ELEVENTH RESEARCH SYMPOSIUM
JUNE 24, 2019
BLACK ROCK FOREST

Black Rock Forest was formed in 1989 to promote scientific research, education, and conservation in the 4000-acre Black Rock Forest in southeastern New York State. Since 1999 the Forest has hosted a Research Symposium in late June of every second year. The purpose of the Symposium is to communicate research taking place in the Forest and to provide a venue for investigators to meet and discuss their work. Since 2007 the Symposium has also included presentations on research elsewhere around the Highlands region.

TALKS (alphabetically ordered by presenting author last name, * indicates presenting author if not listed first)

Applegate, Marissa C., Mackevicius, Emily L., Payne, Hannah L., Scheck, David F., *Aronov, Dmitriy; Columbia University, "*Studying memory in food-caching birds, black-capped chickadees and tufted titmice*."

Auyeung, Novem NYC Parks, **Bowers, Justin** Natural Areas Conservancy, **Forgione, Helen** Natural Areas Conservancy, **Hallett, Richard A.** USDA Forest Service, **Hoehn III, Robert E.** USDA Forest Service, **Johnson, Michelle J.** USDA Forest Service, **Kim, Mina** Natural Areas Conservancy, **Nowak, David J.** USDA Forest Service, **Pregitzer, Clara** Natural Areas Conservancy, **Sonti, Nancy Falxa** USDA Forest Service; "*Ecosystem services of trees in New York City: sampling design implications for management.*"

Vaughn, Ellery Barnard College, **Schuster, William** Black Rock Forest, ***Bower, Peter,** Barnard College, **Macey, Suzanne** American Museum of Natural History; Barnard College, "*Determining the diet of the coyote population at Black Rock Forest.*"

Brewer, Alexis L., Anadon, Jose D. Queens College & CUNY; "*The response of the vertebrate scavenger guild to urbanization follows the intermediate disturbance hypothesis at Black Rock Forest, Hudson Highlands, New York.*"

Buckley, Brendan M. Lamont-Doherty Earth Observatory, **Griffin, Kevin** Lamont-Doherty Earth Observatory & Columbia University, **Palmer, Matt** Columbia University, **Hise, Jeremy** Hise Scientific Instrumentation; "*Site-specific growth response of two oak stands at Black Rock Forest: tree rings and dendrometers.*"

Davis, Steven, Herhold, Hollister, Grimaldi, David American Museum of Natural History; "*Structure and function of the insect respiratory system.*"

Gruber, Simon CUNY & Growing Green Cities; "*Sustainability, health, social and resilience benefits of forests and green space – who is using the science?*"

Heady, Laura Hudson River Estuary Program & Cornell University; "*Local conservation planning in the Hudson Highlands: update on Hudson River Estuary Program projects and grants.*"

Kiviat, Erik Hudsonia; "*Phragmites australis habitat functions for other biota are similar on three continents.*"

Ladyzhets, Betsy Barnard College, **Griffin, Kevin** Lamont-Doherty Earth Observatory & Columbia University; "*Survey of deciduous tree and shrub biomass construction costs at Black Rock Forest demonstrates connection between ecological role and plant physiology*."

LaPoint, Scott Black Rock Forest & Lamont-Doherty Earth Observatory & Max Planck Institute of Animal Behavior, **Schuster, William** Black Rock Forest; "*The Hudson Highlands Wildlife Connectivity Project: carnivore surveys within and near Black Rock Forest.*"

Menge, Duncan N. L. Columbia University, **Bytnerowicz, T.** Columbia University, **Kou-Giesbrecht, Sian** Columbia University, **Akana, Palani R.** Columbia University, **Griffin, Kevin** Lamont-Doherty Earth Observatory & Columbia University, Wolf, Amelia A. University of Texas Austin; "*Nitrogen fixation strategies in Robinia pseudoacacia.*"

Nolan, Terrence & Nieves, Wil Open Space Institute; "*Highlands West: a land conservation initiative in the Black Rock Forest Region.*"

Peteet, Dorothy M. NASA GISS & Lamont-Doherty Earth Observatory, **Maenza-Gmelch, Terryanne** Barnard College, **Menking, Kristen** Vassar College, **Margraf, Sage** Lamont-Doherty Earth Observatory; "*Long-term vegetational history from Black Rock Forest to Mohonk – How does the paleoecology compare?*"

Piana, Max Rutgers University, **Aronson, Myla F. J.** Rutgers University, **Hallett, Richard A.** USDA Forest Service, **Morin, Peter J.** Rutgers University, **Pickett, Steward T. A.,** Cary Institute of Ecosystem Studies, **Handel, Steven N.** Rutgers University; "*Forests in the city: understanding urban-driven changes in forest recruitment dynamics.*"

Reed-Sanchez, Edwin SayCel Technologies & RiskEcon® Lab @Courant Institute of Mathematical Sciences New York University, **Kappagoda, Samantha** RiskEcon® Lab @Courant Institute of Mathematical Sciences New York University, **Mordecai, David KA** RiskEcon® Lab @Courant Institute of Mathematical Sciences New York University; "*The UnWired Forest: a Black Rock Forest mesh wifi network, resilient data collection store and forward nodes.*"

Reinmann, Andrew B. CUNY, **Deas, Ayo Andra J.** CUNY, **Klein, Alison** Hunter College, **Kim, Taewoo** Hunter College, **Ahmed, Tasneem** Brooklyn College; "*Leveraging environmental gradients at Black Rock Forest to understand the responses of tree growth and nonstructural carbohydrate storage to projected changes in climate.*"

Savant, Neha The Nature Conservancy, **Fowles, Gretchen** NJ Division of Fish and Wildlife, **Hall, Mackenzie** NJ Division of Fish and Wildlife, **Olsen, Eric** The Nature Conservancy, **Shanahan, Mike** The Nature Conservancy, **Sherwood, Scott** The Nature Conservancy, **Zarate, Brian** NJ Division of Fish and Wildlife; "*Wildlife mortality and camera data help prioritize road mitigation opportunities in a statewide initiative to connect habitat across New Jersey.*"

Schmiege, Stephanie Columbia University & New York Botanical Garden, **Griffin, Kevin** Lamont-Doherty Earth Observatory & Columbia University, **Boelman, Natalie** Lamont-Doherty Earth Observatory & Columbia University, **Vierling, Lee A.**

University of Idaho, **Eitel, Jan** University of Idaho; "*Vertical gradients in light environment alter carbon balance in White Spruce (Picea glauca) at its southernmost and northernmost range extremes.*"

Schuster, William Black Rock Forest, **Grace Palmer** Barnard College; **Clara Odell** Barnard College; "*Recent trends in carbon sequestration in Black Rock Forest.*"

Sonti, Nancy Falxa USDA Forest Service, Hallett, Richard USDA Forest Service, **Griffin, Kevin** Lamont-Doherty Earth Observatory & Columbia University, **Sullivan, Joe** University of Maryland; "*Growth and physiology of white oak and red maple trees in urban vs. rural forest patches.*"

Kilheffer, Chelby R. SUNY ESF, ***Underwood, H. Brian** USGS Wildlife Research Center, **Leopold, Donald J.** SUNY ESF, **Guerrieri, Rachel** SUNY ESF; "*Evaluating legacy impacts of hyper-abundant white-tailed deer in forested stands of Harriman and Bear Mountain State Parks.*"

POSTERS

Balter, Allie Lamont-Doherty Earth Observatory, **Schaefer, Joerg** Lamont-Doherty Earth Observatory, **Young, Nicolás** Lamont-Doherty Earth Observatory, **Schuster, William** Black Rock Forest; "*Dynamics of the Laurentide Ice Sheet in Lower Hudson Valley: Do polished surfaces in Black Rock Forest hold the keys to past warm periods?*"

Bogan, Dan Siena College, **Kays, Roland** North Carolina State University, **Curtis, Paul** Cornell University; "*Eastern coyote diet use in the northern and southern Hudson Valley is mostly natural.*"

Buchanan, Brian Hudson River Estuary Program; *"Ghost dams: finding hidden barriers to fish passage in the Hudson River Estuary."*

Callahan, Hilary Barnard College, **Dolt, Caroline** Barnard College, **Meek, Jared** Columbia University; "*Teaching digital botany: making change, maintaining standards.*"

Gmelch, Nora Monroe Woodbury High School; "*Changes in average body mass of the Aleck Meadow painted turtle population in relation to pond pH and climate change at Black Rock Forest.*"

Hise, Jeremy Hise Scientific Instrumentation, **Griffin, Kevin** Lamont-Doherty Earth Observatory & Columbia University, **Schuster, William** Black Rock Forest; "*Wider access to exploring tree science though DIY electronics.*"

Kelly-Voicu, Petra Hunter College, **Frei, Allan** Hunter College; "*Hydrological and temperature variations between 1900 and 2016 in southern New York State.*"

Kou-Giesbrecht, Sian Columbia University, **Funk, Jennifer L.** Chapman University, **Perakis, Steven S.** USGS, **Wolf, Amelia A.** University of Texas Austin, **Menge, Duncan N. L.** Columbia University; "*Should nitrogen-fixing trees be planted during assisted forest restoration?*"

Maenza-Gmelch, Terryanne Barnard College, **Patterson, Angelica** Columbia University, **Wright, Melissa A.** Columbia University, **Gmelch, Peter L.** NYU, **Schuster, William** Black Rock Forest; "*An enhanced biodiversity blitz model for natural history education at Black Rock Forest, NY.*"

Nardi-Cyrus, Nate Hudson River Estuary Program & Cornell University; "*The Hudson Valley Natural Resource Mapper.*"

Singh-Smith, Kiran Barnard College, **Schuster, William** Black Rock Forest, **Bower, Peter** Barnard College; "*Post-Clean Air Act*

pH, alkalinity, and ecosystem recovery of 26 bodies of water in the Hudson Highlands."

