

Fifth Black Rock Forest Research Symposium Expands to Cover Hudson Highlands

[Note: This is a longer version of the article that appears in the Fall 2007 issue of the [Black Rock Forest News](#).]

This year's Black Rock Forest Research Symposium expanded on the success of earlier symposia in several ways: it lasted two days (June 25 and 26), included researchers from around the Hudson Highlands in addition to those working in the Forest itself, and was cosponsored by the Highlands Environmental Research Institute (HENRI) of the Palisades Interstate Park Commission and the US Forest Service, Northeastern Area State and Private Forestry. Some 30 scientists gave talks on long-term biological studies, biological diversity, invasive species, mapping and monitoring, chemical cycling, earth science and the carbon cycle, and watershed studies, and nine posters were on display throughout the symposium. (Abstracts from the Symposium are available [here](#); these include the names of presentation coauthors and the full titles of talks.)

Long-Term Studies

Thanks to the foresight of Dr. Ernest L. Stillman in designating Black Rock Forest as a research station in 1928, the Forest has tree growth records going back to the 1930s, other data from the 1970s and 1980s, and a great variety of both biotic and abiotic information that has been routinely gathered since the founding of the Consortium in 1989. This abundance of long-term data has proved very useful for scientists conducting research in and around the Forest.

Flora

Black Rock's Executive Director, Dr. William Schuster, discussed 75 years of changes in the Forest, including forest density, tree basal area, and species composition, based on a series of long-term study plots. From the 1930s through the late 1990s, density decreased and basal area increased as the trees grew older, with increased tree mortality during a severe drought in the 1960s and extensive defoliation caused by gypsy moths in the early 1980s. Since 1999, however, without any "obvious proximate cause," canopy tree mortality has resulted in a 10% decline in basal area in the long-term plots. Furthermore, regeneration is lagging for many canopy trees in large part because deer browsing prevents seedlings and saplings from growing into trees.

Species composition is also changing. Throughout the study period, the Forest canopy has been dominated by red and chestnut oaks (*Quercus rubra* and *Q. prinus*), with red oaks demonstrating the greatest growth. However, some formerly common canopy species are now less prominent, including white and black oaks (*Q. alba* and *Q. velutina*), red and sugar maples (*Acer rubrum* and *A. saccharum*), gray and black birch (*Betula populifolia* and *B. lenta*), basswood (*Tilia americana*), and white ash (*Fraxinus americana*). The understory, however, contains almost no oaks, but lots of shade-tolerant red maples.

Dr. Schuster described floristic inventories conducted in the Forest, first by Harvard scientist Dr. Hugh Raup in the 1930s and then by Drs. Kerry Barringer and Steven Clemants of the Brooklyn

Botanic Garden in the 1990s. These show that American elm (*Ulmus americana*), black spruce (*Picea mariana*), and paper birch (*B. papyrifera*), all northern species, have been eliminated from the Forest during this period, while more southern species have become established: catalpa (*Catalpa bignonioides*), slippery elm (*U. rubra*), red mulberry (*Morus rubra*), white poplar (*Populus alba*), tree-of heaven (*Ailanthus altissima*), eastern cottonwood (*Populus deltoides*), and cockspur hawthorn (*Crataegus crus-galli*). “This is consistent with an hypothesis that climatic warming has been altering tree ranges and distributions,” Dr. Schuster said.

Dr. Eric Kiviat of Hudsonia discussed management of long-term, abundant, and widespread invasive plants. Explaining that they can provide a variety of ecosystem services, including attracting biota, stabilizing soil, and growing without maintenance in urban areas, he advocated a site-specific and goal-directed approach to management of such species. He also said their management could create opportunities for innovation, such as breaking up stands of invasive plants instead of attempting to eliminate them.

Fauna

Scientists from the Consortium and around the region reported on long-term studies of a variety of animal species.

