Scientific Research Projects List

The opportunity to ask questions; to find answers; to fulfill part of the Trust's mission as well as to satisfy humanity's thirst for knowledge is why a scientific research program was established with the Trust. The Trust's emphasis on research and education cannot be overstated as they have been a hallmark of its operations since it was founded. To date the Trust has had research partners engaged in close to forty different projects.

The Trust has established relationships with world-class researchers who are recognized experts in their respective fields. By inviting scientists to perform research on the Preserve, the results are measured as mutually beneficial, i.e. the scientists have safe, accessible and diverse environments in which to work and the Trust (and Preserve community members, through the Trust Talk venue of colloquia, lectures, etc.), gleans exciting, useful information which, once again, helps fulfill its mission and helps in creating a sense of place for residents as well as a sense of wonder for each visitor participating in Trust programs.

What follows is a list of the research projects carried out on conservation easement land within the Preserve.

Research Studies to Date (In order, most recent):

42) **Caterpillar Sampling in Fire-Experienced Forest Stands:** Numerous ecological studies have focused on how disturbance affects taxonomic diversity, especially for plants. While we know fire is a crucial element in the maintenance of plant biodiversity, little is known about the impacts of fire on arthropods in many ecosystems. Arthropods are the most abundant and species-rich group of animals in terrestrial systems and have tremendous impacts on ecological processes such as nutrient cycling, net primary production, and food web structure. Thus, arthropods should be included in assessments of the role of fire as it affects biodiversity and other ecosystem parameters.
An additionally informative response variable is the diversity of interactions between plants and animals, specifically with arthropods. Interaction diversity is the number of interactions linking species together into dynamic biotic communities and provides significant insight into correlations between diversity, stability, productivity, and ecosystem services. Analyzing how trophic interaction network topology responds to disturbance, specifically variation in fire frequency and severity, is an effective approach for generating informative patterns about the relationship between disturbance and biodiversity. The interaction diversity measure is particularly important for linking biodiversity to the trillions of dollars of ecosystem services that are provided by natural ecosystems, since those services are all due to a diverse mix of ecological interactions.
The numerous fires across the Southern Appalachian region in the fall of 2016 present an opportunity for assessing the effects of fires on interaction diversity and ecological function. This project involves the establishment of plots in burned and unburned

locations and data collected will empirically document tri-trophic interaction networks between plants, Lepidopteran larvae (i.e. caterpillars), and their natural enemies. Furthermore, these data will also allow for quantifying the diversity of species and interactions. Caterpillars will be field collected and reared in the lab to either adult or eclosion of a parasitoid. Caterpillars will also be photographed shortly after collection to aid in species identification. Host plant resource diversity and density will be quantified within plots. Additional sampling of the overall arthropod community will also take place to document compositional effects.

41) **Biogeography of winter fireflies (Ellychnia corrusca) and requirements for survival:** The winter firefly, *Ellychnia corrusca* (Linnaeus 1767), is a dark firefly i.e. has no lanterns, which has left the species obscured compared to its flashy cousins – even basic aspects of the species biology, such as its Grinnelian niche remains unknown. The following study will inspect the environmental heterogeneity surrounding *E. corrusca* to evaluate their Grinnelian niche. I will go about this by examining an array of environmental variables in different ecozones in order to see how they impact the abundance of *E. corrusca's* population. With an ever so changing environment, quantifying the Grinnelian niche for *E. corrusca is* crucial in understanding what the environmental requirements are for the species, if we want to promote biodiversity. The following study will help lay down the foundation for future studies to come as it will provide the first component to a species ecological niche (environmental requirements), which means future researchers could carry on the work and study the biotic interaction for *E. corrusca*; thus, completing their ecological niche. Once the niche is understood researchers could map the spatial distribution, which will provide information on what the potential species boundaries are. As a result, this will provide information on *E. corrusca* species complex which has been a mystery for years.

40) **Genetic Diversity in Five Wild Populations of American ginseng (*Panax quinquefolius* L.) in Western North Carolina**: Wild American ginseng (*Panax quinquefolius* L.), which grows across the Eastern United States, has been harvested and exported to Asia for over two hundred years for use as a stimulant in Eastern medicinal preparations. Because the biologically active compounds, ginsenosides, are most concentrated in the roots, collection for export requires the removal of the entire plant, which has the potential for negative genetic consequences such as a reduction in allelic diversity or an increase in inbreeding. Aggressive harvesting and non-compliance with harvesting guidelines has caused *P. quinquefolius* to be listed as a CITES Appendix II species since 1973. Studies examining the genetic diversity at allozyme loci have shown loss of genetic diversity, outbreeding, and genetic structure in unprotected populations. This project uses newly published microsatellite primers to assess genetic relatedness among American ginseng individuals in five protected Western North Carolina populations. Leaflets from 158 individuals were collected, total genomic DNA was extracted, and samples were PCR-amplified with 3 different primer sets. Data have shown genetic differences both within and among populations. Genetic data are being correlated with analyses of ginsenoside

