Black Rock Forest Consortium
129 Continental Road, Cornwall, NY 12518

Sixth Research Symposium - June 22, 2009

The Black Rock Forest Consortium is an alliance of academic institutions formed in 1989 to promote scientific research, education, and conservation associated with the nearly 4000 acre Black Rock Forest, located in southeastern New York State. Beginning in 1999, the Consortium has hosted a Research Symposium in late June of every second year. The purpose of the Symposium is to more widely communicate much of the research taking place in the Black Rock Forest and to provide a venue for investigators to meet each other and discuss their work. Since 2007, the Symposium has also included presentations about additional research projects taking place around the Highlands region.

Sessions, Presentation Titles and Authors

Session 1

William Schuster, Black Rock Forest Consortium, "Future of oak forests experiment: Description and early results."

William Schuster, Black Rock Forest Consortium, "Comparison of Black Rock Forest to other forests throughout the Highlands Region."

Jennifer Levy, Lamont Doherty Earth Observatory of Columbia University, "Future of oak forests experiment: Partitioning of autotrophic and heterotrophic respiration at Black Rock Forest."

Stephanie H. Seto, and Sharon Newman, Department of Ecology, Evolution, and Environmental Biology of Columbia University, "Small mammal community dynamics on the north slope of Black Rock Forest."

Christine Johnson, American Museum of Natural History, "Ecology of slave-maker ants: The effect of geographic variation in parasite & host range on co-evolutionary trajectories."

Jason Munshi-South, Baruch College, "Landscape genetics of white-footed mice (*Peromyscus leucopus*) in New York City: Concepts and preliminary results."

Brianna McTeague, Barnard College, "Variation in fine root morphology among 23 tree species in two northeastern forests."

Dorothy Peteet, NASA/Goddard Institute for Space Studies and Lamont Doherty Earth Observatory, T. Maenza-Gmelch, Barnard College, D. Kurdyla, Lawrence Livermore Labs, and T. Guilderson, Lawrence Livermore Labs, "15,000 years of vegetation, climate, and carbon sequestration in the Hudson Valley- An archive from Sutherland Fen, Black Rock Forest, New York."

Edwin M. McGowan, Palisades Interstate Park Commission, "Male body size and mating success in the timber rattlesnake (*Crotalus horridus*): Effects of female habitat selection."

Session 2A

Anthony Carpi, John Jay College, and A. Frei, Hunter College, "Pathways of mercury transport in the Black Rock Forest ecosystem."

Allisyn-Marie T. Gillet, Department of Ecology, Evolution, and Environmental Biology of Columbia University, and C.L. Seewagen Bronx Zoo/Wildlife Conservation Society, "Reproductive effects of mercury in redwinged-blackbirds (*Agelaius phoeniceus*) breeding in the New York metropolitan area."

Diana Hsueh, Department of Ecology, Evolution, and Environmental Biology of Columbia University, "Present and past CO_2 concentrations from our own backyard."

Dallas Abbott, Lamont Doherty Earth Observatory of Columbia University, "The Tamarack Pond core: A Rosetta Stone for impact events."

Don Steinmetz, The Highland Environment Research Institute (HEnRI), "Ramapo River intermunicipal council internet map server."

Timothy E. Kerin, A. Tuininga, and J.D. Lewis, Fordham University, "Eastern hemlock (*Tsuga canadensis*) density in a hardwood landscape influences soil biotic and abiotic characteristics."

J.D. Lewis, L. Rubino, S. Charles, A. Sirulnik, and A. Tuininga, Fordham University, "Scale-dependent effects of an invasive insect on nitrogen cycling and host physiology."

Session 2B

Jay Westerveld, New York Natural History Council, "Migration habits and hibernacula selection of the northern cricket frog in New York State."

Joan G. Ehrenfeld, R. Jordan, and Wes Brooks, Rutgers University, "Distribution of exotic species in parks of northern New Jersey and adjacent New York Highlands: Use of citizen scientists to determine extent of invasion."

Gerry Moore, Brooklyn Botanic Garden, "An overview of the vegetation of the Highlands region."

Catherine Burns, University of Maine, "Understanding biodiversity in an increasingly urban world: The potential for citizen-scientists to contribute to urban-area conservation."

Vladimir Ovtsharenko, and B. Zakharov, American Museum of Natural History, "Seasonal dynamics and biomass of spiders on a pilot project area of the Future of Oak Forests experiment."

Aimee Kemp, and M. Palmer, Department of Ecology, Evolution, and Environmental Biology of Columbia University, "The effects of the invasive shrub *Berberis thunbergii* and exotic earthworms on leaf litter communities and salamander populations in the Hudson Highlands."

Posters

Amanda Elliott, and K.C. Weathers, Cary Institute of Ecosystem Studies, and W. Schuster, Black Rock Forest Consortium, "Ecosystem response to loss of oaks: Nutrient leaching."

Gretchen Gary, and J.D. Lewis, Fordham University, "Changes in plant growth, reproduction and offspring vigor with increasing distance from an urban center."

Terryanne Maenza-Gmelch, Barnard College, "Forest, climate, & fire history of the Hudson Highlands, southeastern New York during the last >12,500 radiocarbon years (BP)."

Matthew Shook, Highlands Environmental Research Institute (HEnRI), "Managing multiple turtle species of greatest conservation need: A survey of wood, spotted, and box turtles in Harriman and Bear Mountain State Parks."

Abby G. Sirulnik, J.D. Lewis, A. Tuininga, and J. Johnson, Fordham University, "Infestations of hemlock woolly adelgid are associated with changes in eastern hemlock ectomycorrhizal fungal communities and soil conditions."

Sanpisa Sritrairat, Lamont Doherty Earth Observatory of Columbia University, Dorothy M. Peteet, NASA/Goddard Institute for Space Studies & Lamont Doherty Earth Observatory of Columbia University, and Tim Kenna, Lamont Doherty Earth Observatory of Columbia University, "Climate variability and human impacts at Tivoli North Bay and Stockport Flats, Hudson River, New York."

