2019 Great Smoky Mountains National Park Science Colloquium
Thursday, March 7, 2019 – Park Vista Hotel, Gatlinburg

9:00 Welcome and introductions
Superintendent's Office (Great Smoky Mountains NP) & Todd Witcher (Discover Life in America, Gatlinburg, TN)

9:10 New evidence of long-term fire and forest history from mesic forests of Great Smoky Mountains NP
Sally P Horn (Geography, UTK), Mathew S Boehm, & Chris A Underwood

9:30 Pine and oak mycorrhizal associations in fire zones following the Chimney Tops 2 Fire
Karen W Hughes (Ecology & Evolutionary Biology, UTK), Alexis Case, P Brandon Matheny, Andrew N Miller, Ronald H Petersen, Jennifer Franklin, & Jennifer Schweitzer

9:50 How the 2016 Chimney Tops Fire is affecting plant-soil function in the Smokies
Kendall Beals (Ecology & Evolutionary Biology, UTK)

10:10 Overstory mortality and regeneration following wildfire and prescribed fire
Jennifer Franklin (Foresty, Wildlife & Fisheries, UTK), Matthew Aldrovandi, Karen Hughes, & Jennifer Schweitzer

10:30 BREAK

10:45 Enhancing the progression chronology of the Chimney Tops 2 Fire with radar & ancillary datasets
Steve Norman (US Forest Service)

11:05 Understanding patterns of vegetation structure and distribution across Great Smoky Mountains NP using LiDAR & meteorology data
Jitendra Kumar (Terrestrial Systems Modeling Group, Oak Ridge National Laboratory, Oak Ridge, TN)

11:25 LUNCH

12:45 American black bear (*Ursus americanus*) movements and food-conditioning along the interface of Great Smoky Mountains NP and private land
Jessica Braunstein (Forestry, Wildlife & Fisheries, UTK), Joseph D Clark & William H Stiver

1:05 Conservation genetics of *Geum radiatum* (Rosaceae)
Matt Estep (Appalachian State University, Boone, NC) & Nik Hay

1:25 Monitoring seasonality, distribution, and diversity of dung beetles in the Great Smoky Mountains NP
Margaret Mamantov (Ecology & Evolutionary Biology, UTK) & Kimberly Sheldon

1:45 Morphological polymorphism associated with alternative reproductive tactics in a plethodontid salamander
Todd Pierson (UTK), Jennifer Deitloff, Stanley K Sessions, Kenneth H Kozak, & Benjamin M Fitzpatrick

2:05 BREAK

2:20 Body size scaling in fish and invertebrate communities from eastern US streams
Daniel McGarvey (Center for Environmental Studies, Virginia Commonwealth University, Richmond)

2:40 Stream temperature monitoring and thermal physiology of fishes in southern Appalachian streams
Anna L Kaz (Ecology & Evolutionary Biology, UTK), **Matthew J Troia** (Ecology, Evolution & Organismal Biology, Kennesaw State Univ, Kennesaw, GA) & Xingli Giam

3:00 WORKSHOP: introducing *Species SnapIt & MapIt*, a citizen science program to map Smokies species
Will Kuhn (Discover Life in America, Gatlinburg, TN)

4:00 Conclusions and farewell

POSTER Mountain wave induced extreme wildfire behavior: the deadly eastern Tennessee fires of 2016
Steve Norman, William Christie, William Hargrove (US Forest Service)

*Information for presenting author(s) (bold) shown here; see abstracts for additional author information. UTK = University of Tennessee, Knoxville.

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ABSTRACTS (by last name of presenting author)

How the 2016 Chimney Tops Fire is affecting plant-soil function in the Smokies

Kendall Beals *(kbeals2@vols.utk.edu, Ecology & Evolutionary Biology, Univ Tennessee, Knoxville)*

As global change accelerates in the coming decades, fire events are predicted to increase rapidly in both rate and intensity. Fire can fundamentally alter abiotic and biotic factors that have profound influences on plant and soil communities and the valuable ecosystem services they provide. The effects of fire on interactions between plants and their root-associated soil microbial communities remains largely unexplored. The 2016 Chimney Tops 2 fire in Great Smokies National Park has created a rare opportunity to examine the effects of fire on plant and soil function. Using soils collected from areas of different burn severity within the Park, we conducted a greenhouse experiment to examine how understory perennial plant species grow across a gradient of soil disturbance. Findings from this research contribute to our understanding of the belowground biotic mechanisms behind ecosystem response to disturbances like fire, which is an essential component to land management and restoration as Earth's natural landscapes become increasingly fragmented.