content, with the long-term goal of attributing patterns of ginsenoside production to specific genotypes. This research aims to bring insight to the level of genetic diversity in wild populations of American ginseng and highlights the possible need to strengthen harvesting guidelines in order to protect the future of this federally protected plant. Principal Investigator: Jonathan Horton Ph.D., Associate Professor; Biology Department CPO#2040, UNC-Asheville

39) **Ramp (Allium tricoccum) harvest methods; North Carolina Arboretum/Cherokee Foundation**: In 2014 the Trust, in cooperation with the North Carolina Arboretum and the Cherokee Foundation and *BMG, LLC, began a research project to help determine best management practices for the harvesting of ramps (*Allium tricoccum*). Virginia Tech and the U.S. Forest Service joined the study in 2016. The study area (one of three in western NC) is ~ 25 m^2 located on CE land off Stemwinder Road on the Preserve.
This study is expected to provide the following benefits:
1) The continued survival of this species in parts of its range (there is heavy anthropocentric-pressure on this species)
2) To help maintain a significantly important cultural tradition in the lives of multiple races/ethnicities of people in the Southern Appalachians who utilize this plant
3) The continued high-value natural resource complement found on the Preserve
Joe-Ann McCoy, PhD, principal investigator
Director, The NC Arboretum Germplasm Repository

38) **Climatic Data Monitoring Station, University of North Carolina -Asheville;** principle investigator: Dr. Chris Godfrey; project duration: autumn 2009, ongoing/permanent. This project will establish a permanent collecting and monitoring station on the Preserve as a way to determine variations, changes, anomalies, etc. in local climate in the extreme western North Carolina (Southern Appalachians) mountains. Initially the station will measure wind, temperature, humidity, precipitation and solar radiation.

37) **Population census of Southern Appalachian stream salamanders on Balsam Mountain Preserve, Western Carolina University;** principle investigators: Kyle Boudreau, et al.; advisor, Dr. Joe Pechmann; project duration: field season 2009. Graduate student project to summarize elevational population density and diversity in stream-dwelling salamanders on the Preserve.

36) **Elevational gradient comparison study of soil microarthropods, University of North Carolina-Asheville;** principle investigator: Margaret Earthman; advisor, Dr. Kitti Reynolds; project duration: autumn 2008 - spring 2009. Differences in elevation have a strong influence on abiotic factors, such as temperature and soil moisture, which in turn can influence the numbers and taxonomic composition of soil fauna.
Soil microarthropods comprise a little-known aspect of biodiversity. They are also important contributors to litter decomposition and nutrient cycling. We propose to investigate the numbers of Collembola and three suborders of Acari (mites) at three sites of different elevations at BMT.

35) **Bluebird (Sialia sialis) next box installation and success on mountain development/golf course, Balsam Mountain Trust;** principle investigator: Blair Ogburn, Trust team, volunteer field assistants David and Melody Dickson; project duration: field season 2008 - ongoing, permanent; Bluebird number were reduced in many populations in the eastern United States. The goal of this project is to utilize open space created by the construction of a mountain golf course, install artificial nest boxes and measure rate of success.

34) **Migratory movements and winter distribution of the wood thrush (Hylochichla mustelina): gaining insights from geo-locators, Smithosonian Institute's Migratory Bird Center,** principle investigator: Nora Diggs, advisor Dr. Pete Marra; project duration: field season 2009 - '11; Natural selection acts on individual animals throughout the annual cycle and events during each phase of the annual cycle likely influence subsequent events. For migratory animals understanding these selection processes has been impossible because of our inability to follow individuals year-round and determine where breeding populations winter; where winter populations breed as well as the routes taken during migration. An understanding of these factors, which could operate in breeding and/or during non-breeding periods, that limit and ultimately determine bird abundance, is of urgent conservation concern. The most pressing need, and to date the most seemingly intractable problem, has been to determine the movement patterns and population connectivity of individuals between their breeding and wintering grounds. This is critical for understanding how limiting factors (e.g. habitat destruction, climate change, etc.) operate in different parts of the birds' annual cycle and for determining population size and local abundance.

