# A HERPETOLOGICAL INVENTORY AT THREE SITES IN THE SOUTHERN APPALACHIANS

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*Abstract* The number of reptiles and amphibians is diminishing worldwide, with habitat destruction and fragmentation as the main cause of decline. The protection of these species depends upon long term studies of herpetofauna and an understanding of species-habitat interactions. Land managers now regard herpetofauna as an important part of land management plans, and the southeastern United States is one of the richest spots in the world for herpetofauna diversity. For this project we inventoried three sites in the southern Appalachians for herpetofauna: Rabun Gap – Nacoochee School, Tessentee Creek Bottomland Preserve, and the Buck Creek Serpentine Barrens. These sites have unique ecological and geological features, are currently being managed, and had never been inventoried for herpetofauna before. Coverboards were placed at all three sites and checked weekly over an approximately one month period. A leaf litter bag technique was used in streams at each site to inventory salamanders. The purpose of this study was to document the diversity of reptile and amphibian species within these three unique sites to provide a baseline for further studies of these areas.

*Key words: Buck Creek; coverboards; herptofauna; inventory; leaf litter bags; Rabun Gap-Nacoochee School; reptiles; salamanders; Serpentine Pine Barrens; Tessentee Creek Bottomland Preserve.*

## INTRODUCTION

Since the 1980s, scientists have noted drastic declines in amphibians and reptiles, known collectively as herpetofauna (Phillips 1994). Studies of these species and their complex and varied roles in ecosystems shed light on the importance of herpetofauna and their vital role in ecosystem function. As products of two distinct lineages separated millions of years ago, reptiles and amphibians are quite different and play significant ecological roles. Many reptiles and amphibians are important predators within their food webs, regulating the number of small mammals and invertebrates, while also falling prey to higher trophic levels of predatory fauna. Salamanders specifically contribute more energy to the food chain than either birds or mammals (Gibbons and Buhlmann 2001). Consumption of plants by reptiles such as turtles in aquatic environments can help to maintain a healthy ecosystem. Reptiles and amphibians are also especially susceptible to changes in their environment, making them potentially valuable as indicators of environmental health.

Worldwide declines in both amphibians and reptiles have been well documented and emphasize the need for long term studies to both track declines and better understand the causes of decline (Alford and Richards 1999). Among vertebrate taxa, amphibians are the most threatened (Rohr et al. 2008). In 1999 the organization Partners in Amphibian and Reptile Conservation outlined six factors contributing to the decline of these species, including habitat destruction, disease and parasitism, pollution, global climate change, non-native invasive species, and unsustainable use (Gibbons et al. 2000). The pathogenic chytrid fungus in particular

has been called the most deadly invasive species on the planet, and since 1980 has driven 67 frog species in the genus *Atelopus* to extinction (Rohr et al. 2008). Habitat destruction has been identified as the greatest threat to biodiversity and has serious implications for the future of herpetofauna, since herps often depend on forested habitats, or forest peripheries like streams and wetlands (Wilcove et al. 1998).

The southeastern United States is the area of greatest diversity for all amphibians and reptiles in this country except lizards; more turtle species are known to occur there than anywhere else in the world. The southern Appalachians constitute a biodiversity hotspot, boasting the richest diversity of salamander species in the world (Gibbons and Buhlmann 2001). The high diversity of herpetofauna in this region will only be protected from impending threats if herpetofauna are identified and monitored. It is important to inventory areas of interest to record species diversity, population sizes, habitat quality, and connectivity.

Historically, management plans have focused on game species, and were intended to manage habitats in ways that were tailored to human interests (i.e., fishing, hunting, logging, etc.) (Gibbons and Buhlmann 2001). Management practices have changed in recent decades to reflect a goal of maintaining biodiversity, and the effects of land management practices on herpetofauna in particular has become a concern (deMaynadier and Hunter 1999). It was the purpose of this study to inventory amphibians and reptiles at three distinct locations in northern Georgia and western North Carolina that had not been previously studied. These three areas included the grounds at Rabun Gap – Nacoochee School in Rabun County, Georgia, and Tessentee Bottomland Preserve and the Serpentine Barrens at Buck Creek in Macon and Clay counties, respectively, in North Carolina. This inventory of herpetofauna will serve as a baseline for future inventories and contribute to the land management plans for each of these locations.

