Twelfth Research Symposium
June 28, 2021
Black Rock Forest

Black Rock Forest Consortium 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 Black Rock Forest has hosted a Research Symposium in late June of every second year. The purpose of the Symposium has been 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 about research elsewhere in the Highlands region.

Full Talks

Dmitriy Aronov, Columbia University - *Flexible use of memory in food-caching birds*

Suzanne Macey, American Museum of Natural History, Jeremy Hise, Hise Scientific Instrumentation, Luke Stuntz, New York University, Devon Bernsley, Barnard College, Kyra Liedtke, Flagler College, Sarah Jathas, Barnard College, Rebecca Garcia, Barnard College, Beckett Johnson-Walters, Jesse Avila Nativi, Andrew Fredricks and Matthew Palmer, Columbia University- *High-resolution tracking of turtles at Black Rock Forest: Development of new tools for wildlife conservation*

Caroline Bayer, Dobbs Ferry High School and Mianus River Gorge- *The impact of anthropogenic effects on North American river otter (Lontra canadensis) behavior at latrine sites.*

Andrew Reinmann, City University of New York, Emilia Peleganotitmus, Bronx High School of Science, Prableen Kaur, Herricks High School, Kamila Agudelo, Calhoun High School, Magdaly Sevilla, City University of New York, Clare Kohler, City University of New York - *Three years into the Black Rock Forest environmental gradient study: soil moisture as a mediator of tree response to climate stress.*

Angelica Patterson, Black Rock Forest- *Leaf physiological response to temperature of northern, central, and southern ranged trees in a northeastern US temperate forest*

Jacob Katz, Riverdale Country School and Knut Vanderbush, Riverdale Country School- *Global methylation and phenotypic plasticity in Picea glauca forest ecology*

Ken Davidson, Brookhaven National Lab and Stony Brook University, Julien Lamour, Brookhaven National Lab, Anna T McPharren, Stony Brook University, and Shawn Serbin Brookhaven National Lab and Stony Brook University - *Evaluating patterns and drivers of leaf water use efficiency with ontogeny in Eastern deciduous forests of New York State*

Edwin Reed-Sanchez, SayCel and City University of New York- *Black Rock Forest wireless mesh network*

Grayson Badgley, Black Rock Forest- *Systematic over-crediting in California's forest carbon offsets program*

Mary Whelan, Rutgers University- *Finding occult carbon in forested ecosystems by tracing photosynthesis*

Isobel Mifsud, Columbia University- *Nitrogen fixation in the larvae of the xylophagous beetle Ceruchus piceus (Weber)*

Palani Akana Columbia University and Duncan Menge Columbia University Department of Ecology - *Winning the lottery of forest soil: Nitrogen availability is concentrated in hotspots, and some seedlings strike it rich*

William Schuster, Black Rock Forest- *Long-term trends in forest carbon storage*

Sarah Bruner, Columbia University, Shahid Naeem, Columbia University, Duncan Menge, Columbia University, Jan Eitel, University of Idaho, and William Schuster, Black Rock Forest - *The portfolio effect in forests: linking tree diversity to community function*

Ralph Green, Pace University and Danielle Begley-Miller, Teatown Lake Reservation- *White-tailed deer harvest success and its Impact on forest understory vegetation: Evaluating management program efficacy in Southeastern New York*

Robert Fahey, University of Connecticut, Chris Gough, Virginia Commonwealth University, Brady Hardiman, Purdue University and Jeff Atkins, USDA Forest Service- *Using experimental defoliation to study tree and forest response to repeat defoliation and disturbance interactions*

Brendan Buckley, Lamont-Doherty Earth Observatory of Columbia University - *Northeastern broadleaf forests and new directions with tree ring analyses*

Kayla Warner, Barnard College, Nancy Sonti, USDA Forest Service, Andrew Reinmann, City University of New York- *Comparing climate drivers of tree growth in urban and rural areas along the Northeast corridor*

Lightning talks

Scott LaPoint, Black Rock Forest and Elie Gurarie, University of Maryland- *Camera traps: what have we been missing?*

Anna Soccorsi, Columbia University- *Gray fox distribution, occupancy, and relative abundance within Black Rock Forest and the surrounding landscape*

Sarah Jathas, Barnard College, Jeremey Hise, Hise Scientific Instrumentation, Matt Palmer, Columbia University and Suzanne Macey, American Museum of Natural History- *Testing accuracy and precision of spatial and thermal monitoring devices for deployment on Eastern box turtles (Terrapene carolina carolina)*

Jenna Lombino, Mianus River Gorge- *Can bobcats be individually identified, visually using camera traps?*

Andy Reinmann, City University of New York and Robert Fahey, University of Connecticut- *A new forest fragmentation study at Black Rock Forest*

Róisín Commane, Lamont-Doherty Earth Observatory of Columbia University, Andrew Reinmann, City University of New York and John Mak, Stony Brook University- *Understanding the impact of biogenic and anthropogenic fluxes on the atmospheric composition of the NYC area*

Robert Fahey, University of Connecticut, Jill Dyer, University of Connecticut, Danielle Tanzer, University of Connecticut, Andrew Reinmann, City University of New York, Chris Gough, Virginia Commonwealth University, Brady Hardiman, Purdue University and Jeff Atkins, USDA Forest Service- *Using experimental defoliation to study tree and forest response to repeat defoliation and disturbance interactions*