33) **Phylogeny and phytogeography of the erectum group (Trillium), Western Carolina University;** principle investigator: Chris Stoehrel, Master's thesis, advisor , Dr. Kathy Mathews; project duration: field season 2008-10; Along the southern range of the Appalachian Mountains lives 11 species of pedicellate Trillium, 6 of which are known to hybridize with varying levels of introgression among species (Case & Case, 1997). While never empirically studied these hybrids appear developmentally normal and interfertile, yet these 6 species remain distinct enough to earn their taxonomic rankings (Case & Case, 1997). From this situation arise questions of what barriers are maintaining species distinctiveness. What is apparent is the way in which certain species are found in sympatric populations and the distribution ranges of other species barely overlap if at all. There are no established phylogenetic relationships that could be used to infer how closely related sympatric species are opposed to allopatric species. The production of fully developed, fertile offspring through hybridization suggests that there is no genetic basis for reproductive isolation and therefore that these species are not fully diverged (Grant, 1981; Coyne, 2004).

32) **Spatial and temporal movements; over-wintering locations for the eastern box turtle (Terrapene carolina carolina), Western Carolina University;** principle investigator: Dr. Ron Davis; project duration: field season 2007 - ongoing; Eastern box turtle populations are faced with many threats, chief among them are habitat fragmentation,

disease, removal from the wild for human pets, mowing in fields and early successional habitats and genetic degradation due release of pet-store turtles. This study will enable the Preserve to assess habitat range across the Preserve as well to determine age-classes to know whether or not there is a healthy box turtle population on the site.

31) **Applied forest management techniques: Crop-tree release and crown thinning, Western Carolina University;** principle investigator: Dr. Pete Bates; project duration: field season 2008 - ongoing; Crown thinning: By removing overstory trees (but not all of them!), gaps are created that allow light to penetrate to the lower crown classes. Space is also freed for the growth of promising trees in the middle canopy. Trees are selected for cutting that are crowding out straighter boled co-dominant trees or are merely competing side-by-side with other trees. Selection is based on health and growth potential, with healthy and higher potential trees left uncut. Crop-tree release: In an unmanaged woodland, competition among trees for light, water, and nutrients is often severe and can result in slow growth or even the death of the more desirable trees. In a woodland under crop-tree management, these crop trees are freed from excessive competition by reducing or eliminating some of the less desirable competing trees. The released crop trees are healthier and more vigorous, more insect and disease resistant, grow faster, and produce additional landowner benefits.

30) **Geomorphic and Anthropogenic controls on stream baseflow discharge in the southern portion of the Blue Ridge Mountains, University of Georgia;** principle investigator: Katie Price; project duration: field season 2007-'08; Baseflow refers to streamflow sustained between precipitation and snowmelt events, contributed from subsurface reservoirs such as bedrock, saprolite, alluvium, or soil. Due to the importance of baseflow in issues of stream ecology and freshwater supply for human use, there exists a critical need to understand not only the relationships between basin physical properties and stream baseflow, but also the ways in which human land use affects these physical properties. Topography and land use, separately, have been demonstrated to exert strong influence on baseflow, but their relative influences and interaction remain unclear.

29) **Spring/seep flow, temporal analysis; University of North Carolina-Asheville;** principle investigator: Alexander Byers; advisor, Dr. Jeff Wilcox; project duration: field season 2008; I am studying temperature, conductivity, and flow in springs and spring-fed streams. Since in North Carolina we have been experiencing drought-like conditions for several years, I am particularly interested in the amount of time it takes rainfall to recharge into our streams. At Balsam Mountain, I am mapping the temperature and conductivity of water in the streams and hypothesize that both will gradually decrease as I travel upstream. The water in our mountains and at Balsam Mountain is very pristine, so near the springheads I expect that the conductivity will be very low and the temperature will be extremely cold. Due to runoff from the golf course. I may see substantial increase in conductivity close to the course compared to other parts of the property.

28) **A longitudinal temperature study of Sugar Loaf Creek, A.B. Technical School, Asheville, NC;** principle investigator: Phyllis Boone; advisor, Dr. Tom Dechant;

project duration: field season 2007; The purpose of this study was to document possible water temperature changes that may have been caused by canopy disturbance on a small Southern Appalachian stream. Sugarloaf Creek, which is located within the Balsam Mountain Preserve, was selected for this study. The vegetative canopy and streamside buffer areas for this stream have been manipulated in some places as a result of the construction of a golf course and associated roads and paths. This construction opened the canopy over significant lengths of the stream. This study established temperature ranges for selected sites along the longitudinal gradient during the traditionally warmest months each year. It is well documented that mountain stream temperatures are influenced by vegetative canopy and this in turn, may affect stream biota.

