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A HERPETOFAUNAL INVENTORY OF THE LOWER ROANOKE RIVER FLOODPLAIN

TRIP LAMB, RUFUS W. GAUL, JR., MARIA L. TRIPP

Department of Biology, East Carolina University
Greenville, NC 27858

JEFFREY M. HORTON

The Nature Conservancy Roanoke River Project
Windsor, NC 27983

BRUCE W. GRANT

Department of Biology, Widener University
Chester, PA 19013

Abstract: An 18 month survey was conducted to inventory the reptiles and amphibians of the lower Roanoke River floodplain, and to generate estimates of herpetofaunal diversity within specific wetland habitats. Our sampling effort integrated 1) visual encounter surveys; 2) patch sampling with aquatic traps; and 3) artificial cover transects comprising wood and tin coverboards (ground cover) and PVC pipes (arboreal cover). Coverboard transects, replicated in two distinct habitats (ridge forest and levee forest), were monitored from May 1996 to July 1997. A total of 1,591 reptiles and amphibians representing 25 species was encountered under artificial cover during 48 site checks. More species were observed in ridge transects (n = 25) than levee forest transects (n = 4). Consequently, estimates of herpetofaunal diversity were higher for ridge (eH′ = 3.5; 5.8) versus levee forest sites (eH′ = 1.0; 1.1). Fewer species inhabiting the levee forests probably reflect fundamental differences in plant community structure but may also be a function of protracted flooding. Through collective sampling efforts, 19 amphibian and 22 reptile species were documented for the lower Roanoke River basin.

Key Words: amphibians; reptiles; monitoring; coverboard transects; wetlands; Roanoke River; North Carolina.

INTRODUCTION

The herpetofauna of the lower Roanoke basin has not been subject to a detailed inventory involving standard field sampling methods. Limited information on this biotic component of the Roanoke River stems from geographic locale: the lower basin is both remote and somewhat inaccessible. As a result, existing species records are based on disparate, largely incidental collecting efforts. Yet the basin's location also represents an important geographic transition zone for reptiles and amphibians, encompassing the northern range termini of many southeastern species as well as southern termini for certain northeastern species (Conant and Collins, 1991; Palmer and Braswell, 1995). Moreover, the lower Roanoke floodplain

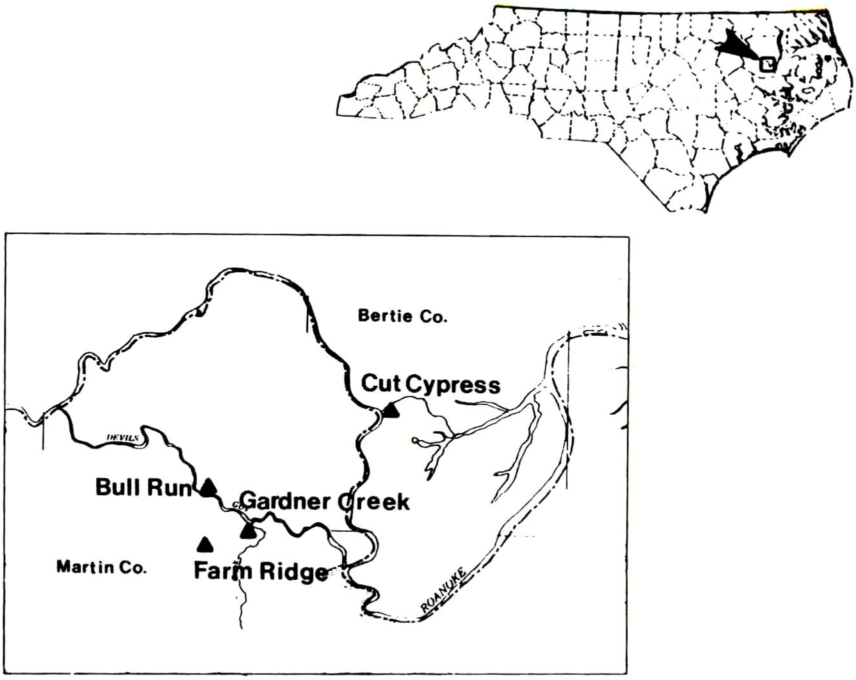

FIG. 1. Map of the lower Roanoke River basin. Artificial cover sites are depicted as Farm Ridge, Gardner Creek Ridge, Cut Cypress, and Bull Run.

retains the largest bottomland hardwood forest in the Mid-Atlantic region and is considered one of the more pristine forested wetlands in the Southeast (Smith et al., 1993). Thus, herpetofaunal species diversity of this watershed has the potential to be high. Herein we report the results of an 18 month survey of the basin's herpetofaunal community. Our research effort was designed to provide: 1) a species list of the reptiles and amphibians of the lower Roanoke basin; and 2) species diversity and relative abundance estimates in certain habitats.

