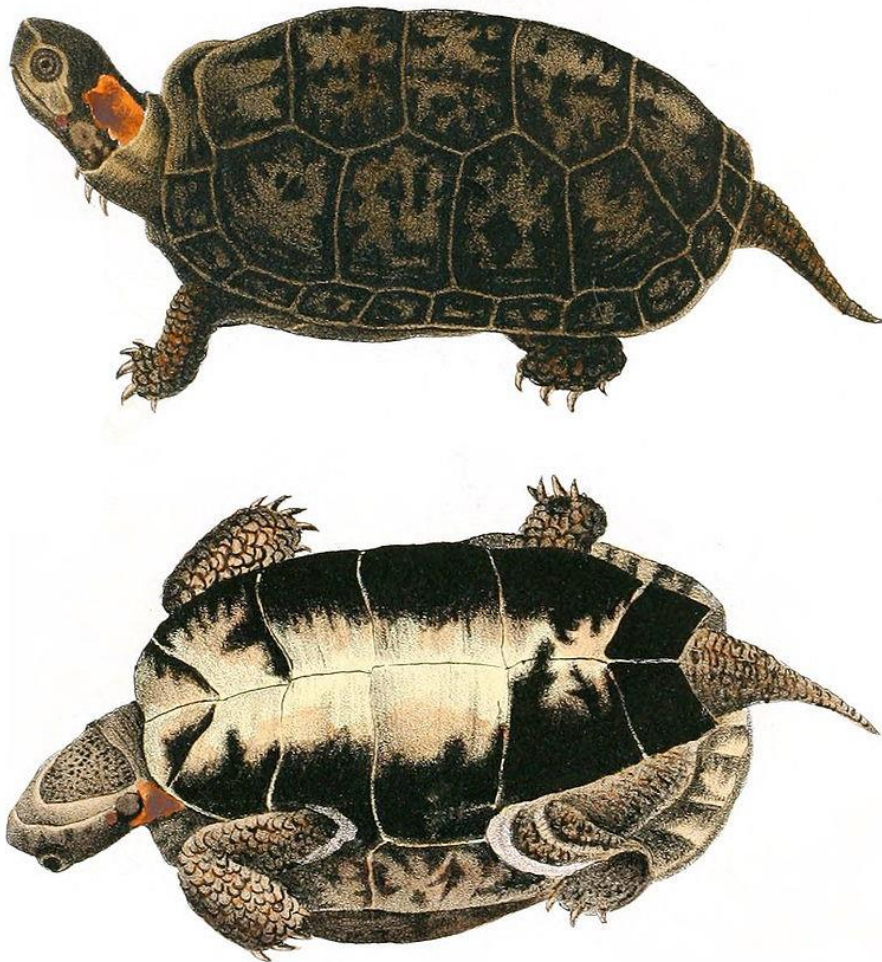


22nd Annual Meeting of the Tennessee Herpetological Society



Zoo Knoxville

[3500 Knoxville Zoo Drive, Knoxville, TN 37914](http://www.zoo-knoxville.com)

September 29-30, 2016

Front Cover Photo, Artwork for T-shirts and name badges:

Holbrook, J.E. 1836. North American herpetology; or, a description of the reptiles inhabiting the United States. Volume 1. J. Dobson, Philadelphia, Pennsylvania.

Zoo Knoxville

The Tennessee Herpetological Society has been fortunate enough to have its annual meeting hosted by Zoo Knoxville. Originally, Zoo Knoxville began as a park for children with the establishment of a 4 acre plot on a hillside in Chilhowee Park in 1935. The City of Knoxville, New Deal, Works Progress Administration, and Tennessee Valley Authority were instrumental in creating the park, known as the Birthday Park, complete with a stone shelter, playground, and wading pool. In 1951, the Birthday Park was renamed the Municipal Zoo. The first attraction of the Municipal Zoo was alligator “Al,” a pet acquired from a Knoxville resident. Since this first attraction, the zoo and its exhibits have grown considerably throughout the years.

While most visitors to Zoo Knoxville are able to view and experience the animals on exhibit, few are aware of the few distinctions not shared by other zoos or of its contributions to conservation. No other zoo in the world has had more red pandas born than Zoo Knoxville. It is also the first zoo in the world to hatch critically



endangered northern spider tortoises. Zoo Knoxville was also the first zoo in the world to successfully breed Arakan forest turtles and common spider tortoises. Accredited by the Association of Zoos and Aquariums (AZA), Zoo Knoxville works with zoos throughout the world on a collective Species Survival Plan, working to maintain a healthy, genetically diverse population of animals in zoos. Zoo Knoxville is also involved in conservation work outside the zoo grounds. The zoo and its staff have worked to save East Tennessee’s endangered bog turtles and are also participating in research with native hellbenders and mudpuppy salamanders.

For more history and Zoo Knoxville conservation efforts, please visit:

<https://www.zooknoxville.org/>

Zoo Knoxville hours of operation are:

9:30 a.m. – 4:30 p.m. Mon-Fri

9:30 a.m. – 6:00 p.m. Sat-Sun

Zoo Knoxville prices of admission are:

Adults \$19.95

Children ages 4-12 \$16.95

Seniors ages 65+ \$16.95

Children under 4 FREE

Park Map: <https://www.zooknoxville.org/visitor-info/zoo-map/>

Zoo Knoxville Map



- RESTROOMS
- HANDICAP ACCESS
- REFRESHMENTS
- GIFT SHOP
- FORT SANDERS RANGERS STATION
- DESIGNATED SMOKING AREA
- ARBORITUM LEVEL ONE TREES

Smoking is permitted ONLY in designated areas.



Look for your chance to recycle at the zoo. Place aluminum and plastic bottles in marked receptacles.

Knoxville NEWS SENTINEL
Special thanks to corporate partner and friend, the Knoxville News Sentinel for their continued support and printing of the zoo map.

Keynote Speaker - Dr. Arthur ‘Sandy’ Echternacht



Dr. Echternacht, most notably known for his work on *Ameiva*, *Anolis*, *Ctenosaura* and *Cyclura*, has long been an active researcher and contributor to herpetology. In 1963, he was awarded a Master's degree in Zoology from Arizona State University and then moved to the University of Kansas. In 1970, he received his PhD in Zoology from KU where his research adviser was Dr. William E. Duellman with Dr. Henry Fitch a member of his dissertation committee. He taught at Boston University and was a Research Associate in Herpetology at the Museum of Comparative Zoology, Harvard University, from 1968-1975 when he joined the faculty of the University of Tennessee, Knoxville. He served as head of the Department of Zoology at UTK from 1985-1996 and as founding head of the Department of Ecology & Evolutionary Biology from 1996-1998. He has published more than 25 peer-reviewed articles, numerous other notes and popular articles and one non-technical book on amphibians and reptiles. He has also served as a mentor or major professor to over 30 graduate students. Since his arrival at UTK, his research has focused on field and laboratory investigations on lizard ecology with an emphasis on the ecology and behavior of anoles and iguanas. This research has been conducted in the southeastern and southwestern U.S., Mexico through Central America to Ecuador, the Cayman Islands, as well as Midway Atoll (Hawaii) and Palau in the Pacific.