John Peregrin, Columbia University- *Multilevel assessment of Eastern hemlock growth: Dendrometers, field methods and foliar spectral analysis*

Mukund Rao, Lamont-Doherty Earth Observatory of Columbia University, Sarah Bruner, Columbia University and Shahid Naeem, Columbia University- *Seasonal changes in canopy vegetation at Black Rock Forest after oak loss derived from drone based remote sensing.*

Nicole Wooten, Hudson Highlands Land Trust- *Beech leaf disease: Data collection on an emerging threat in the Hudson Valley*

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

Winning the lottery of forest soil: Nitrogen availability is concentrated in hotspots, and some seedlings strike it rich

Palani Akana (Columbia University) and Duncan Menge (Columbia University)

Trees in temperate forests rely on soil nitrogen for growth and reproduction, yet the supply of soil nitrogen is notoriously variable in space and time, and this has important implications for plant nutrient access and growth. We characterized the small-scale spatial structure of soil nitrogen in two plots within Black Rock Forest, one dominated by red oak (Quercus rubra) and one dominated by black locust (Robinia pseudoacacia), a nitrogen-fixing tree. In each plot, we quantified nitrogen availability and mineralization rates from 150 soil cores, at distances ranging from 10 cm to 20 m. The black locust plot had higher overall nitrogen supply, unsurprising since black locusts use atmospheric nitrogen to fuel production of their nitrogen-rich leaves, which later decompose and augment soil nitrogen supply. Both plots exhibited similar trends in regards to the spatial distribution of plant-available soil nitrogen: spatial autocorrelation was most apparent at scales less than 2 m, and 25% of plant-available nitrogen was contained within soil hotspots accounting for only 10% of soil area. Using the parameters of spatial structure from our measurements, we simulated hypothetical maps of soil nitrogen and determined that spatial variability in soil nitrogen translates into variability in nitrogen access for seedlings and saplings, meaning that the growth of young trees is dependent on whether or not they are growing in nitrogen-rich or nitrogen-poor soil patches.

Flexible use of memory in food-caching birds

Dmitriy Aronov (Columbia University)

A hallmark of human memory is “flexibility” – the ability of the same memory to be recalled in different contexts and to be used in pursuit of different goals. Is memory in other animals also flexible? We studied memory in black-capped chickadees – food-caching birds that are common in Black Rock Forest. These birds are extreme memory specialists, capable of hiding and later retrieving food items from thousands of concealed locations in their environment. We designed a behavioral arena in which chickadee behavior – including caches, retrievals, and site investigations – are tracked automatically in a high-throughput fashion. Analysis of the resulting behavioral dataset revealed that chickadees use memory in a remarkably flexible fashion. During caching, they avoid sites that already contain food, and are attracted to sites that they remember to be empty. This behavior of spreading food evenly throughout the environment is thought to be a defense against pilfering. During retrieval, chickadees are instead attracted to occupied sites in order to quickly obtain food. Therefore, the same knowledge of a cache is used by chickadees for at least two unrelated goals, demonstrating flexibility of memory in an animal model.

Systematic over-crediting in California's forest carbon offsets program

Grayson Badgley (Black Rock Forest)

Forest carbon offsets are increasingly prominent in corporate and government "net zero" emission strategies but face growing criticism about their efficacy. California's forest offsets program is frequently promoted as a high-quality approach that improves on the failures of earlier efforts. By design, California's program awards large volumes of offset credits to forest projects with carbon stocks that exceed regional averages. This paradigm allows for adverse selection, which could occur if project developers preferentially select forests that are ecologically distinct from unrepresentative regional averages. By digitizing and analyzing comprehensive offset project records alongside detailed forest inventory data, we provide direct evidence that comparing projects against coarse regional carbon averages has led to systematic over-crediting of 30.0 million tCO2e (90% CI: 20.5 to 38.6 million tCO2e) or 29.4% of the credits we analyzed (90% CI: 20.1 to 37.8%). These excess credits are worth an estimated $410 million (90% CI: $280 to $528 million) at recent market prices. Rather than improve forest management to store additional carbon, California's offsets program creates incentives to generate offset credits that do not reflect real climate benefits. Looking globally, our results illustrate how protocol designs with easily exploitable rules can undermine policy objectives and highlight the need for stronger governance in carbon offset markets.

The impact of anthropogenic effects on North American river otter (*Lontra canadensis*) behavior at latrine sites.

Caroline Bayer (Dobbs Ferry High School and Mianus River Gorge)

While it is well known that wildlife is affected by humans due to pollution, the mere presence of humans in close proximity to wildlife can also have an impact. To examine the impact of high human use on river otter (*Lontra canadensis*) activity I measured otters' use of latrine sites located in riparian areas that experience heavy human use and sites in areas of low human use. Otters are tied to riparian areas but repeatedly defecate and leave prey remains at locations known as latrine sites on the shore. From March 21, 2020 to June 11, 2020 I monitored five latrine sites with camera traps to record the amount and timing of otter activity. The amounts levels of human and potential predator (bobcat (*Lynx rufus*), coyote (*Canis latrans*), American black bear (*Ursus americanus*) and red fox (*Vulpes vulpes*)) activity were also calculated at each latrine site. Overall, the levels of otter presence were lower at latrines sites close to roads and trails, and lower at sites with higher levels of both human and predator activity.