METHODS

Study area: The lower Roanoke River floodplain occurs in northeastern Martin and southeastern Bertie counties, North Carolina. Our survey efforts were concentrated at sites on Bull Run and Jamesville islands and along Gardner, Devil's Gut, and Cut Cypress creeks (Fig. 1). The area is characterized by a diverse geomorphology consisting of well-defined ridge and swale topography, narrow levees, alluvial flats, and extensive backswamps. The lower reaches of the area on Jamesville island feature broad zones of saturated peat deposits and a hydrology influenced by wind tides (Rice and Peet, 1997; Townsend, 1997). The property, encompassing some 8,500 ha, is jointly managed through a conservation easement between Georgia-Pacific Corporation and the Nature Conservancy, entitled the GP/TNC Roanoke Ecosystem Partnership.

Inventory approaches: To maximize inventory efforts, we employed a variety of standard monitoring techniques, many of which target specific taxa and special habitats that might otherwise go undetected. Such an approach is especially critical for herpetofaunal surveys. Reptiles and amphibians are among the more difficult groups to assess in field biodiversity studies because of their small size, seasonal activity patterns, and cryptic behavior (Gibbons, 1988). Given inventory sampling constraints, i.e., 1–4 visits per month, our research plan involved integrating several monitoring techniques per visit. These techniques, outlined below, are coupled with information on the target organisms and habitats best served by each approach.

Visual encounter surveys: A visual encounter survey (VES) is one in which field personnel walk or ride through an area for a prescribed distance or period of time, systematically searching for animals. Most of our VES efforts involved boating censuses of basking turtles and snakes while en route to artificial cover sites. As a result, we surveyed stretches of Gardner, Devil's Gut, and Cut Cypress creeks as well as the main channel of the Roanoke River on a monthly basis, from March 1996 to July 1997. We also conducted VES while walking the artificial shelter transects (see below). VES works well for some of the larger reptile species (e.g., cooters, sliders, water snakes) and can provide estimates of abundance and distribution patterns within habitat types.

Live trapping: We used two types of live traps, turtle hoop traps and minnow traps (for aquatic amphibians, amphibian larvae, and small aquatic snakes), set in a variety of aquatic habitats, including streams, sloughs, and temporary ponds. Turtle traps were baited with sardines whereas minnow traps were set unbaited.

Artificial cover transects: We deployed two types of artificial shelter to survey herpetofaunal diversity in two distinct habitats. The first involved arrays of coverboards, sheets of plywood and tin that serve as ground cover, set along transects. The use of ground cover by reptiles and amphibians is well known, and turning ground cover, such as rocks and logs, is a common collecting technique (Conant and Collins, 1991; Heyer et al., 1994). Arrays of coverboards provide transects of artificial cover, and in certain habitats, can generate large numbers of encounters with otherwise cryptic reptiles and amphibians (Grant et al., 1992). The second form of artificial cover involved staking PVC pipes along transects. The hollow PVC pipes provide hiding sites for treefrogs and certain arboreal lizards. The use of artificial shelter in herpetofaunal surveys has been limited (Heyer et al., 1994), but these sampling techniques have potential advantages, providing standardized sampling units that can be replicated easily and applied consistently over time. Moreover, set-up costs and time are moderate, and cover materials can be readily moved to accommodate different sites or new surveys.

Transect deployment: Coverboard transects included two different cover types: sheets of galvanized roofing tin (0.6 m × 1.8 m) and untreated plywood (0.6 m × 1.2 m). Four transects comprising two replicates each in two distinct habitats were established in May 1996. Each transect contained 3–4 rows of 12–25 coverboards set at 10 m intervals along each row. Rows were placed 10–25 m apart.