Dr. Echternacht's presentation, "Lizard Wars: a Silent Invasion," will focus on anoles in the southeast.

Thursday Afternoon, September 29, 2016

<i>Ranger's Station / First Aid</i>	
10:00	Field Trip - Zoo Knoxville
11:00	Field Trip - Zoo Knoxville

<i>Lee Congleton Conference Center</i>	
12:00	Registration
1:00	Opening Remarks
1:05	Welcome - Phil Colclough , Director of Animal Collections and Conservation Zoo Knoxville
1:15	Keynote Address - Lizard Wars: A silent Invasion Dr. Echternacht
2:15	Break

<i>Lee Congleton Conference Center</i>	
<i>Student Session I</i>	
Moderator - Josh Campbell	
2:45	Inhibition of Chytridiomycosis by Cutaneous Microbiota of Plethodontid Salamanders Aubree Hill
3:00	Photo Analysis on the Behavioral Effects of Batrachochytrium salamandrivorans on North American Amphibian Species Aaron Free
3:15	The host, geographic range, and environmental corollaries of <i>Ophidiomyces ophiodiicola</i> the causative agent of snake fungal disease Jacob E. Leys
3:30	Mercury concentrations in three freshwater turtle species of West Tennessee Madison A. Herrboldt
3:45	My Little Python: Science Communication and Outreach via Social Media for Children Allison Metler
4:00	Preliminary survey of two west Tennessee River drainages results in two populations of the Alligator Snapping Turtle (<i>Macrochelys temminckii</i>) Dustin F. Garig II
4:15	THS Journal M. Kevin Hamed and Kristen Cecala

Thursday (cont.), September 29, 2016

<i>Lee Congleton Conference Center</i>	
4:45	THS Business Meeting and Annual Elections

<i>Pilot Flying J Wee Play Adventure Building</i>	
5:30	Poster Presentations / Social

<i>Kids Cove Special Event Tent</i>	
6:30	THS Banquet
7:30	THS Auction

Friday Morning, September 30, 2016

<i>Lee Congleton Conference Center</i>	
<i>Student Session II</i>	
Moderator - Kevin Hamed	
8:30	Genomic data reveal complicated evolutionary relationships in the two-lined salamanders Todd W. Pierson
8:45	A tiny turtle tale: genetic assessment of a captive breeding and release program for the endangered Bog Turtle Cassie M. Dresser
9:00	Searching for the “hidden” salamander: The distribution and ecology of <i>Desmognathus abditus</i> Saunders Drukker
<i>This concludes the student presentations.</i>	
<i>Professional Session I</i>	
Moderator - Kevin Hamed	
9:15	The application of behavior systems theory to snake foraging and anti-predator behavior Gordon M. Burghardt
9:35	The current status of snake fungal disease in Tennessee. Donald M. Walker and Danny Bryan
9:55	Break

Friday Morning (cont.), September 30, 2016

<i>Professional Session II</i>		Moderator - Danny Bryan
<i>Presentation Awards will be issued prior to the start of this session</i>		
11:00	Movement and First-year Home Range in Head-started Bog Turtles (<i>Glyptemys muhlenbergii</i>) in NE Tennessee	Douglas Rice
11:20	Additive impacts of experimental climate change increase risk to an ectotherm at the Arctic's edge	Jon Davenport
11:40	From the bottom or from the top? A salamander's top-down effect on the detritivore ecosystem.	Donald M. Walker
12:00	Nest-site fidelity of Four-toed Salamanders (<i>Hemidactylium scutatum</i>) in Northeast Tennessee	M. Kevin Hamed
12:20	Meeting Wrap-up	

THS Annual Field Trip		
<i>Great Smoky Mountains National Park</i>		
2:00	Meet at Sugarlands Visitor Center	1420 Fighting Creek Gap Rd, Gatlinburg, TN 37738
~3:00	Chimney Tops Picnic Area	35.637052, -83.493422
~4:00	Higher Elevation Site	To be determined

Tennessee Herpetological Society Business Meeting

Agenda Items

Thursday, September 29, 2016

- Reading of the 2015 Meeting Notes
- Treasurer's Report
- Committee Reports
 - Conservation Committee
 - Chad Lewis Memorial Grant Committee
 - Website
 - Publication/Newsletter (Society Journal)
- New Business
- Elections

Positions to be elected during the 2016 meeting:

- President
- Secretary
- West Tennessee Representative
- Sergeant at Arms

Current Tennessee Herpetological Society Board

President: Josh Campbell

Vice President: Kevin Hamed

Secretary: Stephen Nelson

Treasurer: Dustin Thames

West TN Representative: Brian Butterfield

Middle Tennessee Representative: Danny Bryan

East Tennessee Representative: Chris Ogle

Sergeant at Arms: Scott Dykes

Abstracts – Student Presentations

Disease/Contamination

Inhibition of Chytridiomycosis by Cutaneous Microbiota of Plethodontid Salamanders

Aubree J. Hill¹, Gabrielle Russell, Brandon Edelbrock, Fantasia Erdman, Jacob Leys, and Donald M. Walker
Tennessee Technological University
Department of Biology and School of Environmental Studies

Over the last decade, the chytrid fungi *Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal) have caused significant amphibian population declines worldwide. Bsal has not yet been reported in Appalachia, but if such a disaster occurred, it could extirpate vast numbers of salamanders in a global hotspot for biodiversity. Research has focused on the resident bacterial community found on amphibian skin, and several studies have found that the amphibian skin microbiome actively inhibits the spread of pathogens, including Bd. However, little is known about the structure and immune function of the plethodontid microbiome, and few effective probiotic treatments have been developed. The objectives of this study were to (1) capture and swab salamanders from three genera occurring in three Tennessee ecoregions, (2) screen swabs from diseased salamanders for the presence of Bsal, (3) isolate cutaneous bacteria from skin swabs, and (4) challenge all bacterial isolates against Bd to determine which isolates inhibit this fungus. During spring (May 2016) and late summer (July 2016), 359 plethodontid salamanders were captured from nine sites in Tennessee, and skin swab samples were obtained. Two salamanders were observed with skin lesions but tested negative for the presence of Bsal using real-time quantitative PCR. Swabs from 10 additional salamanders were streaked onto R2A agar plates and checked for microbial growth for up to two weeks. A total of 98 bacterial colonies were isolated and grown in pure culture. Thirteen isolates were challenged against Bd on 1% tryptone agar plates. All isolates grew in the presence of Bd, but zones of fungal inhibition could not be measured after two days of growth. Plates will be monitored for another four days and zoospore concentration will be adjusted in later assays if necessary. Future research will help identify probiotic species which occur naturally on the skin of plethodontid salamanders. In addition, ecological variables such as habitat type and seasonality will be investigated, as these variables may affect structure and immune function of the microbial community and may alter disease outcome in the host.