## MATERIALS AND METHODS

### *Study Sites*

Rabun Gap - Nacoochee School (RGNS) is a private preparatory school located in Rabun County, Georgia. The grounds are comprised of about 1300 acres of diverse habitat including wetlands, ponds, fields and forest. The inventory conducted at this site will be shared with the school as part of a larger plan to develop a long-term sustainable management program.

Tessentee Bottomland Preserve is a 64-acre tract of bottomland and river bluff land at the junction of Tessentee Creek and the Little Tennessee River. Owned and managed by the Land Trust for the Little Tennessee, this area provides opportunities for study and restoration efforts (LTLT). Because of the diverse habitat types, from wetlands to upland mixed oak-pine forests, to bottomland Giant River Cane stands, this site was an obvious choice for study.

The serpentine barren at Buck Creek is a unique area in terms of geology and flora. Generally considered low in biotic diversity, serpentine barrens tend to harbor unusual species of flora and fauna in contrast to surrounding areas (Gatrelle 2001). Prone to fire and comprised mainly of pine stands and grassland, this area has a geology dominated by olivine-serpentine outcrops and nutrient-deficient soils, lending to the possibility of interesting herpetofauna species (Mansberg and Wentworth 1984).

### *Methods*

Our herpetological inventories included several search methods. At each site we used coverboards, a method of studying herps that is used widely by researchers (e.g., Harpole and Haas 1999, Pittman and Dorcas 2006, Wilgers and Horne 2006). Coverboards create a shaded but warm protected place for snakes and other herps to seek shelter. Our coverboards were constructed with 24 pieces of galvanized roofing tin cut into rectangular pieces approximately 70×100cm. When checking the coverboards, each one was quickly lifted and any debris underneath it was agitated. When a herp species was found under the coverboard, attempts were made to hand catch the animal, and snout-vent length and total length were recorded. Identification was done in the field using the guides Amphibians and Reptiles of the Carolinas and Virginia by Martof et al. (1980), Reptiles and Amphibians of Eastern/Central North America by Conant and Collins (1991), and The Amphibians of Great Smoky Mountains National Park by Dodd (2004).

As a method of catching stream salamanders and juvenile salamanders, we set out leaf litter bags in streams and tributaries at each site. The leaf litter bags were constructed of nylon mesh "deer exclosure" netting with openings of 2.5cm$^2$. The bags were approximately 50cm$^2$ (Jung et al. 1999). Each site had two transects of leaf litter bags, and the bags were checked once. When depositing the leaf litter bags, they were filled more than ¾ full with various fallen leaves from the stream edge, and submerged in the water at intervals about three meters apart. The bags were secured in the stream bed by placing rocks on top of them. When the bags were recovered, a 5 gallon bucket was filled with stream water and the rocks were removed from the bag as it was quickly lifted from the stream into the bucket. We submerged the bag while agitating the leaf litter with our fingers and rubbing the bag up and down, finally pulling the bag out of the bucket and allowing all water to drain into the bucket. The debris from the bag and water in the bucket were poured through a fine sieve net, and then the remaining debris in the net was sifted through by hand.

We recorded the percent of the bag that was submerged, which salamander species were found, whether they were larval or adult, their snout-vent length and total length at Rabun Gap-Nacoochee School and Tessentee Creek Bottomland Preserve. At Buck Creek we also included the number of *Plecoptera* of the genus *Tallaperla*, snails and crayfish found in each bag. The use of coverboards and leaf litter bags was accompanied by more casual inventory methods, conducting opportunistic searches by flipping terrestrial rocks and decomposing logs in minimal impact fashion (Pike et al. 2010), and flipping rocks in river beds. We were able to catch several individuals this way, and we noted species that we were not able to catch. At each site we also conducted a night search using headlamps, using the same opportunistic methods. When we were able to catch species and record measurements, we recorded snout-vent length, as well as total length in mm.