Elizabeth (E.B.) Tupper, Barnard College, "Examining the effects of urbanization on foliar pigment content in *Quercus rubra* seedlings using hyperspectral remote sensing."

Abstracts Listed Alphabetically by Author

The Tamarack Pond core: A Rosetta Stone for impact events

Dallas Abbott, Lamont Doherty Earth Observatory of Columbia University

We have found seven discrete layers in a bog core from Tamarack Pond in Black Rock Forest about 80 km away from the Atlantic Ocean. All but two layers contain material that is unlikely to be locally derived. In most cases, the material in the layers has been transported thousands of kilometers from its source area. Six out of the seven layers are difficult to explain except through impact processes. One of the two layers of locally derived material is about 2300 B.P. in age, the same age as that of a tsunami layer identified in the Hudson River, near Sandy Hook, New Jersey, and in the Great South Bay of Long Island. The 2300 B.P. layer contains prospective shocked quartz in all three locations and in the Tamarack Pond core. Shocked quartz is unique to impacts. We have also found impact spherules, impact diamonds and other shocked minerals in samples from the Hudson River tsunami layer. If all of these layers are derived from impacts that produced craters, the data imply a very high impact rate during late Holocene time. In addition, we have been able to associate two of the impact ejecta layers with dated tsunami events that span the Atlantic Ocean. If this discovery is validated by further research, it implies a much larger tsunami hazard in the Atlantic Ocean than previously reported.

Understanding biodiversity in an increasingly urban world: The potential for citizen-scientists to contribute to urban-area conservation

Catherine Burns, University of Maine

Habitat loss and alteration due to increasing urban- and suburbanization is a growing concern for the conservation of biodiversity across the planet. Consequently, building an environment where people and nature can sustainably coexist means understanding how plants and animals respond to increasing urbanization, and reconnecting people with the natural environment that sustains them. This project aims to investigate the ecological impacts of urbanization by bringing together collaborative teams of academic scientists, managers and citizen scientists. We aim to quantify the abundance and diversity of mammalian, avian, amphibian and plant communities found within a suite of protected areas spanning the urbanization gradient in the New York metropolitan area to address the following questions: 1) How is biodiversity impacted by increasing urbanization? 2) Are there thresholds of urbanization and land use change beyond which certain species cannot exist? 3) Do amphibians, birds, mammals and plants respond differently to urbanization? and 4) Are there specific features of protected areas within urban regions that are particularly important for supporting biodiversity? Together with project staff, citizen scientists—matched with the project through the Earthwatch Institute—have gathered data using a variety of methods specific to the sampling of each group. During the first two years of this study, over fifty citizen scientists will have contributed to data collection at each of 16 study sites. This represents over 4,000 person-hours contributed to the project by citizen scientists alone. Though many participants were residents of the New York metropolitan region, others came from around the country and from the UK, France and Japan, to participate in the project. While fully answering the study questions requires additional years of study, data collected during the first two field seasons identified intriguing patterns. We observed strong negative impacts of increasing urbanization on some wildlife species, particularly amphibians,

yet positive impacts on others (e.g. small mammals, several avian species, and non-native plants), revealing the complexities awaiting urban-area conservation. Once completed, we hope that this research will inform management of natural and developing areas in metropolitan regions around the world, and will further conservation efforts in urban areas by reconnecting people with the natural environment.

Pathways of mercury transport in the Black Rock Forest ecosystem

Anthony Carpi, John Jay College, and A. Frei, Hunter College

In 2006, we began measuring wet and dry depositional fluxes of mercury at several locations in Black Rock Forest and the remission of deposited mercury to the atmosphere. This presentation will provide a summary of wet deposition measurements, dry deposition estimates, and fluxes of mercury from surfaces to the atmosphere.

Distribution of exotic species in parks of northern New Jersey and adjacent New York Highlands: Use of citizen scientists to determine extent of invasion

Joan G. Ehrenfeld, R. Jordan, and Wes Brooks, Rutgers University

Several exotic plant species are widely distributed throughout the parks and forests of the Highlands region, and new species are infiltrating into the region from both north and south. Although the presence of these species in the region has long been known, the specific locations of populations, and the distribution of these populations with respect to environmental variables is not well known. Many of these species occur in both dense infestations and as isolated occurrences through the forests. Mapping this range of populations presents problems for both ecological analysis and for management, because of the difficulties of detecting populations of understory species across large areas. We have been working with the New York/New Jersey Trail Conference to train volunteers to collect semi-quantitative data on species occurrences and abundances along the extensive trail systems of Highlands open spaces. However, the use of such data depends on the accuracy of the volunteers' observations.

Over the past three years, we trained 164 volunteers, who worked in pairs to collect data along two-mile stretches of hiking trails (160 miles surveyed, in three areas in New Jersey (Ramapos, Norvin Green, Wawayanda) and New York (Harriman and Bear Mountain State Parks)). Volunteers were trained to identify 13 species including both commonly-occurring and newly-emerging exotics, and were also trained to collect semi-quantitative data on location and abundance of each species at 0.1 mile intervals on their assigned section of trail. Accuracy of the data was assessed by checking data on half of the data points by trained ecologists, and by having the volunteers submit pressed samples of each plant species observed. Accuracies of identification from clipped specimens ranged from 43% (*Persicaria perfoliata*) to 100% (most other species). However, accuracies of field observations were much more variable. Invasions were highly localized, so that >90% of all observation points had no invasion in all surveyed areas, but on some trails <10% of observation points were uninvaded. Volunteers varied in their ability to correctly report the absence of invasion (i.e., not mis-identify native plants as exotics); most teams incorrectly reported invasion at <10% of points. Conversely, teams varied greatly in their ability to correctly report the presence of invasions; while median values of invaded observation points missed by hikers was about 5%, in some cases teams missed up to 30% of invaded points. Inaccuracies in identifying invaded and uninvaded points increased with increasing

amounts of invasion; suggesting that in areas with low amounts of invasion, volunteer observers can reliably locate isolated occurrences of invasion. However, species-specific data showed a great range of data reliability. Not surprisingly, volunteers were more accurate at noting presence/absence of species on trailsides than at a distance from the trail, and more than assessing abundance. However, teams varied greatly in their levels of accuracy for both seeing and identifying species, judging abundances, and not missing true occurrences. We conclude that citizen science data on the occurrence and abundance of exotic species requires careful validation to ensure that analyses of ecological correlates and management activities are correctly based.

