BLACK ROCK FOREST NEWS

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Virtual Forest Partnership Links Harlem Schools with Forest

Thanks to a generous $500,000, three-year grant from the Toyota USA Foundation, the Consortium, in partnership with the Center for New Media Teaching and Learning (CCNMTL) at Columbia University and the Abyssinian Development Corporation, is offering middle- and high-school students at a network of eight Harlem public schools the opportunity not only to visit the Forest for field investigations but also to use web-based, interactive modules that teach core content in biology and chemistry, contextualize research questions, prepare them for field work, and facilitate mastery of problem-solving methodologies.

"This partnership provides unparalleled science education opportunities for these "student researchers" in the classroom, the community, and a pristine forest," explains Emily Cunningham, the Consortium's director of program and resource development. "It uses classic teaching techniques but also new media and "real world" research to help students master biology and chemistry."

Dr. Jeff Kidder, the Consortium's new director of education, was immediately enthusiastic about the Virtual Forest Partnership when he arrived at the Forest this past summer. "Not only does the web site provide opportunities for student analysis of real data sets," he said, "but it also allows sharing of curricula with a much wider audience than the students who actually visit the Forest."

The funding also allowed Frederick Douglass Academy, the lead school for the project, to become a Consortium member, paid for additional environmental sensor equipment, and permitted the hiring of an independent consultant to evaluate

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Bill Schuster and student in Toyota USA-funded program pull up turtle trap.

Environmental Data

Monitoring Aids Scientific Research

One of the casualties of the floodwaters from Hurricane Irene was the National Atmospheric Deposition Program (NADP) monitoring station, located at neighboring West Point but managed by Black Rock Forest. Its destruction enabled the Consortium, with the agreement of NADP and the US Geological Survey, to move the monitoring station to the Forest itself, where it joins a dozen or so other stations that monitor environmental variables. The new site is more representative of the Highlands landscape than the old site and makes it easier for Forest staff to collect the samples.

NADP has a network of sites around the country that collect precipitation which is then measured and analyzed for chemical content, including both nutrients and chemicals involved in air pollution and acid rain**,** such as calcium, magnesium, potassium, sodium, chlorine, hydrogen, NH_4, NO_3, and SO_4. The monitoring setup includes an automated collector system and a gauge; Forest staff collect and ship the samples to an NADP lab for analysis. For several years, the Consortium also received funding to manage a Mercury Deposition Network (MDN) monitor; it provided useful data on the background level of mercury deposited from the atmosphere into the Forest.

Other stations at the Forest monitor such environmental data as air temperature, humidity, wind speed and direction, barometric pressure, precipitation, soil temperature, and solar radiation (at both lowland and ridgetop locations, and some of these on the Fire Tower); stream depth and flow, wa-

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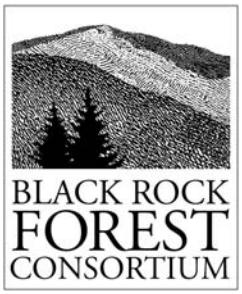

The Black Rock Forest Consortium is an alliance of public and private schools, colleges, universities, and scientific and cultural institutions engaged in research, education, and conservation in the 3835-acre Black Rock Forest. It is a not-for-profit 501(c)(3) organization supported by membership dues, grants, and gifts.

Consortium Institutions

American Museum of Natural History
Barnard College
The Browning School
The Calhoun School
Central Park Conservancy
Columbia University
Cornwall Central School District
The Dalton School
Frederick Douglass Academy
The Hewitt School
Hunter College
Marine Biological Laboratory at Woods Hole—The Ecosystems Center
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New York – New Jersey Trail Conference
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The School at Columbia University
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129 Continental Road
Cornwall NY 12518-2119
Phone: (845) 534-4517
Web: www.blackrockforest.org

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Report from the Executive Director

I recently had the honor of being elected president of the Organization of Biological Field Stations (OBFS), an association of more than 200 field stations that provide facilities for biological research and education. Its mission is to help stations effectively support their critical research, education, and outreach missions. Field stations make it practical and productive to conduct activities in natural settings by preserving access to study areas and organisms, providing facilities and equipment nearby, and fostering an atmosphere of scientific collaboration (OBFS.org).