The portfolio effect in forests: linking tree diversity to community function

Sarah Bruner (Columbia University), Shahid Naeem (Columbia University), Duncan Menge, Columbia University), Jan Eitel (University of Idaho) and William Schuster (Black Rock Forest)

Forests face an ever-increasing number of disturbances, from both the physical environment as well as from other organisms. Stability – the capacity of a community to function in a predictable way over time – depends both on the constituent species' individual properties as well as the redundancy and complementarity of function within the community. How best to measure the emergent property of stability as well as the mechanisms responsible, remains an area of active research. The portfolio effect, diversity-dependent variance-dampening of community function, offers a way to link function to mechanism across scales. This research uses the concept of the portfolio effect to shed light on forest community function by focusing on tree taxonomic and functional diversity's relationship to carbon storage, tree water use, and soil moisture. Buried sensors and point dendrometers at Black Rock' north slope measure soil moisture, tree growth, and tree water-use hourly. Though still in the data-gathering phase, these temporally fine-scale measurements will allow a detailed look into whether tree species respond differently to the same environmental conditions and, in turn, how tree water uptake impacts soil moisture. Understanding the mechanisms by which the ecosystem functions of forests alter in response to changes in community composition is a critical ecological component for predicting the future of our forests and the stability of the ecosystem services they provide.

Northeastern broadleaf forests and new directions with tree ring analyses

Brendan Buckley (Lamont-Doherty Earth Observatory of Columbia University)

The broadleaf deciduous forests of the northeastern US comprise one Earth's fastest growing terrestrial carbon sinks. This trend is due in large part to land use changes over the past two centuries, where once-intensive agriculture and timber harvesting practices have given way to natural reforestation and forest fragmentation. This change in land use has been accompanied by a long-term warming trend, related to anthropogenic climate change, and a forest response that includes shifts in the range distributions of tree species and changing forest community composition and carbon dynamics. Dendrochronology, primarily through the use of radial growth measurements (tree rings) has long been a useful tool for studying trends in environmental conditions (e.g., climate). However, recent advances in the field have given researchers several new tools for studying modern issues related to climate change, including wood anatomical measures and studies of stable isotopes of carbon and oxygen. In combination with ecophysiological research, dendrochronological applications can play a significant role in understanding the future of the northeastern forests and their response to future environmental change throughout the twenty first century.

Evaluating patterns and drivers of leaf water use efficiency with ontogeny in Eastern deciduous forests of New York State

Ken Davidson (Brookhaven National Lab, and Stony Brook University), Julien Lamour (Brookhaven National Lab), Anna T McPharren (Stony Brook University), and Shawn Serbin (Brookhaven National Lab and Stony Brook University)

The physiology of stomata is a critical area for forest conservation science, as stomata play a dual role in limiting water loss via stomatal conductance (gs) and allowing for CO_2 entry into the leaf for use in photosynthesis (A). Variation in stomatal response to photosynthesis leads to a range of water use efficiency (WUE) among genotypes, species, and regions. Despite the fact that WUE directly impacts global carbon and water cycles, lack of knowledge regarding dynamics in WUE remains one of the largest uncertainties in current model predictions of the functioning of North American forests, with almost no studies addressing how WUE shits with leaf ontogeny. Here I present the results (to date) from a project which assesses if, how, and why leaf level WUE shifts with seasonal leaf ontogeny. In this project, I utilize a mix of physiological methods, ranging from traditional leaf-level gas exchange, to more modern remote sensing techniques. Findings from this work will help improve our understanding of intraspecific dynamics in WUE, as well as the physiological, anatomical, and abiotic factors which drive these dynamics. This work also has direct conservation applications via improvements to model predictions of how Black Rock Forest, and other eastern deciduous forests like it, will respond to climate change.

Using experimental defoliation to study tree and forest response to repeat defoliation and disturbance interactions

Robert Fahey (University of Connecticut), Chris Gough (Virginia Commonwealth University), Brady Hardiman (Purdue University) and Jeff Atkins (USDA Forest Service)

The structural characteristics of forest canopies are a defining feature of terrestrial ecosystems and fundamental driver of ecosystem functioning. Forest canopy structure and ecosystem structure-function relationships can be strongly impacted by disturbance, including forest management, with implications for forest resilience to global change drivers. Quantification of canopy structure is important both because of its role as an integrator of ecological factors, and because it provides a basis for studying fundamental structure-function relationships. The lack of a framework for characterizing 3D conceptions of canopy structure has limited research focused on understanding and modeling structure-function linkages. We illustrate a multivariate, structural trait-based approach to quantifying variation in canopy structure among vegetated ecosystems and use this framework to demonstrate differing impacts of disturbance on canopy structure (and associated ecosystem processes and functions) related to variable effects of causal agents and directionalities (i.e., top-down vs. bottom-up) of disturbance. Findings of this research have implications for isolating the distinct role of physical structure in driving ecosystem functioning, elucidating fundamental ecological mechanisms underpinning ecosystem structure-function relationships, effectively representing canopy structure in models, and promoting forest ecosystem structure and resilience through management.