Ecosystem response to loss of oaks: Nutrient leaching

Amanda Elliott, and K.C. Weathers, Cary Institute of Ecosystem Studies, and W. Schuster, Black Rock Forest Consortium

Sudden Oak Death (SOD) was first documented in California in 1995 and has since been seen in natural communities in CA and OR and in nursery trees in 21 states across the country. Studies have shown that some eastern oak species are susceptible to the pathogen, *Phytophthora ramorum*. Black Rock Forest is dominated by oak forests and has been rated as a moderate to high risk for SOD outbreaks based on climate, forest composition, and introduction pathways, and is therefore a logical place to study the impacts large-scale oak mortality may have on forest ecosystems. As part of a large project where trees have been girdled on plots to simulate death by pathogens, we are collecting soil water using gravity lysimeters installed below the rooting zone in each of 5 treatments. We hypothesize that the rapid death of oaks, such as we would see with SOD, will cause increased leaching of ions from the forest floor, though which ions will leach is unknown. There will be more material for decomposition from the dead trees, but other work has shown that soils under oaks in the Catskills have lower nitrification rates compared to mineralization rates than seen under other hardwood species. In the first year of collection, SO_4 and Cl are the major anions and Ca, Na, and Mg are the major cations leaching from the system. Although currently the spatial and temporal variation of ion concentrations is greater than any treatment effects, we expect this to change as trees die and the system changes.

Changes in plant growth, reproduction and offspring vigor with increasing distance from an urban center

Gretchen Gary, and J.D. Lewis, Fordham University

Changes in propagule pressure may be a key factor driving the disproportionate abundance of invasive plants in urban compared to more rural areas. Yet, few studies have examined whether seed production or offspring vigor vary with urbanization. Complementary field and greenhouse studies were conducted to investigate how seed production, resource allocation to seeds, and offspring vigor vary in an annual, invasive plant, *Xanthium strumarium* L., with increasing distance from an urban center. Individuals of *X. strumarium* were planted at four sites ranging in urbanization from the urban Central Park in New York City to the rural Ashokan Reservoir area in the Catskill Mountains. In general, vegetative dry mass production and reproductive output were highest at Central Park and lowest at Ashokan. To examine site-related environmental maternal effects on offspring vigor, fruit randomly collected from three representative maternal plants from each site were germinated and grown in a greenhouse. Each seedling was chosen at random to receive a high, intermediate or low water treatment for 45 days after

emergence. Due to low germination percentages, offspring from the two most rural sites were combined as an "exurban" treatment. Seedlings from Central Park emerged, on average, four days earlier than those from the exurban sites. Decreasing water availability was associated with shorter shoots, fewer leaves, less aboveground dry mass and less belowground dry mass. Seedlings from Central Park maternal plants were significantly taller and had significantly more shoot dry mass, than seedlings from exurban maternal plants, suggesting that offspring vigor may differ between plants grown in urban and rural areas. Our results are consistent with other studies, which have shown that plants may grow faster, produce more seeds, and have increased offspring vigor when grown in environments with less distance from an urban center. Increases in growth rate and increased propagule production may increase the invasiveness of invasive plants in urban areas.

Reproductive effects of mercury in redwinged-blackbirds (*Agelaius phoeniceus*) breeding in the New York metropolitan area

Allisyn-Marie T. Gillet, Department of Ecology, Evolution, and Environmental Biology of Columbia University, and C.L. Seewagen Bronx Zoo/Wildlife Conservation Society

Mercury has been primarily studied in piscivorous birds, but recent evidence shows that it is emerging in passerines occupying comparatively low trophic levels. The bioaccumulation of mercury in invertebrate prey, like spiders and insects that undergo aquatic life stages, are biomagnifying mercury early in the food chain and thus placing insectivorous passerines at a greater risk for heightened mercury exposure. However, the effects of mercury are poorly understood in these species; and so, this study will take a comparative approach in measuring the effects of mercury on reproductive success and breeding behaviors of red-winged blackbirds (*Agelaius phoeniceus*), a passerine that occupies wetland habitats. Based on evidence from aquatic birds, it is conjectured that individuals with higher mercury burdens will experience reductions in clutch sizes, parental attentiveness to chicks, fledging growth rates, and fledging success compared to those with lower burdens. If results verify these assumptions, they will confirm the suspicion that mercury can significantly threaten species of birds that occupy low trophic positions.

Present and past CO_2 concentrations from our own backyard

Diana Hsueh, Department of Ecology, Evolution, and Environmental Biology of Columbia University

As urbanization increases globally, it is important to investigate how our natural ecosystems respond to this change. To study these effects, Black Rock Forest Consortium scientists established an urban-to-rural transect of oak seedlings (Central Park, Lamont-Doherty Earth Observatory (LDEO), Black Rock Forest (BRF), and Catskills) in 2004. Oak seedlings in the city grew larger than those in rural sites; however the cause is still unclear. We know CO_2 concentrations play a crucial role in plant growth, but the distribution of CO_2 concentrations at small temporal and spatial scales is still poorly understood. For that reason, I examined both historical CO_2 concentrations from the past 100-150 years by measuring the radiocarbon (^{14}C) content in tree rings and current CO_2 concentrations to decipher diurnal and seasonal patterns. Current CO_2 is measured in a network of atmospheric monitoring stations, called the Lamont Atmospheric Carbon Observation Project (LACOP). Each monitoring station also measures weather indices so researchers can study CO_2 trends in relationship with variations in weather patterns. The tree core data show that historic CO_2 levels in

Central Park, LDEO, BRF and the Catskills were roughly 15, 7, 4 and 2 ppm above ambient "clean" levels, respectively. Data from LACOP suggests that the overall trend is still the same with the city exposed to higher levels of CO_2, but not consistently. Much of the LACOP data is still undergoing analysis. By examining what CO_2 concentrations past flora were exposed to, current CO_2 levels, and weather data, we can better understand the basic physics, biology (notably plant physiology), and chemistry of our surroundings, and thus have a better understanding of how urbanization affects our environment.