Field stations are exciting places to visit and work, infused with the energy of active minds learning about nature. They are training grounds for future scientists and provide a range of educational opportunities. Most are sponsored by a major institution, often a university. The remainder are self-governed, like Black Rock Forest, which serves two dozen institutions through the consortium model.

Work at field stations has led to developments in applied statistics, the invention of sonar and radar, the discovery of acid rain and its impacts, human health benefits from better understanding of diseases, and knowledge about climate change and the vital benefits and services natural ecosystems provide. One important function is to provide access to unbiased scientific information. Current OBFS President Ian Billick said, "Field stations are in the business of producing the information society needs to address and solve the most important environmental issues of our time."

The Consortium compiles and disseminates a broad array of high quality environmental information (data, publications, curricula, etc.). It can be fun to check the weather, see if the latest earthquake registered in the Forest, or find out if the Science Center is fully powered by the sun. But why are these data of broader importance? Scientists make abundant use of them – all five of the most recent Black Rock-based papers, in journals such as *Tree Physiology*, *Journal of Ecology*, and *Oecologia*, used environmental data from the Forest. These investigators did not necessarily need real-time data access, but others do. In a poll of 55 Forest researchers, nearly three-quarters said access to near-real-time data was "somewhat important" or "very important." Most want ready, remote access to their own data.

Others need the data for larger-scale analyses, reflecting the national or global scale of many important environmental issues. The Forest participates in regional and national networks monitoring CO_2, acid rain, and other parameters and providing data so that scientists anywhere can address questions on scales not possible before. The National Ecological Observatory Network is establishing intensive, thoughtfully designed environmental monitoring facilities across the country to address big questions such as "how are changes in land use and climate affecting our nation's ecosystems and services?" If investigators could fully tap the data repositories of the nation's field stations, this network would be expanded by an order of magnitude.

Many issues must be addressed for this potential to be realized. Ensuring data quality is of paramount importance. Data must be accompanied by enough information (metadata) for others to be able to search for, find, and make sense of it. Standardization may be needed for data from different sources to be comparable. Field stations are adopting a more outward-looking viewpoint to enable networking and the exciting benefits of larger-scale analyses and future forecasting, but they need access to new technology, training, and more support to meet this challenge.

Like the Consortium, OBFS (in association with the nation's marine laboratories) is in the midst of strategic planning. A key goal is "understanding and managing the environment for sustainability in the face of growing human populations and natural resource consumption." Much money is invested in conservation and land preservation, but comparatively little is invested in understanding ecological processes or on the expanded networking and data sharing needed to direct the wise use of conservation funds. This mission is too important to our future to ignore, and each of us can play a role in helping it succeed. ■

— Dr. William Schuster

Virtual Forest *(continued from page 1)* the educational effectiveness of the modules.

The Virtual Forest

The Consortium has been working on the Virtual Forest for a few years, but the educational modules have been designed, with CCNMTL, by professors at Columbia and Barnard for their college-level students (see "Virtual Forest Initiative," Winter 2009). The funds from the Toyota USA Foundation allow the Consortium to work with Harlem public schools to develop modules for middle- and high-school students and to bring students from those schools to the Forest to use what they have learned from the modules to conduct their own field research. These modules will be available for all Consortium members to use with their own middle- and high-school students.

To create the first module, on water chemistry, students from three of the schools visited the Forest for project orientation and planning. They learned how to measure and compare such water quality parameters as temperature, pH, conductivity, dissolved oxygen, and ammonia and NO_3 content of a reservoir and a stream, and contributed their thoughts on making the interactive modules engaging.

The module, now complete, consists of data on water temperature, pH, and dissolved oxygen from environmental sensors at Cascade Brook, rainfall data from the Forest's open lowlands monitoring station, and data from the Hudson and Harlem rivers, as well as a graphing tool and teacher and student guides for twelve activities. These activities include learning about aquatic animal habitats and understanding how temperature, acidity, and dissolved oxygen affect these animals; in the component on the Hudson River, the students also learn about tides, salinity, and fish life cycles.