¹ Aubree Hill was the award recipient for the 2016 Chad Lewis Memorial Grant

Photo Analysis on the Behavioral Effects of *Batrachochytrium salamandrivorans* on North American Amphibian Species

Aaron Free¹, Matthew J. Gray², Davis Carter², Deb L. Miller^{2,3}, and Jenny Spatz²

¹Department of Ecology and Evolutionary Biology, University of Tennessee Knoxville, Knoxville, TN, USA

²Center for Wildlife Health, University of Tennessee, Knoxville, TN, USA

³College of Veterinary Medicine, University of Tennessee, Knoxville, TN, USA

Batrachochytrium salamandrivorans (B.sal) is a recently discovered divergent species of pathogenic non-hyphal fungi closely related to *B. dendrobatidis*. These fungi can cause a lethal skin infection, anorexia, ataxia, and apathy. Although B.sal originates from Asia, due to the extensive pet trade and other forms of human activity, the fungi has been introduced to Europe. The purpose of this experiment, in conjunction with susceptibility screening, is to observe the behavioral effects the fungi has on various N.A amphibian species using photo analysis. In our experiment, we received series of photos at 30 second intervals throughout screenings of species of North American amphibians and recorded data on measures such as head/ posture change, locomotion change, time spent exposed, time spent undercover, time spent with the head covered, and time spent with the tail covered. We observed these measures in individually housed animals in control and dose-response treatment groups and will report preliminary data on species and treatment differences.

The host, geographic range, and environmental corollaries of *Ophidiomyces ophiodiicola* the causative agent of snake fungal disease

Jacob E. Leys¹, Vincent A. Cobb², Danny L. Bryan³, Megan Leys¹, Calvin Hall¹, Dylan Peters¹, John T. Kimrey¹, Robert Buck¹, and Donald M. Walker¹

¹Tennessee Technological University, 1100 N. Dixie Ave, Cookeville, TN 38505

²Middle State Tennessee University, 1301 E Main St, Murfreesboro, TN 37132

³Cumberland University, 1 Cumberland Dr, Lebanon, TN 37087

The causative agent of snake fungal disease, *Ophidiomyces ophiodiicola*, has been scarcely described in the current literature. Previous studies have elucidated clinical presentation, but the life history of the fungus remains largely obfuscated. This study aimed to explicate the geographic range, host distribution, and environmental corollaries of *O. ophiodiicola*.

Cutaneous swabs and soil samples were collected from both hibernacula and point of capture for 17 snake species. These samples (n=65 cutaneous swabs, n=22 soil samples) were subsequently subjected to DNA extraction and quantitative PCR molecular diagnostics to determine the presence/absence of *O. ophiodiicola*. Climatological data was retrieved from Worldclim and point capture data extracted using DIVA-GIS for maximum temperature of the hottest month, minimum temperature of the coldest month, temperature annual range, and annual precipitation. These environmental data were then correlated with *O. ophiodiicola* presence/absence across host species, state and locality.

Ophidiomyces ophiodiicola was detected on 12 of 65 snake individuals sampled, representing 7 of 17 species across five states; Alabama, Arizona, Arkansas, Texas, and Tennessee. The fungus was not detected in Alabama, Arizona, or Texas. All soil samples retrieved from the point of capture as well as known hibernacula of symptomatic snakes were negative for *O. ophiodiicola*, indicating soil may not be a principal reservoir for this fungus. Principle Component Analysis (PCA) of these data showed a positive correlation between detection of *O. ophiodiicola* within areas of greater annual precipitation and a greater annual temperature range (more temperate climates), while showing a negative correlation among areas with more extreme maximum or minimum temperatures. These results shed light on the critical life history characteristics of this emerging reptilian fungal pathogen.

Mercury concentrations in three freshwater turtle species of West Tennessee

Madison A. Herrboldt¹, Caitlin M. Weible¹, Dustin F. Garig II¹, Andrew J. Feltman¹, Rob L. Colvin³, Jeremy S. Dennison³, Joshua R. Ennen², Jon M. Davenport¹, and Rebecka L. Brasso¹

¹Department of Biology, Southeast Missouri State University, Cape Girardeau, MO

²Tennessee Aquarium Conservation Institute, Chattanooga, TN

³Tennessee Wildlife Resources Agency, Jackson, TN

Mercury is a heavy metal that bioaccumulates in a variety of organisms, causing physical and neurological effects. Turtles are one group of organisms that bioaccumulate mercury in their tissues and some species (e.g., *Chelydra serpentina*) are used as biomonitors of mercury. In general, turtles are model organisms for studying bioaccumulation of heavy metals largely because of their longevity. In this study, we focused on three species of turtles, the red-eared slider (*Trachemys scripta*), the common snapping turtle (*Chelydra serpentina*), and the alligator snapping turtle (*Macrochelys temminckii*), to determine mercury concentrations in West Tennessee turtles. To achieve this goal, a total of twelve sites were sampled across West Tennessee from March to July 2016. Toenails were taken from the back feet of each captured turtle and analyzed in a Nippon MA-3000 Direct Mercury (Hg) Analyzer. We found that all species sampled had a significant level of mercury in their toenails, and there was significant difference in mercury levels between species. Secondly, we found that common snapping turtles, which are still harvested, have mercury levels much higher than the EPA recommended consumption level for freshwater fish.

Outreach

My Little Python: Science Communication and Outreach via Social Media for Children

Allison Metler

Bartlett, TN

In the popular media consumed by today's children, many relatable animal characters are involved, but most reptiles, especially snakes are not included at all, and if they are, they are usually evil. As a result, we end up raising children who are biased against certain groups of animals, which simply will not do in today's society and environmental conditions. My Little Python aims to educate these children about snakes via relatable snake characters in an engaging online presence with videos, documents, comics, and other content for children to explore. Social media presences exist for the childrens' parents and focus on interesting animal-related content for parents to share with the children. My Little Python also hosts events and does other scientific communication and outreach in the community to educate children about snakes and animals in general. At these outreach events, animal ambassadors are present. These ambassadors are friendly snakes and other reptiles that children can interact with. Via many varied, child-friendly methods, My Little Python is changing the world, one child at a time.

Turtles

Preliminary survey of two west Tennessee River drainages results in two populations of the Alligator Snapping Turtle (*Macrochelys temminckii*)

Dustin F. Garig II¹, Jon M. Davenport¹, Joshua R. Ennen², Rob L. Colvin³, Jeremy S. Dennison³, Andrew J. Feltmann¹, Madison A. Herrboldt¹, Caitlin M. Weible¹

¹Department of Biology, Southeast Missouri State University, Cape Girardeau, MO

²Tennessee Aquarium Conservation Institute, Chattanooga, TN

³Tennessee Wildlife Resources Agency, Jackson, TN

The Alligator Snapping Turtle (*Macrochelys temminckii*) is the largest freshwater turtle in the United States and is distributed within the Mississippi and Gulf Coast river drainages reaching as far north as Iowa. ASTs are apex predators in these drainages, but have experienced dramatic declines throughout its range due to overexploitation. Despite the type locality from West TN, very little distribution and demographic information is available from this part of their range. For conservation measures from years 1992 to 2005, Tennessee Wildlife Resources Agency (TWRA) released 444 ASTs into West and Middle Tennessee river drainages. Unfortunately, no data is available assessing the success of those introductions along with the current status of the AST. Therefore, our initial work has investigated the distribution and abundance of ASTs in two West TN drainages, the Wolf and Hatchie Rivers. During the spring and fall of 2016, we surveyed 12 sites with baited hoop net arrays of various sizes. The

various sizes allowed us to determine what age classes if any were present. During this sampling period, we located two populations of ASTs. We are confident that only one of these populations is naturally occurring, while the other population is a successful result of the reintroduction efforts by TWRA.