Ecology of slave-maker ants: The effect of geographic variation in parasite & host range on co-evolutionary trajectories

Christine Johnson, American Museum of Natural History

Slave-maker ants are specialized social parasites that repeatedly ransack colonies of other ant species for their young. The stolen brood becomes a work force on which the slave-maker depends for its survival. Slave-makers were once thought to have little impact on their host. However, recent work shows reciprocal selection between parasite and host that is strong in some populations and weak in other populations. This geographic mosaic of co-evolutionary interaction strengths is likely related to variation in numbers of interacting host and parasite species. Two recent studies of a population with two sympatric slave-makers (*Temnothorax duloticus*, *Protomognathus americanus*) that share a single host (*Temnothorax curvispinosus*) suggested that high competition between slave-makers produced ecological shifts in both slave-maker species and attenuated the co-evolutionary 'arms race' between the evolutionarily older slave-maker and the shared host. The study presented here was designed to test this hypothesis by examining the interactions between the slave-maker *P. americanus* and its host from two putative co-evolutionary 'hot-spots' (Black Rock Forest & Hyuck Preserve), where the slave-maker has exclusive access to the available host. In a field enclosure experiment, *P. americanus* were challenged with conspecific colonies and the impact on the host assessed. The slave-maker host dynamics differed between the two New York populations, and the two New York populations differed in key ways from the Ohio population, where *P. americanus* is in competition with *T. duloticus* for its host.

The effects of the invasive shrub *Berberis thunbergii* and exotic earthworms on leaf litter communities and salamander populations in the Hudson Highlands

Aimee Kemp, and M. Palmer, Department of Ecology, Evolution, and Environmental Biology of Columbia University

Invasive species are transforming northeastern deciduous forest ecosystems. The invasive plant, *Berberis thunbergii* (Japanese Barberry) is spreading rapidly and competing with native vegetation. The invasion of barberry is thought to be facilitated by its use as an ornamental shrub, the dispersal of its seeds by various birds, and reduced herbivory by deer due to its protective spines. Leaf litter from *B. thunbergii* causes changes to the chemical and biological characteristics of the surrounding soil, including increases in soil pH. This increase in soil pH facilitates the spread of invasive earthworm populations, which in turn decrease the amount of organic matter in the soil and forest floor. The changes that these invasive species cause are expected to have pronounced effects on the leaf litter layer and subterranean components of forest ecosystems. Research is being conducted from late May until mid-August 2009 on the effects that *B. thunbergii* and exotic earthworms have on salamander populations at Black Rock Forest and the adjoining Kenridge Farm in the

Hudson Highlands region of New York. Using seven pairs of 100 m^2 plots, seven plots dominated by native vegetation and seven dominated by *B. thunbergii*, an estimate of *B. thunbergii* abundance, salamander populations, exotic earthworm populations, and leaf-litter arthropod density and diversity will be calculated. Soil characteristics, including pH, organic matter, leaf litter depth, and soil depth will be measured. Results from the plots dominated by *B. thunbergii* will be compared to plots dominated by native vegetation. I expect that salamander populations will be smaller, soil pH will be higher, organic matter will be lower, leaf litter depth will be lower, arthropod density and diversity will be lower, and earthworm density will be higher in plots dominated by *B. thunbergii* than in plots dominated by native vegetation. This research will illustrate some of the broader impacts of exotic plant and animal invasions on forest floor communities.

Eastern hemlock (*Tsuga canadensis*) density in a hardwood landscape influences soil biotic and abiotic characteristics

Timothy E. Kerin, A. Tuininga, and J.D. Lewis, Fordham University

Eastern hemlock (*Tsuga canadensis*) may become uncommon in southern New York due to herbivory and decline caused by the hemlock woolly adelgid. Increasing temperatures associated with global climate change are also predicted to reduce the occurrence of eastern hemlock while simultaneously increasing the occurrence of oaks. In an effort to predict possible changes at Black Rock Forest associated with such a forest community shift, soil edaphic and mycorrhizal characteristics were studied at single eastern hemlock trees exhibiting varying degrees of isolation within a predominantly oak forest. Hemlock density in study plots ranged from almost entirely hemlock with sporadic interspersed oaks to single hemlock trees surrounded by predominantly oaks. As hemlock density decreased, soil extractable ammonium increased, extractable nitrate decreased and mycorrhizal root tip density increased. Mycorrhizal fungal species evenness increased and occurrence of mycorrhizal fungal symbiont "type 1" increased with decreasing abundance of hemlock, whereas occurrence of *Cenococcum* sp. increased with increasing occurrence of oak. Independent of tree species composition, with increasing extractable ammonium, mycorrhizal fungal species richness, evenness and Shannon's diversity increased, the occurrence of mycorrhizal fungal symbiont "type 2" increased and *Cenococcum* sp. decreased. These trends suggest that both host specificity and edaphic factors control the mycorrhizal fungal community composition at Black Rock Forest, and that increasing isolation of eastern hemlock due to herbivory and climate change may affect soil biotic and abiotic characteristics. In turn, these may ultimately influence the health and survival of remaining eastern hemlock.

Future of oak forests experiment: Partitioning of autotrophic and heterotrophic respiration at Black Rock Forest

Jennifer Levy, Lamont Doherty Earth Observatory of Columbia University

The goal of this study was to evaluate contribution of *Quercus* and its associated mycorrhizal fungi to total soil respiration and to better understand the partitioning of autotrophic and heterotrophic respiration at Black Rock Forest. Trees on twelve plots (75m x75m) in a randomized block design grouped by slope position (high, medium and low) were girdled according to four treatments: girdling all the oaks on the plot (O), girdling half of the oak trees on a plot (0 50), girdling all non-oaks on a plot (NO), and a control (C). In addition to the 12 established plots, one circular plot (50m in diameter) was created where all trees were girdled (ALL). Soil respiration was measured

from May through October on all plots. A conservative estimate of the total autotrophic contribution is 66% as revealed from a fully girdled plot. Rapid declines in both the fully girdled and oak girdled plots observed within the first month of the treatment, 66% and 62% respectively, support a fast turnover between recently fixed photosynthates and their release back to the atmosphere via autotrophic respiration. Responses from the NO and O 50 treatments were similar to the control plots. Due the non proportional decline in respiration rate along a basal area gradient, the contribution of *Quercus* to total soil respiration was unable to be decoupled from overall soil respiration. These findings indicate that both biotic and abiotic controls on photosynthesis may have large implications for the forest carbon budget.