Jeff Kidder discusses how the features of a mammal's skull give clues about its life habits.

The module also contains a research component, in which students can use the data sets and graphing tool to answer questions of their own. Teacher training for this module is scheduled for March, with implementation of the curriculum in the Forest and in classrooms in the spring.

The second Virtual Forest module is on mammals. Work is just beginning, but one component will involve live-trapping (and release) of mammals ranging from shrews and mice to coyotes to create online habitat maps that will illustrate the distribution of mammals in the Forest in relation to specific habitats. Not only will students be able to see this information as part of the Virtual Forest, but they will participate in the live trapping and will be able to see the animals up close but without direct contact. Another component of the module on mammals will involve using skins and skulls to understand their characteristics and adaptations. "A lot can be deduced about an animal's lifestyle from characteristics of the skull," notes Dr. Kidder, "and interesting inquiry-focused teaching and learning can be centered on activities with skulls." He looks forward to developing this module with students, teachers, and the CCNMTL team.

Students learn how to conduct water quality tests from instructor Lorrin Johnson.

The Real Forest

The complementary part of the Virtual Forest Partnership involves bringing students from the participating schools to the Forest. Groups of students have visited the Forest at different times over the past year, with some staying overnight in the Forest Lodge. While focusing on water quality studies, including measuring characteristics of the water in Forest streams, ponds, and reservoirs and examining form and function of macroinvertebrates, they also had the opportunity to explore the Forest, learn about forest ecology, enjoy a bonfire with "s'mores," and preview the new mammal module by looking at the form and function of skulls.

The Future

"Over the next year," says Dr. Kidder, "I plan to develop several curriculum modules on Forest natural history with the support of experts from the Consortium's enormous pool of faculty and graduate student specialists, and with the members of the Virtual Forest Partnership. They will increase science literacy through hands-on and inquiry-centered activities at the Forest, in classrooms, and through the Virtual Forest web site." ■

Student Research Spotlight: Trees and Temperature

by Angelica Patterson

Since the 1930s, Black Rock Forest has lost three tree species and gained seven. Concurrently, a 0.8ºC rise in surface air temperatures in the northeast US has lengthened growing seasons, promoted earlier flowering, and influenced plant migration northwards. Theoretically, the response of plant communities to predicted air temperatures can be observed through changes in geographic distribution, where plants can migrate to suitable habitat, persist in their current range via local adaptation, or be extirpated (local extinction). Species distribution models have shown that migration rates of 1 km/year may be necessary in regions of rapid climate change. However, fossil records and molecular evidence show that tree species may be moving more slowly than this and that the short residence times of local or regional climates have narrowed their opportunity to keep up with the northern movement of ecological niches

My proposed PhD thesis will focus on understanding the physiological response to increasing temperature of tree species that have northern or southern range limits within the Hudson Highlands. It is critical to evaluate rapid changes in forest stand structure due to this area's high dominance of oak species, known to sequester large amounts of carbon in a region that is one of the largest aboveground terrestrial carbon pools in the world. Climate change in this region could promote the introduction of new tree species, through either anthropogenic means or migration, which may negatively influence carbon storage capacity and reduce the set of important ecosystem services oak-dominated forests provide. Through quantitative, observational, and experimental tests, I will ask what species can best acclimate, physiologically, to this region's changing climate, how this will change community composition, and how this will affect the global carbon cycle.

I will begin my data collection at the Forest this summer by mapping trees and recording baseline morphological measurements and photosynthesis and respiration rates. I hope to conduct a controlled growth chamber experiment with field-collected seedlings to obtain information on how physiological capacity may influence forest regeneration and species migration as affected by temperature. ■

Angelica Patterson is a doctoral student in the Department of Earth and Environmental Sciences at Columbia University.