Genetics

Genomic data reveal complicated evolutionary relationships in the two-lined salamanders

Todd W. Pierson¹, Benjamin M. Fitzpatrick¹, and Kenneth H. Kozak²

¹Department of Ecology and Evolutionary Biology, University of Tennessee Knoxville, Knoxville, TN, USA;

²Bell Museum of Natural History and Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, St. Paul, MN, USA

Evolution is messy. Sometimes speciation happens with continuous gene flow. Sometimes secondary contact between otherwise distinct evolutionary lineages brings about a wave of hybridization and introgression. When prevalent, these phenomena may prevent the use of a bifurcating tree model of evolution. The two-lined salamander (*Eurycea bislineata*) species complex is a wide-ranging and abundant group distributed across the eastern United States. Previous molecular phylogenetic studies of the group have suggested greater diversity than is reflected by current taxonomy and have demonstrated paraphyly in some of the named taxa, but inferences of the underlying mechanisms generating this diversity have been limited by the relatively low number of molecular markers available. Here, we use 3RAD—a genome reduction technique similar to ddRAD—to generate and analyze tens of thousands of SNPs to reevaluate relationships in the *E. bislineata* species complex. We analyze this genetic variation using a combination of tree-like (e.g., ML phylogenetic inference) and non-tree-like (e.g., D-statistics) approaches to uncover a complex evolutionary history in the group, focusing on historic and current hybridization and introgression and cryptic diversity uncovered in Tennessee.

A tiny turtle tale: genetic assessment of a captive breeding and release program for the endangered Bog Turtle

Cassie M. Dresser¹, Michael Ogle², Stephen Nelson², Douglas Rice², Ben Fitzpatrick¹

¹Department of Ecology and Evolutionary Biology, University of Tennessee Knoxville, Knoxville, TN, USA, ²Knoxville Zoo, Knoxville, TN, USA

Captive breeding and release programs are one of the primary contributions made by zoos to achieve global conservation objectives. Since 1991, the Knoxville Zoo has developed a captive rearing and release program for the federally threatened bog turtle (*Glyptemys muhlenbergii*), yet the long-term sustainability of the experimental release population has yet to be assessed, despite interest from other conservation agencies considering implementation. We estimated the genetic diversity of the release population relative to its captive and wild source populations using RADseq (N ~ 130 turtles) and

found that the genetic diversity in the release population was greater than the relatively inbred source populations, but lower than expected assuming equal source contribution. Surprisingly, we also found significant population differentiation among sites; even close proximity sites thought to be core and satellite populations based on previous radio telemetry data. Our results suggest that to achieve maximum variability in the captive rearing and release program, each source site should be considered a distinct population an equal number of offspring from each should be introduced into the release population.

Salamanders

Searching for the “hidden” salamander: The distribution and ecology of *Desmognathus abditus*

Saunders Drukker, Kristen Cecala, Philip Gould, Benjamin McKenzie, and Chris Van de Ven
Department of Biology, University of the South, Sewanee, TN 37383

The Cumberland Plateau in Tennessee is largely understudied in respect to stream salamander ecology and distribution. One species, the Cumberland Dusky Salamander *Desmognathus abditus* is the only endemic surface-dwelling salamander to the region. Described in 2003 by Anderson and Tilley the salamander is still relatively understudied, though their ecology is often assumed to be similar to related species such as *D. ochrophaeus* and *D. ocoee*. To accurately describe the distribution and ecology of *D. abditus*, we conducted occupancy and capture-mark-recapture studies throughout their range. The distribution of *D. abditus* across the plateau is characterized by small populations found exclusively in perennial streams off the plateau in the sandstone layer. These sites are often characterized by bedrock cascades and waterfalls, though differences in habitat preferences may occur between northern and southern populations. Furthermore, an apparent gap in occupancy exists between Grassy Cove and Tracy City, Tennessee. Capture-mark-recapture analyses revealed that though survival was equivalent between northern and southern populations ($\psi = 0.49$), southern populations had much smaller temporary emigration rates ($\gamma^{\prime}S=0.13$ relative to $\gamma^{\prime}N=0.84$). Most populations were small with 0-65 individuals, but one locality had up to 534 individuals. Ecological and morphological differences between northern and southern populations require more extensive study to understand genetic and environmental drivers of these differences. A distribution derived from small, isolated populations coupled with specific habitat preferences suggest that attention is needed to ensure that environmental changes have minimal impacts on population persistence.

Abstracts – Professional Presentations

Reptiles

The application of behavior systems theory to snake foraging and anti-predator behavior

Gordon M. Burghardt

Departments of Psychology and Ecology & Evolutionary Biology, University of Tennessee, Knoxville

A long-standing and controversial issue in the study of animal behavior has been the contrast between instinct (innate) behavior and learning (cognition). Reptiles have generally been considered, even by herpetologists, as cognitively limited and learning as a minor factor in their behavior as compared to ‘instinct.’ Natricine snakes, with their lack of postnatal parental care, have been useful in actually empirically testing such assertions in both feeding and anti-predator behavior in studies performed in many labs over decades. Results challenged many assumptions made by both sides of the instinct – learning debate as played out in studies of birds and mammals. However, the actual identification of which factors are most determinative in any given situation in the normal behavioral context confronting an animal is rarely carried out in a definitive fashion. Behavior Systems approaches have the potential to integrate the evolved behavioral repertoire and its organization with learning and experience and herpetologists should consider them as they study the natural history of their preferred subjects. This presentation will briefly review the historical background of behavior systems and present examples to demonstrate that behavior systems approaches should be used as a model framework in many areas of herpetological behavior research.

Movement and First-year Home Range in Head-started Bog Turtles (*Glyptemys muhlenbergii*) in NE Tennessee

Douglas Rice, Michael Ogle

Zoo Knoxville, Knoxville, TN

Zoo Knoxville has been involved with Bog Turtles (*Glyptemys muhlenbergii*) since first being discovered in our state in 1986. Over the years, we have learned a great deal about the natural history of this small, cryptic species. One aspect that is lacking in this project is the survivorship and movement rates of juvenile bog turtles. I will be presenting preliminary results on the Zoo Knoxville’s Bog Turtle head-start radio telemetry project. During the 2015 and 2016 field seasons, we tracked 10 and eight (respectively) year-old juvenile turtles five days/week. These results will largely consist of movement and first-year home range analysis using GPS tracks and minimum convex polygons. I will also be discussing survivability/predation, rate of retention (due to transmitter failure), and future analysis and publication prospects for this data.