Scale-dependent effects of an invasive insect on nitrogen cycling and host physiology

J.D Lewis, L. Rubino, S. Charles, A. Sirulnik, and A. Tuininga, Fordham University

Invasive insects may dramatically alter resource cycling and productivity across forest landscapes. These changes reflect the responses of individual trees to infestation. Yet, relatively little is known about biochemical and physiological responses of host trees to invasive insects. In complementary experiments at Black Rock Forest and the Louis Calder Center, we examined changes in nitrogen (N) uptake and allocation, and needle biochemistry and physiology, in eastern hemlock (*Tsuga canadensis* (L.) Carr) saplings, as well as changes in soil N cycling, associated with infestation by the hemlock woolly adelgid (HWA) (*Adelges tsugae* Annand). The HWA is a non-native insect causing widespread decline of eastern hemlock, a foundation species in the eastern U.S. Soil nitrification was greater beneath infested compared to uninfested saplings. Monitoring of ^{15}N uptake indicated needles accumulated more ^{15}N in infested compared to uninfested saplings. Similarly, needle N and total protein concentrations were 7 and 31% greater, respectively, in infested compared to uninfested saplings. However, within infested saplings, needle N concentration did not vary with HWA density. Light-saturated net photosynthetic rates (A_{sat}) declined by 37% as the mean HWA density increased from 0.1 to 1.3 adelgids per needle, but was relatively unaffected by further increases in HWA density. A_{sat} decreased with stomatal conductance (g_s) but did not vary with needle N concentration. Apparent quantum yield, light compensation point, respiration rate in the light, needle chlorophyll concentration and leaf mass per area did not significantly differ among HWA densities. Variation in soil nitrification rates, ^{15}N uptake, and needle N and protein concentrations were not correlated, suggesting that these variables differed in at least some of the factors that drove their relationships with HWA infestation. Further, our results suggest that HWA densities within trees may be independent of within-tree variation in needle N concentrations under at least some conditions, and that HWA may affect A_{sat} independently of effects on tree N dynamics. Our results suggest that the mechanisms regulating the relationships between infestation by an invasive insect and changes in the biochemistry and physiology of host trees and in ecosystem N cycling may be scale dependent.

Forest, climate, & fire history of the Hudson Highlands, southeastern New York during the last >12,500 radiocarbon years (BP)

Terryanne Maenza-Gmelch, Barnard College

Over 12,500 radiocarbon years (BP) of Hudson Highlands forest, climate, and fire history have been revealed through analysis of plant fossils (pollen, seeds, conifer needles, and charcoal) isolated from sediment cores from Sutherland Pond (Black Rock Forest, NY) and Spruce Pond (Harriman State Park, NY). These fossils serve

as biological indicators of past environmental conditions. The ages were determined using the AMS radiocarbon dating method.

Male body size and mating success in the timber rattlesnake (*Crotalus horridus*): Effects of female habitat selection.

Edwin M. McGowan, Palisades Interstate Park Commission

When female snakes are spatially predictable and males compete through combat for reproductive access, male body size should be an important determinant of male mating success. However, as female dispersion increases, male mating success may depend more on efficient mate-searching than female defense. Using radiotelemetry, I examined spatio-temporal aspects of timber rattlesnake mating behavior during four years in southeastern New York to assess the potential for female defense polygyny in this wide-ranging species. Most sexual pairs (17 of 20) occurred during a 5-week period from late July to late August. Large male body size appeared to be important when females were associated with outcrop skin-shedding habitat during the peak of the mating season but declined in importance after females left outcrops. Small males appeared to employ an alternative tactic based on intercepting females at areas away from outcrops where competition from larger rivals was less intense. These results suggest that the relative contributions of body size and mate-searching abilities to male mating success may change within snake mating seasons in response to changes in female spatial predictability.

Variation in fine root morphology among 23 tree species in two northeastern forests

Brianna McTeague, Barnard College

A comprehensive understanding of plant impacts on ecosystems requires studying the form and function of belowground traits, particularly the resources allocated to the ephemeral fine roots of woody plants. Variation in fine root phenotypes was examined in 23 species of mature forest trees in Black Rock Forest, New York, and the Pennsylvania State Experimental Forest, Pennsylvania. Fine roots were grown in pots installed under each tree for three months and additional unmanipulated root tissue was collected from the surrounding soil. The specific root length (SRL), mean diameter, root tissue density and frequency of tips were measured for the first and second order roots of each sample. There was a significant species effect for all four traits measured: SRL ($P<0.0001$), mean diameter ($P<0.0001$), tissue density ($P<0.0001$), and tip frequency ($P=0.0045$). These patterns held across both forests and there was no significant site effect, suggesting that fine root morphology is species specific despite local environmental differences. There was a significant manipulation effect: roots grown in pots had a lower density ($P<0.0001$) and a higher SRL ($P<0.0001$) than the roots gathered directly from the soil, but there was no difference in mean diameter or tip frequency between the two treatments. Since mean diameter ($P<0.001$) and tissue density ($P<0.001$) are significantly correlated with SRL, the higher SRL in pot grown roots can be attributed mainly to changes in tissue density. This could be due to different water contents between the two treatments or a different degree of mycorrhizae colonization. By improving our understanding of root form and function, such studies may be important for improving efforts to model ecosystem-level effects of rapid climate change and shifts in vegetation boundaries.