New Book on Hudson Highlands Resources and Landscapes

Black Rock Forest lies in the Highlands region of New York, New Jersey, Pennsylvania, and Connecticut, and a new book, *The Highlands: Critical Resources, Treasured Landscapes,* explores the natural and human characteristics of the region. Dr. William Schuster, the Consortium's executive director, contributed a chapter on forest ecology.

Edited by Dr. Richard G. Lathrop, Jr., of Rutgers University, and published by the university's press, the book includes sections on the Highlands' geological setting, water and watersheds, biodiversity, and people and the land. Dr. Lathrop notes that his objective is "to present the scientific, cultural, and natural history behind sound land-use planning and environmental management."

In his chapter on forest ecology, Dr. Schuster interprets data from studies at Black Rock Forest and from the US Forest Service's Forest Inventory and Analysis plots, as well as research by other scientists. After describing the forests of the Highlands, he explores challenges to their capacity for storing carbon, as tree mortality, especially of oaks, has increased He also addresses challenges to species diversity, including the rapid expansion of non-native species, increased introductions of pests and pathogens, the extirpation of top predators, and the subsequent increase in some herbivore species, especially deer, whose overabundance reduces food resources, such as acorns, available to other species and whose browsing severely reduces tree regeneration. Dr. Schuster goes on to discuss the importance of biogeochemical cycling, and disturbance dynamics, including the "unexplained tripling of oak tree mortality and a 15% loss in oak canopy in the Black Rock Forest since 1999" and widespread regeneration failure.

In conclusion, Dr. Schuster looks to the future. "Envisioning the Highlands in as little as fifty years – after the current oak canopy is largely gone and in a warmer climate – raises several concerns." These include less forested area, more species becoming regionally extinct, changes in forest composition as northern species disappear and southern species move in, a reduction in wood quality, reduced native wildlife species diversity due to the replacement of acorns by less nutritious seeds, and potential effects on land values and recreation suitability. He explains that "appropriate and effective responses will necessitate coordinated ecosystem management" by the many stakeholders in the region, and that key actions include forest conservation, reduction of atmospheric pollution, active ecological fire management, invasive species control, protection of native carnivores, and reduction of deer populations, among other activities.

"We cannot re-create the Highlands forests of the past," he concludes. "We also cannot simply preserve current forests and assume that all will remain well. . . . Deeper understanding will be required to comprehend more fully the relative importance and interactions among the suite of current challenges to Highlands forests and the consequences for ecosystem health and services. Such an understanding could enable us to develop effective response strategies for future land planning and forest management, to ensure healthy and sustainable forests for the future." ■

Monitoring *(continued from page 1)*

ter temperature, pH, conductivity, and dissolved oxygen in Cascade Brook; and air temperature, humidity, water usage, energy usage and other parameters related to the "green architecture" of the Science Center. These data are sent by telemetry to the Science Center, which sends them to servers at Lamont-Doherty Earth Observatory and the Columbia University main campus where they are made available over the internet. The performance of the solar panels on the Center and adjacent structures is also logged and stored on a Forest computer.

The Consortium and some of the scientists who work at the Forest operate a panoply of other monitoring stations. These include two snow sensor stations which collect data on the depth, mass, temperature profile, and energy balance of the snowpack, as well as standard meteorological data; an ozone monitor; and an open-path CO_2 analyzer. As part of the oak forest research project (see "Research on Future of Oak Forests," Winter 2010), there are sensor stations monitoring soil temperature, soil moisture, subcanopy air temperature, and light. There is also a seismograph station that is part of the Lamont-Doherty Cooperative Seismographic Network.

Why Monitor?

"We monitor environmental variables because living organisms, and systems, are strongly influenced by environmental conditions, and these vary in space and time," explains the Consortium's executive director, Dr. William Schuster. "Parameters such as temperature, water availability, sunlight, and levels of nutrients must occur within specific ranges for different species, and thus can determine where species can and cannot occur and the productivity of ecosystems." These variables must be monitored over time because it may be the average conditions or the minimums or maximums that are most important for any given organism or process.

