Thirteenth Biennial Research Symposium
June 26, 2023

BLACK ROCK FOREST

Black Rock Forest Consortium was formed in 1989 to promote scientific research, education, and conservation in the 3,920-acre Black Rock Forest in southeastern New York State. Since 1999, Black Rock Forest has hosted a biennial Research Symposium 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 in the Hudson Highlands region.

Full Talks (in order presented)

Brady, John (Black Rock Forest) and **Dana Linck** (Great Chain Archaeological Consulting): "*A brief introduction to forest history and land use and up to date archaeology work.*"

Bruner, Sarah (Columbia University), **Naeem, Shahid** (Columbia University), **Eitel, Jan U. H**. (University of Idaho), **Griffin, Kevin** (Columbia University), **Menge, Duncan N. L**. (Columbia University), **Rao, Mukund P**. (Columbia University), **Terlizzi, Katie** (Black Rock Forest), and **William Schuster** (Black Rock Forest): "*Stand diversity mediates rate of biomass recovery after loss of the dominant tree genus in a temperate forest.*"

Terlizzi, Katie (Black Rock Forest), **Heslop, Calvin** (Harvard University), **Taylor, Benton** (Harvard University), **Schuster, William** (Black Rock Forest) and **Matthew Palmer** (Columbia University): "*The effect of canopy disturbance and deer herbivory on understory cover and diversity.*"

Baker, Patrick (West Point Military Academy), **Williams, Paris** (West Point Military Academy), **Hughes, Rachel** (Oregon State University), **Wolff, Patrick** (Army Corps of Engineers) and **Aaron Rice** (Cornell University): *"Calling phenology of amphibian assemblages in the Hudson Highlands."*

Silverman, Kimberely (Lisman Laboratories, Riverdale Country School), **Gerber, Max** (Lisman Laboratories, Riverdale Country School), **Levey*, Daniel** (Lisman Laboratories, Riverdale Country School), **Gentille, Daniel** (Lisman Laboratories, Riverdale Country School and Berkely Carrol School) and **Rachel Cox** (Lisman Laboratories, Riverdale Country School): "*Epigenetic response to drought stress in red oaks of Black Rock Forest.*"

Peregrin, John (Columbia University), Palmer, Matt (Columbia University) and Kevin Griffin (Columbia University): "*Physiological responses of eastern hemlock to imidacloprid and dinotefuran basal bark spray in southern New York.*"

Nagy, Chris (Mianus River Gorge Preserve), **Bottini, Mike** (Seatuck Environmental Association), **Santos, Arielle** (Seatuck Environmental Association) and **Carol Henger** (Cold Spring Harbor Lab): "*Distribution and relatedness of coyotes in NYC and Long Island, 2011-2022.*"

Davidson, Kenneth (Brookhaven National Lab and Stony Brook University), **Lamour, Julien** (Brookhaven National Lab), **McPherran, Anna T.**, (Stony Brook University), **Anderson, Jeremiah** (Brookhaven National Lab), **Rogers, Alistair** (Brookhaven National Lab), and **Shawn P. Serbin** (Brookhaven National Lab and Stony Brook University): "*Moving from leaf to canopy: An analysis of mechanisms regulating seasonal dynamics of stand scale water use efficiency in eastern deciduous forests.*"

Schuster, William (Black Rock Forest), **Terlizzi, Katie** (Black Rock Forest), **Ashton, Isabel** (Black Rock Forest) and **Kevin Griffin** (Columbia University): "*Insights from a 90+ year record of forest growth, carbon sequestration, and change from Black Rock Forest, an aggrading deciduous forest in southeastern New York State.*"

Bowers, Justin (City University of New York, Earth and Environmental Science Graduate Center), **Reinmann, Andrew** (Advanced Science Research Center), **Piana, Max** (US Forest Service) and **Richard Hallett** (US Forest Service): "*Assessing impacts of beech leaf disease on forest structure and composition: towards informing management along a gradient of anthropogenic influence.*"

LaPoint, Scott (Black Rock Forest and Lamont-Doherty Earth Observatory of Columbia University), **Burgstahler, Katherine** (Pamona College), **Fyfe, Andy** (NYS Office of Parks, Recreation& Historic Preservation), **Moser, Kathy** (Open Space Institute), **Novak, Elizabeth** (NYS Thruway Authority), **Stuntz, Luke** (Black Rock Forest), **Terlizzi, Katie** (Black Rock Forest), and **William Schuster** (Black Rock Forest): "*EcoBridge update: assessing highway impacts on wildlife distributions, behaviors, gene flow, and mortality.*"