American black bear (*Ursus americanus*) movements and food-conditioning along the interface of Great Smoky Mountains National Park and private land

Jessica Braunstein *(jgiacomi@vols.utk.edu, Univ Tennessee, Knoxville); Joseph D Clark (USGS, Southern Appalachian Research Branch, Knoxville); William H Stiver (Great Smoky Mountains National Park)*

The American black bear, *Ursus americanus*, is an iconic symbol of Great Smoky Mountains National Park (GRSM or park), and the park has adopted a proactive management approach that focuses on preventing the establishment of conflict behavior in bears. However, in recent years, park officials have noticed bears displaying more advanced conflict behavior (i.e., frequenting campground and picnic areas during the daytime). Although park officials speculated that these bears may have developed conflict behavior outside of the park's boundaries, the origin and cause of this behavior was unclear. The aim of this study was to better understand black bear space use within GRSM and on surrounding private lands and identify factors resulting in advanced conflict behavior in the park.

I used isotopic signatures, $\delta^{13}C$ and $\delta^{15}N$, from black bear hairs to distinguish between food-conditioned (FC) and non-food-conditioned (NFC) bears using logistic regression. I estimated annual and seasonal 95% kernel density estimation (KDE) home range, 50% KDE core area sizes, and the proportion of development comprising these areas in relation to mean $\delta^{13}C$. I used conditional logistic regression to estimate a step selection function (SSF) to characterize movement of bears based on landscape characteristics and to evaluate how bears with higher mean $\delta^{13}C$ used the landscape differently. The top logistic regression model used only $\delta^{13}C$ as a predictor variable, and 24 bear hair samples were classified as FC and 37 were classified as NFC out of a total of 61 hair samples. Annual 95% KDE home-range and 50% KDE core area sizes of female bears differed by year (P = 0.003-0.007) but not mean $\delta^{13}C$ (P = 0.230-0.240). Seasonal 95% KDE home-range sizes of female bears differed by season (P = 0.030) but not mean $\delta^{13}C$ (P = 0.318). Seasonal 50% KDE core areas of female bears did not differ by season (P = 0.065) or mean $\delta^{13}C$ (P = 0.238). The mean proportion of development within female 95% KDE home ranges and 50% KDE core areas differed by mean $\delta^{13}C$ ($P < 0.001$), and the mean proportion of development within home ranges and core areas tended to increase as mean $\delta^{13}C$ increased. Annual 95% KDE home-range sizes of male bears did not differ based on mean $\delta^{13}C$ (P = 0.132) or year (P = 0.520). Seasonal 95% KDE home-range sizes of male bears differed by season (P = 0.010) but not mean $\delta^{13}C$ (P = 0.160). The mean proportion of development within male 95% KDE home ranges differed by mean $\delta^{13}C$ (P = 0.022), and the mean proportion of development within home ranges tended to increase as mean $\delta^{13}C$ increased.

The top SSF model included interaction effects between mean $\delta^{13}C$ and percent canopy and slope. Bears with higher mean $\delta^{13}C$ had higher selection for low to moderate percent canopy cover compared to bears with lower mean $\delta^{13}C$. Selection for intermediate slope values was higher for bears with higher mean $\delta^{13}C$. Managers will need to continue to collaborate with the communities surrounding GRSM to effectively minimize the development of conflict behavior, it is likely that the issue of habituation needs to be emphasized in conjunction with food-conditioning as the number of tourists continues to increase.