Stuntz, Luke NYU, **Bernsley, Devon** Barnard College, **Hise, Jeremy** Hise Scientific Instrumentation, **Macey, Suzanne** American Museum of Natural History, **Porzecanski, Ana Luz** American Museum of Natural History, **Raxworthy, Chris** American Museum of Natural History, **Palmer, Matt** Columbia University; "*Radio tracking vs. GPS tracking: developing tools for investigating the spatial and thermal ecology of rare turtles at Black Rock Forest.*"

Vaughn, Ellery Barnard College, **Schuster, William** Black Rock Forest, **Macey, Suzanne** American Museum of Natural History; *Dietary analysis of the coyote (Canis latrans) population at Black Rock Forest.*"

Winters, Daniel SUNY Albany, **Bogan, Dan** Siena College, **Robinson, George** SUNY Albany; "*Preliminary results of fisher (Pekania pennanti) detection rates in the APBP landscape using occupancy modeling.*"

Xu, Meng Pace University; "*Using the maximum entropy theory of ecology to predict the most empirically plausible metabolic scaling exponent - a case study from the North Slope forest plot at Black Rock Forest.*"

ABSTRACTS (alphabetically ordered by presenting author last name)

Studying memory in food-caching birds, black-capped chickadees and tufted titmice

Applegate, Marissa C.; Mackevicius, Emily L.; Payne, Hannah L.; Scheck, David F.; Aronov, Dmitriy (Columbia University)

Throughout the day, the brain captures snapshots of distinct events and experiences, forming "episodic memories" that last a lifetime. The ability to store and recall these kinds of memories depends on a brain region called the hippocampus. We study the hippocampus in animals that are extremely specialized for using memory in the wild: food-caching birds from the *Paridae* family (chickadees and titmice). These birds are resident in the winter and cope with unstable food supplies by caching thousands of food items at scattered, hidden locations throughout their territory. They have a grossly enlarged hippocampus compared to other species and use memory to accurately find their caches up to a month later. I will describe fully automated behavioral arenas that we have developed to study food caching in a laboratory setting. I will also discuss our progress in using an array of modern neuroscience tools to study the hippocampus of these birds. The hope is that by studying food caching in chickadees and titmice, we will obtain general insights into how the brain stores and recalls memories in other animals, including humans.

Ecosystem services of trees in NYC: Sampling design implications for management

Auyeung, Novem (NYC Parks); Bowers, Justin (Natural Areas Conservancy); Forgione, Helen (Natural Areas Conservancy); Hallett, Richard A. (USDA Forest Service); Hoehn III, Robert E.

(USDA Forest Service); Johnson, Michelle J. (USDA Forest Service); Kim, Mina (Natural Areas Conservancy); Nowak, David J. (USDA Forest Service); Pregitzer, Clara (Natural Areas Conservancy); Falxa Sonti, Nancy (USDA Forest Service)

Since the 1990s, NYC Parks has worked with the US Forest Service on several ecosystem service studies to quantify the benefits of trees citywide. These studies played an important role in the creation of the successful MillionTreesNYC program, a goal to plant one million trees in New York City. Recently, a US Forest Service report, the *Urban Forests of New York City*, provides an updated assessment of forest structure and ecosystem services in New York City using the i-Tree model and data from two studies conducted around the same time (2013-2014): one used random plots stratified by borough across the city, another – conducted by the Natural Areas Conservancy -- used systematic random sampling within forested areas on city parkland. These studies tell two different stories about NYC's urban forest structure and value. Based on the citywide study, there are roughly 7 million trees citywide, and the overall density is 36 trees per acre. Within forested areas, there are roughly 3.3 million trees, and the density is 130 trees per acre, indicating these areas have disproportionately more trees and provide greater ecosystem service benefits relative to their geographic size. While the citywide study found that the most common species are exotic, within forested parkland, the most common species are native. These two studies provide a case study of how different sampling designs (*e.g*., sample size, areas sampled) influence our valuation and ecological understanding of the urban forest and how studies at different scales can be used in management.

Determining the diet of the coyote population at Black Rock Forest

Vaughn, Ellery (Barnard College); Schuster, William (Black Rock Forest)' *Bower, Peter (Barnard College); Macey, Suzanne (American Museum of Natural History; Barnard College)

Coyotes (*Canis latrans*) historically occupied the grasslands of central North America; however, in the early 1900s they began a rapid colonization of much of North America. This rapid expansion was, in part, facilitated by human extirpation of larger, apex predators and conversion of forests to agricultural landscapes; ecosystem modifications that enabled the coyote to become a top terrestrial predator in the northeastern U.S. Genetic, morphological, and ecological differences between western and northeastern coyotes suggest that northeastern coyotes hybridized with wolf populations prior to their colonization into the northeastern U.S. This hybridization introduced genetic variation into the expanding front of northeastern coyotes, potentially enabling them to occupy the niche previously filled by wolves and to become a more efficient deer predator. One way to study how these predators are potentially affecting prey populations is to study their diet. Determining the key prey species and the breadth of prey species consumed by a carnivore provides important insight into their role in an ecosystem. In this study, the diet of the coyotes in Black Rock Forest (Cornwall, New York) is analyzed to further our understanding of how this relatively recently established carnivore of the BRF ecosystem is interacting with its environment. Coyote scats were collected at Black Rock Forest opportunistically from December 2017 to July 2018. Diet items were identified using bone and hair analysis. I identified white-tailed deer (*Odocoileus virginianus*) remains in 68.1% of the 69 scat samples analyzed. There is a significant difference in the amount of deer remains observed in the scats between the three seasons, winter, spring and summer, with the highest proportion of deer remains observed in winter. Other species included were squirrel (*Sciurus caroliniensis*), muskrat (*Ondatra zibethicus*), groundhog (*Marmota monax*), raccoon (*Procyon lotor*), vole (*Microtus* spp.), skunk (*Mephitis mephitis*), rabbit (*Sylvilagus floridanus*), shrew (*Sorex cinereus*), beaver (*Castor canadensis*), opossum (*Didelphis virginiana*) and Eastern chipmunk (*Tamias striatus*). This study, the first formal analysis of the coyote's diet in Black Rock Forest, determined that white-tailed deer do

constitute a large portion of the Black Rock Forest coyote population's diet as seen by the high proportion of deer remains found in the coyote scat throughout the year. It is unknown to what extent this is the result of coyotes killing the deer themselves or scavenging deer remains. The conclusion that white-tailed deer, an ecologically and economically important species, constitutes a large part of this carnivore's diet, is important information for forest managers. Knowing that coyotes consume a lot of deer is important when determining annual hunting quotas, for both deer and coyotes, and also for more informed decision making as a result of overall better understanding of the system.

The response of the vertebrate scavenger guild to urbanization follows the intermediate disturbance hypothesis

Brewer, Alexis L. & Anadon, Jose D. (Queens College & CUNY)

Vertebrate scavenging is an important ecosystem process that increases nutrient cycling, decreases the spread of disease, and stabilizes ecosystems. The responses of vertebrate scavengers to urbanization also varies according to species and community level traits. Understanding these responses is pivotal as urbanization is projected to rise over the coming century. Therefore, we assessed the vertebrate scavenger community composition and functional efficacy along a 400-mile urbanization gradient. We conducted 196 successful camera trap trials in New York between 2016 and 2018. We baited each camera with a chicken over a one-week period and weighed the carcass at the beginning, middle, and end of the experiment. We used generalized linear mixed models to determine how (1) scavenger community composition, (2) scavenger efficiency, and (3) carcass persistence changed with urbanization level. The vertebrate scavenger community was more diverse at moderate urbanization levels. Larger species dominated natural habitats, while smaller animals occurred more frequently in urban settings. Scavenger efficiency and carcass persistence were stable across urbanization levels indicating carrion is a high value food source. These results also suggest top down mediation is a primary driver in natural areas. However, high urbanization levels appear to act as a filter for larger scavengers, which releases the smaller species from competitive effects and allows for them to dominate carcass removal. Therefore, we propose that the response of the vertebrate scavenger community to urbanization supports the intermediate disturbance hypothesis, insofar as moderate urbanization levels allow for a wider range of vertebrate scavengers to co-exist.