Dr. Schuster also notes that most scientists working at the Forest request environmental data sets relevant to their research, and that there is growing agreement in the scientific community that these data are of wide importance and should be carefully managed and documented and made available to investigators over the internet. With funding from the National Science Foundation and elsewhere (see "NSF Grant Awarded," Fall 2010), the Consortium has added equipment and software that allow it to automate the data streams from the monitors and permit ready data access and storage. Providing these data to scientists is part of the impetus behind the Consortium's growing Virtual Forest Initiative.

Robust, real-world data are also important for education. "The ability to explore data sets and extract knowledge from them is one of the best ways we can teach students to develop a facility for science and an understanding of the world around them," says Dr. Schuster, "and can enable them to produce new insights about how the world works."

Long-Term Understanding

Black Rock Forest has been monitoring tree growth since 1930, weather parameters since 1958, and precipitation chemistry since 1979. Along with newer monitoring programs, these provide insight into long-term trends. While the environment and the natural world are always changing, this change has perhaps never been faster than it is now. Dr. Schuster notes that long-term environmental monitoring is absolutely essential to make any sense out of the changes occurring in our ecosystems and to make any attempt to predict future states.

The tree growth monitoring has been particularly fruitful in terms of research. A recent paper by Xu *et al.* in the *Journal of Ecology* used long-term Forest data to address a controversy about tree and forest growth. Their analysis demonstrated that oaks up to 135 years old do not slow their growth as they age, but that forest stands experience slowing growth due to mortality of canopy trees.

"New technologies are being developed for remote and automated monitoring of the living, as well as the abiotic, components of ecosystems," Dr. Schuster says. "We may have the opportunity to test some of these in the Forest and study in incredible detail the interplay between organisms and our environment." ■

Preparing the new NADP site (left)) and the monitoring station, with rain gauge on left and precipitation collector on right (right).

Research at the Forest

The Black Rock Forest Consortium is committed to encouraging collaboration among member institutions and also between researchers and students. To help members learn what other members are doing and explore opportunities for collaboration, we here present a list of current research projects at the Forest, along with contact information. ■

Scaling of Variability in Populations, Individuals, and Ecosystems: Taylor's Law and Beyond. Joel E. Cohen (Rockefeller University and Columbia University), Meng Xu (Rockefeller University), and William Schuster (Black Rock Forest). *Contact: William Schuster (*

Consequences of Oak Loss on Microbial Community Composition and Function. Krista L. McGuire (Barnard College).

Impacts of Oak Mortality on the Black-Legged Tick (*Ixodes scapularis*), the Primary Vector of Lyme Disease. Mary Killilea (New York University).

The Future of Oak Forests. William Schuster (Black Rock Forest), Kevin Griffin (Lamont-Doherty Earth Observatory of Columbia University), Shahid Naeem (Columbia University), Kathleen Weathers (Cary Institute for Ecosystem Studies), and Jerry Melillo (The Ecosystems Center, Marine Biological Laboratory). *Contact: William Schuster*

Population Dynamics of Painted Turtles in the Black Rock Forest. Christopher Raxworthy (American Museum of Natural History), William Schuster (Black Rock Forest), and Martha Villaba (Barnard College). *Contact: William Schuster*

The Ecological and Evolutionary Processes of Invasive Species Integration into Native Communities. Richard Lankau (University of Illinois at Urbana-Champaign).

Native Plant Performance along an Urbanization Gradient. Kevin Griffin and Natalie Boelman (Lamont-Doherty Earth Observatory), William Schuster (Black Rock Forest), Matthew Brown (Central Park Conservancy), and J. D. Lewis (Fordham University). *Contact: Kevin Griffin*

Ecology of Slave-Maker Ants and Their Hosts: The Effect of Geographic Variation in Parasite and Host Range on Co-Evolutionary Trajectories. Christine A. Johnson (American Museum of Natural History).

