The ARNOLD ARBORETUM of HARVARD UNIVERSITY

8 January 2020

Dear UCAR Steering Committee:

I am writing to express my interest in the UCAR CPAESS NOAA Climate & Global Change Postdoctoral program. I will graduate with a PhD in Organismic and Evolutionary Biology from Harvard University in May 2021, and I am confident my experience as an ecologist and climate scientist will allow me to contribute to the successful integration and expansion of climate change research as well as collaboration with North Carolina State University, US Forest Service and The Nature Conservancy.

As part of the proposed research plan, I will work alongside Dr. Zakiya Leggett, who will act as my primary advisor and represent the host institution of North Carolina State University. By working with Dr. Leggett, I will expand my knowledge in soil ecology, nutrient cycling and carbon storage. I will also have access to new phytotron and greenhouse facilities on cam- pus. My research plan also includes a postdoctoral committee, who will act as collaborators and mentors throughout my proposed research program: Dr. Colleen Doherty, an associate professor in the College of Agriculture and Life Sciences at North Carolina State; Dr. Tara Keyser, Director with the USDA Forest Service Southern Research Station and adjunct associate professor in the College of Natural Resources at North Carolina State University; and Dr. Liz Kalies, Director of Science at The Nature Conservancy in Durham, North Carolina.

If given the opportunity to work alongside Dr. Leggett, Dr. Doherty, Dr. Keyser and Dr. Kalies, I will not only learn and grow as an individual scientist but I will also be able to extend and build interdisciplinary research outcomes that will target a broader audience of climate leadership. As a postdoctoral fellow, I will help train BIPOC students using a pipeline program, where I will mentor graduate students, graduate students will mentor undergraduate students and undergraduate students will mentor high school students. This pipeline program and integration of other non-academic agencies will help bolster climate change re- search and train future generations of climate scientists.

I first learned of this opportunity through my current research advisor, Dr. Elizabeth Wolkovich. I would relish the opportunity to leverage my research and communication skills to better align with the NOAA Climate Program Office. Thank you for your consideration.

Sincerely,
Catherine J Chamberlain

Catherine Chamberlain

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EDUCATION

Harvard University Cambridge, MA
Ph.D. in Organismic and Evolutionary Biology Expected May 2021
Trinity College Dublin Dublin, Ireland
M.S. in Biodiversity and Conservation November, 2015
Michigan State University East Lansing, MI
B.S. in Zoology, Concentration in Ecology Evolution and Organismal Biology May, 2013
Minor in Spanish

RESEARCH EXPERIENCE

PhD Researcher September 2016-Present
Department of Organismic and Evolutionary Biology**,** Harvard University Cambridge, MA

- Use meta-analysis and gridded climate data to understand the effects of climate change on forest systems
- Run greenhouse experiments with 384 plants and assess forest and common garden phenology observations for 5 years
- Analyze results using Bayesian hierarchical models in R assist peers in statistical analysis leading to a publication in *Nature Climate Change* and *Tree Physiology*
- Collaborate with an international team of researchers

Data Scientist November 2018-Present
The Nature Conservancy Northampton, MA

- Provide volunteer support to develop a machine learning tool to identify camera trap images with a 12-member team
- Coordinate with camera trap users nationwide to implement a standardized output for collaboration

Data Scientist, Tree Spotters Citizen Science Project May 2016-Present
Arnold Arboretum, through the National Phenology Network Boston, MA

- Analyze data for 75 individuals across 15 tree species at the Arnold Arboretum with over 300,000 observations
- Prepare reports and deliver results to 5-member team and to 80 active volunteers

Consultant May 2020-August 2020
The Nature Conservancy Northampton, MA

- Drafted landowner a handbook for the New England *Family Forest Carbon Program*
- Edited and gathered information from primary and secondary literature

Research Technician May 2016-August 2016
Harvard University - Arnold Arboretum Boston, MA

- Developed linear and logistic Bayesian models using R and Stan to investigate the effects of climate change on temperate trees
- Assisted researchers survey tree diversity, richness and age across 30-50 sites at four forest field stations

Researcher May 2015-August 2015
Gorongosa National Park Goinha, Mozambique

- Assisted the research team with various vegetation surveys
- Aided other researchers with behavioral studies of antelope in the park
- Contributed samples to the herbarium

LEADERSHIP & TEACHING EXPERIENCE

Guest Lecturer July 2020
Harvard Summer School Cambridge, MA
International Environmental Governance, Policy, and Social Justice

- Delivered 3 hour virtual lecture entitled *Phenology, Citizen Science and Climate Change* to 30 students ranging from high schoolers to professionals
- Co-delivered 3 hour virtual lecture on *Conservation Management, Human-Wildlife Conflict and Foreign Affairs* with international colleague

Teaching Fellow Fall 2018-Present
Harvard University Cambridge, MA

- Guide 18 first year PhD students on time management, teaching, grant writing and public outreach
- Led weekly discussion section and laboratory sessions virtually to 16 students in topics on Introduction to Organismic and Evolutionary Biology
- Advised 15 students in laboratory sessions on topics in Biology of Plants
- Assisted in teaching 30 students in topics of evolution and the history of evolutionary theory
- Supervised students in final projects and reports, graded assignments and exams

Mentor May 2019-August 2019
Harvard University – Arnold Arboretum Boston, MA

- Mentored 2 students on different research projects through 2 different programs
- Met weekly to advise students on experimental design, literature reviews, statistical analyses and presenting results

Teaching Assistant April 2016
Trinity College Dublin Limpopo, South Africa

- Guided 16 Masters students in Field Skills in Conservation
- Instructed students how to use dichotomous keys, run field surveys and assess management techniques at 2 conservation reserves

PUBLICATIONS

Ettinger A. K., Buonaiuto D.M., **Chamberlain C. J.**, Morales-Castilla I. & Wolkovich E.M. 2020. Spatial and temporal shifts in photoperiod with climate change. *New Phytologist.*

Chamberlain C. J., Cook B. I., Morales-Castilla I. & Wolkovich E. M. 2020. Climate change reshapes the drivers of false spring risk across European trees. *New Phytologist*

Ettinger A. K., **Chamberlain C. J.,** Morales-Castilla I., Buonaiuto D. M., Flynn D. F. B., Savas T., Samaha J. A. & Wolkovich E. M. 2020. Chilling dominates spring phenological responses to warming. *Nature Climate Change*

Chamberlain C. J., Cook B. I., García de Cortázar-Atauri I. & Wolkovich E. M. 2019. Rethinking false spring risk. *Global Change Biology.*

Chamberlain C. J. & Wolkovich, E.M. *(in review)*. False springs coupled with warming winters alter temperate tree growth.

Wolkovich E. M., Auerbach J. L., **Chamberlain C. J.**, Buonauito D. M., Ettinger A. K. & Gelman A. *(in review)*. A simple explanation for declining temperature sensitivity with warming.