27) **Response and restoration/mitigation of a Southern Appalachian stream following an irrigation pond failure, Institute for the Environment, Highlands Biological Station;** principle investigator: Jason E. H. Baker, advisors Drs. Jim Costa and Anya Hinkle; project duration: field season 2007; This paper documents and evaluates the success of the cleanup process, both physically and procedurally, and attempts to analyze protocols which may aid in response to future water quality issues.

26) **Spatial and temporal movements of timber rattlesnakes (Crotalus horridus horridus), Western Carolina University;** principle investigator: Dr. Ron Davis; project duration: field season 2007-'09; Telemetry implants in timber rattlensakes were undertaken to determine movement and acquisition of hibernancula on the Preserve. Effects of human development, location of historic hibernacula and whether or not snakes would survive destruction of same by moving to new winteing areas.

25) **Behavior of different age stump sprouts in woody plant species, Clemson University;** principle investigator: Adam Becker, Master's candidate, advisor Dr. Geof Wang; project duration: winter 2006-'07; This project is designed to investigate behavior of stump sprouts of major hardwood species and its implication to hardwood management, especially crop-tree management.

24) **Using limited devleopment to conserve land and natural resources, Cornell University;** principle investigator: Jeffrey Milder, Master's candidate project; project duration: field season 2005-'06; This study looked at numerous developments across the United States in an attempt to determine how effective "green developments" are in both conservation strategy and as a way to develop an effective, profitable business model.

23) **Small mammal survey for undergraduate field experience, University of Tennessee-Knoxville;** principle investigator: Dr. Jay Clark; project duration: Oct. - Nov. 2004; This was an introduction to field sampling techniques for Dr. Clark's undergraduate zoology students.

22) **Sediment and erosion control grant project, University of North Carolina and North Carolina State University;** principle investigators: Dr. Rich McLaughlin, Dr. Greg Jennings, John Calabria, UNC/NCSU cooperative research; project duration: winter 2003 - winter

2005; This project investigated, developed, implemented and codified best management practices for soil/sediment erosion control within mountain development/construction projects.

21) **Caddisflies of Balsam Mountain Preserve, Clemson University;** principle investigators: Ian Stocks, Lauren Harvey; advisor, Dr. John Morse; project duration: autumn 2003 - winter 2005; Study was conducted in streams and seeps throughout varied elevational gradients. Water quality is a key factor to a healthy population of these insects.

20) **Surveys for invasive plant species and establishment of a control program, Western Carolina University;** principle investigators: Sunny Himes, Dr. Dan Pittillo, Ron Lance; project duration: field season 2003 - on-going, permanent; Basis of program establishment was to identify and eradicate invasive species; this on-going program for aggressive non-native invasive plants.

19) **Effects of clear-cutting different forest types and the resulting impact/success of herbaceous plants, Duke University;** principle investigator: Steve Mitchell for Master's thesis; project duration: field season 2003-'04; Steve investigated the impact of growing success of herbaceous plant species across different forest types and the time in which sections of the forests were logged (clear-cut).

18) **Small mammal survey in chrono-sequenced age-classes of forest, Western Carolina University;** principle investigator: Shannon Rabby for Master's thesis; project duration: field season 2003-'04; Shannon's research was looking for correlations between different age-classes of forest (sections of the Preserve's forests were logged at different times across a one hundred year time span) and what small mammals were found there.

17) **Bryophte survey (mosses, liverworts, hornworts), University of North Alabama and University of Tennessee-Knoxville;** principle investigators: Dr. Paul Davison and Dr. David Smith; project duration: autumn 2002 - summer 2003; Another of the natural history surveys conducted to determine the quality and/or quantity of the biodiversity on the Preserve.

16) **Relationship of salamanders to coarse woody debris, Duke University;** principle investigator: Jason Davis, Duke University master's candidate; project duration field season 2002; Terrestrial salamanders seek out and utilize nurse logs and other coarse woody debris for scavenging/foraging, nesting and cover. This study looked at Plethodontid salamander diversity in relationship to chrono-sequence of woody debris on the Preserve.

15) **Salamander survey, National Park Service, Great Smoky Mountains Science Research;** principle investigator: Paul Super, Science Coordinator; project duration: field season 2002; Another of the natural history surveys conducted to assess the quality and/or quantity of the biodiversity of the Preserve.