Site-specific growth response of two oak stands at Black Rock Forest: tree rings and dendrometers

Buckley, Brendan M. (Lamont-Doherty Earth Observatory); Griffin, Kevin (Lamont-Doherty Earth Observatory & Columbia University); Palmer, Matt (Columbia University); Hise, Jeremy (Hise Scientific Instrumentation)

We compare the growth characteristics of oak-dominated sites at Black Rock Forest in the Hudson Highlands of New York: one relatively xeric and one relatively mesic. Each of these sites is monitored daily (15 minute intervals) with point dendrometers on five oak trees at each site, soil moisture meters, photosynthetically active radiation sensors as well as temperature and precipitation. These sites are part of the Black Rock Forest long-term plot study, so stand level data has been collected on them regularly since ca. 1930. We obtained 5mm diameter core samples from each of the five instrumented trees at each site, as well as several additional trees in the vicinity of each stand, allowing a detailed comparison between the two sites. The tree ring width measurements reveal that the more mesic site exhibits higher growth rates than the more xeric site, as would be expected. In addition, the moisture

sensitivity of the xeric site is enhanced relative to the more mesic site, but the overall climate response of both sites reflect the broader-scale impact of regional climate. In general, oak annual ring width growth from BRF is directly correlated with the spring hydroclimate, which is in turn linked to sea surface temperature of the near-shore Atlantic Ocean. Understanding the sensitivity of tree growth rates to past climate will help us to interpret both the 85-year record of forest change and the short-term (i.e., 3-year) but high frequency record of growth recorded by the dendrometers. The dendrometer network is expanding to additional sites and species and represents an opportunity to study forest change at a very fine temporal resolution.

Structure and function of the insect respiratory system

Davis, Steven; Herhold, Hollister; Grimaldi, David (American Museum of Natural History)

With nearly one million described species, insects represent the largest arthropod lineage that are not only remarkable in their species diversity but also in their rich assortment of physical features, behaviors, and natural histories. Current research is aimed at exploring and describing various components of this extraordinary morphological diversity. For example, the respiratory (tracheal) system of insects is a highly branching cuticular network of tubes that delivers oxygen to tissues and facilitates removal of respiratory products. Primitively, the tracheal system is simple and tubular, but becomes vastly more complex, forming arrays of air sacs and chambers in more derived and metabolically active insect groups. While tracheal systems have been characterized for select insect groups, detailed examinations using modern imaging techniques are lacking, as are broadly comparative surveys. This study utilizes micro-CT imaging to characterize and compare the tracheal network across the insect orders and to infer trends in tracheal system architecture and function.

Sustainability, health, social and resilience benefits of forests and green space – Who is using the science?

Gruber, Simon (Fellow, Institute for Sustainable Cities at Hunter College, CUNY, and Project Director, Growing Green Cities, a sponsored project of the Open Space Institute)

New York State's sustainability goals and specific targets use the reduction of greenhouse gas (GHG) emissions as the central, quantifiable metric for measuring progress. For his participation in the development of the Mid-Hudson Regional Sustainability Plan completed in March 2013 with funding from the NY State Energy Research and Development Authority, Gruber sought to demonstrate more significant GHG reductions from trees and other green stormwater infrastructure, as compared to the types and magnitude of energy and GHG benefits that have commonly been ascribed to these stormwater practices in recent education and training work in the region. He posed two sets of questions: a) What does the literature tell us about these benefits and how they have been described in existing research, and in educational guidance resources for local government and other decision-makers? b) Who is using this information in policies, programs, education and training, design of the built environment, and other sectors in NY State? Starting in 2013, the same questions have been studied for a wide range of other benefits identified in scientific research relating to physical, mental, and emotional health, social connectivity and cohesion, child development and education, and many other priorities. The findings to date show that in many respects, with some exceptions, many, if not most, relevant programs, policies and initiatives by government and other organizations are not using much of this information. In a recent, deeper focus on the children's education and development

sectors, however, it is clear there is a lot of awareness and application of relevant research and ideas in many private organizations in this region and elsewhere.

Local conservation planning in the Hudson Highlands: Update on Hudson River Estuary program projects and grants

Heady, Laura, Conservation and Land Use Program Coordinator, (Hudson River Estuary Program/Cornell University)

To address community goals related to clean water, wildlife habitat, climate resiliency, and recreational opportunities, municipalities in New York can use their home rule authority to implement conservation plans and policies. However, municipal decision-makers often lack technical expertise or access to scientific data. For two decades, the Hudson River Estuary Program and Cornell University have partnered to improve our understanding of conservation priorities in the estuary watershed and share those priorities with land-use planners. In 2006, our *Hudson River Estuary Wildlife and Habitat Conservation Framework* identified and described 22 significant biodiversity areas in the estuary watershed. The Hudson Highlands were included, recognized as a large corridor of undeveloped forests, wetlands, and grasslands with high concentrations of biodiversity. We've also collaborated with the New York Natural Heritage Program (NYNHP) to adapt the state's biodiversity databases into the *Important Areas* data set, which models conservation zones for rare animals, rare plants, and ecological communities, thus providing a more useful planning tool for community use. Currently, we're funding a watershed-wide analysis by NYNHP to better identify local and regional forest priorities.

To ensure these data and priorities are integrated into all scales of land-use and conservation planning, the Estuary Program provides training, technical assistance, and funding. In the Hudson Highlands, past projects have included volunteer habitat mapping in the towns of Philipstown, Putnam Valley, Somers, and Yorktown and in western Rockland County, and a biodiversity report for the *Moodna Creek Watershed Conservation and Management Plan* (2010). Following publication of our guidebook, *Creating a Natural Resources Inventory: A Guide for Communities in the Hudson River Estuary Watershed* (2014), recent projects have included a joint open space inventory in the Town of Blooming Grove and Town and Village of Cornwall, and natural resources inventories in the City of Beacon and Town of Putnam Valley. Local-scale conservation and planning initiatives require dedicated volunteers and strong, enduring partnerships, but they provide opportunity to find new collaborative approaches to address regional priorities and emerging issues, incorporate new data and scientific understanding, and utilize funding opportunities to advance conservation in the Hudson Highlands.

Phragmites australis habitat functions for other biota are similar on three continents

Kiviat, Erik (Hudsonia)

Common reed (*Phragmites australis*) is one of the most widely distributed, most abundant, and best-studied vascular plants worldwide but there has been no broad comparative analysis of reed-associated biota on different continents. A survey of observational data on (mostly terrestrial) organisms using *P. australis* reedbeds revealed ecological similarities among North America, Europe, and sub-Saharan Africa. I present examples for a selected group of 29 habitat functions (i.e., features of the reed plant or reedbed used in particular ways by certain groups of organisms). Habitat functions include animals

eating particular portions of reed, birds roosting in reedbeds, animals using reed for nest material, bryophytes growing beneath the reed canopy, and vines using reeds for support. These similarities in habitat functions in biogeographically distinct world regions suggest a fundamental character of reed ecological relationships related to the large size, extensive stands, high productivity, deep litter layers, and other traits of reed. The data also underline the biodiversity support functions of reed and their similarity among continents. Managers can consider reed functions and user guilds to design management approaches and predict outcomes of conservation, management, or other environmental changes affecting reedbeds, whether native or introduced, over-abundant or under-abundant.