James Beemer from the US Military Academy (USMA) at West Point provided an overview of the biodiversity of the Hudson Highlands, going back to late 19th century studies by noted naturalist Edward A. Mearns, an army surgeon and Highland Falls native whose collections, begun as a teenager, were ultimately given to the American Museum of Natural History and the Smithsonian Institution. Between 1878 and 1898, Dr. Mearns documented birds, mammals, reptiles, amphibians, and fishes over 20 square miles on both sides of the Hudson River. Dr. Beemer and other members of the USMA Natural Resources Branch have recently carried out similar surveys (and looked at other studies conducted in the region) and found that “biodiversity has remained high and even increased” with, for example, black bears and beavers returning to the region. They also observed some changes in species, in birds for example, with more northern species declining and more southern species moving in. The USMA researchers and other scientists also counted some groups not examined by Mearns, such as sea birds migrating along the Hudson, Odonates (dragonflies and damselflies), Lepidoptera (butterflies and moths), spiders, freshwater mollusks, and vascular plants. “Geology, human land usage patterns, geological history, and proximity to the Atlantic coast all contribute to this rich biodiversity and its persistence,” he concluded.

Forest Manager John Brady presented 35 years of population data for white-tailed deer (*Odocoileus virginianus*) within Black Rock Forest, correlating deer numbers with stresses such as drought, harsh winters, defoliation due to gypsy moth infestations, and (since 1996) with annual acorn crops. He also discussed deer management policies: since the founding of the Consortium in 1989, deer hunters have been assigned to zones, thus spreading them around the Forest, and a deer sanctuary has been set aside in the center of the Forest. These policies give male deer increased chances of getting older: a better age structure for the herd leads to healthier deer.

Two scientists discussed timber rattlesnakes (*Crotalus horridus*), a threatened species in New York. Around the state, according to Randy Stechert, a consultant for the New York State

Department of Environmental Conservation, populations are declining largely due to “escalating human pressures,” especially “habitat fragmentation from explosive residential development,” road construction, mining and quarrying, and expanding pipelines and transmission lines. He also noted that internet site information leads amateur collectors to rattlesnake dens. Mr. Stechert predicts that, within New York State, rattlesnakes will soon only be able to survive inside public lands.

Dr. Edwin McGowan of the Palisades Interstate Park Commission studied predator-prey cycles involving a “keystone” food resource in oak forests: acorns. To look at the connection between fluctuations in acorn crops and populations of predators of animals that primarily eat acorns, he analyzed timber rattlesnake reproductive success, populations of rodents (the main prey animal), and acorn crops (the main food source for many rodents). The study relied on long-term records of rattlesnake reproduction (litters seen/year) and acorn production; a gypsy moth outbreak provided “a natural experiment for comparing patterns of rattlesnake reproduction in an intact forest (pre-gypsy moth) with those in a badly disturbed and acorn-limited environment (gypsy moth impacted).” He discovered that, as predicted, a large acorn crop in year one led to more rodents in year two and thus more snake foraging and mating, leading ultimately to more rattlesnake litters in year three.

Two researchers looked at bird populations. Alan Wells reported on birds in the marshes on Iona Island, a bird sanctuary off the west shore of the Hudson just south of the Bear Mountain Bridge. The study compared birds present in 2000-2004 with those documented in a 1986-1987 count. It revealed an increase in red-winged blackbirds (*Agelaius phoeniceus*) and a loss of marsh bird species, as well as a shift in the vegetation from *Typha* (cattails) to *Phragmites* (reeds). The researchers documented 14 bird species in the marsh and some 75-80 species overall.

Dr. John Confer of Ithaca College studied golden-winged warblers (*Vermivora chrysoptera*) in Sterling Forest. Overall, in the eastern United States, this species is declining at 8.1%/yr and is “one of the most rapidly declining vertebrates,” partly due to the regrowth of forests replacing early succession vegetation in former farmland and partly due to intrusion of another species, the blue-winged warbler (*V. pinus*). However, in Sterling Forest, golden-winged warblers continue to nest successfully in swamp forests (while the blue-winged species does not) and in an upland site restored to an early succession shrubland condition.

Biological Diversity

The rich biological diversity of the Hudson Highlands, particularly in Black Rock Forest, was the subject of a series of presentations covering species ranging from small mammals to microorganisms.

