. Landscape Ecology.

Freestone, A.L. In press. Facilitation influences local abundance and regional distribution of a rare plant in a harsh environment. Ecology.

Freestone, A. L., and Inouye, B.D. In press. Dispersal limitation and environmental heterogeneity shape scale-dependent diversity patterns in a plant community. Ecology.

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