Conservation genetics of *Geum radiatum* (Rosaceae)

Matt Estep *(estepmc@appstate.edu); Nik Hay (Appalachian State University, Boone, NC)*

Geum radiatum is a federally endangered high-elevation rock outcrop endemic herb that is widely recognized as hexaploid and a relic species. Little is currently known about *G. radiatum* genetic diversity, population interactions, or the effect of past augmentations of populations. This study sampled every known population of *G. radiatum* and used microsatellite markers, F-statistics, STRUCTURE, GENODIVE, and the R package *polysat* to measure diversity and genetic structure of the species. The analysis demonstrates that there is interconnectedness and structure among populations. In addition, the analysis was able to differentiate augmented populations and identify punitive hybrids individuals within augmented populations. *Geum radiatum* exhibits diversity within and among populations and suggests current gene flow in the northern populations. This information provides a greater understanding of the genetic sustainability of the species and should inform future management plans.

Overstory mortality and regeneration following wildfire and prescribed fire

Jennifer Franklin *(jafranklin@utk.edu, Forestry, Wildlife & Fisheries, Univ Tennessee, Knoxville); Matthew Aldrovandi (Oak Ridge National Lab, Oak Ridge, TN); Karen Hughes & Jennifer Schweitzer (Ecology & Evolutionary Biology, Univ Tennessee, Knoxville)*

In the Great Smoky Mountains National Park periodic fire is a common natural disturbance that initiates the replacement of overstory trees. Periodic fire is thought have contributed to the prevalence of oaks (*Quercus* spp.) in our forests today, and prescribed fire is used across the eastern US to mimic natural fire regimes with the goal of promoting oak regeneration. However, the effects of fire on forest regeneration are complex, and the specific characteristics needed to promote oak regeneration are unclear. In the fall of 2018, we characterized overstory mortality and regeneration following fire on sites of differing fire intensity, from both prescribed fires and the Chimney Tops 2 fire. To predict delayed mortality, we measured the extent of fire scars. The density and species composition of tree seedlings and of new shoots developing from surviving root systems was measured. Overstory mortality was found to be the best descriptor of fire intensity, and predictor of tree regeneration. The occurrence and size of fire scars was not influenced by tree size or species. Areas of high tree mortality have very few oak seedlings but surviving roots systems of chestnut oak (*Quercus prinus*), red maple (*Acer rubrum*) and blackgum (*Nyssa sylvatica*) sprouted prolifically. The density of oak seedlings in areas of low intensity burns was similar to that in the unburned plots and did not differ between prescribed fire and wildfire areas.

New evidence of long-term fire and forest history from mesic forests of Great Smoky Mountains National Park, Tennessee, USA

Sally P Horn *(shorn@utk.edu) & Matthew S Boehm* **(***Geography, Univ Tennessee, Knoxville); Christopher A Underwood (Geography, Univ Wisconsin, Platteville)*

The recent Chimney Tops 2 fire focused new attention on the risks and roles of fire in Appalachian forests. Understanding the long-term interplay of fire and vegetation in the Appalachian region requires us to think about fire over time scales that extend beyond written records and evidence provided by fire-scarred trees. Here we report initial findings from a study of macroscopic soil charcoal as an indicator of long-term fire and forest history in the eastern, Tennessee portion of Great Smoky Mountains National Park. Charcoal fragments from past fires can be preserved for thousands of years in soils and can be taxonomically identified and dated by AMS radiocarbon analysis to provide information on both the timing of past fires and the plants that burned in those fires. From 14 plots across five sites we recovered 54 soil cores. Our sampling plots were located in vegetation presently categorized as cove forest, chestnut oak forest, oak hickory forest, northern hardwood forest, and yellow pine forest. We collected cores in 10-cm increments to the depth of refusal (total ca. 280 core increments) using an Eijkelkamp root auger. Charcoal fragments ≥2 mm were isolated from each core increment by wet sieving, and a random subset of fragments was selected for identification and radiocarbon dating. Sixty-two individual charcoal fragments have been identified and submitted for dating. These samples include charcoal from eastern hemlock, white pine, yellow pine, cedar, oak, chestnut, maple, and birch. Charcoal fragment ages mainly fall within the last 4000 years (calibrated age before CE 1950), but several fragments are from 8000 to over 10,000 years in age. Because of the mixing of soil by bioturbation and geomorphic processes, soil charcoal is not stratified by age in park soils. Consequently, reconstructing past fire history from charcoal in soils requires individually dating a large number of charcoal fragments, an expensive undertaking. However, this approach is of great value to understanding the role of fire as a disturbance in Appalachian forests because it allows us to obtain stand-specific information on fire history and forest history over a much longer period of time than is possible using other methods.