Dr. Catherine Burns of WildMetro is studying the impact of urbanization on small mammal diversity, including the influence of habitat and patch size. Using live trapping and tracking methods, she and her colleagues are surveying nocturnal small mammals such as white-footed mice (*Peromyscus leucopus*), meadow voles (*Microtus pennsylvanicus*), shrews (Soricidae), and chipmunks (*Tamias striatus*) at 14 sites across four habitat types (forest, marsh, meadows, and shrubland). They found that smaller patches (which are more common in urban areas) support “higher densities of small mammals, but with a lower overall diversity,” and that high densities

of white-tailed deer negatively impact small mammal communities, probably through habitat alteration (the destruction of the understory, which provides cover).

Peter Warny of Western Connecticut State University gave a slide presentation on reptile and amphibian breeding sites along the east coast and discussed some efforts to provide habitats in which these animals can be conserved. He identified some of the threats to reptiles and amphibians, including “parasites, diseases, turtle nest predation, road kill mortality, wetland eutrophication, [and] invasive species.”

Turning to invertebrates, presentations covered spider and ant diversity in Black Rock Forest. Between 1999 and 2003, Dr. Vladimir Ovtsharenko, from Hostos Community College (CUNY) and the American Museum of Natural History, with Andrei Tanasevitch from the All-Russian Research Institute for Nature Protection, identified some 300 species of spiders in the Forest, comprising 133 genera and 27 families; they then established a [database, field guide, and gallery of spiders](#), an identification key, and a research collection of the Forest species at the Museum. Dr. Ovtsharenko noted that spiders are predators and one of the main components of biodiversity. He hopes to expand his survey to include all arachnids and eventually all insects.

Sydne Record of Harvard University discussed a baseline inventory of ant species in the study plots for Black Rock’s oak forest sustainability project (see “What Will Happen to Our Forests if the Oaks Die,” [Spring 2006](#)), noting that this project would offer an excellent opportunity to see how ants, which are “key indicators of ecological change,” might respond to “dramatic changes in vegetation structure in temperate forests.” She and her colleagues tested five different collecting methods that have proved useful in tropical surveys and determined that litter sampling and structured hand sampling together are sufficient for surveys in northern temperate forests. They identified 33 species in 14 genera in the study plot (with *Aphaenogaster rudis*, *Myrmica punctiventris*, and *Formica neogagates* the most common and abundant), and estimate that there are likely to be 38-58 ant species in the Forest overall. They suspect that a loss of oaks could lead to an increase in “species that nest in decomposing wood and open-habitat specialists.”

Dr. Shahid Naeem, of Columbia University’s Department of Ecology, Evolution, and Environmental Biology, pointed out that one of the scientific roles of Black Rock Forest is “serving as a living laboratory to test leading theories in ecology, evolution, and environmental biology.” In this area, his lab is currently conducting five research projects, examining ecosystem function and the role of biological diversity, plant biodiversity, microbial biodiversity, and faunal biodiversity, as well as trait-based modeling of ecosystem functioning. He noted that these studies, collectively, are providing evidence that “naturally diverse habitats may be more resilient and provide greater magnitudes of ecosystem functioning than the more depauperate systems they are being replaced with.” He also hailed the Forest as not only “a place for testing theory, but also a place that will provide unprecedented insights into the science of ecology and the environmental value of forests of the northeastern United States.”

Invasive Species

One of the factors changing our region’s biodiversity is the influx of invasive species: scientists presented talks on a variety of challenges facing the Hudson Highlands region and some attempts to address them.

How will increased urbanization and the “heat islands” it creates affect the spread of invasive plants, and why is there a “disproportionate abundance of invasive plants in urban compared to more rural areas?” Dr. J.D. Lewis of Fordham University and a team of researchers from Black Rock Forest, Columbia University, and the Central Park Conservancy are examining this topic as part of the Forest’s ongoing study of native plant performance along an urbanization gradient, which aims to estimate the “ecological footprint” of New York City on surrounding areas (see “Impact of Cities on Plant Growth,” [Winter 2006](#), and “Urban-Rural Gradient: Field Season Yields Plant Growth Data,” [Winter 2007](#)). This part of the research project used both field and greenhouse studies to examine plant growth, seed production, and offspring vigor of cocklebur (*Xanthium strumarium* L.), an annual invasive plant, at four sites along an urbanization gradient from Central Park in New York City to the Catskill Mountains. Dr. Lewis reported that seedlings emerged earlier at the more urban sites and that seedlings grown from urban seeds grew larger in the greenhouse than seedlings grown from rural seeds; he also noted that, irrespective of the source of the seeds, “decreasing water availability was associated” with less growth. “These results,” he said “suggest that cocklebur may grow faster, produce more seeds, and have increased offspring vigor in urban areas than in rural areas . . . [and] highlight the need to focus urban plant invasion research not only on disturbance but also on other environmental factors that may influence plant growth and offspring vigor.”