The first habitat type, ridge forest (the upland component of ridge and swale complexes), was represented by two sites designated the Farm and Gardner Creek ridges. The Farm Ridge site, established 7–8 May 1996, included both tin (40 sheets) and plywood (100 sheets) transects. This tin/plywood array allowed us to examine the potential effects of different coverboard types on encounter rates and species composition. The second site, Gardner Creek Ridge, is an insular ridge adjacent the confluence of Gardner Creek and Devil's Gut. Gardner Creek transect, established 8–10 May 1996, consisted of 100 sheets of tin. We selected levee floodplain forest as our second habitat type. Two coverboard transects, Cut Cypress (100 tin sheets) and Bull Run (50 tin sheets) were established on 1 May and 10 May 1996, respectively. PVC pipe sections (3.2 cm diameter, 1.8 m length,) were staked at the Farm, Gardner Creek, and Cut Cypress sites in May 1996. Ten poles per transect were set at Cut Cypress and Gardner Creek, whereas 20 poles were set at the Farm Ridge (10 along the plywood transect, 10 along the tin transect).

Transect habitats: Ridge versus levee floodplain forests (sensu Rice and Peet, 1997) represent very different hydric regimes within the lower Roanoke basin. Levee forests lie adjacent to brownwater swamp forests that experience routine and often protracted seasonal flooding, whereas ridge forests seldom flood. Descriptions of these two distinct habitats, detailed below, correspond to vegetation classes formulated by Rice and Peet (1997).

Ridge Forest = *Quercus laurifolia-Quercus michauxii-Liquidambar styraciflua-Carpinus carolininiana* forest (Rice and Peet, 1997). This community is dominated by oaks (*Quercus laurifolia, Q. michauxii, Q. pagota*), sweetgum (*Liquidambar styraciflua*), and loblolly pine (*Pinus taeda*). The subcanopy includes American hornbeam (*Carpinus carolininana*), red maple (*Acer rubrum*), sparkleberry (*Vaccinium elliotii*), and hawthorn (*Crataegus macrosperma*). These plant species characterize the high ridges of the ridge and swale complexes found throughout the Devil's Gut region.

Levee Forest = *Acer rubrum-Acer saccharinum-Celtis laevigata- Quercus laurifolia* forest (Rice and Peet, 1997). This community, dominated by silver maple (*Acer saccharinum*), red maple (*A. rubrum*), sugarberry (*Celtis laevigata*), laurel oak (*Quercus laurifolia*), American sycamore (*Platanus occidentalis*), and boxelder (*Acer negundo*), occurs on narrow (~10 m) levees that experience temporary to seasonal flooding. Coverboard transects were established along ecotones between levee forests and extensive brownwater backswamps dominated by bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*).

Species diversity estimates: Species diversity was estimated using the Shannon index (H'), which provides a measure of the number of different species found in a sample (Pielou, 1977). High values of H' denote high biodiversity. The Shannon index is advantageous over simply counting the total number of different species because the latter is greatly affected by sampling effort (plot size and total number of individuals sampled). The greater the sample, the more likely rare species will be encountered. The Shannon index is superior because it is calculated from proportions; as a result, rare species contribute very little to the analysis. Thus, it is insensitive to the random inclusion or omission of rare species that occur with any sampling effort. The Shannon index equation is:

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

where the p_i's are the proportion of all observations in the ith species category, and S is the total number of species Although the index H' itself is "unitless," the exponent of this index, eH′, provides a measure of the equivalent number of equally common species (Pielou, 1977).

RESULTS AND DISCUSSION

We made 52 visits to the study area from March 1996 to July 1997, logging 608 person hr of field time. Results of the survey efforts were summarized by census technique.

Visual encounter surveys: Two species of aquatic turtles, the yellowbellied slider (*Trachemys scripta*) and Florida cooter (*Pseudemys floridana*), were common and were observed basking or in the water during every outing. Use of binoculars, under conditions of optimal lighting, allowed us to confirm markings on the carapace of certain basking *Pseudemys* as those which are diagnostic of *P. floridana.* However, confirmed identifications of all *Pseudemys* tallied by VES were confounded by two factors. First, records of another *Pseudemys,* the river cooter (*P. concinna*), have been reported from the coastal plain of North Carolina, where individuals often assume *floridana-like* patterns (Palmer and Braswell, 1995). Second, some herpetologists view the river cooter and Florida cooter as conspecific, given extensive intergradation in the upper coastal plain, and thus treat the Florida cooter as a subspecies of *P. concinna* (Seidel, 1994). Two other aquatic species were observed: eastern painted turtles (*Chrysemys picta*), though less common, were recorded each month, and common musk turtles (*Sternotherus odoratus*) were observed occasionally at Devil's Gut.