Warner, Kyla (Advanced Science Research Center and Barnard College), **Sonti, Nancy** (US Forest Service), **Cook, Elizabeth** (Barnard College), **Hallet, Richard** (US Forest Service) and **Andrew Reinmann*** (City University of New York, Advanced Science Research Center): "*Urbanization exacerbates climate sensitivity of eastern U.S. broadleaf trees.*"

Boston, Brian (City University of New York) and **Andrew Reinmann** (Advanced Science Research Center): "*Integrating dendrochronology with remote sensing to support monitoring and managing hemlock decline.*"

Posters

Durone, Sophia (Barnard College), **Bower, Peter** (Barnard College) and **William Schuster** (Black Rock Forest): *"Above ground biomass of Sugar Maple (*Acer saccharum*): Comparison of actual measured vs allometric equation, Black rock Forest, Cornwall, NY."*

Garcia, Becca (Barnard College), **Macey, Suzanne** (American Museum of Natural History), **Fredericks, Andrew** (Hamilton College) and **Matthew Palmer** (Columbia University): *"Assessing box turtle home ranges to determine optimal thermal sensor placement."*

Hale, Stephanie (Columbia University)**, Chettih, Selmaan** (Columbia University) and **Dmitriy Aronov** (Columbia University): *"Chickadee nest box study in two forests in New York state."*

Opel, Sydney (State University of New York, College of Environmental Science and Forestry), **Gurarie, Eliezer** (State University of New York, College of Environmental Science and Forestry) and **Scott LaPoint** (Black Rock Forest): *"How does urban development affect niche partitioning of mesopredators*?"

Abstracts (listed in alphabetical order by first author, * indicates co-presenters and non-first author presenters)

Calling phenology of amphibian assemblages in the Hudson Highlands

Baker, Patrick (West Point Military Academy), Williams, Paris (West Point Military Academy), Hughes, Rachel (Oregon State University), Wolff, Patrick (Army Corps of Engineers) and Aaron Rice (Cornell University)

Passive acoustic monitoring (PAM) of advertisement calls allows for non-invasive assessment of species diversity and reproductive activity of amphibian communities. The PAM approach is useful when surveying assemblages of amphibians in training areas on military lands that would be otherwise difficult to access for traditional surveys. We deployed PAM recorders at three locations on the United States Military Academy Reservation from 2020 to 2023 to determine species composition, phenology of breeding based on calling activity, and to relate the timing of activity to environmental conditions. Although our locations are separated by less than 15 km they span > 350 m of elevation from Constitution Island (sea level) to Bear Swamp, near the summit of Bull Hill. The date of first chorus varied by year and location; however, the onset of calling activity typically began in March (Julian Day 62-84) with Spring Peepers (*Pseudacris crucifer*) and Wood Frogs (*Lithobates sylvaticus)* followed by American Toads (*Anaxyrus americanus*) and Pickerel Frogs (*Lithobates palustris*). Choruses of Grey Tree Frogs (*Dryophytes versicolor*), Green Frogs (*Lithobates clamitans*), and Bullfrogs (*Lithobates catesbeianus*) began in early to late May (Julian Day 124-139). Fowler's Toads (*Anaxyrus fowleri*) were only found at one location (Morgan Farm) and were the last species to initiate chorus activity (Julian Day 180). The Date of First Call for Spring Peepers and Wood Frogs was correlated with Growing Degree Days (Base temperature 3C).