Amphibians

Additive impacts of experimental climate change increase risk to an ectotherm at the Arctic's edge

Jon M. Davenport¹, Blake R. Hossack², and LeeAnn Fishback³

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²U.S. Geological Survey, Northern Rocky Mountain Science Center, Aldo Leopold Wilderness Research Institute, 790 E. Beckwith Ave., Missoula, MT, USA 59801

³Churchill Northern Studies Centre, Churchill, MB, Canada R0B 0E0

Ectotherms are particularly susceptible to environmental change (e.g., warming and wetland drying). Several studies in temperate environments have examined the adaptive capacity of organisms to greater understand the potential repercussions of warming and associated accelerated drying for freshwater ecosystems. However, few experiments have examined these impacts in Arctic or Subarctic freshwater ecosystems, where the climate is changing most rapidly. To evaluate the capacity of a widespread ectotherm to anticipated environmental changes, we conducted a mesocosm experiment with the wood frog (*Rana sylvatica*) in the Subarctic. Three warming treatments were fully crossed with three drying treatments to simulate a range of predicted changes in wetland environments. We measured survival, growth rate, and size at metamorphosis. We predicted wetland warming and drying would act synergistically, with water temperature partially compensating for some of the negative effects of accelerated drying.

Across all drying regimes, a 1°C increase in water temperature increased the odds of survival by 1.79, and tadpoles in 52-day and 64-day hydroperiod tanks were 4.1–4.3 times more likely to survive to metamorphosis than tadpoles in 45-day tanks. For individuals who survived to metamorphosis, there was only a weak negative effect of temperature on size. Our results reveal that one of the dominant herbivores in Subarctic wetlands, wood frog tadpoles, are capable of increasing their developmental rates in response to increased temperature and accelerated drying, but only in an additive manner. The strong negative effects of drying on frog survival suggest that drastic alterations may be occurring in Subarctic wetland communities.

From the bottom or from the top? A salamander's top-down effect on the detritivore ecosystem.

Donald M. Walker¹, Doug Talbert², David Smith³, Paul Tinker², Tom Crowther⁴

¹Tennessee Technological University, Department of Biology, Cookeville, TN USA

²Tennessee Technological University, Department of Computer Science, Cookeville, TN USA

³Tennessee Technological University, Department of Mathematics, Cookeville, TN USA

⁴Netherlands Institute of Ecology, Wageningen, The Netherlands

The soil decomposer community is a primary driver of carbon cycling in forest ecosystems. Understanding the processes that regulate this community is critical to our understanding of the global carbon cycle. The flow of energy within an ecosystem can be considered either top-down, where predators influence consumers, or bottom-up, where producers influence consumers. *Plethodon cinereus* (Red-backed Salamander) is a terrestrial keystone predator that feeds on invertebrates within the forest ecosystem. We investigated the impact of the removal of *P. cinereus* on the detritivore food web in a mesocosm study simulating an upland deciduous forest in West Virginia, USA. A total of 14 salamanders were captured and a block of soil including a cover object and all associated leaf litter was excavated from the exact point of salamander capture and placed into a plastic Tupperware box. Each mesocosm contained one salamander at the beginning of the experiment (n=3 treatments). On Day 1 of the experiment, four mesocosms were randomly assigned to the 'Absence' treatment and salamanders were evicted from these mesocosms. On Day 42 of the experiment, an additional five salamanders were randomly chosen and evicted from their respective mesocosms (eviction treatment). Salamanders were allowed to remain in the last five mesocosms for the duration of the 84 day (12 week) experiment (presence treatment). Soil cores were taken on a weekly basis (n=13 sample times, weeks 0-12), DNA was extracted, fungal-specific amplification of the ITS1 region performed, and sequencing completed on the Illumina MiSeq platform. Changes in overall fungal community composition differed between presence and absence treatments over time (two-way nested ANOSIM; $R=0.22$, $p=0.001$) and pre/post-eviction treatments over time (two way nested ANOSIM; $R=0.234$, $p=0.019$). These patterns were visually confirmed using a non-metric multidimensional scaling ordination (2D stress 0.27). FUNGuild was used to assign functional groups to fungal OTUs in presence and absence mesocosms. Species of symbiotrophic and saprobic fungi decreased in species diversity in absence when compared to presence mesocosms. Conversely, species of fungi in pathotrophic or pathotrophic-saprotrophic categories either remained the same or increased in species diversity in absence when compared to presence mesocosms. We concluded that *P. cinereus*, a keystone predator in the detritivore food chain does affect the overall composition and function of soil fungal communities. Given their capacity to govern the compositions of functionally important fungal communities, the activity of these amphibians is critical to the functioning (carbon and nutrient cycling) of temperate forest ecosystems.

Nest-site fidelity of Four-toed Salamanders (*Hemidactylium scutatum*) in Northeast Tennessee

M. Kevin Hamed¹, Matthew J. Gray², Thomas F. Laughlin³

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Four-toed Salamanders (*Hemidactylium scutatum*) require shallow ponds or pools for larval development, which is atypical for plethodontid salamanders. This species has been documented to return to the same pond for multiple years, but nest-site fidelity within a pond has not been investigated. From 2009–12 and 2015–16 we located and marked four-toed salamander nests at the edges of ditches and small pools from the Tennessee Valley Authorities' South Holston Weir Dam site in Northeast Tennessee. We photographed the ventral surface of each nesting female salamander and utilized human observers and the identification software Wild-ID to identify returning female salamanders. We collected data on each female salamander's nesting attempt and evaluated their relationships to the probability of exhibiting nest site fidelity with logistic regression and AIC model selection. Observers correctly located 96% of returning female salamanders while Wild-ID identified 78%. Females exhibiting nest site fidelity ranged from 8% (2010) – 14% (2016) of all females located. Of returning females, 96% reused the same pool or ditch and 83% nested at the exact location as prior years, including a female salamander that nested in the exact same location for 3 consecutive years. The probability of a female salamander exhibiting nest site fidelity increased as percent of embryos surviving from the previous nesting attempt increased. Our results show four-toed salamanders exhibit extreme nest-site fidelity.

Abstracts - Poster Presentations

Distributions of crevice-dwelling salamanders on the southern Cumberland Plateau of Tennessee

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Lungless salamanders in family Plethodontidae rely on cutaneous respiration that drives habitat selection. Refuge from warm, dry microclimates on the Cumberland Plateau may often be found in crevices within sandstone and limestone bluffs. The objective of our study was to describe patterns of crevice occupancy by Plethodontid salamanders on the southern Cumberland Plateau. We surveyed 6.5 km of bluff habitat and measured microclimate environmental factors at random locations and at salamander detection locations. We found seven species of Plethodontid salamanders using crevice habitats, but only three species were abundant enough for statistical analyses. *Eurycea lucifuga* occupancy was best predicted by geographical location. *Aneides aeneus* occupancy was negatively correlated with forest loss, and *Plethodon glutinosus* presence was associated with cooler temperatures and water presence. Salamanders on the Cumberland Plateau regularly use crevice habitat potentially as one mechanism for avoiding unfavorable climates.