At Tessentee Creek Bottomland Preserve, 24 pieces of galvanized roofing tin had been placed in three transects of eight by Jason Love in May and June 2009, and these were checked periodically and the findings recorded. The first transect was located in an edge habitat between early successional forest and a field. The second transect was along the path through a red cedar savannah, an area characterized by native grasses and flowers. The third transect was in a second-growth mixed pine/hardwood forest.

The coverboards at Tessentee Creek were checked four times on a weekly basis from 9/10 – 10/11. A night search was conducted on 10/4. Our inventory also included a search of the wetland on the property and a rocky bluff. Thirteen leaf litter bags were placed at this site on

10/29, with seven in a tributary of Tessentee Creek at a low flow site and six in a tributary of the Little Tennessee River in a low flow area. The bags were recovered on 11/8.

Coverboards had been placed at the Rabun Gap-Nacoochee School by Jason Love in August, with three transects of eight coverboards. The first transect was placed on the edge of an open field, bordered by a stand of trees. The second transect was placed in a mixed oak/pine forest, and the third was along the edge of a small pond that was a former rock quarry filled with water. Coverboards were checked four times on a weekly basis from 9/10 – 10/11. A night search was conducted on 10/11 at Indian Lake, the small recreational lake on the school grounds. Other areas searched on the property included the wooded area surrounding a cemetery, and a degraded wetland surrounded by cow pasture. In addition, a search was done under the highway 441 bridge that passes over Betty's Creek on the RGNS property to seek out a *Cryptobranchus alleganiensis alleganiensis* (Eastern hellbender) individual that had been found there in 2009. Twenty leaf litter bags were placed in two transects on 11/8. Ten bags were placed along Betty's Creek, and another 10 were placed at the seep by the school alumni center. All bags were recovered on 11/15.

We placed 24 coverboards at the Buck Creek Serpentine Barrens on 9/17. The first two transects were at low and mid-level elevation on either side of Buck Creek with slopes of 10-15%, where pitch pine and white oak are the dominant tree species, and the understory is dominated by grasses, many of them rare for this part of the country (more typical of the Midwest). Each of these transects had seven coverboards in place. A third transect was placed at a higher elevation with similar vegetation. Ten coverboards were placed in this transect, following the ridge line with a slope of approximately 10%. The coverboards at Buck Creek were checked five times on a weekly basis from 9/17 – 10/15. A night search was conducted on 10/19 for about one hour. Opportunistic searches were conducted several times around the coverboard transects, and the tributary to Buck Creek that runs through the barrens close to our second transect was searched for salamander species. Twenty leaf litter bags were deposited at the Buck Creek Serpentine Barrens on 11/8. Ten were deposited in this tributary to Buck Creek, and ten were placed in Buck Creek. These bags were recovered on 11/19.

### *Analysis*

The three sites at which the inventories were conducted were located in different counties: Buck Creek in Clay County, North Carolina, Tessentee in Macon County, North Carolina, and RGNS in Rabun County, Georgia. All species found at the North Carolina sites were compared to the county inventories found on the Carolina Herp Atlas website for Macon and Clay counties (http://www.carolinaherpatlas.org). The information is based on reports submitted by observers in the field and not to be considered a complete listing of all species per county, but it served as a growing database with which to compare our findings. A list of herp species recorded for Rabun County was acquired from John Jensen at the Georgia Department of Natural Resources, and our species list for Rabun County was compared to this document. These resources were used to establish whether the species that we found had previously been recorded in these locations. The global (G) and state (S) conservation status of each species was also checked with the website Nature Serve (http://www.natureserve.org). A number system of 1 through 5 was used to reflect the level of concern: 1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, and 5 = secure.