Pine and oak mycorrhizal associations in fire zones following the Chimney Tops 2 Fire

Karen W Hughes *(khughes@utk.edu), Alexis Case & P Brandon Matheny (Ecology & Evolutionary Biology, Univ Tennessee, Knoxville); Andrew N Miller (Illinois Natural History Survey, Univ Illinois Urbana-Champaign); Ronald H Petersen (Ecology & Evolutionary Biology, Univ Tennessee, Knoxville); Jennifer Franklin (Forestry Wildlife & Fisheries, Univ Tennessee, Knoxville); Jennifer Schweitzer (Ecology & Evolutionary Biology, Univ Tennessee, Knoxville)*

Understanding fungal symbionts associated with trees seedling post-fire is important for understanding the legacy effects of fire disturbance on soil biodiversity, as well as forest recovery after fire. *Pinus pungens* seeds germinated in three severe fire zones (Baskins Creek, Two Mile Lead and Cove Mountain) approximately 6 months after the Chimneys 2 fire. Pine seedlings were sacrificed, and roots examined for ectomycorrhizae approximately quarterly for two years. DNA was extracted from individual root tips, PCR-amplified and sequenced to obtain the fungal sequence barcode (nrITS). Mycorrhizae were identified to genus (family or order in a few cases) by a blast search of GenBank. Results show that initial mycorrhizal associations were in the *Thelephora*/*Tomentella* group, the Pezizaceae, (especially *Sphaerosporella*) and *Laccaria trichodermorpha*. Both *Sphaerosporella* and *Laccaria trichodermorpha* fruited in severe fire zones. In year two, pine mycorrhizae included the *Thelephora*/*Tomentella*, *Laccaria*, and *Suillus*, *Tylopilus*, *Xerocomus* and *Rhizopogon* with a reduction in Pezizaceae over time. Oak acorns germinated in moderate fire zones in the spring and summer of 2018 from fall 2017 acorns. Seedlings were collected from a range of burn intensities (medium, low and no burn) and from roots of coppicing oaks in severe burn areas. Overall, the ectomycorrhizal genus *Russula* was most frequently encountered with *Laccaria* and *Thelephora*/*Tomentella* also significant. More than 20 putative taxa of *Russula* are represented on oak roots, some presently known only from environmental sequences. Overall, both oak and pine share mycorrhizae belonging to *Thelephora*/*Tomentella* and *Laccaria* but further work is needed to determine if the species within these clades are shared between oaks and pines.

Stream temperature monitoring and thermal physiology of fishes in southern Appalachian streams

Anna Kaz *(akaz@vols.utk.edu);* ***Matthew J Troia*** *(Ecology, Evolution & Organismal Biology, Kennesaw State Univ, Kennesaw, GA); Xingli Giam (Ecology & Evolutionary Biology, Univ Tennessee, Knoxville)*

Stream temperature regimes vary considerably along gradients of stream size, elevation, and land use and play a key role in survival, growth, and reproduction of fishes. Since May 2017 we have continuously monitored temperatures in 160 streams in the southern Appalachian Mountains (>7.4 million temperature readings, to date) with the goal of understanding how temperature has structured historical fish distributions and forecasting impacts from climate and land use change. We have integrated these temperature data with laboratory-based thermal tolerances of endemic minnows (*Etheostoma rufilineatum*, *E. chlorobranchium*) and darters (*Notropis leuciodus*, *N. rubricroceus*) to estimate risk of heat stress under historical and future climates. While potential for heat stress increases from high to low elevation, all four species exhibited adequate thermal tolerances to survive extreme heat events under both historical and projected future climates. Future research will characterize sublethal thermal effects which are poorly understood for minnows and darters and constrain distributions of comparatively well-studied fishes (*i.e.*, salmonids). In a second field study, we monitored stream temperatures at 162 locations in six streams of the Little River system (Blount County, TN) with the goal of assessing spatial patterns and environmental drivers of fine scale temperature heterogeneity. We show that temperature heterogeneity increases with stream size and from high to low elevation. Despite greater temperature heterogeneity, large low-elevation streams had more warm microhabitat anomalies than cold ones which suggests limited opportunities for fish to seek cold refugia during heat waves. Overall, temperature heterogeneity was greater between reaches and seasons than it was between microhabitats within a reach.