White-tailed deer harvest success and its Impact on forest understory vegetation: Evaluating management program efficacy in Southeastern New York

Ralph Green (Pace University) and Danielle Begley-Miller (Teatown Lake Reservation)

In southeastern New York, white-tailed deer (Odocoileus virginianus) populations have increased over the last 50 years from a lack of natural predation, increase in food resources from land use changes, and restrictive hunting regulations. Unmanaged deer populations have severe negative impacts on understory plant communities, a key contributor to forest regeneration and biodiversity, affecting other plant and animal species. Numerous strategies are employed by land managers throughout the Hudson Valley region of New York to manage deer via lethal means. This study aims to better understand the effectiveness of different white-tailed deer removal programs (i.e., culling, archery, and firearms seasons) compared to no management in improving forest understory conditions across 7 nature preserves in the Hudson Valley. Deer density estimates decreased or stabilized across all program types in the first 4 years of management ($F(4,18) = 2.3$, $p = 0.098$), and harvest efficiency (number of deer harvested per hour effort) decreased at all sites with time ($F(3,23) = 8.974$, $p < 0.001$). Culling (5.32 deer/per hour) was the most efficient harvest strategy compared to archery (0.22 deer/per hour) and firearms (0.02 deer/per hour) programs. While management programs did reduce deer densities, those changes did not correlate consistently with seedling density ($F(1,16) = 0.483$, $p = 0.49$), and seedling height ($F(1,13) = 1.131$, $p = 0.72$), but did with understory diversity ($F(1,43) = 11.184$, $p = 0.002$). Vegetation responses appear site-specific and driven by additional site limitations beyond deer density, but data analysis was limited by inconsistent data collection strategies across sites.

Global methylation and phenotypic plasticity in *Picea glauca* forest ecology

Jacob Katz (Riverdale Country School) and Knut Vanderbush (Riverdale Country School)

Phenotypic variability provides individuals with appropriate response patterns to rapid environmental challenges such as those encountered by climate change. As such, epigenetic analysis offers insight into molecular mechanisms that control adaptation, and this informs practices in environmental conservation. *Picea glauca*, a northern temperate and boreal forest dominant species across Canada and the Northern United States, provides critical ecological functions such as decreased soil erosion, sequestered atmospheric carbon, and habitat diversity. The Black Rock Forest community offers an opportunity to better understand individual epigenetic response patterns for trees that span the southernmost geographic regions of this species. This area is especially critical considering current models that predict a northward shift of the boreal zone due to climate change. Our research focuses on global epigenetic modification, in *Picea glauca* both within an individual, as well as between individuals from a single population. Specifically, by analyzing variable global methylation, we compared embryonic to mature needles on individual trees. In addition, we assessed methylation patterns between individuals within a single population. When comparing embryonic to mature growth, we did not find statistically divergent patterns of methylation. However, we noticed that the standard deviation of methylation levels between individuals is greater for embryonic than mature growth. This pattern is consistent with our observations of methylation in needles of *Picea glauca* conspecifics living at arctic tree line. In addition, we found that two groups of *Picea* trees, separated by less than a mile at Black Rock Forest, display significant and repeatable differences in global methylation patterns. We hypothesize that this difference is due to divergent environmental conditions. This result corroborates our preliminary findings from arctic Alaska that show higher methylation in trees living at higher latitudes, where harsh conditions create a more stressful environment. Overall, our Black Rock Forest findings demonstrate that individual members of the *Picea glauca* forest community display differential epigenetic profiles. This suggests that, even within the confines of a small forest, epigenetic alteration may play an important, variable and potentially predictable role in orchestrating adaptive stress response. This information is critical to our overall general understanding of diversity and adaptation in forest communities.

High-resolution tracking of turtles at Black Rock Forest: Development of new tools for wildlife conservation

Suzanne Macey (American Museum of Natural History), Jeremy Hise (Hise Scientific Instrumentation), Luke Stuntz (New York University), Devon (Bernsley Barnard College), Kyra Liedtke (Flagler College), Sarah Jathas (Barnard College), Rebecca Garcia (Barnard College), Beckett Johnson-Walters, Jesse Avila Nativi, Andrew Fredricks and Matthew Palmer (Columbia University)

Black Rock Forest has recently installed self-powered nodes for a new wireless mesh network providing researchers with connectivity to real-time data from environmental monitoring stations. Additionally, this network could be leveraged to accurately monitor fine-scale movement of animals. With support from the David Redden Conservation Science Fund, our team has worked with several high school and college students since 2019 to 1) survey for turtle populations, 2) obtain locality, movement, and size data on multiple turtle species, 3) investigate thermal ecology dynamics, and 4) develop and deploy user-built GPS backpacks to gather movement data. With innovative monitoring technologies and connection to the wireless mesh network, we intend to make advancements towards the automation of data retrieval from units deployed on turtles in 2021. This study is establishing improved methodologies and understanding of using affordable GPS trackers and thermal dataloggers in forested and aquatic environments. The efforts and results will be applicable to a broad range of ecologists.