Integrating dendrochronology with remote sensing to support monitoring and managing hemlock decline

Boston, Brian (City University of New York) and Andrew Reinmann (Advanced Science Research Center)

Eastern Hemlock (*Tsuga canadensis)* is a coniferous tree species native to Eastern North American forests. The deep shade it casts and its capacity to produce self-perpetuating conifer stands in landscapes otherwise dominated by deciduous trees creates unique microenvironment conditions that make it an important foundation species. Eastern hemlock has been experiencing decline across a growing portion of its range because of the Hemlock Woolly Adelgid (*Adelges tsugae*) (HWA), an invasive sap-sucking insect native to Japan that was first detected in the U.S. in 1951. HWA is a key management and conservation concern of researchers and practitioners. Progress is being made in testing biological controls of HWA, but there is dire need for practitioner-friendly tools to assist with (1) locating appropriate stands for deployment and (2) assessing control efficacy. Remote sensing products provide opportunities to assist practitioners and complement limiting and resource-intensive field surveys. However, the specialized training needed for existing remote sensing models developed by researchers coupled with the often high-cost of data products has precluded implementation by practitioners. Since 2021, we have been working to develop a cost-effective, user-friendly remote sensing model using high spatial

resolution and freely-available orthoimagery with the goal of aiding practitioners in early detection and tracking of hemlock decline. Critical to the development of this model is connecting remote sensing model output with tree-scale physiological processes. HWA has been at Black Rock Forest (BRF) for several decades, causing a range of decline in hemlocks and providing the ideal location to test a key question: *To what extent do temporal patterns of decline detected with our remote sensing model match temporal patterns of tree decline?* We will use dendrochronology analyses of hemlock trees in varying states of decline across BRF to quantify correlation or hysteresis in the timing of declines in tree growth and canopy health as determined from remote sensing analyses. This work will produce three important data products: (1) a ground-validated remote sensing model for detecting hemlock decline, (2) maps of spatiotemporal patterns in hemlock decline across Black Rock Forest, and (3) datasets for assessing some of the roles site conditions play in mediating rates of hemlock decline following infestation. Additionally, this work will provide the foundation to assess hemlock recovery should HWA control measures be implemented.

Assessing impacts of beech leaf disease on forest structure and composition: towards informing management along a gradient of anthropogenic influence

Bowers, Justin (City University of New York, Earth and Environmental Science Graduate Center), Reinmann, Andrew (Advanced Science Research Center), Piana, Max (US Forest Service) and Richard Hallett (US Forest Service)

Beech Leaf Disease (BLD) is an emerging threat to Northeastern Forests. First identified in Ohio in 2012, the disease is caused by the foliar nematode *Litylenchus crenatae.* The disease progresses quickly from discoloration and curling of leaves, to the death of subsequent buds, branch dieback, and the death of the tree. There is currently no treatment for thes disease and can be fatal to beech within 5-7 years. BLD has spread quickly and is now present throughout the northeastern US. As northeastern forests contain many beech, which are late successional and among the most shade tolerant native tree species, their sudden loss will create a large number of disturbance gaps with very little existing vegetation in the understory. This in turn will create a large area of native forest that is exposed to invasion by invasive species.

For our study, we are establishing 40+ BLD monitoring plots following a protocol set up by the US Forest Service. The plots will be established in parks following an urban to rural gradient, from New York City at the southern end and stretching up to the Catskills. We will study the trajectory of succession along this gradient to examine the impacts of differing levels of existing invasive pressure, herbivory, and climate on the composition of newly formed forest gaps. Initial establishment of plots will take place during the summer of 2023, with data collection to proceed through 2025.

A brief introduction to forest history and land use and up to date archaeology work

Brady, John (Black Rock Forest) and Dana Linck (Great Chain Archaeological Consulting)

Black Rock Forest (BRF) has a long narrative history, dating back to 1927 when its founder Dr. Ernest Stillman (1884-1949) hired the first forest director, Henry Tryon and Forest Managers

James and Arthur Babcock. For twenty years the team-Stillman, Tryon, Babcock and the woods crew would strive to elevate BRF to a reputable demonstration and research forest. Tryon's data on early forest science and management is compartmentalized, well organized and readily accessible in forest archives. Additionally, evidence is found throughout the forest of human use and occupation dating from prehistoric times through the late colonial era and well into the nineteenth century. This land use history of road building, upland farming, charcoal making, wood cutting and subsequent brush fires is relevant to current forest management and of potential importance to various research projects. Archeologist Dana Linck is assisting BRF with a preliminary archeological investigation of the 40-50 known historic and prehistoric sites in the forest boundaries. This early phase of research relies heavily upon prior historic research and field investigations of Forest Historian John Brady. Limited archeological testing at two sites and assessment of found artifacts from many others in BRF, is beginning to reveal the character of life in the upland Highlands and the contributions of inhabitants to regional industry and national independence. Continuing research of known occupants is expected to reveal significantly more data about the locals and permit even more detailed interpretation of the artifacts and sites from which they came. This, in turn, will reveal forest and general land use practices of mountain society before the Stillman era land purchases between 1890-1920. The character of BRF today is inextricably linked with its (obscure) past. Defining that past through archeology and historic research helps provide a solid base for understanding its present condition as well as its potential future.