PRESENTATIONS

Ecological Society of America August 2020

False spring damage on temperate tree seedlings is amplified with warming winter temperatures

New Tools for Analyzing and Sharing Wildlife Camera Images: Machine Learning and Online Databases to Minimize Time and Maximize Impact

European Geosciences Union, Talk May 2020

Climate change reshapes the major drivers of false spring risk across European trees

Extreme Climate Event Symposium, Talk February 2020

Climate change reshapes the major drivers of false spring risk across European trees

Canadian Society for Ecology and Evolution, Poster May 2017

The effects of false spring events on foliate phenophases and the duration of vegetative risk

Public Lectures: May 2016-Present

12 public lectures in the Boston area

1 lecture series at the Arnold Arboretum, Boston, MA

SKILLS

Quantitative: Mixed-effects including Bayesian approaches, analysis of covariance, linear and logistic regression models, meta-analysis statistics, climate change analyses and model building

Computer languages: Git, LaTeX, R, Stan, Sweave, RMarkdown, Microsoft Office Suite, Machine Learning skills, basic Python and Shell skills

Field and Mapping skills: ArcGIS and QGIS, Trimble and Garmin GPS units, field surveys, ecological sampling methodologies, camera traps

Professional References

1. **Dr. Elizabeth Wolkovich – primary advisor**
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   University of British Columbia
   3041 - 2424 Main Mall
   Vancouver, BC V6T 1Z4
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   Harvard University
   16 Divinity Ave., Room 3119
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   Phone: 617-496-0603

3. **Dr. Laura Marx**
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   Address: The Nature Conservancy
   The Felt Building
   136 West Street, Suite 202
   Northampton, MA 01060
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4. **Dr. Benjamin Cook**
   Email: benjamin.i.cook@nasa.gov
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   NASA Goddard Institute for Space Studies
   2880 Broadway
   New York, NY 10025 USA
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PhD Dissertation Abstract

Temperate tree and shrub species are at risk of damage from late spring freezing events, however the extent of damage and the frequency and intensity of these events is still largely unknown. Individuals that initiate budburst before the last spring freeze are at risk of leaf tissue loss, damage to the xylem, and slowed, or even stalled, canopy development. These damaging events are called false springs and have the potential to detrimentally affect forest growth and sustainability, which can result in highly adverse ecological and economic consequences. It is crucial for scientists and management teams to have a better understanding of false spring future trends in order to better conserve our forest ecosystems.

Chapter 1: ***Rethinking false spring risk***

Climate change has brought renewed interest to a major factor that shapes the life history of many non-tropical plant species: false spring events. While increased interest has led to a growing number of studies, much of the research takes a simplified view of these events, which—I argued—can lead to incorrect estimates and forecasting. Combining theory from ecology, climatology, physiology, biogeography and crop science we examined the effects of false springs, and the complexity of factors that drive plants' risk to frost damage.

Chapter 2: ***Climate change reshapes the drivers of false spring risk across European trees***

Here, I asked which climatic and geographic factors are the strongest predictors of false springs across six tree species, and how these predictors have shifted with recent climate change. By investigating leafout observations of six deciduous tree species from Europe, we unraveled the effects of species, spring temperature, elevation, distance from the coast and NAO index on false spring risk with climate change. We found that recent warming has reshaped the influence of these factors and magnified species-level variation in false spring risk.

Chapter 3: ***False spring damage to temperate tree saplings is amplified with winter warming***

For this experiment, I investigated the interplay of false spring events and warmer winters (generally expected to reduce chilling) across eight temperate deciduous tree species examining a suite of phenological, growth and leaf tissue traits. I found that false springs increased tissue damage, decreased leaf toughness and leaf thickness, and slowed budburst to leafout timing---extending the period of maximum freezing risk. Chilling, however, shortened this period of maximum risk, even under false spring conditions, thus compensating for some of the more adverse phenological effects of false springs. Despite major shifts in phenology from false springs and chilling I did not find evidence of phenological reordering within the community of species we studied. The results instead suggest climate change will reshape forest communities through impacts on growth and leaf traits from the coupled effects of false springs and warmer winters under future climate change.

Chapter 4: ***Assessing budburst phenology observations and simulations to better understand growing degree day models and methods***

Often we use mixed models to answer ecological questions, though we do not always understand the intricacies of the model output, nor do we investigate what is missing from the model output. Here, I work to understand mixed models using simulation data and test myriad hypotheses through these simulations. These methods can be applied to many ecological questions investigating climate data across global habitats but I specifically investigate spring plant phenology and how using different methods to measure climate can impact predictions. Understanding and predicting spring plant phenology is essential for determining growing season length and predicting and individual's risk of false spring under climate change.

Understanding the effects of climate change on forest resilience and carbon storage in southern Appalachia

Climate change is impacting plant and animal communities, which can ultimately reshape ecosystem services and forest management practices those communities support. Many plant and animal species are under threat from warming and must rapidly adapt through phenological shifts and/or range shifts northward to avoid harsher southern climatic conditions [Parmesan & Yohe, 2003; Schwartz et al., 2006]. There is increasing evidence that climate change is exasperated at higher elevations [Giorgi et al., 1997; Rangwala & Miller, 2012; Pepin et al., 2015] and species' ranges could be restricted in these areas, potentially leading to regional extinction [Bachelet et al., 2001; Potter et al., 2008]. Thus, through the effects of stress and disturbance from warming, tree species' migration will be adversely affected, leading to profound impacts on forests and carbon sinks [Opdam & Wascher, 2004].

Natural forests are some of the most biodiverse habitats in the United States [White & Miller, 1988] and with climate change, the southeastern forests of Appalachia (Figure 1) are predicted to be under threat from increased wildfires and rapid conversion to savanna [Bachelet et al., 2001]. Due to exploitative logging, clearcutting, grazing and wildfires at mid-elevations, these forests have become less complex over time, converted from historically mixed-oak stands to more homogenized stands of yellow poplar or red maple and American beech [Runkle, 1982; Lorimer, 1989; Rentch et al., 2003a, 2003b]. Climate change coupled with rapid land-use change is resulting in the creation of gaps of varying size within forest canopies [Canham et al., 1999]. The effects of these gaps on forest recruitment and resilience---or the ability of a forest to recover after a disturbance---are not fully understood.

Figure 1: Picture from research site in southern Appalachian forest in Asheville, NC.

Climate change is impacting forests in myriad ways—some of which are positive (i.e., increased CO2 fertilization and longer growing seasons)—but many are detrimental such as rising temperatures and decreasing precipitation leading to increased tree mortality from stress and drought [Ayres & Lombardero, 2000; Bachelet et al., 2001; Lloyd & Bunn, 2007; Allen et al., 2010]. Repeated incidence of drought generally leads to increased vulnerability and subsequent decreases in forest resilience [Allen et al., 2010; Anderegg et al., 2020]. Understanding initial drought tolerance is therefore essential to predict future shifts in forest community dynamics. Some species will be more at risk of pests and pathogens following a drought and other habitats will have larger microclimatic variation, leading to a mosaic of drought risk within a forest [Ayres & Lombardero, 2000; Anderegg et al., 2020]. By assessing both inter- and intra-specific variation in drought tolerance, pest damage and microclimatic impact, we can better predict the effects of climate change on temperate forests.