Survey of deciduous tree and shrub biomass construction costs at Black Rock Forest demonstrates connection between ecological role and plant physiology

Ladyzhets, Betsy (Biology, Barnard College); Kevin Griffin (Earth & Environmental Sciences, Columbia University)

In the past century, normal patterns of ecological succession in northeastern U.S. forests have been complicated by rising temperatures, native forest recovery, and continued human disturbance. Under these conditions, secondary growth species may be pushed out more easily by invasive species that take command of disturbed areas. A plant's ability to take over new environments is tied to its growth rate, which in turn is tied to the efficiency at which the plant can mobilize its energy resources. Thus, one method of quantifying patterns of ecological disturbance is through the biomass construction cost (CC) metric, which measures the amount of stored glucose required to construct one unit of leaf material in deciduous species. CC has been used to compare native and invasive plants on a specific, individual comparison basis. This survey expands upon such application of CC by utilizing the metric in a survey of 33 deciduous tree and shrub species at Black Rock Forest, an ecology research site in the Hudson Highlands of upstate New York. We chose representative species of native, expanding invasive, and widespread invasive ecological positions at the Forest for sampling, and calculated CC of each species. Resulting CC values demonstrate that the energy investments of native-class deciduous tree species are significantly higher than the energy investments of widespread invasive-class tree species. Sub-surveys of shrub species and of red maple *(Acer rubrum)* in different forest habitats add additional context to these results. These results support our hypothesis that a plant's ecological position is connected to its energy use; further research may investigate the chemical mechanisms for such connections and variation within individuals of the same species.

The Hudson Highlands Wildlife Connectivity Project: carnivore surveys within and near Black Rock Forest

LaPoint, Scott (Black Rock Forest, Lamont-Doherty Earth Observatory, Max Planck Institute of Animal Behavior); Schuster, William (Black Rock Forest)

All things must move. Facilitating the successful movements of our native biota therefore is a worthy conservation goal. Black Rock Forest, a non-profit, science, education, and conservation organization has long worked to ensure the functional connectivity of the Hudson Highlands landscape. One possible validation of these efforts is the partial, natural re-colonization of fishers (*Pekania pennanti*) into Black Rock Forest, a species absent from the Forest for ca. 150 years. Fishers are medium-sized, forest-dependent native carnivores whose range was drastically reduced via intensive timber and fur harvesting. We developed the Hudson Highlands Wildlife Connectivity Project to (1) document the distribution of fishers in the area, (2) record high spatial- and temporal-resolution movements of

fishers via GPS tracking, and (3) use these datasets to estimate functional connectivity to provide data-driven strategies for facilitating connectivity and mitigating movement barriers. We completed our first winter field season, tallying 3641 days of camera trapping across 60 sites within Black Rock Forest (n = 30) and in nearby public, conservation, and private lands (n = 30), yielding 243617 images of 6089 passes of mammals. Our efforts documented the expected suite of native carnivores, yet with a noticeable absence of Mustelid species (i.e., weasels). Spatial patterns are also present, with bobcats (*Lynx rufus*) detected regularly inside Black Rock Forest, but rare elsewhere, and both fishers and grey fox (*Urocyon cinereoargenteus*) being absent in Black Rock Forest, but detected elsewhere. Further, the spatial distribution of fishers and bobcats appears largely affected by Interstates 84 and 87; both species' distributions suggest that the highways are major barriers to their movements. Entering our second field season this fall, we will begin live-trapping efforts to fit fishers with GPS tracking collars to better understand their habitat preferences and movement behaviors, with particular emphasis on the permeability of I-87.

Nitrogen fixation strategies in *Robinia pseudoacacia*

Menge, Duncan N. L. (Columbia University), Bytnerowicz, T. (Columbia University); Kou-Giesbrecht, Sian (Columbia University); Akana, Palani R. (Columbia University); Griffin, Kevin (Lamont-Doherty Earth Observatory & Columbia University); Wolf, Amelia A. (University of Texas Austin)

Theory shows that the degree to which nitrogen-fixing symbioses adjust their rate of nitrogen fixation has important implications for plant communities, water quality, and global climate change. However, these "nitrogen fixation strategies" are challenging to study, so little is known about them. Over the past few years we have studied the details of nitrogen fixation strategies in the symbiosis between *Robinia pseudoacacia* (black locust) and it's symbiotic *Rhizobia* bacteria using a combination of field experiments at Black Rock Forest, greenhouse experiments, and controlled environment chambers. Each of these individual studies shows striking results, yet some conflict with each other, yielding a nuanced overall picture about nitrogen fixation strategies in *Robinia pseudoacacia*.

Highlands West: A land conservation initiative in the Black Rock Forest region

Nolan, Terrence & Nieves, Wil (Open Space Institute)

For 3 decades, the Open Space Institute ("OSI") has led an effort to protect land in the region around Black Rock Forest. Now, OSI is spearheading an initiative to connect Black Rock Forest to 6 state parks and enhance public access while managing for habitat protection. The speakers will present a new plan to improve public access and habitat connectivity in the broader region around the Forest.

Long-term vegetational history from Black Rock Forest to Mohonk -How does the paleoecology compare?

Peteet, Dorothy M. (NASA/GISS & Lamont Doherty Earth Observatory (LDEO); Maenza-Gmelch Terryanne; (Barnard College) Menking, Kirsten; (Vassar College); Margraf, Sage (LDEO)

Long-term pollen and macrofossil records from Sutherland Pond, Sutherland Fen, and Tamarack Pond in Black Rock Forest document the shifts in vegetation from tundra to oak-dominated forest today. The

earliest deglaciation is from Tamarack Pond at 16,900 calendar years ago and records a Dryas zone which lasts for about a thousand years before boreal forest is present. A comparison of these records with analysis of sediment cores from Mohonk Lake, Minnewaska Lake, and Rhododendron Swamp show differences in the two regional forests indicating that higher *Betula* (birch) and *Tsuga* (hemlock) with lower percentages of *Quercus* (oak) reflect the higher latitude and slightly colder/wetter conditions to the north. Dramatic indications of drought in records from both sites about 5,000 years ago show declines in hemlock concurrent with *Castanea* (chestnut) increases. Human impact 400-100 years ago in both forests indicates declines in *Pinus* (pine), oak, and hemlock with the rise in weedy species, but the Rhododendron Swamp pollen record shows the recovery in these trees in the twentieth century.

Forests in the city: understanding urban-driven changes in forest recruitment dynamics

Piana, Max (Rutgers University); Aronson, Myla F. J. (Rutgers University); Hallett, Richard A. (USDA Forest Service); Morin, Peter J. (Rutgers University)' Pickett, Steward T. A. (Cary Institute of Ecosystem Studies); Handel, Steven N. (Rutgers University)

Understanding the functional differences between urban and rural habitats is a critical focus for urban ecology and the sustainable management of urban natural areas. Early recruitment processes are critical to determining future forest structure and composition. Some studies have observed suppressed recruitment of native plant species in urban forests, but the ecological barriers to regeneration are not well understood. Here we present the results from a three-year experimental field study that examines seed production, seed dispersal, seed predation, and early establishment in urban and rural oak-hickory forests in and around New York City. Using a series of nested experiments in six urban and rural forest sites, this research asks: (1) What is the difference in the composition and abundance of woody plant species in the seed rain, seed bank, and vegetation, including seedling, sapling and canopy layers? (2) What is the difference in seed removal rates for native and non-native species? (3) What is the difference in the contribution of seed production, seed dispersal, post-dispersal, and early-establishment recruitment limitation in urban and rural forests? Answers to these questions were framed using a combination of seed traps, caged and uncaged seed addition plots, natural regeneration plots, and a cafeteria experiment.

This experiment identifies multiple life-history stages that contribute to increased recruitment limitation for native plants in urban forests. In both urban and rural sites, significant differences were observed in the composition of the seed rain, seed banks, and vegetation strata. However, greater dissimilarity and abundance of non-native species were observed in urban forests. Seed predation rates fluctuated among years in rural sites, while in urban forests seed removal was sustained, and relatively high, across all three years. Additionally, native species experienced greater seed removal than non-native species in both forest types. These findings suggest that urban forests deviate from temporal patterns of seed predation of rural forests dominated by masting tree species, a significant urban-driven shift in a basic community ecology dynamic. Finally, the seed addition experiment determined that urban forests were significantly more recruitment limited than rural forests. Urban forests are characterized by greater seed and site limitation. Collectively, these findings provide evidence of urban-driven changes in forest ecological processes. By determining processes that may limit regeneration in cities, we may begin to develop restoration and management strategies better able to sustain our urban forests, so important to urban well-being.

The UnWired Forest: a Black Rock Forest mesh wifi network, resilient data collection store and forward nodes

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The Black Rock Forest Wifi Mesh Network is a National Science Foundation-funded project and collaboration between BRF, RiskEcon® Lab at the Courant Institute of Mathematical Sciences New York University, and SayCel Technologies. The purpose of the network is to bring communications and connectivity for the deployment of environmental sensors for forest research. In addition to the wifi infrastructure, the system will deploy "Store and Forward Nodes". These will act as local data loggers that will be resilient to network disconnections and have an API that will allow scientists to query and efficiently gather data remotely. The store and forward wifi nodes are being developed by SayCel, based on research & development conducted and funded by RiskEcon® Lab (https://wp.nyu.edu/riskeconlab/) at the Courant Institute of Mathematical Sciences of New York University. The network is currently in construction with a target date of 2020 for use by Consortium members. Edwin Reed-Sanchez is the project liaison for the network and is looking for input from scientists who are interested in using the network for their research. You can contact him at edwin@saycel.com.