Nitrogen fixation in the larvae of the xylophagous beetle *Ceruchus piceus* (Weber)

Isobel Mifsud (Columbia University)

Nitrogen is an essential nutrient required by all organisms for growth. However, many insects feed on substances with an extremely low nitrogen content, such as decaying wood, and cannot obtain adequate nutrition from these food sources alone. These insects are "saproxylic" - dependent on dead wood - and are important for decomposition. Decomposition returns nutrients from dead wood back to the soil, fuelling plant growth. I am investigating the possibility that the saproxylic beetle, *Ceruchus piceus*, acquires nitrogen from nitrogen fixation. Nitrogen fixation is the process by which specialized bacteria convert dinitrogen gas into biologically-available nitrogen, essentially creating protein from the air. I hypothesized that *C. piceus* houses these specialized bacteria within its gut, and uses the nitrogen they provide to balance its diet. I made two major discoveries. (1) As I hypothesized, *C. piceus* houses nitrogen-fixing bacteria, and uses the nitrogen they fix to help balance its diet. (2) The rate of nitrogen fixation in *C. piceus* is among the highest recorded in insects. My first discovery expands our knowledge of natural history. Previous studies have shown that other species of insect associate with nitrogen-fixing bacteria, but none had reported on *C. piceus*. My second discovery has broader implications. Previous studies of nitrogen fixation in insects have reported much lower rates of nitrogen fixation than I found, but my findings suggest these are artificially low. The standard method involves incubating the insects for 24 hours before measuring, whereas I used a novel method that produces results continuously. My results show that nitrogen fixation declines rapidly when

C. piceus is removed from its natural habitat (59% per hour). This suggests that previous studies could be severely under-reporting nitrogen fixation. This has exciting implications for insect nutritional ecology and ecosystem nutrient cycling.

Leaf physiological response to temperature of northern, central, and southern ranged trees in a northeastern US temperate forest

Angelica Patterson (Black Rock Forest)

Carbon cycling in northeastern US forests is expected to change as climate-induced tree migrations shift the species composition of plant communities. Comparing the physiological temperature responses of trees with historically different geographical range distributions will be necessary to predict which species will be tolerant of a warming climate and how forest carbon dynamics will be impacted. In this study, foliar photosynthesis and respiration rates of seventeen co-located broadleaved tree species were measured under three temperatures (16°C, 23°C, and 29°C) and compared based upon their historic range distribution (northern, central, and southern). Central ranged species had significantly lower RUBP-carboxylation (Vcmax), maximum electron transport rate (Jmax), triose phosphate utilization (TPU), and dark respiration (Rd) when compared to northern and southern species. When all species were pooled, Vcmax was 26-28% lower at 16°C when compared to ambient and elevated temperatures. Historic range distribution was not a significant factor in the rates of photosynthesis (A) or on carbon use efficiency (the ratio of A to Rd) at ambient temperatures. Although no significant interaction effect was found between range group and temperature, the photosynthetic capacity of central ranged trees trended downward as temperatures increased from 23°C to 29°C. Leaf trait comparisons revealed that southern species had significantly higher mass-based nitrogen (N_{mass}), and lower area-based nitrogen (N_{area}), foliar carbon to nitrogen ratio (C:N), and leaf mass area (L) than their northern and central counterparts. A Pearson correlation analysis of leaf and physiological traits revealed a strong negative correlation between L and A. The evidence presented here suggests that central ranged trees may be at a physiological disadvantage under a warming climate, which could negatively impact the abundance of centrally dominant species, such as the northern red oak, and alter the carbon storage potential of northeastern US temperate forests.

Black Rock Forest wireless mesh network

Edwin Reed-Sanchez (SayCel and City University of New York)

The Black Rock Forest Wireless Mesh Network is a National Science Foundation-funded project and collaboration with BRFC and SayCel Technologies. The network provides connectivity for environmental research and hosts phenocams, critter-cams, dendrometers, and other sensor systems. Edwin Reed-Sanchez (CUNY) and German Martinez (Universidad Nacional del Nordeste, Argentina) are currently developing additional ease of use tools for scientists and forest looking to deploy this type of infrastructure. The main project is the "Store and Forward Nodes," which act as local resilient data loggers and allow scientist to create their sensor systems using open-source hardware. Other improvements include making it easier to do visualizations using Grafana, managing field sensors and libraries for creating your sensor kits. You read more about the project at blackrock.treefi.net

Three years into the Black Rock Forest environmental gradient study: soil moisture as a mediator of tree response to climate stress.

Andrew Reinmann (City University of New York), Emilia Peleganotitmus* (Bronx High School of Science), Prableen Kaur (Herricks High School), Kamila Agudelo (Calhoun High School), Magdaly Sevilla (City University of New York), Clare Kohler (City University of New York)*

Tree growth and physiological processes are highly sensitive to water stress, even in mesic ecosystems such as the temperate deciduous forests of the northeastern U.S. While climate models project wetter conditions across the northeastern U.S. as the climate warms, much of this increase in precipitation is expected to occur in the winter and spring. By contrast, warmer and longer growing seasons are projected to reduce soil moisture and increase water stress during the summer. The rugged and hilly topography of Black Rock Forest creates large gradients in soil moisture conditions and provides opportunities to study how common tree species such as red maple (*Acer rubrum*) and red oak (*Quercus rubra*) might respond to future climate conditions with greater growing season water stress. In 2018, we established an environmental gradient study to assess variations in tree physiological processes and radial growth response to climate between mesic and xeric sites along a transect between Mt. Misery and Hill of Pines. During the first three years of this study, Black Rock Forest experienced a "normal" growing season (2018), a late-summer flash drought (2019), and a late-spring defoliating frost event (2020). During our presentation we will provide an overview of what we are learning about the response of tree growth, nonstructural carbohydrate pools, and photosynthesis to these climate events and natural gradients in soil moisture. We will also describe some new directions for this research.