Stand diversity mediates rate of biomass recovery after loss of the dominant tree genus in a temperate forest

Bruner, Sarah (Columbia University), Naeem, Shahid (Columbia University), Eitel, Jan U. H. (University of Idaho), Griffin, Kevin (Columbia University), Menge, Duncan N. L. (Columbia University), Rao, Mukund P. (Columbia University), Terlizzi, Katie (Black Rock Forest), and William Schuster (Black Rock Forest)

Temperate forests are often dominated by a single or several congeneric species which strongly influence ecosystem functioning. Loss of such species, here termed "dominant species," is therefore likely to have complex, potentially dramatic impacts on forests, but the duration and magnitude of these impacts likely depends on how remaining non-dominant, or subordinate, species influence recovery over the long term. The role subordinate species play in recovery from dominant species loss, however, remains poorly understood. Using experimental manipulation of oak trees (*Quercus spp.*) – a dominant group of tree species throughout many temperate eastern North American forests – we tested how aboveground biomass, species richness, and species identity of the non-dominant species influence the rate of biomass accumulation after experimentally manipulating oak abundance. We established three treatments by girdling which kills a tree by severing the cambium and sapwood, but leaves it standing, similar to the effect of pathogens, such as oak wilt, on trees. Treatments were: (1) 100%, (2) 50%, and (3) 0% of oaks girdled, each replicated three times. Trees were girdled in 2008 and censused yearly 2007-2020, using allometric models for aboveground tree biomass to calculate plot, tree, and species-specific relative growth. Plots with more trees girdled gained more biomass and this relationship was exponential: the plot which lost 94% of it living biomass

regained over 250% of its lost mass. This relationship suggests that the remaining non-girdled species are experiencing competitive release and compensating for the loss in biomass of the dominant oak species with increased growth. Maples (*Acer spp*.) in particular showed increased growth with oak girdling. After removing the effect of plot biomass, relative growth rate of the tree communities was slightly positively associated with plot species richness (slope = 0.04). Our results suggest the diversity and abundance of subordinate species mediates recovery of biomass after the loss of a dominant species.

Moving from leaf to canopy: An analysis of mechanisms regulating seasonal dynamics of stand scale water use efficiency in eastern deciduous forests

Davidson, Kenneth (Brookhaven National Lab and Stony Brook University), Lamour, Julien (Brookhaven National Lab), McPherran, Anna T., (Stony Brook University), Anderson, Jeremiah (Brookhaven National Lab), Rogers, Alistair (Brookhaven National Lab), and Shawn P. Serbin (Brookhaven National Lab and Stony Brook University)

Understanding the physiological and structural mechanisms which regulate canopy gas exchange is an essential aspect of forest conservation science, as canopy gas exchange plays an important role in ecosystem hydrology, carbon flux, and energy balance. Seasonal variation in stomatal response to photosynthesis leads to a range of leaf level water use efficiency (WUE), and seasonality in canopy structure and albedo leads to dynamic within-canopy meteorology and latent heat flux. Despite the fact that variation in WUE and canopy structure directly impact local carbon and water cycles, lack of knowledge regarding dynamics in these parameters remains one of the largest uncertainties in current model predictions of the functioning of North American forests, with almost no studies addressing a mechanistic link between seasonality and dynamics of WUE. During the 2021 growing season, we investigated seasonal patterns in leaf-level physiological, hydraulic, and anatomical properties, including the seasonal progress of the stomatal slope parameter (g1; inversely proportional to WUE) and the maximum carboxylation rate (V_{cmax}). V_{cmax} and g1 were seasonally variable, however their patterns were not temporally synchronized. g1 generally showed an increasing trend until late in the season, while V_{cmax} peaked during the mid-summer months. Seasonal progression of V_{cmax} was primarily driven by changes in leaf structural, and anatomical characteristics, while seasonal changes in g1 were most strongly related to changes in V_{cmax} and leaf hydraulics. Using a seasonally variable V_{cmax} and g1 to parameterize a canopy scale gas exchange model increased seasonally aggregated A and E by 3% and 16% respectively. In fall 2022, we installed a network of sap flux sensors and began autonomously collecting sap velocity data. The aim of this data collection is to enable monitoring of seasonality in transpiration, which will help in our evaluation of the core mechanistic drivers of seasonal variation in WUE. I will present information on the development and design of these sensors, as well as some preliminary data from the first six months of the sensor's deployment.