Leveraging environmental gradients at Black Rock Forest to understand the responses of tree growth and nonstructural carbohydrate storage to projected changes in climate

Reinmann, Andrew B. (CUNY); Deas, Ayo Andra J. (CUNY); Klein, Alison (Hunter College); Kim, Taewoo (Hunter College); Ahmed, Tasneem (Brooklyn College)

Forest ecosystems provide a suite of services including maintaining air and water quality and mitigating climate change by removing carbon dioxide from the atmosphere and storing the carbon as biomass. However, projected changes in climate across the northeastern U.S. may exacerbate seasonal water stress and drought conditions, which can adversely impact tree growth and forest ecosystem productivity. Understanding how the region's forests might respond to these changes in climate is complicated by ongoing shifts in tree species composition characterized by a decline in more drought-tolerant oak (*Quercus spp.*) trees and an increase in less drought tolerant red maple (*Acer rubrum*) trees. We are leveraging environmental gradients at Black Rock Forest to advance understanding of how canopy red maple trees and black oak (*Q. velutina*) trees respond to variations in water availability. During the summer of 2018, we established three pilot plots spanning mesic valleys and dry hillslopes. In each plot, we collected tree cores and root samples from red maple trees (n=3) and black oak trees (n=3) to quantify how these gradients in water availability might impact tree growth and storage of nonstructural carbohydrates (i.e. energy reserves) across these two species. Preliminary results indicate that interannual variations in tree growth are higher in red maple trees than black oak trees, but this variability increases by ~50% between our wettest and driest sites for both species. Further, we are finding that, at least for red maple trees, nonstructural carbohydrate storage tends to decrease from the wettest to driest sites. During the 2019 field season, we will be expanding the study

from three plots to 15 plots that span a wide gradient in water availability at Black Rock Forest. To the extent that the environmental gradient used here provides a useful analog for understanding forest response to water stress, our early results suggest that these changes in climate coupled with an increase in the relative abundance of red maple trees could reduce the productivity of our forests and their resiliency to additional environmental stressors (e.g., defoliation events).

Wildlife mortality and camera data help prioritize road mitigation opportunities in a statewide initiative to connect habitat across New Jersey

Savant, Neha (The Nature Conservancy); Fowles, Gretchen (NJ Division of Fish and Wildlife); Hall, Mackenzie (NJ Division of Fish and Wildlife); Olsen, Eric (The Nature Conservancy); Shanahan, Mike (The Nature Conservancy); Sherwood, Scott (The Nature Conservancy); Zarate, Brian (NJ Division of Fish and Wildlife)

New Jersey supports a diverse array of wildlife and serves as an important connection between the Hudson Highlands and the Central Appalachian Valley. However, roads present a frequent barrier to wildlife movement and habitat connectivity across the state, particularly due to its location between two major U.S. cities. In 2016, the New Jersey Department of Environmental Protection (NJDEP) created a collaborative state-wide initiative, "Connecting Habitat Across New Jersey" (CHANJ) that provides tools and guidance for landowners and planners to improve habitat connectivity for wildlife. One of these tools is a model that outlines the state's remaining core & corridor habitats as well as road segments that bisect these habitats. To understand where we should prioritize road mitigation efforts and to confirm if these predicted road segments are truly where wildlife are crossing, The Nature Conservancy partnered with the NJDEP to collect data on wildlife crossings using roadkill surveys and wildlife camera traps in Bobcat Alley, a priority conservation area in northwest New Jersey. During the first year of this collaboration, 312 live and dead animals were observed in Bobcat Alley, 47% of which were found on mapped road segments. Between June 2018 and March 2019, wildlife cameras placed near bridges and culverts captured 845 observations of 21 species. The roadkill data is now being used to identify hotspots of wildlife mortality, while the camera data is being used to understand how various terrestrial wildlife are using existing below-road structures in Bobcat Alley. In combination with the tools from the CHANJ initiative, these findings provide essential information for landowners, transportation planners and other interested stakeholders to identify where opportunities for road mitigation exist and which techniques may be best suited to allow habitat connectivity across New Jersey and surrounding areas.

Vertical gradients in light environment alter carbon balance in White Spruce (*Picea glauca*) at its southernmost and northernmost range extremes

Schmiege, Stephanie (Columbia University & New York Botanical Garden); Griffin, Kevin (Lamont-Doherty Earth Observatory & Columbia University); Boelman, Natalie (Lamont-Doherty Earth Observatory & Columbia University); Vierling, Lee A. (University of Idaho)' Eitel, Jan (University of Idaho)

White Spruce (*Picea glauca*), one of the dominant species of the boreal forest, has a species range which extends from the forest tundra ecotone (FTE) at 68° latitude to mixed deciduous forests at 41° latitude. These latitudinal differences lead to large gradients in light availability and climate conditions that may impact the allocation of the photosynthetic machinery and other resources throughout the tree canopy. In most forested ecosystems, the photosynthetic apparatus is distributed along a vertical canopy gradient corresponding to light availability. However, at the FTE, mature trees do not create a dense forest canopy, but remain widely spaced with sparse individual canopies, likely limiting branch self-shading and altering traditional gradients in canopy physiology and carbon balance. To examine this further we compared a suite of physiological variables measured on high and low canopy needles of mature White Spruce trees at two contrasting sites: the FTE of northern Alaska and Black Rock Forest (BRF) in New York. Using a linear mixed effect model to account for random effects of individual trees, we found expected significant ($P<0.05$) light-driven canopy-level differences in physiology at BRF. In contrast, at the FTE, we found no significant differences in photosynthetic characteristics. Furthermore, the maximum carboxylation rate of Rubisco (Vc_{max}) and maximum electron transport rate (J_{max}) decreased unexpectedly in the high canopy positions at the FTE. We suspect that a less steep light gradient throughout the FTE White Spruce canopies may explain the convergence between canopy positions in much of our data at the FTE, and that canopy-driven temperature differences may explain the decreases in Vc_{max} and J_{max}. The differences in canopy physiology within this boreal forest species at the northern and southern range extents urge caution when examining carbon dynamics in species spanning vastly different latitudinal locations.

Recent trends in carbon sequestration in Black Rock Forest

Schuster, William (Black Rock Forest); Palmer, Grace (Barnard College); Odell, Clara (Barnard College)

In a 2008 paper in Tree Physiology, Schuster et al. documented trends in composition, structure, live aboveground biomass (AGB) and estimated total ecosystem carbon sequestration over a 76 year period from 1930 to 2006. Using data from a set of long term plots and allometic equations relating tree size to AGB that were selected to be appropriate for Black Rock Forest, they reported mean live AGB density increasing from 74 metric tons per hectare per year in 1936 to 215 metric tons per hectare by the year 2000. However mortality exceeded growth in several subsequent years resulting in a loss of about 10% of live AGB. Total ecosystem carbon density was estimated at 177 metric tons C per hectare in 2006. Because of the importance of carbon sequestration in atmospheric CO_2 concentration and related climate change, and because this and other forests in the northeastern US had recently reported plateaus or decreases in carbon storage, we decided to update these estimates, and improve them where possible, for 2019. The study is still in process but clearly the biomass growth and carbon storage capacity have rebounded since 2005. Total ecosystem carbon storage is now estimated at 215 metric tons per hectare and has been increasing at a rate of 1.6 metric tons per hectare in recent years, comparable to storage rates in favorable periods of the 20th century. Investigations are now underway to produce more refined estimates of soil carbon density, and more accurate allometric equations for red oak, the most dominant species in the forest, and black birch, the fastest increasing component of the forest understory.