Landscape genetics of white-footed mice (*Peromyscus leucopus*) in New York City: Concepts and preliminary results

Jason Munshi-South, Baruch College

Urban areas were once thought of as harsh, biologically sparse environments with little ecological value, but urban habitat fragments can support substantial wildlife populations. The degree to which wildlife can exchange genes between these fragments (often city parks) is strongly influenced by the intervening urban environment. This study examines native white-footed mice and two other species in the New York City (NYC) metro area as models for the impacts of urbanization on population connectivity and genetic structure. We are using molecular genetic tools (18 microsatellite loci) in combination with geographic data sets to determine I) how many evolutionarily-unique small mammal populations exist in NYC, II) how long they have been isolated (or exchanging migrants), and III) what types of urban land use facilitate or hinder the movement of small mammals and their genes between urban habitat fragments. Preliminary results from white-footed mice in the Bronx provide differing levels of support for landscape genetics models based on classic isolation-by-distance, least cost paths, and isolation-by-resistance (an adaptation of circuit theory to landscape ecology).

An overview of the vegetation of the Highlands region

Gerry Moore, Brooklyn Botanic Garden

ABSTRACT NOT AVAILABLE

Seasonal dynamics and biomass of spiders on a pilot project area of the Future of Oak Forests experiment

Vladimir Ovtsharenko, and B. Zakharov, American Museum of Natural History

Spiders were monitored for ten years in Black Rock Forest. In 2008, we censused spiders from eight plots (four fenced plots and four unfenced plots). We placed four lines of pitfall traps (3 pitfalls per line) in each plot for a total of 24 pitfall traps. Pitfalls were checked on a regular basis, approximately every 7-10 days from April 2008 till November 2008. Eventually we collected all groups of invertebrates, including spiders, ticks, insects, myriapods, isopods, and snails. Collected specimens were removed from pitfalls and transferred to separate jars with ethanol alcohol. Collected material was delivered to the Division of Invertebrate Zoology at the American Museum of Natural History. All collected material was sorted by students from the City University of New York. A preliminary list of spiders relative to the soil and leaf litter of the oak forest is completed and includes 80 species belonging to 12 families. The seasonal dynamics of spider biomass was similar in all four of the experimental plots, which was characterized by one distinctive pick of spider biomass between mid-June and mid-July. This type of seasonal dynamic tends to be more common for spider species that have with one generation per year. Differences in spider biomass in the four experimental plots will be discussed.

15,000 years of vegetation, climate, and carbon sequestration in the Hudson Valley- An archive from Sutherland Fen, Black Rock Forest, New York

D. Peteet, NASA/Goddard Institute for Space Studies and Lamont Doherty Earth Observatory, T. Maenza-Gmelch, Barnard College, D. Kurdyla, Lawrence Livermore Labs, and T. Guilderson, Lawrence Livermore Labs

Sutherland Fen formed about 12,600 ^{14}C years ago (15,000 calendar years), the same time as adjacent Sutherland Pond and regional deglaciation. High-resolution (2 cm) analysis of the 3.2 m fen core indicates three major macrofossils zones indicative of climate shifts. These climate shifts were defined over fifty years ago through pollen stratigraphy of the regional northeastern US, but macrofossils provide new details concerning hydrological and ecological shifts. The lowest (SUB-1) dated to the late-glacial, is indicative of a shallow pond characterized by *Najas*, *Nuphar*, and *Potamogeton* seeds and containing *Salix* (willow*)* buds, a *Rubus* (berry) seed, and *Picea glauca* (white spruce) needles and sterigmata from the surrounding upland. Sedimentation rates are highest in this boreal environmental zone. The overlying zone (SUB-2) beginning at 11,500 years ago (Holocene) indicates a continuing pond environment with aquatics such as *Najas, Nuphar,* and *Brasenia,* but *Picea* disappears and *Pinus strobus* (white pine) dominates the lower section of the zone. A warmer, drier climate produces sustained charcoal in the record at the Holocene boundary. *Pinus strobus* needles and seeds subsequently disappear and are replaced from 9000 to 7500 years ago by *Pinus rigida* (pitch pine), *Betula populifolia/papyrifera* (grey/paper birch), and emergent wetland plants such as *Decodon*, *Cladium*, and *Cephalanthus*, as well as *Dulichium, Eleocharis,* and *Carex*, suggesting a shallowing pond and a drier climate. *Chara* oospores indicate probable groundwater influx into the fen. About 4000 years ago, charcoal again is present. In the subsequent late Holocene a more acidic, moist, fen environment is dominated by *Sphagnum, Rubus, Hypericum, Viola, Chamaedaphne,* and *Carex*, though *Brasenia* and *Potamogeton* (pond indicators) are occasionally present. Charcoal is present again in this uppermost zone. Increased Sphagnum in recent millennia with aquatics suggests a cooler, wetter climate. The continued presence of Sphagnum led to high carbon accumulation because of less decomposition. Charcoal re-appears briefly in the uppermost sediment. Carbon accumulation rates indicate a drop in C accumulation during the Younger Dryas, followed by highest rates during the early Holocene. The warm, dry interval from 8500 to 4500 records low C accumulation due to low sedimentation rates. The overall peat accumulation curve is convex.

Ramapo River intermunicipal council internet map server

Don Steinmetz, The Highland Environment Research Institute (HEnRI)

HEnRI, in conjunction with the Town of Ramapo, is developing an internet map service that will allow any concerned parties to access, view, and query interactive maps depicting a variety of hydrologic, geologic, and political data representing conditions within the Ramapo watershed. The Ramapo is a designated sole source aquifer serving approximately two million people in the Highlands of New York and New Jersey. The Intermunicipal Council is comprised of the 26 municipalities and four counties that contain the watershed, and all have agreed to cooperate in the protection and management of this irreplaceable resource. We expect this map server to be an essential tool in disseminating scientific data, riparian zoning, and land use information to all concerned parties; providing transparency and a solid foundation for dialogue.