Long-term trends in forest carbon storage

William Schuster (Black Rock Forest)

Current total ecosystem carbon storage in Black Rock Forest is estimated at 197.3 metric tons of carbon per hectare. The long-term net carbon sequestration rate is 1.9 metric tons of carbon per hectare per year, taking into account reductions and losses due to factors such as extended droughts, insect defoliations, and other causes of tree mortality. The estimates are produced relying heavily on allometric equations that relate tree size to biomass and carbon content. The equations have been developed for red oak, chestnut oak, and black birch by felling drying and weighing a total of 45 trees to date. For other tree species equations have been selected from published studies from similar sites. For the major pools of soil carbon and carbon in Coarse Woody Debris (CWD) the estimates are based on regional estimates from sources such as the US Forest Service and modified by extrapolations from field studies conducted in Black Rock Forest. A series of 8 long term plots measured since the early 1930s provide the core of the data for these long-term estimates, supported by forest-wide inventory data from 1930 and 1985. Since 2007 the estimates have been modified by additional annual measurements of 600+ trees on 3 plots that help make the suite of plots more representative of the range of site conditions in the forest. Over the past 13 years, average annual sequestration rates of 1.6 metric tons of carbon per hectare per year in the aboveground live tree component alone document that sequestration is still occurring approximately as rapidly as it did in the 20th century and that sequestration has recovered from a multi-year downturn period around the start of the 21rst century.

Comparing climate drivers of tree growth in urban and rural areas along the Northeast corridor

Kayla Warner (Barnard College), Nancy Sonti (USDA Forest Service), Andrew Reinmann (City University of New York)

Information regarding the many impacts of climate change upon tree growth is of great importance for assessments which inform conservation decisions and policy. While the impacts of climate change including increased temperatures and changes in precipitation can affect all types of forest ecosystems, there might be a difference in the magnitude of these effects between urban and rural locations, particularly due to the urban heat island effect. This study uses dendrochronology analyses of tree cores from 85 oaks and 85 red maples to examine the relationship between tree growth and climate across the three cities of New York City, Philadelphia, and Baltimore alongside reference rural sites for each city, including Black Rock Forest. The climate variables we are exploring in this study include maximum growing season temperature, number of days over maximum July temperature, SPEI_2, and precipitation. In this presentation we will present our early findings.

Finding occult carbon in forested ecosystems by tracing photosynthesis

Mary Whelan (Rutgers University)

No abstract available

Lightning Talks (in lieu of poster session)

Understanding the impact of biogenic and anthropogenic fluxes on the atmospheric composition of the NYC area

Róisín Commane (Lamont-Doherty Earth Observatory of Columbia University), Andrew Reinmann (City University of New York) and John Mak (Stony Brook University)

Nearly 70% of all carbon emissions to the atmosphere occur in urban areas and New York City is the largest source of urban carbon emissions in the US. Cities like NYC are proud of their "million" street trees. But what impact do these trees have on the atmospheric composition of NYC? If we want to measure the anthropogenic emissions of carbon into the atmosphere, we also need to understand the carbon uptake by vegetation within the city. In this recently funded project, we are using the trees of Black Rock Forest to understand the effects of fragmentation and the contribution of street trees to the atmospheric fluxes of carbon and Volatile Organic Compounds (VOCs) such as isoprene.

Using experimental defoliation to study tree and forest response to repeat defoliation and disturbance interactions

Robert Fahey (University of Connecticut), Jill Dyer (University of Connecticut), Danielle Tanzer (University of Connecticut), Andrew Reinmann (City University of New York), Chris Gough (Virginia Commonwealth University), Brady Hardiman (Purdue University) and Jeff Atkins (USDA Forest Service)

Canopy defoliation is an important source of disturbance in forest ecosystems that has rarely been represented in large-scale manipulation experiments. Scalable crown to canopy level experimental defoliation is needed to disentangle effects of variable intensity, timing, and frequency on forest structure, function, and mortality. We are using a novel pressure washing-based defoliation method to conduct branch to crown to canopy-scale experiments on defoliation disturbance in forested ecosystems. Research will address defoliation effects on tree physiology and growth and support future work toward development of synthetic understanding of defoliation effects across forest types, ecoregions, and defoliation sources.