Growth and physiology of White Oak and Red Maple trees in urban vs. rural forest patches

Sonti, Nancy Falxa (USDA Forest Service); Hallett, Richard (USDA Forest Service); Griffin, Kevin (Lamont-Doherty Earth Observatory & Columbia University); Sullivan, Joe (University of Maryland)

The provisioning of critical ecosystem services to cities of the eastern United States depends on the health and physiological function of trees in urban woodlands and forest patches. Many aspects of the urban environment have the potential to affect tree growth and physiology in forest patches, including higher temperatures, elevated CO_2 concentrations, and modified soil biogeochemistry from increased nutrient and heavy metal inputs. Changes in tree growth and physiology are likely to vary by species and across urban areas, reflecting the local environmental conditions associated with the idiosyncratic trajectory of development in a city. In this study, we examined growth rates and leaf-level physiology of two dominant native tree species (white oak (*Quercus alba* L.) and red maple (*Acer rubrum* L.)) across urban and reference forest sites of three major cities in the eastern United States (New York, NY; Philadelphia, PA; and Baltimore, MD). Throughout the growing season, the urban sites had consistently warmer daytime and nighttime temperatures than reference sites. Urban forest patch soils also had elevated calcium, magnesium, and heavy metal concentrations compared to reference forest soils. Urban vs. reference tree growth rates varied by species, by city, and over time. Despite differences in the two native species' ecophysiology, both grew more rapidly in the urban environment than at nearby reference sites, particularly in recent decades. Over the entire 145-year tree ring record analyzed, white oak basal area increment was significantly higher in urban trees compared to reference trees. In addition, white oaks show more variation in chlorophyll fluorescence parameters and leaf traits by city and site type (urban vs. reference) than red maples. Across all sites, red maple trees in this study had higher thermal tolerance of photosynthesis (Tcrit) than white oaks, suggesting a greater ability to withstand temperature stress from the urban heat island effect and climate change. However, the highest average values of Tcrit were found in the Baltimore urban white oaks, suggesting that species suitability and response to the urban environment varies across a latitudinal gradient. Urban red maple foliage was higher in calcium and magnesium than reference foliage, and red maple stomatal pore index (SPI) was higher in urban trees, while white oak SPI was significantly lower in urban trees. Overall, the results do not indicate that urban forest patches provide a more difficult growing environment than nearby reference forests. Perhaps due to their ability to persist in a wide variety of environmental conditions, mature trees of both species appear to be acclimating to urban forest patch conditions of the eastern U.S. and in some cases are experiencing enhanced growth rates compared to trees in nearby reference forests. An understanding of past and present growth rates of trees in urban forest patches can provide insight into future ecosystem functioning of these urban green spaces as well as that of more rural ecosystems experiencing environmental change factors similar to those associated with urbanization.

Evaluating legacy impacts of hyper-abundant white-tailed deer in forested stands of Harriman and Bear Mountain State Parks

Kilheffer, Chelby R. (SUNY ESF); *Underwood, H. Brian (USGS Wildlife Research Center); Leopold, Donald J. (SUNY ESF); Guerrieri, Rachel (SUNY ESF)

As an alternative to a long-term exclosure study, we designed a case-control study to describe the relationship between indicators of forest recovery and regulated white - tailed deer harvest. We inferred recovery by comparing characteristics on five adjacent sites in the Lower Hudson Valley with similar ecological communities and land uses, but different deer population management histories. We accounted for differences in forest recovery not attributable to deer by first matching case and control plots along several important ecological gradients (i.e., slope, aspect, elevation, moisture, canopy

openness). We sought associations between measured forest condition and deer herbivory reduction through population management. We surveyed over 200 plots in upland forest types across case and control sites by estimating density (no./unit area), composition and cover (%) of important vegetation constituents in ground, shrub, subcanopy and canopy layers of the forest. We recorded 37 tree species, 22 shrub species, 57 herbaceous species, and 19 species of grasses and sedges in our plot surveys, including a number of non-native and invasive plants. Impacts of over 100 years of chronic deer browsing manifest in low herbaceous ground cover and little to no tree recruitment (i.e., saplings) on lands without deer management. In contrast, sustained deer management resulted in forests with conditions indicating substantial recovery from chronic herbivory in the ground, shrub and subcanopy layers. Sites with ongoing deer management exhibited greater species diversity and ground cover of tree seedlings and herbs, and less ground cover of interfering vegetation and non-native species. The well-developed subcanopy layer of small trees, saplings, and tall shrubs on sites with deer management indicates a high potential for sapling recruitment to the canopy of the future forest. To successfully promote a more desirable forest condition that includes fewer non-native plant species, more tree recruitment into the forest canopy, and a diverse and abundant herbaceous understory, future management should include herbivory reduction and management of interfering vegetation where necessary.

POSTERS

Dynamics of the Laurentide Ice Sheet in lower Hudson Valley: Do polished surfaces in Black Rock Forest hold the keys to past warm periods?

Balter, Allie; Schaefer, Joerg; Young, Nicolás (Lamont-Doherty Earth Observatory); Schuster, William (Black Rock Forest)

The Laurentide Ice Sheet (LIS) was the Earth's dominant continental ice sheet during the Last Glacial Maximum (LGM) ~21,000 years ago and the waxing and waning of the LIS has been the most impactful element of our planet's glacial-interglacial cycles. In fact, the freshwater forcing of the North Atlantic by the melting LIS communicates the dramatic climate change during glacial-interglacial transitions (referred to as 'Terminations') to the southern hemisphere, acting as a globalizer. Thus, understanding of the LIS dynamics is critical to our understanding of extreme global climate changes.

Glacial moraines, glacially polished surfaces and other glacial features in the lower Hudson Valley region of New York provide evidence of the maximum extent and subsequent retreat of the LIS. Preliminary ^{10}Be surface exposure dates from boulders on the LIS terminal moraines that form Long Island and from moraines in Harriman State Park indicate that substantial LIS retreat over this area began around 20,000 years ago.

However, pilot data from a glacially polished surface in Black Rock Forest indicate an overall exposure period of this site of almost 100,000 years! This implies that this surface contains cosmogenic nuclides from many ice-free periods, most likely during previous interglacials, which somehow got preserved by resisting sub-glacial erosion during subsequent ice ages when the LIS covered this site for tens of thousands of years. The goal of our 'BRF-Drilling Project' is to open this cosmogenic archive of ice-free periods by applying modern isotope techniques to bedrock cores taken from these surfaces. We expect to uncover basic information about the LIS response to past warm-periods, delivering important information of ice-sheet dynamics in a warming world.

Eastern Coyote diet use in the northern and southern Hudson Valley is mostly natural

Bogan, Dan (Siena College); Kays, Roland (North Carolina State University); Curtis, Paul (Cornell University)

Anthropogenic change has altered the ecology of the Northeastern US. Historically, the Northeast held greater carnivore diversity with extant populations of wolves, mountain lions, lynx, bobcats, and fisher. While some species remain extirpated, others maintain reduced species ranges. Coyotes expanded their range and now occupy this ecological void as a *de facto* top-predator. To investigate the ecology of coyotes in eastern NY, we conducted diet studies in three areas within the Hudson Valley region (Albany area, 2001–2004, scats: n = 483; Westchester county, 2006–2008, scats: n = 442, and Albany & Rensselaer County 2017-2018, scats: n = 451). For each study, we collected carnivore scat once per month along standardized trail systems. In each study area, either white-tailed deer or cottontail were the most frequently detected mammalian diet item found in carnivore scats. Approximately 42 categories of omnivorous diet items composed the remaining scats. Interestingly, while 3 of the 4 study areas ranged from suburban to urban, few anthropogenic materials were detected in carnivore scats. Examining carnivore scat provides insight into coyote community ecology, yet our results should be interpreted with caution. Specifically, it is difficult to assess biomass of prey from scat, and unreliable for estimating numbers of prey consumed. However, the general diet patterns are important to understand how coyotes are using the available resources in the Northeast.

Ghost dams: finding hidden barriers to fish passage in the Hudson River Estuary

Buchanan, Brian (Hudson River Estuary Program)

As the old conservation adage goes: "you can't manage what you don't know." In the case of dams and dam removal, we know quite a lot. We know, for example, that dams alter natural flow, sediment and nutrient regimes, and fragment sensitive aquatic ecosystems - contributing to the decline of many imperiled aquatic species. Dams also represent substantial financial liabilities and public safety hazards. Surprisingly, in the case of many dams, what we don't know is simply where they are. Indeed, a recent study found that the National Inventory of Dams underestimated the true number of dams across New England by 3.5 times simply because many smaller dams were never cataloged. This suggests that, although there are roughly 1,500 known dams in the Hudson River Estuary Watershed, there are likely many thousands more uninventoried "ghost dams" lurking in the woods waiting to block the passage of unsuspecting aquatic organisms.

Using a combination of differential evolution optimization and machine learning, this study aims to identify these hidden dams from publicly available datasets, such as LiDAR, land use and the National Hydrography Dataset. Preliminary results and challenges will be presented, along with a discussion of future directions.