The combined effects of increasing temperatures and decreasing precipitation is impacting tree species differently, with extensive effects on drought-intolerant species leading to northward and westward range shifts [Fei et al., 2017]. Additionally, there is growing evidence that southern Appalachian forests are transitioning to shade-tolerant, fire-resistant species such as red maple and American beech [Fei et al., 2017; Knott et al., 2019] and there is a reduction in foundation species' regeneration [Izbicki et al., 2020].

Oak species (i.e., Quercus genus) are considered foundation species in many temperate systems [Ellison et al., 2005; Mitchell et al., 2019] and are generally fire-resistant, though they are also shade-intolerant, thus forest management teams are working to regenerate oaks by establishing gaps in canopies in combination with prescribed fires. Recent studies suggest gaps must be large enough for oaks to regenerate successfully and demonstrate significant increases in photosynthetic rates and growing season lengths [Zhang & Yi, 2020]. Oaks greatly influence forest hydrology, nutrient cycling [Arthur et al., 2012] and contribute to increases in biodiversity [Mitchell et al., 2019; Izbicki et al., 2020]. It is therefore essential to understand the effects of climate change on southern Appalachian forest habitats—with a strong focus on oak species—and the cascading impacts to our crucial carbon sinks.

Disturbance to canopy trees and the creation of gaps in forests can lead to a multitude of effects including increased competition through light availability as well as changes to soil temperature, moisture and microbial community structure. Canopy disturbance often leads to increases in soil nitrogen availability, which can allow for understory species to out-compete regenerating seedlings and saplings like oaks [Mladenoff, 1987; Taylor et al., 2017]. Canopy gaps—especially more northern gaps, where sun angles are lower—with higher soil temperatures have significantly higher total growing season carbon flux than those with lower temperatures and less light availability [Raymond et al., 2006; Schatz et al., 2012]. Thus, identifying microclimatic soil variation among gap and closed-canopy sites is essential for accurate carbon flux forecasting and, by maintaining mixed-forest growth, there is a reduction in risk from the adverse effects of global climate change.

RESEARCH OBJECTIVES:

The overall aim of the proposed research is to understand how gap size impacts the reestablishment and maintenance of mixed-forest and regenerative growth. To do this I will investigate gap sites of varying sizes and compare these to closed-canopy sites in the southern Appalachian Mountains to assess (1) forest recruitment of the dominant species and report diversity and richness of shade-tolerant vs shade-intolerant tree and shrub species over time, (2) drought tolerance of the dominant tree species across the gap and closed-canopy sites using a greenhouse and phytotron cutting experiment and (3) soil microbial community structure, variability in soil nutrients, soil temperature, soil moisture and incident PAR of the gap sites versus the closed-canopy sites to understand and predict the impacts of climate change on temperate forest resilience.

Hypothesis 1: *The effects of gap size and location will impact species composition, recruitment and phenology*. Using various gap types in comparison to closed-canopy forested sites in the southern Appalachian Mountains, I will examine 10 different woody plant tree and shrub species—with overlapping phylogenies (Figure 2)—with 24 individuals per species: *Acer rubrum*, *Acer saccharum*, *Betula nigra, Corylus cornuta, Carpinus caroliniana, Fagus grandifolia, Hammamelis virginiana, Quercus alba, Quercus montana* and *Quercus rubra*. For each individual, I will measure a radius of 5m around each tree and record all species present within that circle. With this experiment I propose to: evaluate percent herbivory of the focal individual and monitor herbivory over the growing season; quantify and classify the number of seedlings and saplings of each dominant tree species within the site to evaluate recruitment; measure the diameter at breast height (DBH) for all trees and shrubs within the site to understand tree age and growth; monitor

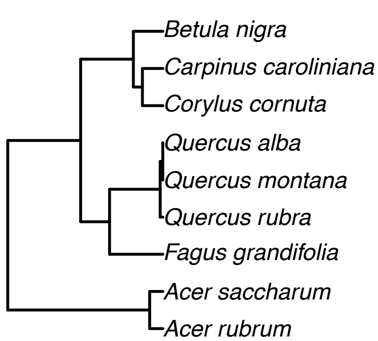

Figure 2: Phylogenetic tree of the focal tree species.

early season phenology (i.e., budburst and leafout) of the focal individual and also late season phenology (i.e., leaf drop and budset); and record carbon sequestration measurements.

Expected Outcomes and Significance: This experiment will greatly improve forecasts for mixed-forest, mid-elevation sites under climate change by developing equations and metrics of inter- and intraspecific variation in fitness to be used in climate models. I expect sites at the northern edge of large gap sites (i.e., gaps with diameter as larger or larger than the height of the surrounding canopy trees [Raymond et al., 2006]) will have longer growing seasons, warmer soil temperatures and greater carbon flux than closed-canopy sites. I also anticipate that mixed-forest, heterogeneous sites will have larger levels of recruitment and soil nutrients than more homogenized sites. Understanding the effects of warming—and the subsequent risk of disturbances—on temperate forests is essential for informing climate forecast models and determining forest resilience.

Hypothesis 2: *Drought tolerance of the dominant tree species will vary across the gap and closed-canopy sites*. Using a phytotron and greenhouse experiment, I will take cuttings from the focal tree individuals in Experiment 1 to test drought tolerance coupled with warming nighttime temperatures. Nighttime temperatures are increasing at a faster rate than daytime temperatures with warming [Fu et al., 2016] and impact individual phenologies differently than daytime temperatures. There is also evidence for increased stress on plants from nighttime temperatures [Grinevich et al., 2019]. We will additionally expose control and treatment individuals to varying increases in nighttime temperatures in the early season and during drought conditions. In the fall of 2021—after budset and before complete leaf drop, I will take 10-16 cuttings of approximately 30cm for each individual. Upon delivery to the lab, I will place the cuttings in dormancy conditions of 4°C for 10 weeks (Figure 3), rotating individuals every two weeks to minimize bias from possible phytotron effects. After 10 weeks, I will place the individuals in phytotron conditions and expose to 8 hour photoperiod and 15°C daytime temperatures and 10°C, 12°C and 15°C nighttime temperatures until leafout. Once full leafout is achieved, I will expose individuals to three levels of drought conditions: (1) control group, (2) little to no precipitation, (3) medium levels of precipitation, coupled with a full factorial experiment of increased nighttime temperatures (+0°C, +2°C and +5°C) for each drought group for a total of 9 treatments. Phenology, mortality, soil moisture, soil temperature and nutrient levels will be evaluated. After 8 weeks of drought conditions and increased nighttime temperatures, we will water half of the treatment groups to evaluate recovery by observing end of season growth through phenological measurements, canopy development, mortality and shoot apical meristem damage [Burgess, 2006; Blackman et al., 2009; Brodribb & Cochard, 2009].

Figure 3: Example of phytotron experiment

Expected Outcomes and Significance: By evaluating initial drought tolerance across the 10 dominant species of southern Appalachia coupled with nighttime warming, I will be able to better predict the effects of increasing temperatures and decreasing precipitation from climate change on mixed-forest growth. I expect higher interspecific variability in drought tolerance and also low levels of intraspecific variation across the gap size and locations, with individuals from larger gaps having higher levels of drought tolerance than closed-canopy individuals due to increased heat tolerance. In addition, I expect individuals exposed to higher nighttime temperatures will demonstrate increased mortality and decreased recovery from drought. These findings are critical for forecasts as stress and disturbance are predicted to increase with warming.