The species diversity at each site was calculated using the Shannon-Wiener Diversity Index. Scores for this index tend to fall between 1.5, indicative of low species richness and evenness, and 3.5, indicative of high species richness and evenness. However, values are not limited to this range and can vary widely among locations. The formula used to calculate the Shannon-Wiener Diversity Index, H, is shown below.

$$H = -\sum_{i=1}^{S} (p_i (\ln p_i))$$

In this equation, $S$ is the number of species found, and $p_i$ is the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community.

## RESULTS AND DISCUSSION

Our surveys yielded a total of 14 species of reptiles and amphibians (Table 1). A species list supplemented with notes and measurements is presented in Appendix A. *Eurycea wilderae* (Blue Ridge two-line salamander) was found at all three sites, the only species in common to all sites and representing more than 50% of the individuals found at some sites (Fig. 2). This is a very common species throughout the southern Appalachians, so it is unsurprising that this species was so well represented. However, the lack of diversity is unusual and suggests that our samples are not exhaustive for the communities at these sites. At each site the number of amphibians found far exceeded the number of reptiles, reflective of the species composition in the southern Blue Ridge, where species richness of frogs, toads, turtles, snakes and lizards decreases as altitude increases (Taylor 2001).

TABLE 1. Recorded species and number of individuals by site.

| Site | Scientific name | Common name | Count |
|---|---|---|---|
| Tessentee Creek | *Diadophis punctatus edwardsii* | Ringneck snake | 1 |
| | *Coluber constrictor constrictor* | Northern black racer | 1 |
| | *Lampropeltis getula getula* | Eastern kingsnake | 1 |
| | *Eurycea wilderae* | Blue Ridge two-lined salamander | 13 |
| | *Desmognathus ocoee* | Ocoee salamander | 7 |
| | *Bufo woodhousii fowleri* | Fowlers toad | 1 |
| TOTAL | | | 24 |
| Rabun Gap NS | *Nerodia sipedon* | Northern watersnake | 1 |
| | *Sceloporus undulatus* | Eastern fence lizard | 1 |
| | *Eurycea longicauda guttolineata* | Three-lined salamander | 1 |
| | *Eurycea wilderae* | Blue Ridge two-lined salamander | 5 |
| | *Cryptobranchus alleganiensis* | Eastern Hellbender | 1 |
| | *Rana clamitans* | Green frog | 2 |
| TOTAL | | | 11 |
| Buck Creek | *Crotalus horridus* | Timber rattlesnake | 1 |
| | *Sceloporus undulates* | Eastern fence lizard | 1 |
| | *Desmognathus monticola* | Seal salamander | 6 |
| | *Desmognathus ocoee* | Ocoee salamander | 1 |
| | *Eurycea wilderae* | Blue Ridge two-lined salamander | 9 |
| | *Plethodon shermani* | Red-Legged salamander | 3 |
| TOTAL | | | 21 |

The low species count is also reflected by the scores for Shannon-Wiener Diversity Index (Table 2), which fell below the range of scores that is expected when using the index. This doesn't necessarily reflect poor richness in diversity but may be a result of the short duration of our study. Index scores did show a difference between the sites studied: Buck Creek scored the highest in diversity followed by Tessentee Creek and then RGNS. Even though Tessentee and Buck Creek yielded the same numbers of species, evenness differed between sites resulting in a lower score for Tessentee. RGNS had the same count of species as Buck Creek and Tessentee, but with a lower total and Shannon-Wiener score.

TABLE 2. Shannon-Wiener Diversity Index by site.

| Site | Shannon-Wiener Diversity Index |
|---|---|
| Rabun Gap NS | 1.04 |
| Tessentee Creek | 1.22 |
| Buck Creek | 1.43 |

This herpetological inventory contributes to Jason Love's previous inventory, and providing baseline data that others can use in the future. Other herpetological inventories that we consulted that were performed in the southern Appalachians yielded many more species (King 1939, Huheey and Stupka 1965, Taylor 2001). Though these surveys were over greater areas, their results indicate that long-term inventories at our sites should yield more herp species.