Understanding patterns of vegetation structure and distribution across Great Smoky Mountains National Park using LiDAR & meteorology data

Jitendra Kumar *(jkumar@climatemodeling.org, Terrestrial System Modeling Group, Oak Ridge National Laboratory, Oak Ridge, TN)*

Great Smoky Mountains National Park (GSMNP) in Tennessee is a biodiversity hotspot and home to a large number of plant, animal and bird species. Driven by gradients of climate (ex. temperature, precipitation regimes), topography (ex. elevation, slope, aspect), geology (ex. soil types, textures, depth), hydrology (ex. drainage, moisture availability) etc. GSMNP offers a diverse composition and distribution of vegetation which in turn supports an array of wildlife. Understanding the vegetation canopy structure is critical to understand, monitor and manage the complex forest ecosystems like the Great Smoky Mountain National Park (GSMNP). Vegetation canopies not only help understand the vegetation, but are also a critically important habitat characteristics of many threatened and endangered animal and bird species that GSMNP is home to. Using airborne Light Detection and Ranging (LiDAR) we characterize the three-dimensional structure of the vegetation. LiDAR based analysis gives detailed insight in the canopy structure (overstory and understory) and its spatial variability within and across forest types. Vegetation structure and spatial distribution show strong correlation with climate, topographic, and edaphic variables and our multivariate analysis not just mines rich and large LiDAR data but presents ecological insights and data for vegetation within the park that can be useful to forest managers in their management and conservation efforts.

Monitoring seasonality, distribution, and diversity of dung beetles in the Great Smoky Mountains National Park

Margaret Mamantov *(mmamanto@vols.utk.edu) & Kimberly Sheldon (Ecology & Evolutionary Biology, Univ Tennessee, Knoxville)*

Dung beetles communities provide crucial ecosystem services in a diverse range of habitats. As part of their breeding activities, dung beetles remove portions of a dung source and bury it under the soil. This behavior adds nutrients to the soil, aerates the soil, and disperses seeds. Dung beetle species are numerous in forest, prairie, savanna, and pasture ecosystems across the globe, but species have different habitat preferences and varying thermal tolerances. Therefore, dung beetle communities vary across both elevational gradients and habitat type. A variety of dung beetle species are native to the southeast region of the US, but we have limited knowledge of the life history and community assemblage of these species. Previous research on Southeastern dung beetles has focused primarily on censusing the species inhabiting agricultural pasture land; bioinventories of dung beetle communities in the Appalachian mountain regions are thus incomplete. To fill this knowledge gap, we performed a census of dung beetle in the Great Smoky Mountains National Park, quantifying differences in abundance and distribution across season, habitat type, and elevation. Using pit fall traps baited for 24-hour periods, we identified dung beetles in six All Taxa Biodiversity Inventory (ATBI) plots biweekly from April to September 2017. We found that communities of dung beetles varied both temporally and geographically. Low-elevation communities were more diverse than high-elevation communities, and population abundance peaked in late summer.

Body size scaling in fish and invertebrate communities from eastern US streams

Daniel McGarvey *(djmcgarvey@vcu.edu, Center for Environmental Studies, Virginia Commonwealth University, Richmond)*

Size-structure within aquatic communities often adheres to simple scaling laws, where abundance and/or biomass are a power-law function of average individual size. This fundamental 'size spectrum' has been documented in a variety of ecosystems and critical comparisons are now being used to characterize central tendencies, as well as anomalies, in model parameters (regression model slopes and intercepts). The present study takes a further step by examining taxonomic and functional trait structure within the discrete log-2 size classes that are used in traditional size spectra models. Basic size spectra parameters will first be compared among a selection of forested, eastern U.S. streams (including Fighting Creek, Great Smoky Mountains National Park). Total biomass within each size class will then be partitioned into taxonomic and functional feeding group components (e.g. summed biomass of caddisflies or predators within each size class). Comparisons of size-specific taxonomic and functional feeding group components among streams will be used to test the hypothesis that the size spectrum is an emergent construct of common taxonomic and/or functional building blocks.