Hypothesis 3: *The variability in soil temperature, soil moisture and soil nutrients will increase with increased gap size*. Understanding soil microbial community structure is a strong predictor for site response to environmental change. I will record hourly soil temperature at each site using Hobo Loggers buried 5cm below the soil surface and evaluate light availability using hemispherical canopy photos and then analyzing photos using Gap Analyzer software [Burton et al, 2014, Canham, 1990, Forrester et al., 2014]. Volumetric soil moisture will be measured monthly using a portable soil moisture probe and throughfall will be recorded for each field season. I will collect soil cores from 0-10cm and 10-20cm for each field season and compare to soil cores collected at the same or similar sites from 2017 to compare soil microbial functional groups and nutrient content. I will then submit the soil cores to NCSU Soil Lab for standard nutrient analysis and to Microbial ID lab (Newark, DE) for PLFA analysis. Using structural equation modeling, I will evaluate the relationship of vertical and horizontal structure and soil microbial community structure.

Expected Outcomes and Significance: Through the interactive effects of climate change and rapid land-use change, gap size and location will influence soil microclimatic conditions as well as nutrient availability. I expect light availability and soil temperatures to be greatest in the northern portion of the gap, while maximum soil moisture will occur in the southern portion of the gap [Schatz et al., 2012; Raymond et al., 2006]. By examining belowground responses to canopy gaps through soil moisture, temperature and nutrient composition, I will be able to greatly improve predictive climate models for the region and likely contribute to global modelling systems.

JUSTIFICATION OF SPONSORING SCIENTIST AND HOST INSTITUTION:

The proposed project and broader impact programs will be carried out in the lab of Dr. Zakiya Leggett in the College of Natural Resources at North Carolina State University. This project will allow me to transition to career independence and help broaden my skills from phenology observations and modelling [Chamberlain et al., 2020; Chamberlain et al., 2019; Ettinger et al., 2020; Furze et al., 2020] to studying ecosystem-scale processes---with a focus on both above and belowground systems---and forest resilience. In addition to developing my scientific skills, I will also leverage my leadership, professional development and diversity and inclusion initiatives. By joining the Leggett Lab, I will be able to further develop these skills while maintaining an interface with the nonprofit sector but I will also gain new research skills in soil carbon and nutrient cycling measurements. I have chosen to work with Dr. Leggett because my career goals are to work with BIPOC communities and, in the Leggett lab, I will have the opportunity to learn new, valuable teaching and mentoring skills---with a focus on BIPOC training---as well as expand my research and scientific toolkit to be more field based and incorporate more intensive field measurement skills.

BROADER IMPACTS

Teaching: I will further sharpen my skills in meeting facilitation for ecology and natural resources by co-mentoring graduate students in the College of Education focused on a project entitled Natural Resources Diversity Curriculum Integration. The main project goal is to review entry level courses at North Carolina State University and develop modules to incorporate diversity and inclusion into these courses since they impact a large body of students early in their college experience. I will also co-facilitate working groups with an NSF funded RCN - The Undergraduate Network for Increasing Diversity of Ecologists (UNIDE). The project aims to build a sustainable and interdisciplinary network of ecologists, educators and social scientists to address how cultural and social barriers impact human diversity in ecology and environmental disciplines (EE). These two opportunities will help develop skills in the area of cross-sector engagement and meeting facilitation.

Mentoring: I propose to establish a mentorship pipeline for BIPOC individuals within the National Needs Fellowship (NNF) Program and the Doris Duke Conservation Scholars (DDCS) Program—where Dr.Leggett is lead PI and campus director. Both the NNF and DDCS programs have goals of recruiting and increasing diverse students in the field of ecology. Under the pipeline program I plan to develop, I will train graduate students, who will train undergraduate students who will in turn train high school students, with the goal of increasing diversity and interest in ecology at all levels. By providing this training. Dr. Leggett is developing/building upon an existing training developed for the Doris Duke Conservation Scholars Program for mentors that have never advised BIPOC students for her NNF program, which will be used for the pipeline training program.

Career Development and Community-level Outreach: In addition to my work with increasing diversity and inclusion at all levels, I intend to attend webinars and workshops offered by North Carolina State University designed for postdocs to hone project development and grant writing skills. I will also assist with grant writing to develop a collaborative project with The Nature Conservancy, which is working towards a project to evaluate forest carbon sequestration and increasing diversity and inclusion in program participants. I will also help Dr. Leggett develop research and education grants including expanding the National Needs Fellowship Program to include more students and developing a funding source for a dual degree program she has developed with Tuskegee University and North Carolina State University. Finally, I will work alongside Dr. Leggett, Dr. Asia Dowtin and Dr. Caren Cooper in the development and implementation of a large scale citizen science project which will involve students and communities across the nation that focuses on urban forestry/tree cover and BIPOC communities. Research has shown that BIPOC students are drawn to scientific pursuits that help local communities but deterred from disciplines that promote science as an isolating field [Puritty et al., 2017]. Therefore this citizen science project will provide an opportunity for these students and the participating public to nurture their interest in science while bringing awareness to their communities.

PROPOSED RESEARCH TIMELINE:

Year	Semester	Research	Broader Impacts
2021	Summer	Identify focal individuals and plots Deploy hobo loggers Record observations for Exp 1 & 3	Develop IDP Recruit students for pipeline program Assist with citizen science study Co-facilitate UNIDE working group
2021	Fall	Record phenology; take cuttings for Exp 2	Begin mentoring and training students
2021	Spring	Set up Exp 2 Begin drought treatments for Exp 2	Maintain mentorship program
2022	Summer	Record phenology for Exp 1 Record observations for Exp 1 & 3	Train students in field skills Supervise/advise undergraduates
2022	Fall	Record phenology & Begin analyses	
2023	Spring	Prepare manuscripts for submission	Maintain pipeline program

References

Allen, C.D., Macalady, A.K., Chenchouni, H., Bachelet, D., McDowell, N., Vennetier, M., Kitzberger, T., Rigling, A., Breshears, D.D., Hogg, E.T., Gonzalez, P., Fensham, R., Zhang, Z., Castro, J., Demidova, N., Lim, J.H., Allard, G., Running, S.W., Semerci, A. & Cobb, N. (2010) A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *Forest Ecology and Management* **259**, 660 – 684, adaptation of Forests and Forest Management to Changing Climate.

Anderegg, W.R.L., Trugman, A.T., Badgley, G., Konings, A.G. & Shaw, J. (2020) Divergent forest sensitivity to repeated extreme droughts. *Nature Climate Change* .

Arthur, M.A., Alexander, H.D., Dey, D.C., Schweitzer, C.J. & Loftis, D.L. (2012) Refining the oak-fire hypothesis for management of oak-dominated forests of the eastern United States. *Journal of Forestry* **110**, 257–266.

Ayres, M.P. & Lombardero, M.J. (2000) Assessing the consequences of global change for forest disturbance from herbivores and pathogens. *Science of The Total Environment* **262**, 263–286.