One reason exotic species thrive is that native species often don’t recognize them as a food source. Over two years, and at multiple sites, Dr. Lindsay R. Milbrath of the United States Department of Agriculture’s (USDA) Agriculture Research Service surveyed insects and mites on two species of swallow-worts (perennial vines related to milkweed): pale swallow-wort (*Vincetoxicum rossicum*, from Ukraine and southeastern European Russia) and black swallow-wort (*V. nigrum*, from southwestern Europe), both of which are becoming increasingly invasive, “producing large, dense stands capable of reducing floral and faunal biodiversity.” He found only eight generalist species of arthropods on these plants; further, they were not abundant and were present only on leaves and stems (that is, not feeding internally), thus causing little damage to the plants.

Dr. Schuster discussed current threats to oak forests, including Black Rock, noting that long-term data show that “canopy tree mortality has increased substantially” in the past several years, and that the causes go beyond such proximal factors as “fires, wind/ice storms, and the decimation of the eastern hemlock (*Tsuga canadensis*) by the introduced hemlock woolly adelgid (*Adelges tsugae*)” to “widespread tree stress” on sites with poorer soil, “exacerbated by periodic droughts.” Additionally, all major tree species are threatened by one or more pests or pathogens: for oaks, a dominant or “foundation” species, these include the possibility of sudden oak death caused by the pathogen *Phytophthora ramorum* spreading from the western US to the east coast. As a foundation species, oaks provide key ecosystem services, including soil formation, nutrient cycling, timber, shelter and food for wildlife, air purification, watershed protection, prevention of flooding and erosion, and scenic beauty. A team of scientists, including Dr. Schuster and researchers from Columbia University and the Ecosystems Center of the Marine Biological Laboratory, is conducting a multiyear study at Black Rock Forest to determine some of the cascades of impacts of the loss of this key species group to our northeastern forests (see “What Will Happen to Our Forests if the Oaks Die?,” [Spring 2006](#)).

Dr. David Mellor, from Rutgers University, described a collaborative project with the New York-New Jersey Trail Conference and Palisades Interstate Park Commission to use hikers and other nonscientist volunteers to identify and survey invasive plants in Harriman and Ringwood State Parks. Researchers trained the volunteers and then checked the accuracy of their results. The researchers viewed the project as an opportunity not only to evaluate the ability of volunteers to collect useful and meaningful data but also to evaluate the effect of conducting the survey on the participants' knowledge of and attitude towards the problems caused by invasive plants and the nature and role of scientists and the scientific method in solving ecological problems.

Mapping and Monitoring

Mapping and monitoring allow scientists to track changes in ecological factors and identify potential problems. Four researchers presented studies ranging from regional to local.

Dr. John Mickelson of the Center for International Earth Science Information Network (CIESIN) at Columbia University, the lead partner for the US Geological Service (USGS) National Biological Information Infrastructure (NBII) Northeast Information Node (NIN), presented an overview of geospatial research efforts to understand potential shifts in the natural vegetation of the Hudson River region. (Geospatial tools include geographic information systems (GIS), the global positioning system (GPS), remote sensing, and computerized data systems and software.) Dr. Mickelson and his colleagues have created and continue to improve and expand land cover, habitat, and ecosystem databases for the greater Black Rock Forest region and beyond. The general goal, he explained is to understand place-specific trends in plant communities over time, including composition, structure, function, and integrity, using baseline information and historical information to compare past vegetation patterns to projected future changes, including those that climate change might create. Dr. Mickelson also reported on a US Forest Service Northern Research Station project to model potential changes in 134 northeastern forest canopy trees.