Three species of water snakes, the banded water snake (*Nerodia fasciata*), redbellied water snake (*N. erythrogaster*), and brown water snake (*N. taxispilota*), and the eastern cottonmouth (*Agkistrodon piscivorous*) were common and active most months of the year. One specimen of the mud snake (*Farancia abacura*) was collected 2 April 1996 east of the study area in Broad Creek.

Additional species were documented by VES while walking coverboard transects. For example, eastern box turtles (*Terrapene carolina*) were recorded at both the Farm and Gardner Creek ridges. Sole sighting of the dwarf salamander (*Eurycea quadridigitata*) occurred on 19 July 1996 under natural cover at the Farm Ridge. Southern cricket frogs (*Acris gryllus*) were common and observed on every site check at the Farm Ridge. Another notable sighting was that of a spotted turtle (*Clemmys guttata*) within 1 km of the Farm Ridge on 24 May 1996.

Live trapping: Turtle hoop traps were set in two distinct aquatic habitats at the Farm Ridge site: 1) a temporary swale pond, and 2) a 1st order stream and associated sloughs. A total of 2,400 trap hr was logged during April–June 1996 and March–April 1997. No turtles were captured in the swale pond. Three species of turtles were captured in the stream: the common snapping turtle, *Chelydra serpentina* (n = 6), common musk turtle, *Sternotherus minor* (n = 2), and yellowbelly slider, *Trachemys scripta* (n = 1). Each captured turtle was marked for future identification by filing a notch in a marginal scute to monitor recapture rates. Four of the six snapping turtles were recaptured at least once, and one individual was recaptured three times.

Minnow traps were set in the same two habitats at the Farm ridge site as well as two habitats, a 1st order stream and cypress-tupelo swamp, at the Cut Cypress site for a total of 5,664 trap hr during April–June 1996 and March–April 1997. However, yields for reptiles and amphibians were meager; none were captured at

Table 1. Species list for the 1,591 herpetofaunal encounters in the artificial cover survey. Coverboards yielded 1,512 encounters whereas PVC pipes yielded 79 encounters.

Species	Common Name	# Encountered
Salamanders: n = 329		
Amphiuma means	Two-toed amphiuma	1
Ambystoma opacum	Marbled salamander	39
Plethodon chlorobryonis	Slimy salamander	279
Stereochilus marginatus	Many-lined salamander	9
Notophthalmus viridescens	Red-spotted newt	1
Frogs: n = 1,070		
Acris gryllus	Southern cricket frog	1
*Hyla cinerea**	Green treefrog	15
*Hyla chrysoscelis**	Gray treefrog	12
*Hyla squirella**	Squirrel treefrog	51
Bufo terrestris	Southern toad	3
Bufo fowleri	Fowler's toad	2
Rana clamitans	Green frog	1
Rana utricularia	Southern leopard frog	966
Gastrophryne carolinensis	Eastern narrowmouth toad	19
Lizards: n = 68		
Eumeces laticeps	Broadheaded skink	4
Eumeces fasciatus	Five-lined skink	4
Scincella lateralis	Ground skink	59
*Anolis carolinensis**	Green anole	1
Snakes: n = 124		
Coluber constrictor	Northern black racer	5
Carphophis amoenus	Eastern worm snake	35
Diadophis punctatus	Southern ringneck snake	23
Nerodia fasciata	Banded water snake	35
Nerodia erythrogaster	Redbellied water snake	21
Storeria occicipitomaculata	Redbellied snake	3
Agkistrodon piscivorous	Eastern Cottonmouth	2

* Designates those species encountered in PVC pipe cover.

the Farm Ridge swale pond, nor were any taken at Cut Cypress. Four amphibian and one snake species were captured at the Farm Ridge stream. These included the greater siren, *Siren lacertina* (n = 1), two-toed amphiuma, *Amphiuma means* (n = 1), bullfrog, *Rana catesbeiana* (n = 2), southern leopard frog, *Rana utricularia* (n = 6), and banded water snake, *Nerodia fasciata* (n = 1).