Testing accuracy and precision of spatial and thermal monitoring devices for deployment on Eastern box turtles *(Terrapene carolina carolina)*

Sarah Jathas (Barnard College), Jeremy Hise (Hise Scientific Instrumentation), Matt Palmer (Columbia University), and Suzanne Macey (American Museum of Natural History)

The Eastern box turtle occupies a variety of regions with changes in their activity patterns reflecting variation in seasonal climate. The sparse knowledge of movement patterns across different populations promotes the need for empirical research by region. Advances in methods for collecting spatial data from wild animals provide insights on habitat selection needed for concerted conservation efforts. Currently, the options for simultaneous collection of data on both the environment, the movement, and thermal patterns of small animals are expensive and/or labor-intensive. To improve movement data collection methods, this study investigated an open-source user-built GPS backpack and commercial temperature loggers. The GPS backpacks encase a mini-GPS unit, a computer chip, and a battery, which operate as a data logger obtaining and recording the position of the turtle. Functionality, precision, and accuracy of the GPS units were assessed through performance in stationary deployment; placement of three conditions mimicked the habitat selection (lower, canopy, open) of the Eastern box turtle to evaluate field performance. Our GPS units cannot always obtain fine-scale (< 30 m) movement data among various habitat types, but experiments with different technical settings showed that achievement of higher accuracy is possible. Increasing the number of satellite connections refines the accuracy but decreases the battery life. Temperature loggers had high precision within brands and our results suggested that variation between different types of units may be due to different responses to solar radiation. High accuracy in low-cost GPS loggers can support the improved sampling of wild populations, thereby facilitating more fine-scale spatial analysis. Eliminating errors from data logging equipment can improve analysis of animal patterns allowing for better conservation management through movement pattern awareness.

Camera traps: what have we been missing?

Scott LaPoint (Black Rock Forest) and Elie Gurarie (University of Maryland)

Camera traps are popular tools for monitoring wildlife populations globally. They have tremendous potential, but detection probabilities vary across sites, species, and camera trap models and are rarely quantified, thereby limiting their value for drawing large scale conclusions. To assess this variation, we compared camera trap detection rates of passing carnivores with observed carnivore movement patterns via snow tracking across a 0.54 ha study plot containing 54, non-baited camera traps arranged in a 6 by 9 grid within the Edmund Niles Huyck Preserve. Camera traps varied in make, model, and focal bearing, ran continuously from 22 December 2017 through 28 March 2018 and again the following winter, 19 December 2018 through 8 April 2019. During this time our cameras recorded 834 passes by 10 identifiable wild mammal species (0.07 passes per deployment day), with white-tailed deer (Odocoileus virginianus; 322) and grey squirrel (*Sciurus carolinensis*; 187) being the most frequently detected. We recorded passes by four carnivores: fisher (*Pekania pennanti*; 113), raccoon (*Procyon lotor*; 99), coyote (*Canis latrans*; 58), and red fox (*Vulpes vulpes*; 37). Snow tracking surveys yielded 19 usable passes through our study plot. Maximum detection distances, measured via walk tests, varied between camera trap models (ANOVA, $p < 0.03$), with the Reconyx HC500 detection distance being significantly shorter (~1-m less) than the remaining two models. Detection rates of wild mammal species varied between camera trap models (ANOVA, $p < 0.001$), but not within species. Latency to detection data suggest 18 days was sufficient to detect the most prevalent species of winter-active mammals within this area of the Preserve. The likelihood of a camera trap recording a mammal when it enters the theoretically possible range of the camera trap is generally low and varies between species, from 0.15 for fisher to 0.50 for white-tailed deer, suggesting camera trap detections significantly underrepresent true mammal passes, with Reconyx HC500, Bushnell Trophy CamHD, and Reconyx PC800 camera traps detecting 28.6%, 28.9%, and 53.8% of passes, respectively. Our efforts here suggest that camera trap-based species distribution information is likely conservative and scales with species body size, providing practitioners with valuable tools for interpreting survey results.

Can bobcats be individually identified, visually using camera traps?

Jenna Lombino (Mianus River Gorge)

Being able to decipher between individual animals within the same species on camera trap photographs allows for robust estimation of abundance and other important ecological characteristics. Typically, individual identification is enabled by using artificial marks or tags, and if the focal species have unique fur patterns, they can be identified visually without the need for artificial marking. Bobcat coats in the east tend to have grayer coats with minimal spots as opposed to bobcats in the west. I am testing camera models, camera station setup, lures, and media format (video versus photographs) of bobcats (*Lynx rufus*), to determine whether eastern bobcats can be identified individually from pelage patterns at the Mianus River Gorge Preserve in Bedford, NY. In 2020 we used video cameras, and found that unique, identifying markings are most common on the inside of the limbs, tail, and ears, although it was difficult to ensure simultaneous pictures of both sides of the animals while arranging the cameras so that the infrared flashes from one camera did not interfere with the other camera of the pair. During this study I documented the first observation of bobcat breeding in the Preserve, as well as multiple black bears using the area. Bobcats are top predators in the northeast. Surveying their return to this area and use of exurban, suburban, and urban landscapes would enable conservation groups and organizations to analyze how well they are approaching their conservation efforts, what they can do better, and what goals to set for in the future.