Teaching digital botany: making change, maintaining standards

Callahan, Hilary (Barnard College); Dolt, Caroline (Barnard College); Meek, Jared (Columbia University)

Barnard College recently introduced a requirement for all undergraduates: a course that teaches "digital and technological thinking." Now, my students and I are learning in new ways about botany, community ecology, evolution, biogeography and biodiversity conservation. Using GitHub Classroom, R-Studio and several R OpenSci packages, my upper-level course includes a series of digital labs, portfolio assignments, and individualized projects. All involve asking questions about biodiversity and answering them with data from the Global Biodiversity Information Facility (GBIF), the Botanical Information and Ecological Network (BIEN), the International Union for the Conservation of Nature (IUCN), the Biodiversity Heritage Library (BHL) or digital herbaria at the New York Botanical Gardens and the Mid-Atlantic Herbaria Consortium and I-DigBio. Concepts in nomenclature and taxonomy or in precision and accuracy, topics students have often found to be archaic or obtuse, are now problems that are both meaningful and solvable via specific protocols. We continue to engage with physical vouchers, living greenhouse collections and nearby nature. Also, I have added non-traditional and critical reading assignments to deepen and broaden perspectives on who has contributed, is contributing, and can contribute to and benefit from the investigation, use and management of botanical biodiversity. The poster presents outcomes of pre-test and post-tests and examples of student projects.

Changes in average body mass of the Aleck Meadow Painted Turtle population in relation to pond pH and climate change at Black Rock Forest, Cornwall, NY 1998-2018

Gmelch, Nora (Monroe Woodbury High School, Central Valley, New York)

Climate change is a real science issue and is supported solidly by scientific evidence. Consequences of climate change so far include higher annual air temperatures, rising sea levels, and influences on plant and animal populations. Acid precipitation is another environmental concern. Turtles could be affected by both climate change and pond acidification. The objectives of this study were to examine how Painted Turtles in Aleck Meadow Pond at Black Rock Forest, in Orange County, NY have responded to these issues. Average body mass is used as a proxy for population health. Databases of Painted Turtle masses, air temperature and pH were analyzed for trends. Analyses have revealed that average body masses have increased while average annual temperature increased and pond pH has recovered over the last approximately 20 years at Aleck Meadow Pond. Previous research by others shows that the other ponds that are more acidic do not have as healthy turtle populations. Since climate affects all ponds equally, it seems logical to conclude that recovery from acidification is the more important factor impacting turtle health at Black Rock Forest.

Wider access to exploring tree science through DIY electronics

Hise, Jeremy Hise (Scientific Instrumentation); Griffin, Kevin (Lamont-Doherty Earth Observatory & Columbia University); Schuster, William (Black Rock Forest)

We designed and constructed electronic wireless point-dendrometers to record micrometer-level changes in tree stem size at various locations in the Hudson Valley, NY. In addition to using the device for scientific research, the dendrometers provided a multifaceted platform for STEM programming for middle-school-aged children.

Using inexpensive, easily accessible components, we constructed 21 devices comprised of the Arduino MCU, a 16bit ADC, XBee Wi-Fi radio module, a linear potentiometer and mounting bracket. The 21 units were installed on various red and sugar maples, birch, oak and a London planetree. Installations

were conducted in forested and urban settings in the summers of 2017, 2018 and 2019. We also developed a hands-on workshop that allowed kids to fully engage the scientific method. In this summer camp program, kids learned about tree growth, developed hypotheses, built tools to record the required measurements, reviewed the results and discussed their conclusions.

We found that for considerably less cost than commercial offerings researchers and educators can benefit from a DIY wireless point-dendrometer. Using this sensor, we were able to explore changes in tree-stem size, which yielded interesting signals related to phenology and environmental factors. In education, middle-school-aged children demonstrated they were quite capable of assembling and deploying the device and understanding the results.

As pricing for high-quality electronics components continue to fall, researchers and educators should reevaluate what is technologically and economically feasible. Combining dendrometer data with other data sets, such as tree ring, environmental and meteorological, researchers can explore important questions related to tree physiology and broader associated themes. As an educational platform, programming can provide younger students with a robust foundation in science and educators an opportunity to develop interdisciplinary curriculum.

Hydrological and temperature variations between 1900 and 2016 in southern New York State

Kelly-Voicu, Petra (Hunter College); Frei, Allan (Hunter College)

In this study, we identify a set of stations in southern New York State, near the Catskill Mountains, that are appropriate for climatological analysis, and examine variations in precipitation, streamflow, and temperature, between 1900 and 2016. We find that the most significant hydroclimatic events on record include the cold drought of the 1960s which was a year-round phenomenon, and the wet period between the late 1990s and 2012 which was primarily a warm season phenomenon. We also find increasing temperatures since the mid-20th century, in particular daily minimum temperatures, which vary with season and elevation. As a result, diurnal temperature ranges have tended to decrease in this region, particularly during the warm season and at lower elevations. Cyclic behavior is found more in hydrologic than in temperature variables, and more during the cold season where periodicity peaking at 28 years is identified. These results are consistent with previous studies based on station-records as well as paleoclimate studies, and in the context of millennial scale variations suggest that some aspects of these recent fluctuations may be unusual in the climatological history of this region

Should nitrogen-fixing trees be planted during assisted forest restoration?

Kou-Giesbrecht, Sian (Columbia University); Funk, Jennifer L. (Chapman University); Perakis, Steven S. (USGS); Wolf, Amelia A. (University of Texas); Menge, Duncan N. L. (Columbia University)

Forests are a significant CO_2 sink, sequestering a quarter of anthropogenic CO_2 emissions. However, the negative radiative forcing of forest CO_2 sequestration is offset by the positive radiative forcing of soil emissions of nitrous oxide (N_2O), a potent greenhouse gas. Forest restoration has predominantly focused on maximizing CO_2 sequestration, without considering soil N_2O emissions. As such, nitrogen-fixing trees have been recommended for planting during forest restoration: they are proposed to relieve nitrogen limitation of neighboring plant growth by enriching soil nitrogen. However, by enriching soil nitrogen, they can stimulate significant soil N_2O emissions. We show preliminary results that a nitrogen-fixing tree species promotes net CO_2 sequestration relative to a non-fixing tree species under

low nitrogen supply but net soil N_2O emissions under high nitrogen supply. These results are replicated with a modeling approach suggesting that they are generalizable. Using the model, we projected CO_2 sequestration and soil N_2O emissions stimulated by nitrogen-fixing trees over time, and estimate the time intervals over which planting nitrogen-fixing trees is effective for climate change mitigation. Due to projected intensifying nitrogen deposition these results suggest that planting nitrogen-fixing trees will be less effective than planting non-fixing trees in assisted forest restoration for climate change mitigation.

An enhanced biodiversity blitz model for natural history education at Black Rock Forest, NY

Maenza-Gmelch, Terryanne (Barnard College); Patterson, Angelica (Columbia University); Wright, Melissa A. (Columbia University); Gmelch, Peter L. (NYU); Schuster, William (Black Rock Forest)
A week-long biodiversity blitz for middle school students has been offered at Black Rock Forest for ten years in the format of an academic summer science class. Students begin each day with guided readings and discussion related to the daily topics which include biodiversity, classification of life, ecosystem services, plant and bird identification, and field survey methods. Midday includes hikes and data collection followed by games, art, cooking, data analysis and presentations. Black Rock Forest is a nearly 4000 acre private field station and conservation area (Audubon IBA) in Orange County, NY that features oak-dominated deciduous forest, hemlock ravines, pitch pine and scrub oak ridgetops, early successional fields and numerous ponds and streams. This array of topo- and chronosequences contributes to high habitat diversity. For the last five years (2014-2018) we used pre- and post-course surveys to assess the effectiveness of this experience on student learning (n = 47), including a question that asked students to describe or draw a forest before and after the experience. Students had ten minutes to complete each response. Surveys were rated by two different instructors to ensure reliability. A simple holistic rubric was used to obtain average scores for the surveys. A t-test yields a p value of <0.001 showing that student learning gains were highly significant and the Cohen's d statistic (1.303) indicates a very large effect size. This information is useful as evidence of a meaningful student experience and as a guide for successful natural history curriculum development.

The Hudson Valley Natural Resource Mapper

Nardi-Cyrus, Nate (Hudson River Estuary Program & Cornell University)

The Natural Resource Mapper is a new online, interactive tool to assist local land-use decision makers in New York's Hudson Valley with identifying and understanding important habitat and water resources, the connections between them, and their broader regional context. It compiles geographic data for the 10-county Hudson River estuary watershed organized by themes including the estuary, streams and watersheds, wetlands, forests, biodiversity, and scenic and recreation resources. Estuarine resources shown include bathymetry, submerged aquatic vegetation, tidal wetlands, significant coastal fish and wildlife habitats, and migratory fish runs. Users can zoom into an area of interest and turn on individual layers to create custom, printable maps, as well as click on features to access data attributes and links to more information. The tool is intended for general information and planning purposes, and complements technical assistance available to municipalities and watershed groups from Hudson River Estuary Program staff. The Natural Resource Mapper can inform: public education and outreach, preliminary environmental review, identification of conservation priorities, natural resource inventories, comprehensive planning and zoning updates, watershed assessment and planning, and

open space planning and land acquisition. This poster will provide an overview of the mapper's contents, functions, and applications, and a tablet will be available on hand for a live demo.