Bachelet, D., Neilson, R.P., Lenihan, J.M. & Drapek, R.J. (2001) Climate change effects on vegetation distribution and carbon budget in the united states. *Ecosystems* **4**, 164–185.

Blackman, C.J., Brodribb, T.J. & Jordan G.J. (2009) Leaf hydraulics and drought stress: response, recovery and survivorship in four woody temperate plant species. *Plant, Cell & Environment* **32**, 1584-1595.

Brodribb, T.J. & Cochard, H. (2009) Hydraulic failure defines the recovery and point of death in water-stressed conifers. *Plant Physiology* **149**, 575-584.

Burgess, S.S.O. (2006) Measuring transpiration responses to summer precipitation in a Mediterranean climate: a simple screening tool for identifying plant water-use strategies. *Physiologia Plantarum* **127**, 404-412.

Canham, C.D., Kobe, R.K., Latty, E.F. & Chazdon, R.L. (1999) Interspecific and intraspecific variation in tree seedling survival: effects of allocation to roots versus carbohydrate reserves. *Oecologia* **121**, 1–11.

Chamberlain, C. J., Cook, B. I., García de Cortázar-Atauri, I., & Wolkovich, E. M. (2019). Rethinking false spring risk. *Global change biology* ***25***, 2209-2220.

Chamberlain, C. J., Cook, B. I., Morales-Castilla, I., & Wolkovich, E. M. (2020). Climate change reshapes the drivers of false spring risk across European trees. *New Phytologist*.

Ellison, A.M., Bank, M.S., Clinton, B.D., Colburn, E.A., Elliott, K., Ford, C.R., Foster, D.R., Kloeppel, B.D., Knoepp, J.D., Lovett, G.M., Mohan, J., Orwig, D.A., Rodenhouse, N.L., Sobczak, W.V., Stinson, K.A., Stone, J.K., Swan, C.M., Thompson, J., Von Holle, B. & Webster, J.R. (2005) Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. *Frontiers in Ecology and the Environment* **3**, 479–486.

Ettinger, A. K., Chamberlain, C. J., Morales-Castilla, I., Buonaiuto, D. M., Flynn, D. F. B., Savas, T., Samaha, J.A. & Wolkovich, E. M. (2020). Winter temperatures predominate in spring phenological responses to warming. *Nature Climate Change*, 1-6.

Fei, S., Desprez, J.M., Potter, K.M., Jo, I., Knott, J.A. & Oswalt, C.M. (2017) Divergence of species responses to climate change. *Science Advances* **3**.

Fu, Y.H., Liu, Y., De Boeck, H.J., Menzel, A., Nijs, I., Peaucelle, M., Peñuelas, J., Piao, S. & Janssens, I.A. (2016) Three times greater weight of daytime than of night-time temperature on leaf unfolding phenology in temperate trees. *New Phytologist* **212**, 590-597.

Furze, M. E., Huggett, B. A., Chamberlain, C. J., Wieringa, M. M., Aubrecht, D. M., Carbone, M. S., Walker, J.C., Xu, X., Czimczik, C.I. & Richardson, A. D. (2020). Seasonal fluctuation of nonstructural carbohydrates reveals the metabolic availability of stemwood

reserves in temperate trees with contrasting wood anatomy. *Tree Physiology* **40**, 1355-1365.
Giorgi, F., Hurrell, J.W., Marinucci, M.R. & Beniston, M. (1997) Elevation dependency of the surface climate change signal: a model study. *Journal of Climate* **10**, 288–296
Grinevich, D.O., Desai, J.S., Stroup, K.P., Duan, J., Slabaugh, E. & Doherty, C.J. (2019) Novel transcriptional responses to heat revealed by turning up the heat at night. *Plant Molecular Biology* **101**, 1-19.
Izbicki, B.J., Alexander, H.D., Paulson, A.K., Frey, B.R., McEwan, R.W. & Berry, A.I. (2020) Prescribed fire and natural canopy gap disturbances: Impacts on upland oak regeneration. *Forest Ecology and Management* **465**, 118107.
Knott, J.A., Desprez, J.M., Oswalt, C.M. & Fei, S. (2019) Shifts in forest composition in the eastern United States. *Forest Ecology and Management* **433**, 176–183.
Lloyd, A.H. & Bunn, A.G. (2007) Responses of the circumpolar boreal forest to 20th century climate variability. *Environmental Research Letters* **2**, 045013.
Lorimer, C.G. (1989) Relative effects of small and large disturbances on temperate hardwood forest structure. *Ecology* **70**, 565–567.
Mitchell, R.J., Bellamy, P.E., Ellis, C.J., Hewison, R.L., Hodgetts, N.G., Iason, G.R., Littlewood, N.A., Newey, S., Stockan, J.A. & Taylor, A.F.S. (2019) Collapsing foundations: The ecology of the British oak, implications of its decline and mitigation options. *Biological Conservation* **233**, 316–327.
Mladenoff, D.J. (1987) Dynamics of nitrogen mineralization and nitrification in hemlock and hardwood treefall gaps. *Ecology* **68**, 1171–1180.
Opdam, P. & Wascher, D. (2004) Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. *Biological conservation* **117**, 285–297.
Parmesan, C. & Yohe, G. (2003) A globally coherent fingerprint of climate change impacts across natural systems. *Nature* **421**, 37.
Pepin, N., Bradley, R.S., Diaz, H.F., Baraer, M., Caceres, E.B., Forsythe, N., Fowler, H., Greenwood, G., Hashmi, M.Z., Liu, X.D., Miller, J.R., Ning, L., Ohmura, A., Palazzi, E., Rangwala, I., Schöner, W., Severskiy, I., Shahgedanova, M., Wang, M.B., Williamson, S.N., Yang, D.Q. & Group, M.R.I.E.W. (2015) Elevation-dependent warming in mountain regions of the world. *Nature Climate Change* **5**, 424–430.
Potter, K.M., Frampton, J., Josserand, S.A. & Nelson, C.D. (2008) Genetic variation and population structure in fraser fir (*Abies fraseri*): a microsatellite assessment of young trees. *Canadian Journal of Forest Research* **38**, 2128–2137.
Purrity, C., Strickland, L.R., Alia, E., Blonder, B., Klein, E., Kohl, M.T., McGee, E., Quintana, M., Ridley, R.E., Tellman, B. & Gerber, L.R. (2017) Without inclusion, diversity initiatives may not be enough. *Science* **357,** 1101-1102.
Rangwala, I. & Miller, J.R. (2012) Climate change in mountains: a review of elevation-dependent warming and its possible causes. *Climatic Change* **114**, 527–547.
Raymond, P., Munson, A.D., Ruel, J.C. & Coates, K.D. (2006) Spatial patterns of soil microclimate, light, regeneration, and growth within silvicultural gaps of mixed tolerant hardwood white pine stands. *Canadian Journal of Forest Research* **36**, 639–651.
Rentch, J.S., Fajvan, M.A. & Hicks, Ray R., J. (2003a) Spatial and temporal disturbance characteristics of oak-dominated old-growth stands in the Central Hardwood Forest region. *Forest Science* **49**, 778–789.
Rentch, J.S., Fajvan, M.A. & Hicks, R.R. (2003b) Oak establishment and canopy accession strategies in five old-growth stands in the Central Hardwood Forest region. *Forest Ecology and Management* **184**, 285 – 297.
Runkle, J.R. (1982) Patterns of disturbance in some old-growth mesic forests of eastern North America. *Ecology* **63**, 1533–1546.