Above ground biomass of Sugar Maple (*Acer saccharum*): Comparison of actual measured vs allometric equation, Black rock Forest, Cornwall, NY

Durone, Sophia (Barnard College), Schuster, William (Black Rock Forest) and Peter Bower (Barnard College)

Sugar maple (*Acer saccharum*) is the fourth-most abundant tree species in the eastern U.S. However, as climate change dries out its habitats, the species' population will decline in locations like Black Rock Forest (BRF). Estimating carbon content of a forest plot using allometric (biomass at varying diameters) equations is increasingly important as trees are relied on as carbon sinks to combat carbon sources. Black Rock Forest uses a generalized allometric equation for NY sugar maple plots (Tritton, 1982). Working to develop a site-specific equation and testing the existing one are vital steps for understanding carbon storage reliance and thus forest management strategies. Estimating carbon content of a forest plot using allometric (biomass at varying diameters) equations is increasingly important as trees are relied on as carbon sinks to combat carbon sources. Black Rock Forest uses a generalized allometric equation for NY sugar maple plots (Tritton, 1982). Working to develop a site-specific equation and testing the existing one are vital steps for understanding carbon storage reliance and thus forest management strategies.

Assessing box turtle home ranges to determine optimal thermal sensor placement

Garcia, Becca (Barnard College), Macey, Suzanne (American Museum of Natural History), Fredericks, Andrew (Hamilton College) and Matthew Palmer (Columbia University)

As the world's human population continues to grow, and land gets developed, habitat fragmentation is increasing. For eastern box turtles *(Latin name*)*,* this can have an impact on the success of their habitat and the success of their populations (e.g., mortality, reproduction, homeostasis). Understanding turtle habitat needs and their natural history will help conservationists make management decisions. The goal of this project is to analyze the points at which the Box Turtles in Black Rock Forest are found, and as a result, determine where to place Hobo Tidbit arrays in order to collect temperature data to assess microhabitat selection. From 2019 - 2021 eastern box turtles were located, affixed with a VHF transmitters and iButton thermal sensors. Turtles were then relocated periodically throughout the field season and locations were analyzed using QGIS. Individual turtles varied in their thermal patterns during the sampling period, however, we found little variation in temperature between Hobo Tidbi T arrays despite sensors being placed in different microhabitats. More data needs to be collected to better understand the correlation between turtle behavior and their habitat.

Chickadee nest box study in two forests in New York state

Hale, Stephanie (Columbia University), Chettih, Selmaan (Columbia University) and Dmitriy Aronov (Columbia University)

Black-capped chickadees are specialist food-caching birds that hide up to thousands of food items throughout the forest. They use memory to retrieve these caches later in time. This remarkable ability makes chickadees an excellent model to study memory. In the past several years, we have engineered setups that allow birds to cache and retrieve food in laboratory conditions, as we perform detailed automated tracking and recording of their behaviors. However, chickadees are wild animals, which creates logistical problems for studying them. It also makes it difficult to study the development of the caching behavior in young birds. To address these issues, we have set up a network of nest boxes at two field sites in New York State: Black Rock Forest and Brookhaven National Laboratory on Long Island. The two field sites were established in 2020 and 2022, respectively and have ~50 nest boxes each. We have experimented with different box designs and microhabitats at both sites. These boxes have provided us with the opportunity to observe and quantify nesting behaviors across different locations, as well as to collect small numbers of nestlings for hand rearing. Our hope is that hand rearing will produce adult birds that are less stressed by humans, possibly willing to breed in captivity, and will also allow us to study the ontogeny of the food caching behavior.