Effects of forest management on plethodontid salamander abundance

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Amphibian ecology is sensitive to changes in temperature and humidity of forest floor ecosystems. Forest management and conversion alter microenvironmental climate regimes that can contribute to population declines. The Cumberland Plateau is a highly diverse region with some of the largest tracts of privately owned and managed native forests in the southeastern United States and an area of human population growth. Our objective was to assess density of terrestrial salamanders in four different managed forest types on the top of the Cumberland Plateau including native forest, exurban forests, thinned forests, and forests with prescribed fire. Salamanders were sampled using a cover board array over multiple days, and abundance of captured species was modeled using a repeated count model. Estimates of salamander density were influenced by forest type with native forest and thinned forest having equivalent densities of zigzag salamanders (*Plethodon dorsalis*). *Plethodon dorsalis* had abundances four times higher than native and thinned forest in burned and 5 times higher in exurban forests. *Plethodon glutinosus* had low densities in native forest, thinned, and burned forests and 3 times higher densities in exurban forests. Climatic variance was higher among plots than among treatments, but we did find that the availability of woody debris was higher in exurban forests and burned forests providing more refuge for plethodontid salamanders. Exurban forests in this area may have remained

more stable than other forest types providing terrestrial salamanders refuge from additional land-use changes.

The snake cutaneous microbiome: using resident probiotic skin bacteria to combat *Ophidiomyces ophiodiicola*, the causative agent of snake fungal disease

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Recently, there are increasing concerns regarding the role of snake fungal disease (SFD) in population declines of snake species. SFD is a severe ulcerative dermatitis caused by infection with *Ophidiomyces ophiodiicola* (Oo). The vertebrate cutaneous microbiome has been documented to serve as the first line of pathogen defense in many different species; however, very little is known about symbiotic microbial associations in snakes. The reptilian skin microbiome may affect the pathogenicity of Oo by outcompeting the pathogen for space, producing antifungal metabolites, and/or stabilizing the microbial community and potentially increasing innate defensive immunity. Identification of these beneficial bacterial species and their effects on pathogen defense may aid in future conservation management plans. The objectives of this project were to 1) isolate the resident skin microflora from three different snake species in Tennessee, 2) genotype all isolated bacteria and fungi, 3) and determine if the resident bacteria possess antifungal activity when challenged against Oo. A timber rattlesnake, black racer, and black king snake were captured in Tennessee with signs suggestive of SFD. At necropsy, lesions consistent with SFD were detected and Oo infection was confirmed with quantitative PCR in the black racer. Infection with Oo was not detected in the timber rattlesnake or king snake. Using standard microbiological practice, we obtained and genotyped 23 bacterial and 12 fungal isolates from all three snakes. All species possessed their own unique microbiome with no overlapping associations. Two isolated fungal taxa belonged to the *Fusarium solani* complex and genus *Trichophyton*, potentially accounting for the dermatophytic lesions on the timber rattlesnake and king snake, respectively. Bacterial isolates were challenged using in vitro assays against Oo and zones of fungal inhibition recorded. Three bacterial strains belonging to the genera *Myroides*, *Morganella*, and *Aeromonas*, all isolated from the timber rattlesnake, inhibited Oo growth. The remaining 20 bacterial isolates did not show any activity against Oo. Results highlight the importance of the snake microbiome in pathogen defense.

Using environmental DNA and citizen science to monitor stream salamanders in Great Smoky Mountains National Park

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Scientists tasked with the inventory and monitoring of wildlife often face challenges posed by organisms that are difficult to detect or to identify. Aquatic and semi-aquatic salamanders of the family Plethodontidae—and especially, their larvae—often fall into both of these categories. The indirect detection of organisms through the isolation and identification of DNA shed into their environment (i.e., environmental DNA; eDNA) is a promising technique for overcoming some of these challenges, and the potential for using standardized and streamlined field collection techniques makes the method amenable to citizen science initiatives. Using PCR primers designed to amplify a short, taxonomically informative mitochondrial DNA locus and a reference library created from publicly available sequence data and newly acquired, local salamander tissues, we created an environmental DNA metabarcoding assay to characterize plethodontid salamander communities in Appalachian streams. Here, we present preliminary results from a year of monthly sampling led by citizen scientists at Pigpen Branch, a long-term research site with 16 years of continuous salamander monitoring using traditional field methods.

Life History and Demography of the Two-lined Salamanders (*Eurycea cf. aquatica*) in the Upper Tennessee River

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The two-lined salamander (*Eurycea bislineata*) species complex is one of the most widely distributed and common groups of plethodontid salamanders in North America, and it shows great variation in habitat across this distribution. Currently, five species are recognized in this group, including *E. bislineata*, *E. junaluska*, *E. wilderae*, *E. cirrigera* and *E. aquatica*. The recognition of the brown-backed salamander (*E. aquatica*) has been a point of contention in the literature, although convincing genetic, morphological, and ecological data now exists to suggest that it is distinct from the occasionally sympatric *E. cirrigera*. Where they co-occur in close proximity, *E. aquatica* is found primarily in headwater springs and spring runs, while *E. cirrigera* is found along streams. *E. aquatica* also varies morphologically from *E. cirrigera* in head shape and body size. Because the *E. bislineata* species complex occupies a large geographic extent and broad ecological niche space, it is an interesting model for studying life history variation. For example, dates of egg deposition, patterns of parental care, length of larval period, and the timing of and size at metamorphosis all vary across the distribution of the species. Most studies of life history variation in this group have focused on *E. bislineata* in the northeastern United States or *E. wilderae* in the southern Appalachians. Here, we present preliminary

life history data from a species of two-lined salamander closely related to *Eurycea aquatica* in the Upper Tennessee River.

Moving forward in understanding disease of wild hellbenders

Rebecca Hardman, Debra Miller
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The Hellbender, *Cryptobranchus alleganiensis*, is a large aquatic salamander containing two subspecies (Ozark Hellbender, *C. a. bishopi* and Eastern Hellbender, *C. a. alleganiensis*) from the Ozark mountains and eastern U.S., respectively. Both subspecies have seen population declines over the past 25 years, especially in *C. a. bishopi* which is federally endangered. Habitat degradation and possibly low genetic diversity may lead to secondary infections with amphibian pathogens such as Ranavirus and *Batrachochytrium dendrobatidis* (Bd). Other pathogens such as the emerging salamander chytrid (*Batrachochytrium salamandrivorans* or Bsal) and other bacterial or fungal species are also of concern as either primary or secondary causes of disease. Our objective is to determine prevalence of these pathogens in both subspecies to understand the role of emerging amphibian pathogens in *C. alleganiensis* declines. We collected tail tissue and skin swabs from *C. a. bishopi* and *C. a. alleganiensis* individuals from Arkansas and Tennessee respectively during the summers of 2011-2014. We used qPCR analysis to determine presence of Ranavirus and Bd from tail samples and skin swabs, respectively. In the latter two years we collected swabs for metagenomic analyses of active lesions. Overall, for *C. a. bishopi*, we detected 27% prevalence of Bd and 3 cases of ranaviral infections; for *C. a. alleganiensis*, we detected 15% prevalence of Bd and 3% prevalence of Ranavirus. We have not found any Bsal positive individuals. These data reveal that Bd is present in these populations. We are currently in our second phase of investigating morbidity and mortality in hellbenders. We are incorporating metagenomic comparisons of lesions and healthy skin, bacterial peptide production, and classification of chytrid strains potentially unique to wild hellbender populations.