14) **Mycological survey (fungi), independent consultants and principle investigators: Dr. Henry Mainwaring and Ed Grand;** project duration: summer 2002; Another of the natural history surveys conducted to assess the quality and/or quantity of the biodiversity of the Preserve.
13) **Small mammal reconnaissance, U.T. Knoxville;** principle investigator: Dr. Mike Pelton; project duration: spring 2002; Another of the natural history surveys conducted to assess the quality and/or quantity of the biodiversity on the Preserve.
12) **Survey for large mammals, including nuisance species, e.g. wild pigs, with management recommendations, North Carolina Wildlife Resources Divsion, NCDENR;** principle investigator: Mike Carraway, wildlife biologist; project duration: spring 2002; Another of the natural history surveys conducted to assess the quality and/or quantity of the biodiversity on the Preserve.

11) **Survey for lepidoptera, Don Hendershot and Bob Olthoff,** consulting naturalists and principle investigators; project duration: autumn 2002; Another of the natural history surveys conducted to assess the quality and/or quantity of the biodiversity on the Preserve.

10) **Survey for aquatic biodiversity, Preserve streams, Breedlove, Dennis and Associates consultants;** initial principle investigator: Dr. Mike Dennis; project duration: winter 2001 - present, ongoing. Another of the natural history surveys conducted to assess the quality and/or quantity of the biodiversity on the Preserve. Other projects since considered specific bio-strata of stream life, e.g. mayflies, caddisflies, stoneflies, etc.

9) **Survey for threatened and endangered species, North Carolina Department of Environment and Natural Resources, Wildlife Resources Division;** principle investigator: Chris McGrath, wildlife biologist; project duration: September 2001; As part of the Preserve's and Trust's commitment to the stewardship and management of the biodiversity on the Preserve this was one of many inventory assessments engaged early in the project's history.

8) **Sustainable forest management; application of best management practices on Balsam Mountain Preserve;** Western Carolina University (WCU); principle investigator: Dr. Pete Bates, Rob Lamb, Ron Lance; project duration: autumn 2001 - present, ongoing; The Trust established contractual relationship with the Natural Resources department at WCU to assist with the management of the forest resources (woody plants) on the Preserve. The Preserve was logged for one hundred years and the Trust and Preserve felt it was incumbent that a stewardship role was established and maintained.

7) **Geology of the Preserve, Western Carolina University (WCU);** principle investigator: Dr. Steve Yurkovich; project duration: autumn 2001; Survey of the geological make-up of the Preserve was performed and data was entered into GIS layers maintained by WCU. Map of rock types was created.

6) **Sustainable forest management, Greenleaf Forest Management consultants;** principle investigators: Monty Wooten, Ron Lance; project duration: field season 2001 - present, ongoing; performance of surveys, data collection and recommendations for action for forest health, e.g. disease, invasive species, etc.

5) **Water quality monitoring, Balsam Mountain Preserve; principle investigators: Fish and Wildlife Associates (FWA), Whittier, NC, Trust staff;** project duration: summer 2001 - present, ongoing; Initially twenty-one stations were established to perform physical tests for water quality on the Preserve; that was later (in 2007) reduced to thirteen stations. As of summer 2009, FWA has suspended testing; Trust staff are now performing monitoring.

4) **Breeding bird/migrant counts/Audubon Christmas Bird Count, Balsam Mountain Preserve;** principle investigators: independent consultants/Trust staff; project duration: field season 2001 - present, ongoing; Surveys provide data on seasonal variability of birds based on spatial (where) and temporal (when) metrics (measure). By performing surveys annually/seasonally data can be compared to determine changes in individual species composition, numbers, etc. The Preserve is included as part of one of the Important Bird Areas define by the National Audubon Society.

3) **Botanical surveys of Trust land and homesteads on Balsam Mountain Preserve, Western Carolina University;** principle investigators: Dr. Dan Pittillo, Mike Ivey, Ron Lance; project duration: field season 2001 - present, ongoing; Botanical surveys are linked to herbarium collection. Goal of these surveys is to quantify species make-up of forest types as well as to provide homestead owners with a botanical inventory.

2) **Genetic sampling for Appalachian brook trout (Salvelinus fontinalis) in Preserve streams, Western Carolina University;** principle investigator: Dr. Peter Galbreath; project duration: field season 2000. The introduction of the northern brook trout and the degradation of water quality in southern Appalachian streams has made the survival of the southern strain of this species somewhat problematic. Results of this survey showed genetic purity of brook trout on the Preserve range from 100% to about 60% southern strain.

1**) Botanical sampling for establishing Trust herbarium collection, Western Carolina University/Trust;** principle investigators: Dr. Dan Pittillo, Mike Ivey, Ron Lance; project duration: field season: 2000 - present, ongoing; Establishment of herbarium collection for the Trust which has, to date, yielded over 700 species of plants. Herbarium is housed in the Nature Center.