Artificial cover transects: Coverboard arrays were visited monthly (except for December 1996) or twice monthly from May 1996 to July 1997. A total of 1,512 reptile and amphibian encounters was recorded during 48 site checks, representing 21 different species (10 reptiles, 11 amphibians) beneath 4,703 coverboards (Table 1). We used the term "encounters" en lieu of individuals, as certain individuals were probably observed repeatedly. Without using mark-recapture identification techniques, e.g., toe-clipping or scale clipping, it was not possible to tally numbers of individuals or infer specific population estimates. However, the data provided insight to patterns of seasonal activity as well as general abundance of the species encountered (Tables 1, 2). Encounter data also revealed coverboard sampling effectiveness as a function of time by tabulating cumulative number of species

Table 2. List of reptile and amphibian species encountered using artificial cover. Large X's indicate first encounter date; small x's indicate subsequent encounters. Asterisks designate those species encountered in PVC pipe cover. Bottom row reflects the cumulative number of species encountered, by month, from May 1996 through July 1997.

Species	May	June	July	Aug	Sept	Oct	Nov	Jan	Feb	Mar	Apr	May	June	July
Salamanders														
Amphiuma means	X													
Ambystoma opacum	X		x			x	x	x	x	x	x	x	x	x
Notophthalmus viridescens													X	
Plethodon chlorobryonis	X	x	x	x	x	x	x	x	x	x	x	x	x	x
Stereochilus marginatus										X		x	x	x
Frogs														
Bufo terrestris	X	x			x								x	
Bufo fowleri	X												x	
Acris gryllus												X		
*Hyla cinerea**			X	x	x	x				x	x		x	x
*Hyla chrysoscelis**		X	x	x	x	x				x	x			
*Hyla squirella**				X		x				x	x		x	
Gastrophryne carolinensis		X	x	x	x							x		x
Rana clamitans										X				
Rana utricularia	X	x	x	x	x	x	x	x	x	x	x	x	x	x
Lizards														
Eumeces fasciatus			X				x			x	x			
Eumeces laticeps	X										x			
Scincella lateralis	X	x	x	x	x	x	x		x	x	x	x	x	x
*Anolis carolinensis**								X						
Snakes														
Carphophis amoenus		X	x	x	x					x	x	x	x	
Coluber constrictor										X	x	x		x
Diadophis punctatus	X	x	x	x	x	x				x	x	x	x	x
Nerodia erythrogaster	X													
Nerodia fasciata	X													
Storeria occipitomaculata								X			x	x	x	
Agkistrodon piscivorous						X				x	x			
Cumulative Totals	11	14	16	17	17	18	18	20	20	23	23	24	25	25

Table 3. Species list for herpetofaunal encounters in the artificial cover survey partitioned by transect site.

Site Species	# Encounters
Bull Run n = 169	
Rana utricularia	169
Cut Cypress n = 576	
Stereochilus marginatus	8
Rana utricularia	565
Nerodia fasciata	2
Nerodia erythrogaster	1
Gardner Ck n = 264	
Amphiuma means	1
Ambystoma opacum	4
Stereochilus marginatus	1
Notophthalmus viridescens	1
Bufo fowleri	2
Hyla chrysoscelis	2
Rana utricularia	182
Eumeces fasciatus	3
Eumeces laticeps	4
Carphophis amoenus	14
Coluber constrictor	1
Diadophis punctatus	8
Nerodia fasciata	28
Nerodia erythrogaster	13
Farm Ridge n = 582	
Ambystoma opacum	35
Plethodon chlorobryonis	279
Acris gryllus	1
Bufo terrestris	3
Gastrophryne carolinensis	19
Hyla cinerea	15
Hyla chrysoscelis	10
Hyla squirella	51
Rana clamitans	1
Rana utricularia	50
Anolis carolinensis	1
Eumeces fasciatus	1
Scincella lateralis	59
Agkistrodon piscivorous	2
Carphophis amoenus	21
Coluber constrictor	4
Diadophis punctatus	15
Nerodia fasciata	5
Nerodia erythrogaster	7
Storeria occicipitomaculata	3

observed across months (Table 2). For example, 10 of the 21 species recorded under coverboards were observed during the first site visit in May 1996, but the final six species were not observed until March, May, or June 1997.