Dr. Inga P. LaPuma of Rutgers University discussed techniques for combining a ground-based forest inventory and satellite (Landsat) remote sensing to statistically model the impact of development on forest biomass in the Highlands region of New Jersey. The model estimated the amount of biomass lost in areas that were forested in 1995 but had been converted to urban or so-called "transitional" lands by 2002.

Robert Kakerbeck, a forestry technician in the Natural Resources Division at the US Military Academy (USMA) at West Point, which is directly adjacent to the Forest, presented an overview of the ecological communities found there, based on a 1993 field survey. He noted that the rugged topography and the impact of fires, military training, and logging have created complex combinations of communities, including microcommunities.

Christopher Pray, also of the USMA Natural Resource Division, reported on a series of efforts to map the vernal pools on the military reservation and identify the flora and fauna within them, starting in 1998. He and his colleagues initially mapped 99 pools, measured their pH, and identified a variety of vernal pool specialist species, such as wood frogs (*Rana sylvatica*), spotted salamanders (*Ambystoma maculatum*), marbled salamanders (*Ambystoma opacum*), and fairy

shrimp (*Anostraca* spp.). In subsequent years, they have focused on “high quality” pools and on monitoring species of management concern.

Chemical Cycling

Scientists reported on biogeochemical cycles in Black Rock Forest and on mercury cycles and the impact of mercury on terrestrial species.

Dr. Josslyn Shapiro studied the cycles of a variety of chemicals in the Cascade Brook watershed as part of her doctoral research at Columbia University (see “Precipitation, Stream Chemistry Key to Ecosystem Processes,” [Winter 2005](#)), including inputs to the ecosystem through precipitation and dry deposition and outputs through stream flow. Dr. Schuster, who collaborated in the research, presented her report. Dr. Shapiro and her colleagues discovered that there is more chloride (Cl⁻) in the system than would be predicted from sea-salt inputs from winter marine storms, and that this excess comes primarily from a process called sea-salt dechlorination in which sulfuric and nitric acids, created in the atmosphere by human activities, interact with sea salt aerosols, as well as from coal combustion and waste incineration. She also determined that precipitation deposition of sulfate (SO₄²⁻), hydrogen ion (H⁺), and nitrate (NO₃⁻) has been decreasing since 1981 as a result of regional and national air pollution controls. Finally, she discovered that sulfate exported in streamwater “substantially exceeds” the amount expected based on measured wet deposition and modeled dry deposition, implying that dry deposition was underestimated; in addition, sulfate may be leaching out of the soil and/or organic materials deposited when sulfate inputs were higher may be decomposing.

Black Rock Forest has become a regional center of research on mercury, a toxic chemical that affects human, animal, and environmental health (see “Mercury Research Takes Off in Forest,” [Spring 2007](#)). Dr. Allan Frei, from Hunter College, part of the City University of New York (CUNY), reported on research he is conducting in collaboration with colleagues from John Jay College (also part of CUNY) and the University of Alaska to quantify the mercury cycle in Black Rock Forest. As part of their efforts to measure the inputs of mercury to the system, they have enabled the Forest to join the national Mercury Deposition Network by establishing a monitoring station for wet deposition on West Point land adjacent to the Forest’s National Atmospheric Deposition Program (NADP) site. They will also measure dry deposition and emissions of mercury from soil and snow surfaces. Their research goals include understanding the mechanisms of mercury cycling and incorporating field and lab results into models that will allow them to improve regional and global estimates of the mercury cycle under different climate and policy scenarios.

Dr. David Evers, of the BioDiversity Research Institute, presented his research on mercury in terrestrial wildlife, including forest-dwelling songbirds (most research on mercury in wildlife has focused on fish and the birds that eat them). He measured concentrations of methylmercury (the biologically available form of mercury) in wildlife at 40 different sites in the northeast, including Black Rock Forest, and found mercury concentrations in many insectivores higher than those in birds that eat fish, although different species seemed to have different levels of sensitivity. He is analyzing temporal and spatial trends, including the relationship to emission sources; he is also interested in exploring the possible connections between low calcium levels in areas affected by acid precipitation and increased methylation of elemental mercury by bacteria.