The study was limited by several factors, including time, season and number of coverboards/leaf litter bags used. Past studies that used coverboards have recommended that vegetation be cleared from under the coverboards, and the coverboards should be undisturbed after their placement for a significant period of time so that snakes will accept them as a part of the habitat. Because snakes are so sensitive to disturbance, the coverboards should be checked with less frequency, closer to once a month than once a week (Pittman and Dorcas 2006). Placing more coverboards would also be an effective method of finding more herp species, especially at RGNS, which has 1300 acres. The time of year of our study was also less favorable for herps, especially for snakes who are only active during the day when it is warmer. We experienced daytime temperatures averaging 50˚F, with temperatures even lower at night, inhibiting our findings on night searches.

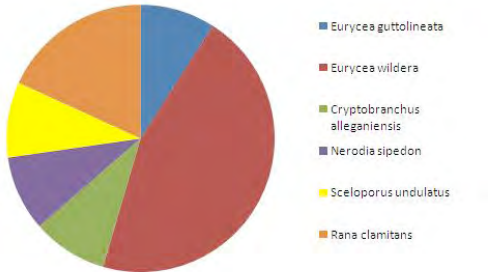


FIG. 1. Relative abundance of species found at Rabun Gap Nacoochee School.

The inventory of Tessentee Creek Bottomland Preserve has been going on longest of the three inventories we conducted, and we collected more herp species here than at any other site. This is probably partially because the preserve has such a diversity of habitats in a continuous landscape, but also suggests that a long term inventory done with coverboards yields a higher and more accurate count of snake species, and presents more opportunities for observing amphibians and reptiles in the greater area. Each snake species that we found while conducting the inventory at Tessentee Creek had already been found and recorded at this site by Jason Love. *Diadophis punctatus* (northern ringneck snake) was found in the same habitat type before, the second-growth mixed pine/hardwood forest transect. The recovery of *D. punctatus* again confirms the continued survival of the species here. Multiple *Coluber constrictor* (northern black racer) individuals have been found before in the red cedar savannah, so our data confirms this species continues to populate the area. *Lampropeltis getula* (eastern kingsnake) was also found in the red cedar savannah transect. The *L. getula* recorded previously was an adult, while the individual found

during this inventory was a juvenile, indicating that *L. getula* is still breeding in this area. All three snake species recovered are common in North Carolina and have a conservation status of G5, globally secure. We recommend that future inventories at this site include herp searches in as many different types of habitat as possible, since more than ten different habitat types have been described at the preserve. Further searches should include the bluff lands in particular, with rocky outcroppings that could be good for species like the timber rattlesnake, skinks, and lizards, as well as the wetland complex, which could harbor water snakes, turtles, and a diversity of amphibians.

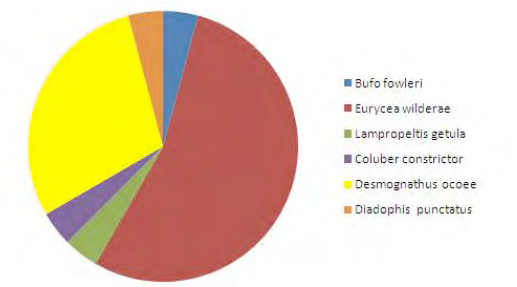


FIG. 2. Relative abundance of species found at Tessentee Creek.

Rabun-Gap Nacoochee School was the site with the greatest amount of acreage (approximately 1300 acres), but the fewest species were found here. A longer inventory period would likely yield more results, and because of the size of the property, creating a matrix of habitat patches to study would be more reflective of the diversity that can probably be found there. Because the coverboards had been placed for the first time only two weeks prior to checking them, we would recommend a longer study period with the coverboards. Future inventories of RGNS should include more searches at Indian Lake and the surrounding wetland habitat. The coverboard transect by the alumni center should be moved, since the adjacent field is mowed regularly, creating a major disturbance for reptiles and amphibians. In general, RGNS is more disturbed and fragmented than the other two sites, and this may have been another reason that so few species were found here. *Cryptobranchus alleganiensis alleganiensis* (eastern hellbender) had been found under the highway 441 bridge at Betty's Creek in July 2009 by Jason Love. The measurements recorded for the two individuals only differed by about 2 cm. Considering the small home range of *C. a. alleganiensis,* it is probable that the individual found in 2010 was the same one found in 2009. The continued presence of this individual indicates that Betty's Creek is a fairly clean stream, free of heavy sedimentation or pollution. *Cryptobranchus a. alleganiensis* is very habitat specific, and requires cool clean water with minimal sedimentation and a rocky/cobble bottom. A proposed widening of highway 441 at the location of this bridge may be impacted by the presence of this individual, which has a rounded global status of T3, vulnerable, and a state status in Georgia of S2, imperiled. We did not find any salamanders in our leaf litter bags placed in Betty's Creek, possibly because the creek flow is too fast and the water is too high for them.