Post-Clean Air Act pH, alkalinity, and ecosystem recovery of 26 bodies of water in the Hudson Highlands"

Singh-Smith, Kiran (Barnard College); Schuster, William (Black Rock Forest); Bower, Peter (Barnard College)

In 1985, 25 bodies of water in Black Rock Forest (BRF) and the surrounding NY Hudson Highlands were measured as having low alkalinity and pH values as a result of acid rain formed by anthropogenic emissions of sulfate (SO_4^{2-}) and nitrogen oxides (NO_x). Since then, the 1990 Clean Air Act amendment has led to significant decreases in SO_4^{2-} and NO_x emissions in this region, corresponding to an increase in the average annual precipitation pH from 4.2 in 1985 to 5.1 in 2017. These 25 ponds - plus one extra for a total of 26 - were revisited, at which time water samples were collected; pH, alkalinity, and ion concentrations were measured; and historical water chemistry and fish population data were compiled. On the basis of pH, 13 ponds had statistically significantly higher pH values, and a greater proportion were classified as satisfactory for aquatic life in 2018 than in 1985. On the basis of alkalinity, 16 ponds had statistically significantly higher alkalinity levels, and a greater proportion were classified as less vulnerable to acid deposition in 2018 than in 1985. Though 15 lakes had statistically significantly lower SO_4^{2-} concentrations in 2018, comparisons for other ions were limited due to a lack of historical data. Pond pH was found to increase with decreasing elevation, and all six BRF ponds had higher pH levels and ion concentrations than the local precipitation. Finally, most of the ponds in BRF, except for Arthur's Pond, have gained more acid-sensitive species since 1987, with 2018 fish species abundance in both BRF and Harriman State Park appearing to positively correlate with pH. These findings suggest that most of the lakes have experienced increases in pH and alkalinity since 1985, but also that the rate and extent of chemical and biological recovery depend on other variables such as the underlying geology and surrounding environment.

Radio tracking vs. GPS tracking: developing tools for investigating the spatial and thermal ecology of rare turtles at Black Rock Forest

Stuntz, Luke (NYU); Bernsley, Devon (Barnard College); Hise, Jeremy (Hise Scientific Instrumentation); Macey, Suzanne (American Museum of Natural History); Porzecanski, Ana Luz (American Museum of Natural History); Raxworthy, Chris (American Museum of Natural History); Palmer, Matt (Columbia University)

Spotted turtles (*Clemmys guttata*), wood turtles (*Glyptemys insculpta*), and eastern box turtles (*Terrapene carolina carolina*) are all recognized as New York State species of special concern and have all previously been identified within Black Rock Forest. This ongoing research is attempting to address a gap in the knowledge regarding the general ecology of these understudied populations. Through a series of intensive surveys for these species, we are attempting to build an understanding of the demographics, ranges, and sizes of these elusive populations. Identified turtles will be equipped with VHF transmitters and will be tracked on a frequent basis to understand their movements and home ranges. Additionally, microhabitat indicators including vegetation, temperature, and humidity will be monitored to identify the factors important in the habitat selection process of semi-aquatic turtles. In addition to VHF transmitters, we are in the process of developing low-cost GPS tracker backpacks to be affixed to the carapace of turtles – hopefully providing spatial data with a higher

temporal resolution at a lower level of active researcher involvement. Overall, this project will work to gain an experimental understanding of the logistical, financial, and technological constraints of multiple methods of wildlife tracking that we hope will inform the decision making processes in future research at Black Rock Forest.

Dietary analysis of the coyote (*Canis latrans*) population at Black Rock Forest

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Coyotes (*Canis latrans*) historically occupied the grasslands of central North America; however, in the early 1900s they began a rapid colonization of much of North America. This rapid expansion was, in part, facilitated by human extirpation of larger, apex predators and conversion of forests to agricultural landscapes; ecosystem modifications that enabled the coyote to become a top terrestrial predator in the northeastern U.S. Genetic, morphological, and ecological differences between western and northeastern coyotes suggest that northeastern coyotes hybridized with wolf populations prior to their colonization into the northeastern U.S. This hybridization introduced genetic variation into the expanding front of northeastern coyotes, potentially enabling them to occupy the niche previously filled by wolves and to become a more efficient deer predator. One way to study how these predators are potentially affecting prey populations is to study their diet. Determining the key prey species and the breadth of prey species consumed by a carnivore provides important insight into their role in an ecosystem. In this study, the diet of the coyotes in Black Rock Forest (Cornwall, New York) is analyzed to further our understanding of how this relatively recently established carnivore of the BRF ecosystem is interacting with its environment. Coyote scats were collected at Black Rock Forest opportunistically from December 2017 to July 2018. Diet items were identified using bone and hair analysis. I identified white-tailed deer (*Odocoileus virginianus*) remains in 68.1% of the 69 scat samples analyzed. There is a significant difference in the amount of deer remains observed in the scats between the three seasons, winter, spring and summer, with the highest proportion of deer remains observed in winter. Other species included were squirrel (*Sciurus caroliniensis*), muskrat (*Ondatra zibethicus*), groundhog (*Marmota monax*), raccoon (*Procyon lotor*), vole (*Microtus* spp.), skunk (*Mephitis mephitis*), rabbit (*Sylvilagus floridanus*), shrew (*Sorex cinereus*), beaver (*Castor canadensis*), opossum (*Didelphis virginiana*) and Eastern chipmunk (*Tamias striatus*). This study, the first formal analysis of the coyote's diet in Black Rock Forest, determined that white-tailed deer do constitute a large portion of the Black Rock Forest coyote population's diet as seen by the high proportion of deer remains found in the coyote scat throughout the year. It is unknown to what extent this is the result of coyotes killing the deer themselves or scavenging deer remains. The conclusion that white-tailed deer, an ecologically and economically important species, constitutes a large part of this carnivore's diet, is important information for forest managers. Knowing that coyotes consume a lot of deer is important when determining annual hunting quotas, for both deer and coyotes, and also for more informed decision making as a result of overall better understanding of the system.

Preliminary results of fisher (*Pekania pennanti*) detection rates in the APBP landscape using occupancy modeling

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Fishers (*Pekania pennanti*) have gradually expanded their range across New York State as they recover from historical persecution through over-trapping and habitat loss. This medium sized carnivore, suited

to manage populations of small vertebrates in ecological communities, is now emerging in suburban habitats around the capital region of New York State. This includes the managed Albany Pine Bush Nature Preserve (APBP). However, these fragmented landscapes are still readily disturbed by human activities. We are using single-season occupancy modeling to understand where fishers are persisting in this human-impacted landscape. We recently deployed 23 motion-sensing trail cameras in the capital region of NY (May 5th, 2019 to June 16th, 2019) to detect fishers in various habitat types throughout a 60 km^2 study area. We placed cameras following a systematic sampling grid using 2.25 km^2 grid-cells (1.5 x 1.5 km). Fishers were detected in 10 out of the 23 sites, resulting in a naive occupancy rate of 43% of sites occupied. The average detection probability was 0.0319 analyzed based on modeling detection histories from the survey. These preliminary results suggest that fishers are selecting and occupying habitat in this suburban, impacted landscape, and that they are readily being detected in various habitat types. We will continue our study by investigating habitat covariates on site occupancy and imperfect detection rates to understand how fisher are utilizing the suburban landscape of the capital region and managed habitats within the APBP to help inform conservation and management decisions.

Using the maximum entropy theory of ecology to predict the most empirically plausible metabolic scaling exponent - a case study from the North Slope forest plot at Black Rock Forest

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The maximum entropy theory of ecology (METE) applies the concept of "entropy" from information theory to ecology based on constraints of macroecological metrics. METE can generate various analytic predictions about the distribution and dependence of metabolic energy, abundance, and species richness within an ecological community or population. The energetic predictions of METE are based on hypothetical metabolic scaling with predetermined scaling exponent. In this work we treat the metabolic scaling exponent within METE as a free parameter, allowing the size distribution predictions of METE to be comparable with other models using likelihood functions. We test the method using the tree diameter data from the North Slope of the Black Rock Forest. Our preliminary results show that the metabolic scaling as estimated by the parameterized METE deviates from that of the metabolic theory of ecology, at both community and population levels. This ongoing study gives a first example of using the constraint-based method, as exemplified by METE, to reveal the biological process of individual organisms. We suggest that parameterized constraint-based models should be further studied and evaluated against other theories.