EcoBridge update: assessing highway impacts on wildlife distributions, behaviors, gene flow, and mortality

LaPoint, Scott (Black Rock Forest and Lamont-Doherty Earth Observatory of Columbia University), Burgstahler, Katherine (Pamona College), Fyfe, Andy (NYS Office of Parks, Recreation& Historic Preservation), Moser, Kathy (Open Space Institute), Novak, Elizabeth (NYS Thruway Authority), Stuntz, Luke (Black Rock Forest), Terlizzi, Katie (Black Rock Forest), and William Schuster (Black Rock Forest)

Facilitating successful movements is fundamental to sustaining wildlife populations. Roads impede successful movements via barrier effects and as direct mortality sources. Quantifying such impacts is challenging but desirable for mitigation efforts and justifying associated costs. We have initiated a before-after-control-impact study design to quantify the impacts of a 4-lane highway in southern New York on local wildlife distributions, movement behaviors, gene flow, and mortality. Four years of camera trap surveys across our study area suggest distribution impacts from the highway, with some species detected only on one side of the highway (e.g., fisher *Pekania pennanti* and porcupine *Erethrizon dorsatum*). GPS-collar tracking of bobcats (*Lynx rufus*) reveals modified behaviors adjacent to major roads as well as preferred locations for road and highway crossing, both under and over. Observed highway crossing behaviors spurred monitoring efforts of eight culverts beneath the highway via a 4-camera trap per culvert design, suggesting species-level patterns in willingness to approach the highway, frequency of 'turn back' behavior, and likelihood of successfully crossing, including associations with culvert attributes and human use frequency. Deer-vehicle collision reports suggest >2.7 deer-vehicle collisions per mile annually (since 1998), however internal records from the NYS Thruway suggest the number of white-tailed deer (*Odocoileus virginianus*) carcasses removed is 30% greater (i.e., 3.5 deer per mile during 2021). We have initiated our own semi-weekly road mortality survey to bolster these data finding an estimated 39.1 roadkills per mile annually. Fecal DNA sampling of four carnivore species (i.e., black bear *Ursus americanus*, coyote *Canis latrans*, red fox *Vulpes vulpes*, and bobcat) is underway to quantify landscape-level gene flow. Plans for systematic surveys for small mammals, bats, and terrestrial herpetofauna are being developed for initiation in summer of 2023. Our goal is to robustly quantify and justify the need for improved connectivity across this major highway, ultimately guiding the design and implementation of rigorous mitigation plans to restore functional connectivity to this biologically rich but fragmented landscape.

Distribution and relatedness of coyotes in NYC and Long Island, 2011-2022

Nagy, Chris (Mianus River Gorge Preserve), Bottini, Mike (Seatuck Environmental Association), Santos, Arielle (Seatuck Environmental Association) and Carol Henger (Cold Spring Harbor Lab)

The Gotham Coyote Project (GCP) was formed over a decade ago as a collaboration of researchers and officials interested in studying the expanding coyote population in New York City (NYC). Since 2011, we have tracked the distribution, breeding status, diet, and relatedness of coyotes across 4 boroughs of NYC. As coyotes have now started colonizing Nassau and Suffolk County, we have also joined the Long Island Coyote Study Group, which seeks to address similar questions across the whole of Long Island. Here, we present the timeline of coyote expansion through NYC and Long Island, some observations and predictions on habitat use and site quality, and results from a population genetics study completed in 2020.

How does urban development affect niche partitioning of mesopredators?

Opel, Sydney (State University of New York, College of Environmental Science and Forestry), Gurarie, Eliezer (State University of New York, College of Environmental Science and Forestry) and Scott LaPoint (Black Rock Forest)

Due to the extirpation of many apex predators in New York (e.g., *Puma concolor*, *Canis lupus*), mesopredators have become top predators in many areas. These include: bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and red foxes (*Vulpes vulpes*). Our goal is to understand how these species partition resources in rural areas compared to suburban and urban areas. We predict that each species will respond to urbanization differently depending on a variety of factors including sensitivity to human presence, competition with other mesopredators, and prey density. We will compare three areas where mesopredators have been and continue to be studied spanning the rural to urban gradient: Black Rock Forest (rural), Teatown (suburban) and NYC (urban). We will use camera trap data collected in all three locations to assess and compare spatial and temporal patterns of use. Lastly, we will collect and analyze scats collected from these locations to obtain data on diet.