Future of oak forests experiment: Description and early results

William Schuster, Black Rock Forest Consortium

A focal goal of this experiment is to test our understanding of the role of Foundation Taxa, in this case oak trees (genus *Quercus*), by removing them from an ecosystem in a replicated, controlled experiment. Foundation Taxa are "taxa that are locally abundant and regionally common, whose structural or functional characteristics create habitat for a large number of associated species, and which modulate core ecosystem processes" (Dayton, 1972). The research also has practical goals: to study important impacts of oak loss from forests, to predict possible future states, and to direct future management actions. Oak trees in the Highlands region are currently under threat from Oak Dieback, Bacterial Leaf Scorch and regeneration failure, and in the future could be impacted by expanding pathogenic threats such as Oak Leaf Wilt and Sudden Oak Death. The experiment aims to analyze impacts and cascades of impacts on ecosystem processes and throughout food web, collecting data for use in modeling long term (50+ years) impacts, and eventually comparing results with other Foundation Taxon experiments at Harvard Forest and Coweeta Forest to determine generalizable, as opposed to system-specific, results.

The experiment is a "species removal"-type experiment, with manipulations made over a large area (nearly 10 hectares), and results studied over a long time (2 years pre-manipulation and at least 5 years post-manipulation) by a large, multi-disciplinary group of investigators. The treatments are 1) girdling all oak trees around the trunk to mimic death by a pathogen such as Sudden Oak Death, 2) girdling half of the oak trees, and 3) girdling all non-oaks. Each treatment has been replicated three times on plots 0.56 hectares in size with a series of unmanipulated control plots. Thus plots now vary from 0% to 100% oak composition. A series of hypotheses are being tested specific to the Foundation roles played by oak trees in terms of controlling nitrogen cycling, deer-tick-mouse-Lyme Disease dynamics, carbon sequestration, and native species biological diversity. In addition the role of deer in regulating response to canopy tree loss is being studied in a nested set of deer exclosures on each plot. Key study parameters include environmental conditions, plant species composition, tree biomass and growth rate, tree regeneration, carbon flux, decomposition, nitrogen availability and mineralization, soil water chemistry, arthropods (ants, spiders, and ticks), small mammals, deer browse activity, and soil fungi and microbial dynamics.

Early results indicate live aboveground biomass was reduced approximately 70% by the oak girdling, 35% by girdling half of the oaks, and 25% by girdling the non-oaks, although many trees (especially non-oaks) retained leaves and/or leafed out again after treatment. Treated plots show higher levels of soil moisture due to reduced transpiration and cooler summer soil temperatures. Soil respiration rates declined substantially after treatment. Increased ammonium and nitrate levels have been observed on some treated plots. Fenced areas began to exhibit different plant species composition in the first year. Data are currently being collected to determine impacts on other components and processes, to test treatment interaction effects, to use computer modeling to predict longer-term consequences, and to enable comparisons to other Foundation Taxon experiments.

Comparison of Black Rock Forest to other forests throughout the Highlands region

William Schuster, Black Rock Forest Consortium

The goal of this project was to determine how Black Rock Forest compares to other forests around the Highlands Physiographic Province to better understand if/how results of studies in Black Rock Forest might be more widely applicable. The Highlands Province is entirely underlain by Precambrian bedrock from the Reading Prong formation and stretches from eastern Pennsylvania to western Connecticut. I compared data from Black Rock Forest's database (original survey data, 1985 forest inventory, environmental records, long term plot database, Brooklyn Botanic Garden vegetation studies) with data available from around the Highlands region (US Forest Service FIA data, County Forest data, USFS Highlands Region website, etc.). I examined a suite of parameters about environmental conditions, forest stand characteristics, soils and nutrient cycling, energy flow, trophic structure, disturbance regimes and challenges and threats.

The climatic regime of the Black Rock Forest is typical for the Highlands due to its near-central location, although average growing season length differs by a week or more across the length of the Highlands. Black Rock's average stand age is about 95 years, compared to the Highlands-wide average of 71 years indicated by FIA data. Only 36 percent of the Highlands region south of the Pleistocene glaciation margin (roughly corresponding to Interstate 80 in northern New Jersey) is forested, and these areas are more heavily fragmented, compared to 69 percent forest cover in the Highlands north of the glacial margin. The topography south of the glacial margin is generally less steep and mountainous, with less exposed bedrock and better soils, and much more historical and current use for agriculture and development compared to Black Rock Forest and other areas north of the glacial margin. While the entire Highlands region is dominated by oaks, species composition in the southernmost areas includes a greater proportion of trees such as yellow poplar, black cherry, and black locust, while the northernmost areas have a greater proportion of sugar maple, paper birch, white pine and eastern hemlock. Black Rock Forest features nearly 70 percent oaks, but also features a mix of both southern and northern tree species. Black Rock Forest and some of the northern areas with more contiguous forest have a more complete trophic structure including top carnivores that are absent elsewhere. A suite of challenges and threats (such as regeneration failure and spread of non-native species) are widespread throughout the Highlands. Black Rock Forest experiences most of these, some more so (e.g. acidification) and some less so (fragmentation, invasives) compared to other Highlands forests.

Small mammal community dynamics on the north slope of Black Rock Forest

Stephanie H. Seto, and Sharon Newman, Department of Ecology, Evolution, and Environmental Biology of Columbia University

Sudden Oak Death has caused substantial tree mortalities in the western United States and the causal pathogen (*Phytophthora ramorum*) is at risk of spreading eastwards across the country. The ecosystem effects of massive disease-induced mortalities of tree species are not well known. This study is part of a larger project investigating the effects of oak removal on a northeastern ecosystem, replicating Sudden Oak Death. Oak trees and non-oaks were girdled to create four experimental plot types: control (unaltered), all oaks removed, 50% oaks removed, and all non-oaks removed. This study is investigating the effects of oak removal on the small mammal community and its species composition. It is important to understand the natural preliminary state of the small mammal

community prior to or close to any significant changes in the environment, and because the first summer of trapping coincided with the summer of girdling, this study will serve as a baseline for abundance, distribution, and foraging habit of common mammal species compared to future years of trapping. Trapping began in July 2008 and each plot was sampled for three consecutive nights each month. Using abundance data from live trapping (2160 trap nights) and foraging ecology information from mammal scat analyses (n=658), we initiated an examination of whether the loss of tree species in an ecosystem results in changes in the community dynamics of small mammals or a food web cascade that affects small mammal species. We found that in the first summer immediately following the girdling of oaks, small mammal abundance and distribution did not vary. No significant differences in species diversity exist between the four plot types. Small mammal populations resemble those in other typical northeastern oak forests, with white-footed mice (*Peromyscus leucopus*) and Eastern chipmunks (*Tamias striatus*) comprising the majority of the small mammal species composition. We found that small mammal species diet did not vary between plot types. No significant differences in feeding habits existed within species on different plots. With future years of trapping data, we may see effects from oak removal, and we expect that habitat with a substantial loss of oak species will experience a change in small mammal species composition compared to oak-dominated habitat. Foraging habits and diet composition may also change, where small mammals relying on oaks as a food source may shift to alternate food sources in plots where oaks have been lost. This study is important because of its implications for pathogen invasion, and the data will contribute to a better understanding of trophic interactions within an ecosystem.