The Carbon and Nitrogen Dynamics of Coarse Woody Debris in an Oak-Dominated Northern Forest. Matthew Palmer and Dan Flynn (Columbia University) and Kevin Griffin (Lamont-Doherty Earth Observatory, Columbia University). *Contact: Matthew Palmer*

Linking Holocene Vegetation and Carbon Accumulation with Hydrological Change using Macrofossils, C/N, Stable Isotopes and Biomarkers from Sutherland Pond/Fen and Tamarack Pond. Dorothy Peteet (Lamont-Doherty Earth Observatory, Columbia University).

Small Mammal Response to Oak Removal. Kate McFadden (Department of Ecology, Evolution and Environmental Biology, Columbia University).

Insect and Arachnid Diversity of Black Rock Forest. Vladimir I. Ovtsharenko and Boris Zakharov (American Museum of Natural History). *Contact: Vladimir Ovtsharenko*

Total Below-Ground Carbon Budget in Black Rock Forest. Kevin Griffin and Jennifer Levy (Lamont-Doherty Earth Observatory, Columbia University. *Contact Kevin Griffin* ■

Festive Luncheon!

What can science tell us about New York's future? At "The Weather Event," the Black Rock Forest Consortium's spring benefit luncheon, keynote speaker Dr. Heidi Cullen, author of *The Weather of the Future* and recipient of a doctorate from Lamont-Doherty Earth Observatory at Columbia University, will address this issue. The festive event is scheduled for May 8 from 12 to 2 PM at the Yale Club in New York City.

At the luncheon, the William T. Golden Award for lasting and innovative achievement in promoting science and science education will be presented to Dr. Frank Moretti, the president of the Black Rock Forest Consortium, a supporter of the Forest since before the Consortium existed, and the director of the Columbia Center for New Media Teaching and Learning. Helene L. Kaplan was the first recipient of this award at the Consortium's 20th anniversary celebration (see "Consortium Celebrates Its 20th Anniversary," Spring 2009]).

Vivian Donnelley and Valerie Colas-Ohrstrom, both members of the Consortium's Leadership Council, are co-chairing the benefit, and a committee is in formation. Ticket categories are named after Greek gods and goddesses of weather; they start with Iris, the goddess of the rainbow, for a $250 ticket, and move upwards to Zephyrus, the god of the western wind and the bringer of spring and summer breezes, for the highest priced table, $10,000. If you are interested in buying tickets or a table, or in joining the committee, please contact Emily Cunningham, the Consortium's director of program and resource development, at the Forest's main phone number, extension 26.

"This luncheon is an opportunity for friends of the Forest to get together with each other and to introduce potential new friends to the exciting scientific research and environmental education taking place in Black Rock Forest," says Consortium executive director Dr. William Schuster. "Like our 20th anniversary celebration, it is sure to be both fun and informative about how science benefits our society." ■

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☐ Individual	$20
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☐ Family	$25

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Forest News in Brief

Bill Schuster Heads OBFS for Two Years. Consortium Executive Director Dr. William Schuster has been elected the new president of the Organization of Biological Field Stations (OBFS) for a two-year term. OBFS consists of some 250 field stations, almost entirely in North America but with a scattering of members around the world. It provides educational and scientific resources for its members; in 2008, it held its annual meeting in Black Rock Forest.

Educator Workshop March 23 and 24. For the third year, the Consortium will hold an in-service training program (see "Teacher Workshop," Spring 2010). This year's workshop, to be led by Education Director Dr. Jeff Kidder, will include a full day on Friday, March 23; participants will have the option of staying overnight in the Forest Lodge for additional activities on Saturday, March 24. As in the past, educators will have the opportunity to get more familiar with Forest locations, procedures, equipment, and staff and to plan visits for their schools, but this year they will also consider the idea of a biannual Black Rock Forest Education Symposium, to be held in alternate years from the Research Symposium. Among the topics to be discussed are the need for such an event, how it might be scheduled, and what the program might include. Educators interested in participating in the workshop should contact Jeff Kidder.