Multilevel assessment of Eastern hemlock growth: Dendrometers, field methods and foliar spectral analysis

John Peregrin (Columbia University)

The hemlock wooly adelgid (*Adelges tsugae* Annand) (HWA) causes the fatal decline of eastern hemlock (*Tsuga canadensis* (L.) Carr.) manifested through a decrease in growth rate. In this study hemlocks at two sites, Black Rock Forest and Mianus River Gorge, will be selected for a comparative assessment of hemlock growth with and without insecticide treatment for HWA. At each site 10 pairs of trees will be selected of similar size class and environmental conditions (i.e. slope, light exposure, soil moisture) for a total sample size of 40 trees. Each pair at Black rock forest, will contain a proposed insecticide treated and untreated hemlock, and each pair at Mianus river Gorge, an untreated and prior insecticide treated hemlock. I will use a combination of field methods (i.e. branch tip sampling and visual crown ratings), as well as chlorophyll fluorescence measurements, to assess the HWA infestation severity and classify current hemlock health. Dendrometers will be attached to each tree to measure the continuous intra-annual radial growth rate. This growth rate, calibrated with tree classification for HWA treated and untreated trees, can test the correlation strength between levels of HWA and growth, as well as the hemlock growth response to insecticide treatment.

Seasonal changes in canopy vegetation at Black Rock Forest after oak loss derived from drone based remote sensing.

Mukund Palat Rao (Lamont-Doherty Earth Observatory of Columbia University), Sarah Bruner (Columbia University) and Shahid Naeem (Columbia University)

Temperate forests are generally dominated by single species or conspecific species, or foundation species, that can succumb to introduced pests or pathogens. In most cases, documentation of foundation species losses occurs after the pest or pathogen takes its toll, leaving a forest that is significantly changed in species composition and ecosystem properties. Such altered forests may recover their lost function via compensatory growth, though the time course of this possibility remains unclear. In this study, oak species (Quercus spp.), which are the foundation species of Black Rock Forest, comprising ~85% of basal area, were either all killed by ringing, were reduced to half their density by the same process, or were unharmed, and an additional treatment involved removing all non-oak species. These four treatments were replicated three times and one plot was established in which all trees were ringed. We found that mean NDVI and GCC measured from above the canopy using Structure From Motion (SFM) drones in monthly flights conducted ~10 years after the ringing treatment, revealed that the temporal patterns were significantly different among treatments. The standard deviation of both measures of canopy properties, showed significant impacts of the treatments throughout the growing season.

A new forest fragmentation study at Black Rock Forest

Andy Reinmann (City University of New York) and Robert Fahey (University of Connecticut)

Agricultural and urban expansion have transformed much of the terrestrial environment into heterogeneous mosaics of fragmented ecosystems. This is especially true in the northeastern U.S. where nearly one quarter of all forest area is within 30m of a non-forest land cover. Abrupt transitions between forest and non-forest land covers—i.e., edges—characterize these landscapes and create large spatial gradients in microenvironments that exert a strong influence on forest growing conditions, structure, and biogeochemical cycling. The creation of forest edges increases temperate broadleaf forest biomass, carbon uptake, and soil respiration. However, much of our knowledge of temperate broadleaf forest response to fragmentation comes from sites with mature edges that have existed for at least 40 years. As such, relatively little is known about how forest structure, tree physiological processes, and carbon cycling evolve over time following the creation of an edge. We will be taking advantage of Black Rock Forest invasive species management efforts that will also create new forest edges to establish long-term monitoring plots to quantify forest structure and function over time. During this talk, we will describe this project and our proposed suite of measurements.

Gray fox distribution, occupancy, and relative abundance within Black Rock Forest and the surrounding landscape

Anna Soccorsi (Columbia University)

Rapid increases in urbanization are negatively impacting many wildlife populations, especially carnivores. However, certain mesocarnivore species have been successfully adapting to and exploiting urbanized locales due to their flexible resource and habitat requirements. Across much of North America, the gray fox (*Urocyon cinereoargenteus*) is considered an abundant mesocarnivore, yet has experienced recent population declines and distribution shifts in the northeastern and midwestern US and Canada. Notably, these changes have co-occurred with the rapid expansion of coyote (*Canis latrans*), red fox (*Vulpes vulpes*) and other mesocarnivores, which may be causing the gray fox to increasingly inhabit urbanized areas to avoid antagonistic interactions with these species. Black Rock Forest (BRF), a non-profit organization in the western Hudson Highlands region of New York State, has been surveying forest preserves within BRF to document carnivore distributions since late-2018, including gray fox. Notably, gray fox are uncommon within these forests, but have been detected near residential areas. As previous carnivore surveys were forest-centric, my project aims to expand the surveys into urban and semi-urban areas surrounding BRF where I expect gray fox are occurring. More specifically, I will assess the role that co-occurring mesocarnivores and landscape factors (i.e., elevation and distance to roads) play in gray fox distribution, occupancy and relative abundance in the Hudson Highlands region. I predict that gray fox and other mesocarnivore habitat selection is likely influenced by multiple site-specific factors, including prey availability, human density, habitat fragmentation and co-occurring competitors or predators.

Beech leaf disease: Data collection on an emerging threat in the Hudson Valley

Nicole Wooten (Hudson Highlands Land Trust)

Beech leaf disease (BLD), an invasive species correlated with a non-native foliar-feeding nematode, first appeared in the US in 2012. It was observed in NY in 2018, and is currently spreading in the Hudson Valley. The major characteristic is dark interveinal striping of the leaves that progresses to leatheriness, curling, necrosis, and ultimately death in the beech. Sapling mortality takes 3 to 5 years; mature beech mortality is 6 to 10 years. As BLD spreads, land managers are tracking and reporting new sightings to iMapInvasives, iNaturalist, and DEC, and are soliciting help in data collection, analysis, and research into treatments.