Schatz, J.D., Forrester, J.A. & Mladenoff, D.J. (2012) Spatial patterns of soil surface C flux in experimental canopy gaps. *Ecosystems* **15**, 616–623.
Schwartz, M.D., Ahas, R. & Aasa, A. (2006) Onset of spring starting earlier across the Northern Hemisphere. *Global Change Biology* **12**, 343–351.
Taylor, B.N., Patterson, A.E., Ajayi, M., Arkebauer, R., Bao, K., Bray, N., Elliott, R.M., Gauthier, P.P., Gersony, J., Gibson, R., Guerin, M., Lavenhar, S., Leland, C., Lemordant, L., Liao, W., Melillo, J., Oliver, R., Prager, C.M., Schuster, W., Schwartz, N.B., Shen, C., Terlizzi, K.P. & Griffin, K.L. (2017) Growth and physiology of a dominant understory shrub, *Hamamelis virginiana*, following canopy disturbance in a temperate hardwood forest. *Canadian Journal of Forest Research* **47**, 193–202.
White, P.S. & Miller, R.I. (1988) Topographic models of vascular plant richness in the southern Appalachian high peaks **76**, 192–199.
Zhang, M. & Yi, X. (2020) Seedling recruitment in response to artificial gaps: predicting the ecological consequence of forest disturbance. *Plant Ecology* **1**.

Statement Of Relevance and Future Interactions with NOAA

Natural forests are some of the most biodiverse habitats in the United States and with recent climate change, the southeastern forests of Appalachia are predicted to be under threat from increased temperatures and rapid conversion to savanna. Due to exploitative logging and wildfires at mid-elevations, these forests have become less complex over time, converted from historically mixed-oak stands to more homogenized stands. Climate change coupled with rapid land-use change is resulting in the creation of gaps of varying size within forest canopies. These gaps are introducing a mosaic of microclimatic conditions within an ecosystem but the effects of these gaps on forest recruitment and resilience are not fully understood and more research is needed.

Experiment 1: Using the NOAA daily climate data, I will investigate the effects of gap size and canopy closure on species composition, seedling and sapling recruitment and fitness under climate change. I will evaluate the intra- and interspecific variation in tree fitness and mortality across each site and record carbon sequestration. This approach will give me new techniques and experiences that will allow me to develop my future career goals of forest restoration by investigating forest diversity and recruitment. Our understanding of how canopy closure coupled with climate change affects dominant tree species has been largely unexamined but has critical implications, especially at vulnerable southern, mid-elevation habitats.

Experiment 2: Using historic extreme event and drought data from the NOAA database, I will assess the effects of drought and increasing nighttime temperatures on the dominant tree species of the southern Appalachian mountains and how drought tolerance varies across the gap and closed-canopy sites. Using the same focal individuals from Experiment 1, I will take cuttings from each individual and perform a full factorial experiment of three levels of increased nighttime temperatures with three levels of drought treatments to investigate mortality and canopy development. This experiment will examine the effects of predicted disturbance of climate change under various warming scenarios and offer insight into tree resilience under warming.

Experiment 3: Again, using historic extreme event and drought data in combination with current soil temperature and moisture data, I will examine the variability in soil temperature, moisture and nutrients across closed canopy and gap sites. Using the sites identified from Experiment 1, I will record hourly soil temperature, soil moisture and light availability. I will also collect soil cores for each field season and evaluate the soil nutrients and microbial community. This experiment is essential for understanding the entire ecosystem and the effects of climate change on forests to better maintain our carbon sinks.

FUTURE INTERACTIONS:

The proposed project will help inform climate models, global forecasts and forest management plans to reduce the impact of climate change. My project plan will help generate new regional predictive models to better understand the effects of climate change on southern Appalachian forests, which are also highly valued recreational areas, thus these forecasts could provide crucial information on socioeconomic impacts. In addition, I will attend the American Geophysical Union and present my findings after my first year and try to give public lectures throughout my postdoctoral fellowship to various NOAA laboratories. Also, by using many types of climate data from the NOAA National Centers for Environmental Information database, I will be able to leverage the wealth of weather data to enhance my proposed project and further augment the importance and value of the climate forecasts being produced in this work.

NC STATE UNIVERSITY

College of Natural Resources, Box 8008 Phone: 919-515-8679 Department of Forestry and Environmental Resources
zakiya_leggett@ncsu.edu Raleigh, NC 27695-8008

8 January 2020

Dear UCAR Steering Committee:
As the proposed host scientist, I enthusiastically support the postdoctoral fellowship application of **Catherine Chamberlain**. The proposed project and its defined goals will broaden Catherine's current skill set and provide training in evaluating various ecological parameters at an ecosystem scale level in addition to gaining skills focused on evaluating the impact of soil/belowground processes on these parameters. Specifically this proposal focuses on understanding the effects of climate change on forest resilience in the southern Appalachian forest system.

Catherine has a goal of working in a non-academic field which works well with my career path immediately after graduate school. Having worked in forest industry for 10 years prior to joining the faculty at NCSU I have experience working and navigating successfully in a non-academic environment. During my tenure as a sustainability scientist I learned skills (negotiating, prioritizing and budgeting) not necessarily taught in graduate school. Much of my work involved collaborating with outside agencies (government, non- profits, and community groups) to achieve my company's sustainability goals. I look forward to connecting Catherine with a wide range of contacts to explore her career options. For her postdoc fellowship, I have contacted three scientists that have agreed to serve as collaborators and/or mentors during her time here at NCSU.

Catherine's Team of Amazing Scientists: I will serve as Catherine's **primary advisor**, working with her to coordinate all the field and phytotron experiments along with the training she will receive. Most of my research experience is in soil ecology specifically focused on nutrient cycling and carbon processes/storage. Additionally I have research projects focused on citizen science and diversity and inclusion in forestry/natural resources. I also manage two undergraduate programs (Doris Duke Conservation Scholars Program and Scholars for Conservation Leadership Program) and one graduate program (National Needs Fellowship Program) focused on recruiting BIPOC (Black, Indigenous, and People of Color) students and increasing diversity and inclusion in ecology.

Colleen Doherty is an associate professor in the College of Agriculture and Life Sciences here at **NCSU** has agreed to serve as a **collaborator** for the proposed research project. Colleen is a plant ecologist that focuses on the connections between time and stress in plants. She will assist with the experimental design for the chamber-based experiments examining warm nighttime temperature and provide guidance on controlling for timing effects when sampling. Colleen and I are currently working on a proposal evaluating warm nighttime temperature effects on loblolly pine and industrial hemp.