Physiological responses of eastern hemlock to imidacloprid and dinotefuran basal bark spray in southern New York

Peregrin, John (Columbia University), Palmer, Matt (Columbia University) and Kevin Griffin (Columbia University)

Pests and pathogens are increasingly a major stressor in forests globally due to international trade and a warming climate. In the eastern United States the hemlock woolly adelgid (*Adelges tsugae* Annand) (HWA) causes the fatal decline of eastern hemlock (*Tsuga canadensis* (L.) Carr.). Chemical treatments of neonicotinoid compounds, imidacloprid and dinotefuran, are commonly used to suppress pest populations, yet efficacy studies are lacking for treatment effects and duration in southern New York. This study aims to measure the physiological response of HWA infested hemlocks with and without imidacloprid and dinotefuran basal bark spray. From 2021 to 2022 measurements of HWA densities, stem radial growth, chlorophyll fluorescence, foliar nitrogen (N), and foliar carbon (C) isotope ratios were observed in treated and untreated hemlocks, one year post treatment at Black Rock Forest Consortium (BRF), and four years post treatment at Mianus River Gorge Preserve (MRG). At BRF, HWA densities were not significantly different between treatment and control groups for all seasons sampled. At MRG, HWA densities between treatment groups were significant for all seasons sampled throughout the study period, Summer 2021 ($p = 0.037$), Winter 2021 ($p = 0.012$), Summer 2022 ($p = 0.004$), Winter 2022 ($p = 0.001$). At BRF one-year post-treatment growth decreased 18.7% in treated trees from 2021 to 2022. At MRG treated trees increased by 8.9% from 2021 to 2022. For both sites Chlorophyll fluorescence between treatment groups was significant for all seasons sampled. Foliar N and C isotope ratios between treatment groups were also not significant for all seasons sampled. These results illustrate the effectiveness of neonicotinoid treatments in decreasing HWA abundance in infested hemlocks over time and reinforce recent findings that other factors such as leaf area and new shoot growth may be more indicative of tree health then radial growth and leaf level physiology.

Insights from a 90+ year record of forest growth, carbon sequestration, and change from Black Rock Forest, an aggrading deciduous forest in southeastern New York State

Schuster, William (Black Rock Forest), Terlizzi, Katie (Black Rock Forest), Ashton, Isabel (Black Rock Forest) and Kevin Griffin (Columbia University)

Black Rock Forest has been studying forest composition and growth for more than 90 years. In a series of eight long-term plots, we have recorded tree diameter, canopy class, mortality, and recruitment every five years since the 1930s and annually since 1993. Live aboveground carbon storage and sequestration rates have been calculated for each tree using allometric equations, including species-specific equations developed on site for four dominant species comprising more than half of the trees in the dataset. These data are augmented by forest-wide inventories in 1930 and 1985 plus annual survey data since 2006 from additional undisturbed plots. Analysis shows: 1) carbon sequestration is driven by large canopy tree growth, far outstripping the contributions of ingrowth and smaller trees. 2) Live aboveground carbon sequestration in these 120-140 year old stands has continued at nearly the same rate as when they were young. 3) Periodic declines in carbon storage of 3 – 15% of stand totals correspond to mortality following drought or herbivorous insect outbreaks. 4) Canopy mortality in between these declines averages just under 1% per year. Among-plot variance in carbon storage increases after disturbance, while tree density and variance in density continually decrease. 5) Native trees, especially Quercus species, continue to dominate the forest canopy and carbon stocks, with non-native and invasive species making minimal inroads. 6) *Quercus rubra*, *Quercus montana*, and *Acer saccharum* continue to exhibit the highest C sequestration rates. *Acer rubrum*, *Betula lenta* and understory tree species exhibit increasing densities but little carbon storage. Other species have declined substantially.