Managing multiple turtle species of greatest conservation need: A survey of wood, spotted, and box turtles in Harriman and Bear Mountain State Parks.

Matthew Shook, Highlands Environmental Research Institute (HEnRI)

ABSTRACT NOT AVAILABLE

Infestations of hemlock woolly adelgid are associated with changes in eastern hemlock ectomycorrhizal fungal communities and soil conditions

Abby G. Sirulnik, J.D. Lewis, A. Tuininga, and J. Johnson, Fordham University

In the northeastern United States, populations of eastern hemlock (*Tsuga canadensis*) are declining due to defoliation associated with infestations of the introduced invasive insect, the hemlock woolly adelgid (*Adelges tsugae*). Ectomycorrhizal fungal communities, soil chemistry, and soil nutrient cycling associated with eastern hemlock may be affected by adelgid-induced defoliation. To make predictions for changes in eastern US forests after eastern hemlocks die, it is important to understand how the ectomycorrhizal fungal communities and soil conditions that are associated with healthy hemlock stands are changing as a result of infestation of hemlock woolly adelgid. In Black Rock Forest of southern New York, ectomycorrhizal fungal communities and soil chemistry variables were compared between eastern hemlock stands that were infested with hemlock woolly adelgid with those that were relatively healthy. Results of this study showed that hemlock defoliation associated with hemlock woolly adelgid infestations results in lower ectomycorrhizal fungal richness and root tip density. Results of Sorensen's quantitative index suggest that the decline in ectomycorrhizal fungal richness and root tip density does not result in a very

different ectomycorrhizal fungal community composition, but that all morphotypes decline in number, though some of the rarest species are eliminated. Hemlock woolly adelgid infestation also results in higher soil C/N, higher soil NO_3^- concentrations, higher soil NH_4^+ concentrations, and faster net nitrification. Changes in ectomycorrhizal fungal communities and soil chemistry show that the decline of the eastern hemlock could have a large impact on the soil ecology of eastern forests.

Climate variability and human impacts at Tivoli North Bay and Stockport Flats, Hudson River, New York

Sanpisa Sritrairat, Lamont Doherty Earth Observatory of Columbia University, Dorothy M. Peteet, NASA/Goddard Institute for Space Studies & Lamont Doherty Earth Observatory of Columbia University, and Tim Kenna, Lamont Doherty Earth Observatory of Columbia University

The investigation of pollen, spores, charcoal, organic carbon content, LOI, and radiometric dating provides a paleoecological study of Tivoli North Bay and Stockport Flats in the mid-Hudson River. These freshwater tidal marsh records reveal vegetational changes which reflect local and regional vegetational and climatic shifts. Significant charcoal maxima at the base of the core appear to be parallel to the well-dated 500-yr charcoal maxima in Piermont Marsh downriver, implying a regional climatic impact of the Medieval Warming Interval in the lower Hudson Valley. European settlement is marked by very abrupt shift in vegetation and sediment composition as a result of deforestation, invasive species introduction, and infrastructure construction. Significant extended droughts in the Hudson watershed due to natural variability have major implications for future water availability in this landscape. *Betula* became a successful replacement of forest dominants such as *Quercus*, *Pinus*, and *Tsuga*. Weedy species including *Ambrosia*, *Impatiens*, *Chenopodiaceae* and *Graminae* expand as human impact increases. Higher sedimentation rates resulted due to higher inorganic input from land use changes.

Examining the effects of urbanization on foliar pigment content in *Quercus rubra* seedlings using hyperspectral remote sensing

Elizabeth (E.B.) Tupper, Barnard College

Prolonged changes in environmental conditions, such as those associated with urbanization, have the potential to greatly alter the growth rates and physiological processes of terrestrial vegetation. In this study, hyperspectral remote sensing techniques and traditional spectrophotometric methods were used to investigate how the pigment content of *Quercus rubra* seedling foliage differed between an urban environment (Central Park, New York City) and a suburban environment (Lamont-Doherty Earth Observatory; Palisades, NY) between May 2007 and October 2007. The Chlorophyll Index (CHL), the Carotenoid Reflectance Index (CRI), and the Photochemical Reflectance Index (PRI), which estimate chlorophyll, carotenoid, and carotenoid:chlorophyll concentrations, respectively, were calculated from the reflectance data and compared to concentrations determined through wet analysis. Of the three vegetation indices used, CHL exhibited the strongest relationship with its respective concentration measure (r^2=0.74). The traditionally-measured pigment concentration data showed that the Central Park (urban) seedlings, compared to the Lamont-Doherty Earth Observatory (suburban) seedlings, had higher chlorophyll concentrations during 3 of 6 months studied and lower carotenoid:chlorophyll ratios during 4 of 6 months studied. The lower carotenoid:chlorophyll ratios of the urban seedlings indicate that urban environmental factors positively affect Light Use Efficiency.

The results of this study suggest that urbanization positively impacts native tree growth. Furthermore, through remote sensing, we now have tools that will enable quantification of urban and rural differences in foliar form and function at the canopy scale via air or spaceborne remote sensing.

Migration habits and hibernacula selection of the northern cricket frog in New York State

Jay Westerveld, New York Natural History Council

ABSTRACT NOT AVAILABLE

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