Earth Science and the Carbon Cycle

Topics in this session ranged from the very local (heavy metals in an abandoned mine) to the regional (Highlands geology) to the cosmic (the record of comet or asteroid impacts in Black Rock Forest sediments), and also included a carbon-cycle study.

Dr. Jini Gilchrist of Rutgers University and her colleagues conducted a geochemical study of metal pollutants leaching into the water, sediment, and soil from Philips Mine, an abandoned 19th century sulfur mine in Putnam County. They found very acidic water which contained very high concentrations of metals, including rare earth elements and some radioactive elements (uranium and thallium), in some cases at levels that exceed Environmental Protection Agency (EPA) standards. They reported their results to the New York State Department of Environmental Conservation (DEC), which has set some standards higher than those of the EPA. They noted that “the sulfurous mine soil makes the landscape inhospitable for vegetation even 125 years since cessation of mining operations” ; they analyzed the sparse vegetation present and found that some species, such as white birch (*Betula papyrifera*) and mountain laurel (*Kalmia latifolia*), were able to store metals in their roots.

Another Rutgers scientist, Dr. Alec Gates, provided an overview of the geologic history of the Highlands, starting with the collision of two “proto-continent,” one with sedimentary rocks and one with volcanic rocks, more than 10^9 years ago and continuing through a multitude of other geologic events, including several episodes of mountain building and fracture, covering by sedimentary rock, and glaciation. He noted that the geology of the region limits its water quality since water comes from glacial aquifers and fractured bedrock, which does not readily purify groundwater.

Dr. Dallas Abbott from Lamont-Doherty Earth Observatory discussed the presence of impact ejecta – oceanic and terrestrial debris dispersed when a comet or asteroid hits the ocean floor with sufficient force – in a sediment core taken from Tamarack Pond (see “Is There Cosmic Debris in Black Rock Forest?,” [Winter 2007](#)). As part of her global search for evidence of multiple large oceanic impacts on earth, she has identified marine microfossils in several layers of the Black Rock Forest core, as well as minerals and metals that are consistent with impact ejecta, and has correlated the dates of these layers with known impact events around the world, including some that may have led to tsunamis in the Hudson River and Long Island Sound.

For the carbon cycle component of the session, Christopher Burdette, a senior in Columbia’s Department of Ecology, Evolution, and Environmental Biology who is working with Dr. Kevin Griffin of Lamont-Doherty Earth Observatory and other Columbia scientists, presented their work on coarse woody debris (CWD, standing dead trees and large branches and stems that have fallen to the ground) and its decomposition. They are inventorying CWD primarily from three dominant tree species (red oak, *Quercus rubra*; chestnut oak, *Q. prinus*; and red maple, *Acer rubrum*) on the 18 study plots of the long-term oak forest study (see “What Will Happen to Our Forests if the Oaks Die?,” [Spring 2006](#)) to determine, as a baseline, the amount of debris, the degree of its decomposition, its nutrient composition and loss, its elemental and fiber content, and the effects of decomposing fungi. He noted that CWD is important because it is the least studied component of the forest carbon cycle, can remain in the ecosystem for centuries, provides a pool of slowly released nutrients, and creates a habitat for other organisms.

Watershed Studies

Three scientists discussed watershed issues, both statewide and local. Alexander Smith of the New York State Department of Environmental Protection (DEC) kicked off the session with a presentation on biological monitoring of the water quality of the state's streams and rivers, using benthic macroinvertebrate communities. In the Hudson Highlands, the majority of the 89 sites surveyed were categorized as slightly impaired, "predominantly from organic and sewage effluent, nonpoint source nutrient runoff, habitat modification, and erosion and siltation." The DEC is working to develop standards for nitrogen and phosphorus runoff, maintain the diversity of habitats within and alongside streams and rivers, and include macroinvertebrates and shellfish, as well as fish, in state water quality criteria.

Dr. Allison Chatrchyan from Cornell University's [Dutchess County Cooperative Extension](#) spoke on behalf of Rich Oestrike and the [Fishkill Creek Watershed Committee](#), a volunteer group that works to protect the natural environment of the approximately 190 square miles drained by the Fishkill Creek and its tributaries. Working in collaboration not only with Cornell, but also with Marist College, Vassar College, the Institute for Environmental Studies, the state DEC, the Hudson River Estuary Program, and Dutchess County environmental and water quality groups, the Watershed Committee has engaged in environmental planning, identified and investigated impaired sites along Fishkill Creek, and created management strategies, including protecting forested stream buffer areas, encouraging watershed-based education, distributing information to the public through the internet and other media, mapping habitats, monitoring water quality, and working intermunicipally.