Epigenetic Response to Drought Stress in Red Oaks of Black Rock Forest

Silverman*, Kimberely (Lisman Laboratories, Riverdale Country School), Gerber, Max (Lisman Laboratories, Riverdale Country School), Levey*, Daniel (Lisman Laboratories, Riverdale Country School), Gentille, Daniel (Lisman Laboratories, Riverdale Country School and Berkely Carrol School) and Rachel Cox (Lisman Laboratories, Riverdale Country School)

As forests cope with climate change, water deficiency becomes a critical issue. Trees are long-lived, sessile organisms, and thus require large time scales for genetic adaptation. Because climate change is occurring on a short time scale, epigenetic regulation may present a critical adaptive mechanism by which forests may rapidly and transiently respond to water availability. This study aims to explore the extent to which epigenetic changes contribute to drought adaptation. We chose as the object of our study two populations of red oak (Quercus rubra) in Black Rock Forest. This dominant species represents a critical carbon sink for Northeastern forests. Canopy samples of red oak leaves were collected from two sites in Black Rock Forest with differing water access. We returned a year later to collect a second set of samples from the same trees. After observing phenotypic differences such as tree height, leaf color, and leaf waxiness, we extracted DNA from leaf cells for pyrosequencing and analysis. We identified differentially methylated gene pathways that may control adaptive responses such as water movement and lipid biosynthesis. Evidence collected in this investigation offers insight into epigenetic methylation as a key mechanism for climate change adaptation on relatively short time scales.

The effect of canopy disturbance and deer herbivory on understory cover and diversity

Terlizzi, Katie (Black Rock Forest), Heslop, Calvin (Harvard University), Taylor, Benton (Harvard University), Schuster, William (Black Rock Forest) and Matthew Palmer (Columbia University)

Forests are changing at an unprecedented rate due to invasive pests and pathogens and deer overabundance. We set up a manipulative experiment to test how the understory community would respond to the loss of oak trees and decreased deer herbivory. Twelve plots each 75m by 75m were set up in a semi-randomized block design and were assigned one of four treatments (Control, Oak girdled, 50% Oak girdled and non-oak girdled). In addition to girdling treatments we erected a deer exclusion fence in each plot. Ten understory vegetation plots were established outside of fences and ten plots were established inside of fences and percent cover of every species was estimated annually from 2008 to 2018 and then again in 2021. We found that diversity did not change significantly over time however both girdling treatment and exclosures have a positive effect on diversity. Oak girdled and non-oak girdled treatments have higher diversity than control and exclosures have higher diversity than non-exclosed plots. Species richness significantly increased over time and at a faster rate in oak girdled and non-oak girdled plots. Exclosures have higher species richness than un-exclosed plots. Cover of invasive species

was highest outside of deer exclosures in oak girdled plots and all other treatments had roughly the same proportion of invasive species. All treatments are heading towards an oak dominated community except oak-girdled treatments which are heading towards a maple dominated community. Our results show that the understory community responds quickly to disturbance and that these increases in diversity persist for a long time. Our data also show the importance of the reduction of herbivory in both promoting diversity and reducing the impacts of invasive species.

Urbanization exacerbates climate sensitivity of eastern U.S. broadleaf trees.

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Tree growth is a key mechanism driving carbon sequestration in forest ecosystems. Environmental conditions are important regulators of tree growth that can vary considerably between nearby urban and rural forests. For example, trees growing in cities often experience hotter and drier conditions than their rural counterparts while also being exposed to higher levels of light, pollution, and nutrient inputs. However, the extent to which these intrinsic differences in the growing conditions of trees in urban vs. rural forests influence tree growth response to climate is not well known. In this study, we test for differences in the climate sensitivity of tree growth between urban and rural forests along a latitudinal transect in the northeastern United States that includes Boston, Massachusetts, New York City, New York, and Baltimore, Maryland. Using dendrochronology analyses of tree cores from 55 white oak trees (*Quercus alba*), 55 red maple trees (*Acer rubrum*), and 41 red oak trees (*Quercus rubra*) we investigated the impacts of heat stress and water stress on radial growth of individual trees. Across our three city study, we find that tree growth is more closely correlated with climate stress in the cooler climate cities of Boston and New York than in Baltimore. Furthermore, heat stress is a significant hinderance to tree growth in New York and Baltimore while the impacts of water stress appear to be more evenly distributed across cities. We also find that the growth of oak trees, but not red maple trees, in the urban sites of Boston and New York City is more adversely impacted by heat stress than their rural counterparts, but we do not see these urban-rural differences in Maryland. Trees provide a wide range of important ecosystem services and increasing tree canopy cover is typically an important component of urban sustainability strategies. In light of our findings that urbanization can influence how tree growth responds to a warming climate, we suggest municipalities consider these interactions when developing their tree planting palettes and when estimating the capacity of urban forests to contribute to broader sustainability goals into the future.