Enhancing the progression chronology of the Chimney Tops 2 Fire with radar & ancillary datasets

Steve Norman *(stevenorman@fs.fed.us, US Forest Service)*

The extreme wildfire behavior the Park and surrounding areas experienced in November of 2016 resulted from a peculiar local wind phenomenon called a mountain wave. Compared to other 2016 and historical fires of the Appalachians, the high rate of spread and high severity patches formed during this event stand out, as do the impacts to the foothill communities. Yet our understanding of fire progression has been hampered by limited observational data and the complexity of wind and fire behavior in this mountain environment. NEXRAD II radar provides a continuous "movie" of the clouds and smoke plume during the event, and in this research, that dataset, the Look Mountain webcam and weather station data are used to improve our insights into how this wind-driven fire event unfolded. Further insights arise from comparing high fire severity patches with the behavior of clouds and smoke in the radar time series. Together, this leads us toward a more complete narrative of this important event. As warm fall droughts and wildfire are predicted to increase in the Southern Appalachians with climate change, efforts to learn about the hazards of this phenomenon are warranted.

Mountain wave induced extreme wildfire behavior: the deadly eastern Tennessee fires of 2016

Steve Norman (stevenorman@fs.fed.us), William Christie, William Hargrove (US Forest Service)

In many ways, the Sevier County fires of 2016 came as a surprise. Extreme, historically-rare fire behavior is notoriously difficult to predict and quantify in risk assessments. To improve our understanding of hazard and risk in the foothills of and near the Park, we need better knowledge of how mountain winds behave during extreme events. To get at this, we compared the Dec. 28, 2016 wildfire impacts with a meteorologically similar mountain wave event from May 4, 2017 that caused leaf stripping in a way that revealed wind behavior at high resolution. Using 10m Sentinel 2 and 240m MODIS imagery, we map wind impacts across a large part of the eastern Tennessee foothills. As development continues to expand adjacent the park interface, the entire foothills belt of communities may have an underappreciated mountain wave, if not wildfire risk. Aggressive planning and outreach efforts may be needed to limit future losses as the likelihood of extreme weather is expected to increase with climate change. You can download the poster here:

https://forestthreats.org/products/posters/mountain-wave-induced-extreme-wildfire-behavior-the-deadly-eastern-tennessee-fires-of-2016

Morphological polymorphism associated with alternative reproductive tactics in a plethodontid salamander

Todd Pierson *(tpierso1@vols.utk.edu, Ecology & Evolutionary Biology, Univ Tennessee, Knoxville); Jennifer Deitloff (Lock Haven University, Lock Haven, PA); Stanley K Sessions (Biology, Hartwick College, Oneonta, NY); Kenneth H Kozak (Bell Museum of Natural History & Dept Fisheries, Wildlife & Conservation Biology, Univ Minnesota, St Paul); Benjamin M Fitzpatrick (Ecology & Evolutionary Biology, Univ Tennessee, Knoxville)*

Understanding polymorphism is a central problem in evolution and ecology, and alternative reproductive tactics (ARTs) provide compelling examples for studying the origin and maintenance of behavioral and morphological variation. We use genomic, behavioral, karyological, and field observational data to demonstrate one such example in plethodontid salamanders—the two-lined salamander (*Eurycea bislineata*) species complex—in the southern Appalachian Mountains. These ARTs ("searching" and "guarding" males) are associated with different reproductive niches and, unlike most other examples in amphibians, demonstrate substantial morphological differences and inflexibility within a reproductive season. Evidence suggests the existence of these ARTs within three putative species in the *E. bislineata* species complex, with other members of this clade fixed for one of the two tactics. We highlight directions for future research in this system, including the relationship between these ARTs and parental care.