Male-female pairing in green salamanders, *Aneides aeneus*

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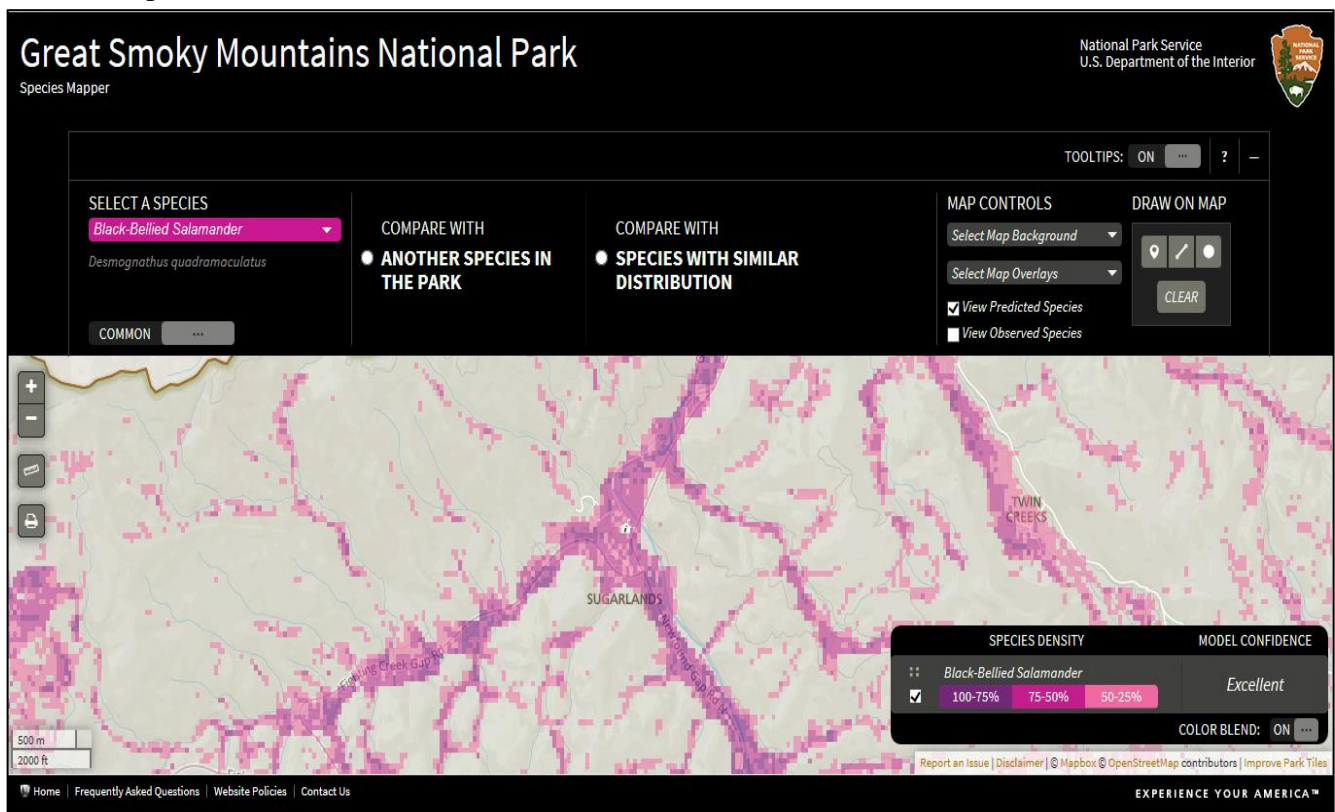
Formation of male-female pairs leading to mating in *Aneides aeneus* may occur during spring and fall. Pairs occur in specific rock crevices for 1-4 weeks during which bonding may occur. Pairs may be divided into two categories: male-female pairs that occur in single crevices or pairs that occur in adjacent crevices. Males and females located in the same crevices often maintain body contact which may be important in bonding. Also, pairs may occur in adjacent crevices for extended periods. Of 136 cases in which females with young were monitored, 48% were preceded by M-F pairs within single crevices. Also, 22% had males and females in adjacent crevices in which males were in association with the female for 1-4 weeks similar to pairs within crevices. Males often remained nearby before and

after egg deposition. The frequency of the presence of males after egg deposition was quite variable in either category. Also, 28% of brooding females appeared in crevices that previously contained males but pairing was not observed. Gravid females were present for a few days or weeks prior to egg deposition and remained in these crevices throughout the brooding period. In 10% of cases, males were never observed prior to arrival of gravid females. A high percentage of females brooding young was preceded by pairing of males and females in close association, whether in single crevices or adjacent crevices. Thus, many *A. aeneus* return to the same rock crevices in subsequent years. By returning to these breeding crevices, males and females have a greater chance of successfully producing young over several years. Over the short-term, pairing within rock crevices or in adjacent crevices allows for mate guarding by males to prevent females from mating with other males during the period prior to egg deposition.

Annual Tennessee Herpetological Field Trip

Because of its proximity to this year's meeting, the annual field trip associated with the meeting will be held at the "Salamander Capital of the World," the Great Smoky Mountains National Park (GSMNP). Thirty species of salamander and 14 species of frogs and toad have been documented in the park. Despite the notoriety of GSMNP being an amphibian hotspot, it boasts a diverse array of reptiles as well, including 8 species of turtles, 9 species of lizards, and 23 species of snake. With such a diversity of documented amphibians and reptiles, this year's field trip should be exciting.

THS members are encouraged to visit <https://science.nature.nps.gov/parks/grsm/species/>. The National Park Service has put together a species mapper website allowing visitors to view areas where species are likely to be found. Based on the locations of the field trip given below and by using the species mapper, THS members can generate a list of species they are most likely to encounter during the field trip.



The field trip will cover stream and forested habitats across at least two different elevations, hopefully increasing the herpetofauna observed. All THS members participating in the field trip need to meet at the Sugarlands Visitor Center at 2:00pm. The field trip will begin here with searches of a stream and surrounding habitat near the visitor center. Next, the field trip will move up in elevation to the Chimney Tops Picnic Area where the surrounding habitat can be searched. If time allows, the field trip will move to a third higher elevation site to continue searches. The field trip is expected to conclude around 5pm.