Tara Keyser is a Director with the **USDA Forest Service Southern Research Station** and an adjunct associate professor in the College of Natural Resources here at NCSU. She has agreed to serve as a **collaborator** for the proposed research project and a **mentor** for Catherine. She and her team manage the research site in the Appalachian Mountains where Catherine will conduct most of her field research. Tara is forest ecologist with a focus on evaluating the effects of anthropogenic and natural disturbance on attributes of ecological complexity. She will assist with the field based portion of the study evaluating the effects of gap size on species composition and seedling and sapling recruitment. Tara has expressed interest in how the overall project's results can help guide some of the future management decisions for the land managed by the Forest Service manages in the Appalachian Mountains. She has also agreed to serve as a mentor for Catherine and will provide insight on working in a non-academic position and within a government agency. Tara and I have served on a graduate student committee together and are co- authoring a publication with that student. Additionally, I have a current graduate student working on a research project on one of Tara's research sites.

Elizabeth (Liz) Kalies is the Director of Science with **The Nature Conservancy (TNC).** Liz is an ecologist and creates the scientific vision for her agency through anticipating challenges, threats and opportunities. She also oversees field research and provides direction for future research. Liz currently has foresters on her team that are interested in Catherine's proposed work and has projects that can add value to the research questions being addressed. Liz also expressed that there are collaborative groups like the Fire Learning Network (FLN) and others that would be interested in Catherine sharing her research findings. Liz serves in a position Catherine has expressed interest in shadowing and she has agreed to serve as a **mentor** for her. Liz is planning for a shadowing experience to occur on a monthly basis and as opportunities arise. Additionally, she will create and foster opportunities for Catherine to be exposed to the larger TNC network. Liz currently serves as one of the Career Partners for the National Needs Fellowship program I manage and we will co-advise a Fellow in Fall 2021 on a proposed project focused on environmental justice and bringing minority landowners into the forest carbon program.

This "Dream Team" network of scientists that will assist with developing new scientific and professional skills for Catherine in addition to providing connections and opportunities that directly support her future career goals. She will gain perspectives from three different people that have experience working in non-academic positions (forest industry, government, and non-profit). The unique training environment here in North Carolina will allow Catherine to be involved in important research in a forest ecosystem in her area of interest while being directly mentored with scientists working in non-academic positions.

Career Development Activities: I have discussed with Catherine what she is hoping to gain for her postdoctoral fellowship experience. We will revisit these conversations immediately upon her starting her position and will work together to develop an **Individual Development Plan (IDP)**. It will not only focus on her postdoc experience but would also include the steps required to get to the next phase of her career. Since Catherine has an interest in a non- academic career, her IDP will include areas where she needs more development to fit her specific career goals. We will also conduct an assessment provided by NCSU's Office of Postdoctoral Affairs (OPA) to determine her areas of strengths and weaknesses so we can identify what trainings and professional development opportunities will be most beneficial. She has also expressed interest in the grant writing and career exploration/consultation services offered through the OPA.

Catherine and I will have one on one meetings weekly and she will meet with her full team of collaborators and mentors on a monthly basis to provide updates on her project development. Separately she will meet with Colleen and Tara on a weekly basis when designing and preparing for the phytotron and field portions of the proposed research.

Teaching: Catherine is planning to develop a 1 credit hour course for Ph.D. students on how to develop postdoctoral grant proposals. She also plans to take these course materials and condense portions of the information into a webinar that can be offered virtually to students globally. She will advertise this webinar to many of the networks I am connected with that involve BIPOC graduate students in ecology. Additionally, I teach a large (~300 student) Introduction to Environmental Science course and she will be offered several opportunities to guest lecture.

NCSU's OPA offers a Teaching and Communication certificate which trains postdocs in various areas related to preparing a job talk, creating a professional ePortfolio, communicating to diverse learners, etc. Catherine has expressed interest in this program and plans to participate.

Mentoring: Catherine has expressed an interest in recruiting and mentoring BIPOC students. As mentioned previously, I serve as PI and campus director for a National Needs Fellowship program (BIPOC graduate students) and the Doris Duke Conservation Scholars Program (BIPOC undergraduate students). Catherine will be directly involved in the recruitment and interviewing efforts associated with the selection of the Scholars and the Fellows for at least one of the selection cycles. Additionally, she will develop a mentor pipeline where some of these students will participate. The graduate students will mentor the undergraduates who will then mentor high school students that are a part of a program we have here at NCSU called EnvironMentors.

Public Science/Community Outreach: Since Catherine is interested in a non-academic position I will ensure she has lots of experience conveying her scientific findings to the public. I have experience in this area from my previous position within forest industry as well as a position I held at the North Carolina Museum of Natural Sciences. She will present once a year as part of their Science Café series. Additionally, Tara and Liz have plans for her to present to their teams as well as at some of the local and national conferences they attend. Catherine will also assist with finalizing a citizen science project I am currently developing with a team of scientists evaluating tree cover in BIPOC communities.

In order to **assess Catherine's needs** in research, teaching and career development skills we will meet monthly to formally address where her current progress lines up with her planned IDP goals and timelines. If there are areas where she has fallen behind or where she needs more assistance, then we will develop a plan to address these areas and seek any necessary outside resources.

Connection of Proposed and Ongoing Research: The goal of the Leggett lab is to build interdisciplinary research projects that provide informative outcomes that can be utilized by a broad range of people (scientists, land managers, agencies, K-12 students, etc.). Working collaboratively with other scientists and professionals has become a great way of accomplishing this goal and a theme within my lab group. I currently have students focused on evaluating soil ecology and microbial communities on sites with artificial and natural gaps in the Appalachian Mountains on the same or similar research sites as those proposed in Catherine's project. Catherine's proposed project will broaden and strengthen this work. This strengthened connection is essential for understanding the impacts on a larger scale which is inclusive of the aboveground ecosystem dynamics.

Limitations: There will not be any issues with continuing or transferring information from this project. I will encourage Catherine to continue to collaborate on this and any associated projects that develop from this experience.

Catherine has proven through her previous research experience that she is an excellent scientist and I will take great pleasure in providing her with an opportunity to expand her knowledge. My primary objective for mentoring/advising Catherine will be to help her continue to excel as a scientist and develop skills as an effective leader for her future career goals.

Sincerely,

Zakiya Leggett, Ph.D., Assistant Professor

There is no direct financial overlap of the proposed project with the current funding and none of the current funding provides postdoctoral support.

Leggett Current and Pending:

- RCN-UBE: The Undergraduate Network for Increasing Diversity of Ecologists (UNIDE) (Co-PI). National Science Foundation, 2020 – 2025

- Doris Duke Conservation Scholars Program (PI). Doris Duke Charitable Foundation, 2020 – 2024

- Forestry of the Future: Improving student readiness and workforce participation of underrepresented minority populations in forest resources (PI). USDA NIFA National Needs Fellowship, 2019 – 2023

- Improving Establishment Practices of Pure and Mixed Hardwood by Refining Soil Suitability Indices for Black Walnut and Evaluating Soil Microbial Communities (Co-PI). USDA Forest Service, 2019 – 2021

- Scholars for Conservation Leadership Program (PI).Land Trust Alliance, 2019 – 2021

- GIS analysis of the benefits of State and Private Forest lands for water supply in the southern United States (Co-PI). USDA Forest Service, 2018 – 2020

- Feasibility of hemp intercropped with loblolly-pine (PI). *(PENDING)* NC Department of Agriculture & Consumer Services

Doherty Current and Pending:

- Time and Space, determining the interactions between the circadian clock and microgravity (PI). NASA ROS-Bio, 2018-2021

- From the Perspective of the Target, a Cis-Regulatory Perspective on the Effects of Microgravity (PI). NASA Appendix G Space Biology, 2019-2021

- Multidisciplinary Graduate Training in Advanced Technologies for High Yield Sustainable Agriculture (Co-PI). USDA NIFA National Needs Fellowship Program, 2016 - 2021

Keyser Current: ***(no pending)***

- Increasing ecological complexity of southern Appalachian mixed-oak forests via disturbance-based management (Co-PI). USDA AFRI NIFA, Program Area 1, 2019 – 2023

Kalies (no current or pending)

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Education and Training

Tuskegee University	Tuskegee, AL	Natural Resources	B.S., 1999
Duke University	Durham, NC	Forestry	M.F., 2000
North Carolina State University	Raleigh, NC	Forest Soils	Ph.D., 2004

Research and Professional Experience

2016 – current **Assistant Professor,** North Carolina State University, Raleigh, NC
2015-2016 **Principal Advisor/Owner,** Sustainable Innovative Solutions, LLC, RTP, NC
2004-2014 **Sustainability Scientist,** Weyerhaeuser Company, Vanceboro, NC
2000-2004 **Graduate Research Assistant**, North Carolina State University, Raleigh, NC
1999 **Soil Science Student Trainee,** USDA Forest Service SRS, Pineville, LA
1998-2000 **Research Assistant**, Duke University School of the Environment, Durham, NC

Selected Publications

Sealey, B., D. Beasley, S. Halsey, C. Schell, Z. H. Leggett, S. Yitbarek, and N. Harris. 2020. Raising Black Excellence by elevating Black ecologists through collaboration, celebration, and promotion. The Bulletin of the Ecological Society of America. https://doi.org/10.1002/bes2.1765

Riley, N.* C.C. Goller, Z.H. Leggett, D. Lewis, K. Ciccone, and R. R. Dunn. 2020. Catalyzing rapid discovery of gold-precipitating bacteria with university students. Peer J. 8:e8925 https://doi.org/10.7717/peerj.8925 *undergraduate student

Cacho, J.*, M. A. Youssef, W. Shi, G. M. Chescheir, R. W. Skaggs, S. Tian, Z. H. Leggett, E. B. Sucre, J. E. Nettles, C. Arellano. 2019. Impacts on soil nitrogen availability of converting managed pine plantation into switchgrass monoculture for bioenergy. Science of the Total Environment. 654:1326-1336. *graduate student

Cacho, J.*, M. A. Youssef, W. Shi, G. M. Chescheir, R. W. Skaggs, S. Tian, Z. H. Leggett, E. B. Sucre, J. E. Nettles, C. Arellano. 2018. Impacts of forest-based bioenergy feedstock production on soil nitrogen cycling. Forest Ecology and Management. 419-420:227-239. *graduate student

Minick, K.J.*, Z. H. Leggett., E. B. Sucre, T.R. Fox, and B.D. Strahm. 2017. Soil and aggregate-associated carbon in a young loblolly pine plantation: Influence of bioenergy intercropping. Soil Science. 182:233-240. *graduate student

Shrestha, P.*, J.R. Seiler, B.D. Strahm, E.B. Sucre, and Z.H. Leggett. 2016. Soil CO2 efflux and root productivity in a switchgrass and loblolly pine intercropping system. Forests. 7:221 *graduate student

Blazier, M.A., T.R. Clason, H.O. Liechty, Z.H. Leggett, E.B. Sucre, S.D. Roberts, K. Krapfl, and E.D. Vance. 2015. Nitrogen and carbon of switchgrass, loblolly pine, and cottonwood biofuel production systems in the Southeast United States. Forest Science. 14-016.

Minick, K.J.*, B.D. Strahm, T.R. Fox, E. Sucre, and Z. H. Leggett. 2015. Microbial nitrogen cycling response to forest-based bioenergy production. Ecological Applications. 25:2366-2381. *graduate student

Strickland, M.*, Z. H. Leggett, E. Sucre, and M. Bradford. 2015. Biofuel intercropping effects on soil carbon and microbial activity. Ecological Applications. 25:140-150. *post-doc researcher

Albaugh, J.M.*, T. Albaugh, R. Heiderman, Z.H. Leggett, J. Stape, K. King, K. O'Neill, and and J.S. King. 2014. Evaluating changes in switchgrass physiology, biomass, and light-use efficiency under artificial shade to estimate yields if intercropped with Pinus taeda. Agroforestry Systems. 88:489-503. *post-doc researcher

Dimov, L., K. J. Howard*, Z. H. Leggett, E. B. Sucre, L. L. Weninegar. 2014. Removal of organic matter from the forest floor in loblolly pine plantations increased ground layer richness and diversity 16 years after treatment. Forest Science. 13-151. *undergraduate student

Mack*, J., J.A. Hatten, E. Sucre, S. Roberts, Z. H. Leggett, and J. Dewey. 2014. The effect of organic matter manipulations on site productivity, soil nutrients, and soil carbon on a southern loblolly pine plantation. Forest Ecology and Management 326: 25-35. *graduate student

Minick, K.J.8, B.D. Strahm, T.R. Fox, E. Sucre, Z. H. Leggett, and J. Zerpa. 2014. Switchgrass intercropping reduces soil inorganic nitrogen in a young loblolly pine plantation located in coastal North Carolina. Forest Ecology and Management. 319:161-168. *graduate student

King, J.S., R. Ceulemans, J.M. Albaugh, S.Y. Dillen, J. Domec, R. Fichot, M. Fischer, Z.H. Leggett, E. Sucre, M. Trnka, and T. Zenone. 2013. The challenge of lignocellulosic bioenergy in a water-limited world. BioScience. 63 (2):102-117

Albaugh, J.A.*, E.B. Sucre, Z.H. Leggett, J.C. Domec, and J.S. King. 2012. Evaluation of intercropped switchgrass establishment under a range of experimental site preparation treatments in a forested setting on the Lower Coastal Plain of North Carolina, U.S.A. Biomass and Bioenergy 46:473:482. *post-doc researcher

Blazier, M.A., T.R. Clason, E.D. Vance, Z.H. Leggett, and E.B. Sucre. 2012. Loblolly pine age density affects switchgrass growth and soil carbon in an agroforestry system. Forest Science 58:485-496.

Leggett, Z. H. and D.L. Kelting. 2006. Fertilization effects on carbon pools in loblolly pine plantations on two upland sites. Soil Science Society of America Journal. 70: 279-286.

Synergistic Activities

- Currently serve as Doris Duke Conservation Scholar Program campus director - The Doris Duke Conservation Scholars Program (DDCSP) provides training, mentorship and internships for students interested in environmental issues and cultural diversity - https://go.ncsu.edu/dorisduke
- Lead PI on National Needs Fellowship (NNF) from USDA NIFA to improve diversity in forestry - https://go.ncsu.edu/nnf-ncsu
- Program Director for The Scholars for Conservation Leadership Program which is a career and leadership development program that aims to expand opportunities for students from underrepresented minority groups in the land conservation field - https://go.ncsu.edu/sclp