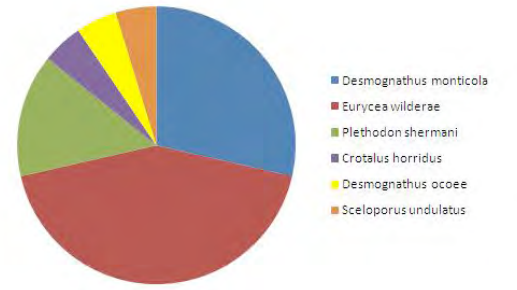


FIG. 3. Relative abundance of species found at Buck Creek.

The geology of Buck Creek Serpentine Barrens creates such a unique fire dependent community of plants that further study of herpetofauna at this site would be advisable. Due to the nature of the shallow soils, this is a variable habitat that is very moist in rainy periods and very

dry in the absence of rain. The acidity of the soil also creates runoff into the tributaries and seeps in the barrens, with potential for unusual species (Mansberg and Wentworth 1984). Though we were able to easily find and record salamanders in the tributary to Buck Creek on multiple occasions, we did not find any salamanders in the leaf litter bags that we placed here. This may be due to the placement of this transect next to the road through the barrens, which is more polluted due to runoff from the gravel road. Another factor that may have affected our litter bags was the high amount of rainfall prior to our checking the bags, which increased the flow of the tributary.

*Crotalus horridus* (timber rattlesnake) was collected at the Buck Creek Serpentine Barrens. *Crotalus horridus* has a global status of G4 but a state status in North Carolina of S3, vulnerable. This species prefers open, early successional habitats much like the barrens. The occurrence of this species at this site should be investigated further for more data since the long term global trend of this species is moderate decline (25-50%), and this is one species for which habitat destruction due to shading over and development is having a major impact. Areas with optimal habitat types like the serpentine barrens should be further investigated for a better understanding of the species-habitat interactions on the landscape.

Reptiles and amphibians around the world now face many threats, and with their sensitivity to pollution and various forms of ecosystem degradation and destruction, their value as biomarkers is to be given priority. Because of the numerous threats to biodiversity and the diminishing numbers of amphibians and reptiles, inventories will play a vital role in future conservation efforts. Inventories not only serve to document abundance and diversity of herpetofauna but can contribute to ecosystem assessment and better land management practices. Long term studies can help us understand more about the interactions between species and their habitat on a landscape and make us better equipped to deal with stressors. Short term inventories can contribute a great deal to long term studies, especially in areas like these that have not been previously inventoried. The data from this study will provide the groundwork for others to build upon and compare findings. As more inventories are carried out, more can be deduced about varying ecosystems and the species that comprise them. With this knowledge we can begin to develop sustainable conservation plans as well as rehabilitation plans for those systems already stressed or threatened.

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## APPENDIX A

Herpetofauna inventory data (tins, leaf litter bags, hand capture) by site and species found (digital archive on attached CD).

## APPENDIX B

Image of site map for Rabun Gap – Nacoochee School, including coverboard transect locations. Constructed in ArcMap (digital archive on attached CD).

## APPENDIX C

Image of site map for Buck Creek Serpentine Barrens, including coverboard transect locations. Constructed in ArcMap (digital archive on attached CD).