Amphibian Checklist for the Great Smoky Mountains National Park

Checklist taken from: <https://www.nps.gov/grsm/learn/nature/amphibian-checklist.htm>

Class AMPHIBIA

Order SALIENTIA—Frogs and Toads

BUFONIDAE

__ *Anaxyrus americanus americanus*—Eastern American toad

__ *Anaxyrus fowleri*—Fowler's toad

HYLIDAE

__ *Acris crepitans crepitans*—Northern cricket frog

__ *Hyla chrysoscelis*—Cope's gray treefrog

__ *Hyla cinerea*—Green treefrog [not native]

__ *Pseudacris crucifer crucifer*—Northern spring peeper

__ *Pseudacris triseriata*—Western chorus frog

MICROHYLIDAE

__ *Gastrophryne carolinensis*—Eastern narrow-mouthed toad

PELOBATIDAE

__ *Scaphiopus holbrooki holbrooki*—Eastern spadefoot toad

RANIDAE

__ *Lithobates catesbeianus*—Bullfrog

__ *Lithobates clamitans melanota*—Green frog

__ *Lithobates palustris*—Pickerel frog

__ *Lithobates sphenoccephalus utricularius*—Southern leopard frog

__ *Lithobates sylvaticus*—Wood frog

Order CAUDATA—Salamanders

AMBYSTOMATIDAE

__ *Ambystoma maculatum*—Spotted salamander

__ *Ambystoma opacum*—Marbled salamander

__ *Ambystoma talpoideum*—Mole salamander

CRYPTOBRANCHIDAE

__ *Cryptobranchus alleganiensis alleganiensis*—Eastern hellbender

PROTEIDAE

__ *Necturus maculosus maculosus*—Mudpuppy

PLETHODONTIDAE

__ **Aneides aeneus*—Green salamander

__ *Desmognathus aeneus*—Seepage salamander

__ *Desmognathus conanti*—Spotted dusky salamander

__ *Desmognathus imitator*—Imitator salamander

__ *Desmognathus marmoratus*—Shovelnose salamander

__ *Desmognathus monticola*—Seal salamander

__ *Desmognathus ocoee*—Ocoee salamander

__ *Desmognathus quadramaculatus*—Black-bellied salamander

__ *Desmognathus santeetlah*—Santeetlah dusky salamander

__ *Desmognathus wrighti*—Pigmy salamander

__ *Eurycea guttolineata*—Three-lined salamander

__ *Eurycea junaluska*—Junaluska salamander

__ *Eurycea longicauda*—Longtail salamander

__ *Eurycea lucifuga*—Cave salamander

__ *Eurycea wilderae*—Blue Ridge two-lined salamander

- ___ *Gyrinophilus porphyriticus danielsi*—Blue Ridge spring salamander
- ___ *Hemidactylium scutatum*—Four-toed salamander
- ___ *Plethodon glutinosus*—Slimy salamander
- ___ *Plethodon jordani*—Jordan’s salamander
- ___ *Plethodon metcalfi*—Southern gray-cheeked salamander
- ___ *Plethodon serratus*—Southern redback salamander
- ___ *Plethodon teyahalee*—Southern Appalachian slimy salamander
- ___ *Plethodon ventralis*—Southern zigzag salamander
- ___ *Pseudotriton montanus diastictus*—Midland mud salamander
- ___ *Pseudotriton ruber schencki*—Blackchin red salamander

SALAMANDRIDAE

- ___ *Notophthalmus viridescens viridescens*—Red-spotted newt

Notes

**Aneides aeneus* has been documented in the park’s fauna, but has not been seen in the park for at least 70 years.

Revised 5-98 by Steve Tilley, Smith College; Sandy Echternacht, University of Tennessee; Dana Soehn and Don Defoe, National Park Service

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Reptile Checklist for the Great Smoky Mountains National Park

Checklist taken from: <https://www.nps.gov/grsm/learn/nature/reptiles.htm>

Class **REPTILIA**

Order **TESTUDINES**—Turtles

CHELYDRIDAE

___ *Chelydra serpentina*—Snapping turtle

EMYDIDAE

___ *Chrysemys picta picta*—Eastern painted turtle

___ *Graptemys geographica*—Common map turtle

___ *Terrapene carolina carolina*—Eastern box turtle

___ *Trachymys scripta troostii*—Cumberland slider

KINOSTERNIDAE

___ *Sternotherus minor peltifer*—Stripeneck musk turtle

___ *Sternotheros odoratus*—Stinkpot

TRIONYCHIDAE

___ *Apalone spinifera spinifera*—Eastern spiny softshell

Order **SQUAMATA**—Lizards and Snakes

Suborder **LACERTILIA**

ANGUIDAE

___ *Ophisaurus attenuatus longicaudus*—Eastern slender glass lizard

PHRYNOSOMATIDAE

___ *Sceloporus undulatus hyacinthinus*—Northern fence lizard

POLYCHROTIDAE

___ *Anolis carolinensis carolinensis*—Northern green anole

SCINCIDAE

- ___ *Eumeces anthracinus*—Coal skink
- ___ *Eumeces fasciatus*—Five-lined skink
- ___ *Eumeces inexpectatus*—Southeastern five-lined skink
- ___ *Eumeces laticeps*—Broadhead skink
- ___ *Scincella lateralis*—Ground skink

TEIIDAE

- ___ *Cnemidophorus sexlineatus sexlineatus*—Six-lined racerunner

Suborder SERPENTES

COLUBRIDAE

- ___ *Carphophis amoenus amoenus*—Eastern worm snake
- ___ *Cemophora coccinea copei*—Northern scarlet snake
- ___ *Coluber constrictor constrictor*—Northern black racer
- ___ *Diadophis punctatus edwardsii*—Northern ring-neck snake
- ___ *Elaphe guttata guttata*—Corn snake
- ___ *Elaphe obsoleta obsoleta*—Black rat snake
- ___ *Heterodon platirhinos*—Eastern hognose snake
- ___ *Lampropeltis calligaster rhombomaculata*—Mole kingsnake
- ___ *Lampropeltis getula getula*—Eastern kingsnake
- ___ *Lampropeltis getula nigra*—Black kingsnake
- ___ *Lampropeltis triangulum elapsoides*—Scarlet kingsnake
- ___ *Lampropeltis triangulum triangulum*—Eastern milk snake
- ___ *Opheodrys aestivus*—Rough green snake
- ___ *Pituophis melanoleucus melanoleucus*—Northern pine snake
- ___ *Tantilla coronata*—Southeastern crowned snake

NATRICIDAE

- ___ *Nerodia sipedon sipedon*—Northern water snake
- ___ *Regina septemvittata*—Queen Snake
- ___ *Storeria dekayi dekayi*—Northern brown snake
- ___ *Storeria dekayi wrightorum*—Midland brown snake
- ___ *Storeria occipitomaculata occipitomaculata*—Northern redbelly snake
- ___ *Thamnophis sirtalis sirtalis*—Eastern garter snake
- ___ *Virginia valeriae valeriae*—Eastern earth snake

VIPERIDAE

- ___ *Agkistrodon Contortrix mokasen*—Northern copperhead (venomous)
- ___ *Crotalus horridus*—Timber rattlesnake (venomous)