PVC pipes proved useful in sampling species not otherwise encountered at

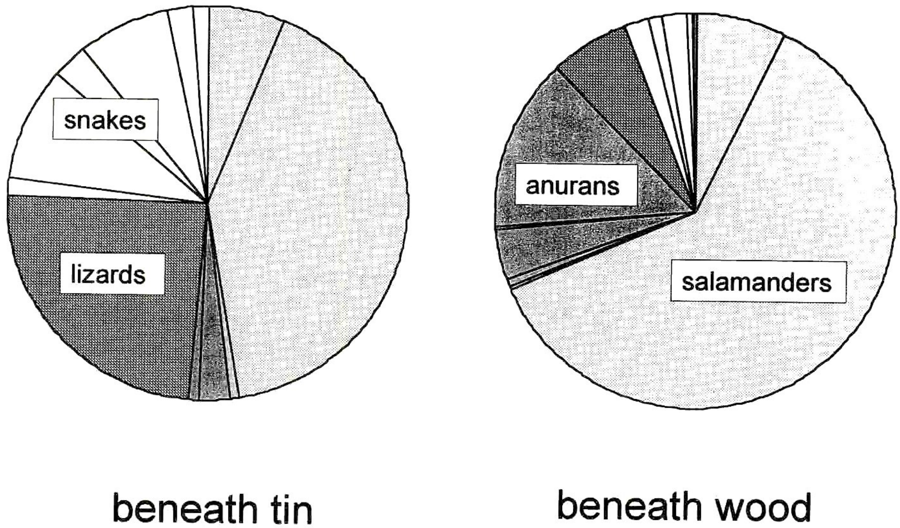

FIG. 2. Pie diagram comparisons of herpetofaunal encounters beneath tin versus plywood coverboards at the Farm Ridge. Gray shading = frogs (anurans); white = snakes; light stippling = salamanders; dark stippling = lizards.

transect sites by the coverboard technique or VES. Three species of treefrogs (gray treefrog, *Hyla chrysoscelis*; green treefrog, *H. cinerea*; squirrel treefrog, *H. squirella*) and one species of lizard (green anole, *Anolis carolinensis*) used the PVC pipes as cover. Treefrogs were never observed beneath coverboards, probably because of their arboreal habits and refuge perches, e.g., tree holes, etc. Thus, the PVC pipes provided an effective means to document treefrogs, thereby complementing coverboards as artificial cover material. Overall, the artificial cover survey documented 1,591 reptile and amphibian encounters, representing 25 species (11 reptiles, 14 amphibians; Table 1).

Herpetofaunal comparisons within and between habitats: Replicate transects in each of the two distinct habitats, ridge forest and levee forest, permitted comparisons within as well as between habitat types. Numbers of encounters of amphibians and reptiles at the levee forest sites (Bull Run and Cut Cypress) are shown in Table 3. Of the 742 amphibians encountered at these two sites, almost all (99%) involved a single species, the southern leopard frog (*Rana utricularia*). The only other amphibian species encountered at these sites was the many-lined salamander (*Stereochilus marginatus*). No reptiles were encountered beneath any of the coverboards at Bull Run, and only three individuals were tallied from Cut Cypress (two banded water snakes and one redbellied water snake). Not unexpectedly, Shannon diversity indices for these sites were correspondingly low (eH' = 1.0 and 1.1 for Bull Run and Cut Cypress, respectively).

A much higher herpetofaunal diversity was observed in the ridge forests (Farm Ridge and Gardner Creek; Table 3). Collectively, 658 amphibians representing 14 species and 189 reptiles representing 11 species were encountered, and Shannon diversity indices were higher (eH' = 3.5 and 5.8 for Gardner Creek and Farm ridges, respectively) than those calculated for the levee forest sites. The Shannon diversity value (eH' = 5.8) for the Farm Ridge was derived from tin coverboard

Table 4. Amphibians and reptiles recorded from the lower Roanoke River floodplain.