Strategic Planning Moves Ahead. With the return of Dr. William Schuster, the Consortium's executive director, from his six-month sabbatical, and the hiring of Dr. Jeffrey Kidder as education director, the Consortium's strategic planning effort has moved into its second phase. Consortium staff held an all-day retreat in February with facilitator Marc Smiley of Solid Ground Consulting, as a follow-up to the board retreat held last year (see "Forest News in Brief," Spring 2011). Over the next few months, staff will work with the Board's planning committee to refine strategies, define specific goals, develop financial sustainability plans for programs, and create methods for measuring how effectively the Consortium meets its goals.

Snow in October. In the unusual October snowstorm, the Forest received a foot of snow while leaves were still on the trees. As noted by Forest Manager John Brady in his report (p. 8), the higher temperatures at lower altitudes led to heavier, wetter snow than at cooler, higher altitudes, resulting in the uprooting of many trees that had already been weakened by Hurricane Irene and record rainfall over the summer.

Science Teacher Association Meeting at Forest. In October, the Association of Science Teacher Education held its Northeast regional meeting at the Forest. Over the course of two days and nights, the educators not only listened to papers, participated in roundtable discussions, and networked with their colleagues, but also had the opportunity to tour the Forest and its green facilities. Dr. Mary Leou from New York University's Steinhardt School of Culture, Education, and Human Development, a Consortium member, was one of the organizers of the conference, and participants came from colleges, universities, and informal education organizations such as the American Museum of Natural History. ■

Black Rock Forest Consortium
129 Continental Road
Cornwall NY 12518-2119

Festive Luncheon!
May 8
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Inside This Issue

Report from the Forest Manager

Forest life and regeneration thrive on natural disturbance, and 2011 brought a hurricane, an October snowstorm, and record rainfall (84.5 inches). Openings in a mature forest canopy allow sunlight to reach the forest floor, instigating plant growth. The 2008 ice storm is a good example. It left a crippled canopy in many forest stands. Two years later, vigorous sprouting can be seen on trees that survived. The forest floor is a tangle of fallen limbs and new growth.

Hurricane Irene's disturbance was of a geologic nature. A strong surge of water rechannelized streambeds; boulders weighing tons that had once slowed the flow of water were swept aside. The straightening of streambeds speeds water flow and drainage from the upper watershed. Debris and soil were scoured from mountainside slopes and deposited in stream bank moraines. The erosion is irreversible, but the accumulation of organic debris will aid the recovery of invertebrate and fish populations.

The October 29 snowstorm added another dose of disturbance. One foot of snow fell on green-leafed trees. Elevations above 900 feet escaped severe damage, as colder temperatures caused lighter snow, but trees in lower elevations with higher temperatures experienced heavy, wet snow. Trees that had been undermined and damaged by Irene's surge finally succumbed. Uprooted, many fell across streambeds, slowing the channelized stream flow and creating new pools for wildlife.

While this was happening, oak trees were experiencing a ripple effect. Acorn production, decimated by the 2008 ice storm, recovered remarkably in 2010 with a historic bumper crop. Acorn-eating mammals, insects, and birds responded. Fueled for the hard winter of 2011, adult mammals were healthy and reproductively successful. Well-fed squirrels and mice, capable of multiple litters per year, jumpstarted the food chain. Fox, coyote, hawks, and owls benefited from rodent abundance as early as spring 2011. Deer, also driven by acorn energy, were vigorous and successfully producing healthy young.

Then, with the abruptness of a hurricane, the 2011 acorn crop was a failure. Alternate food sources then became the limiting factor for growing populations.

By fall, the deer herd displayed the effects. Growing fawns, many having never eaten an acorn, depended on new plant growth in openings created by recent disturbances, a mixture of native and invasive plants varying widely in nutritional value. This resulted in a wide range of fawn body weights, uncharacteristic of stable environments. Yearlings had wide ranges of antler size and body weight. Adult deer compensated well and remained in excellent condition. By winter, coyotes were paying close attention to deer groups while acorn-less rodent populations were in the middle stages of a crash.

Forest change is presumed to be gradual but, influenced by natural disturbances, the succession of mature forest is occasionally abrupt. Consequently, wildlife populations soar and crash. ■

— John Brady