Simon Gruber, a consultant to the [Orange County Water Authority](#), described research, planning and demonstration projects sponsored by the Authority. County-wide stream biomonitoring at some 150 sites, funded with a federal grant and using the same methodology and terminology as the state DEC (see above), provisionally indicates that 11 out of 28 sites in the Highlands are "slightly impacted," 5 are "near the moderately impacted level," and 1 is moderately impacted, while 11 sites are non-impacted. With funding from the state's Hudson River Estuary program and the involvement of an intermunicipal advisory committee, the Authority is developing a plan for the Moodna Creek watershed that will address management of water resources, biodiversity, land use, open space, recreation, and infrastructure. Wastewater management is an important issue in the county: individual septic systems may overwhelm watersheds, while centralized treatment systems are very expensive. Thus, decentralized waste management may be "a more feasible strategy for providing sustainable wastewater treatment." With state and federal funding, the Authority has begun a demonstration decentralized wastewater management project in the Greenwood Lake watershed.

Posters

Nine posters were on display throughout the Symposium, covering topics from forest respiration to snow research to community structure to glacial geology to mercury to water quality. (Again, all collaborators are listed in the [Abstracts](#) posted on this web site.)

Jennifer Levy, a graduate student in Columbia University's Department of Earth and Environmental Science presented a poster on quantifying below-ground carbon in deciduous forests like Black Rock by measuring soil respiration and other components of the below-ground

system. Chengyuan Xu, who recently received his doctorate from Columbia, illustrated a study measuring seasonal variations in red oak (*Quercus rubra*) leaf respiration. Both students worked with Dr. Kevin Griffin of Lamont-Doherty Earth Observatory.

Black Rock Forest's snow research station was the subject of a poster presented by Dr. Allan Frei of Hunter College, who produced it with colleagues from the University of Alaska, John Jay College, and Black Rock Forest. Sensors collect a variety of data at two sites and send it to an [online database at Lamont-Doherty](#); the researchers will use the data to address questions about hydroclimatology, regional water resources, and the impact of climate change.

Jason Sircely, a graduate student in the Department of Ecology, Evolution, and Environmental Biology (E3B) at Columbia, illustrated his research on relationships between composition, distance, and environmental conditions for understory plant communities in Black Rock Forest; it provided evidence for a niche-based community assembly (see "Student Research Spotlight: Roles of Understory Diversity," [Spring 2007](#)). Ellen Trimarco, another E3B graduate student, produced a poster on her observational study of the community structure of macroinvertebrates and salamanders in the Forest's leaf litter community and the impact of the macroinvertebrate trophic structure on decomposition processes in northeastern deciduous forests.

Rebecca Steinberg, a Barnard College student working with scientists from Lamont-Doherty, illustrated research on the use of cosmogenic beryllium nuclides (^{10}Be) to date glacial features in the Hudson Valley and thus the rate of retreat of the Laurentide ice sheet which terminated on Long Island. Deanna Filosa, a doctoral student at John Jay College, presented a poster on the techniques she and her colleagues are using to estimate dry deposition of mercury in Black Rock Forest and the larger implications of being able to quantify total fluxes of mercury within the Forest and the global ecosystem.

J. Kelly Nolan of Watershed Assessment Associates had two posters on display: one illustrating water quality data for the Ramapo River obtained using biological stream monitoring methods and one on a research program for college students, called Lotic Scene Investigation, which trains students to assess watershed quality through lectures, field and lab practice, and field station experience.

"This symposium has provided a snapshot of much of the environmental research currently underway in the Highlands region," Dr. Schuster said. "The sponsors hope that it will facilitate meaningful interchange, potentially lead to new collaborations, and facilitate increased environmental understanding of the region. Plans are underway for another Black Rock Forest/Highlands Research Symposium to take place in June 2009."