Amphibia	
Salamanders	
Amphiumidae	
Amphiuma means	Two-toed amphiuma
Sirenidae	
Siren lacertina	Greater siren
Salamandridae	
Notophthalmus viridescens	Eastern newt
Ambystomatidae	
Ambystoma opacum	Marbled salamander
Plethodontidae	
Eurycea quadridigitata	Dwarf salamander
Plethodon chlorobryonis	Atlantic Coast Slimy salamander
Stereochilus marginatus	Many-lined salamander
Frogs and Toads	
Bufonidae	
Bufo terrestris	Southern toad
Bufo fowleri	Fowler's toad
Hylidae	
Acris gryllus	Southern cricket frog
Hyla chrysoscelis	Gray treefrog
Hyla cinerea	Green treefrog
Hyla femoralis	Pine woods treefrog
Hyla squirella	Squirrel treefrog
Pseudacris crucifer	Spring peeper
Microhylidae	
Gastrophryne carolinensis	Eastern narrowmouth toad
Ranidae	
Rana catesbeiana	Bullfrog
Rana clamitans	Green frog
Rana utricularia	Southern Leopard frog
Reptilia	
Turtles	
Chelydridae	
Chelydra serpentina	Snapping turtle
Kinosternidae	
Sternotherus odoratus	Stinkpot
Emydidae	
Chrysemys picta	Eastern Painted turtle
Clemmys guttata	Spotted turtle
Pseudemys floridana	Florida Cooter
Trachemys scripta	Yellow-bellied Slider
Terrapene carolina	Eastern Box turtle
Lizards	
Polychrotidae	
Anolis carolinensis	Green anole
Scincidae	
Eumeces fasciatus	Five-lined skink
Eumeces laticeps	Broadhead skink
Scincella lateralis	Ground skink

Table 4. Continued

Reptilia	
Snakes	
Colubridae	
Carphophis amoenus	Eastern worm snake
Coluber constrictor	Black racer
Diadophis punctatus	Ringneck snake
Elaphe obsoleta	Rat snake
Farancia abacura	Mud snake
Nerodia erythrogaster	Redbellied water snake
Nerodia fasciata	Banded water snake
Nerodia taxispilota	Brown water snake
Storeria occipitomaculata	Redbellied snake
Viperidae (Subfamily Crotalinae)	
Agkistrodon contortrix	Copperhead*
Agkistrodon piscivorus	Cottonmouth

* Observed at Farm Ridge subsequent to completion of survey.

encounters only. Since coverboard arrays at the other three sites were represented solely by tin, we elected to restrict the Farm Ridge diversity calculation to tin data, at least initially, for comparative purposes. However, when tin and plywood coverboard data from the Farm Ridge were combined, the Shannon diversity index increased slightly ($eH' = 6.9$).

At Gardner Creek Ridge, the amphibian community was also dominated by southern leopard flogs (182 encounters), although five additional species of amphibians were observed. Gardner Creek was the only site where the red spotted newt (*Notophthalmus viridescens*) was documented. However, higher herpetofaunal diversity at Gardner Creek, relative to the levee forest sites, was a function of reptile abundance, most notably the snakes *Carphophis amoenus* (worm snake), *Nerodia fasciata* (banded water snake), *N. erythrogaster* (redbellied water snake), and *Diadophis punctatus* (southern ringneck snake).

The Farm Ridge also exhibited a much higher diversity than either floodplain site, although its species composition differed somewhat from that of Gardner Creek Ridge. With respect to amphibians, Atlantic coast slimy salamander, *Plethodon chlorobryonis* (279 encounters), marbled salamander, *Ambystoma opacum* (35 encounters), and eastern narrowmouth toad, *Gastrophryne carolinensis* (19 encounters), were common. Slimy salamanders and narrowmouth toads were never observed at Gardner Creek. More similarities existed between ridge sites with respect to reptiles; banded water snakes, worm snakes and ringneck snakes were all abundant. However, the numerically-dominant reptile species at the Farm Ridge was a more upland-associated lizard, the ground skink, *Scincella lateralis* (59 encounters). No ground skinks were observed at Gardner Creek.

Effect of coverboard type: Results from a previous comparison of plywood versus tin coverboard types set around a Carolina bay indicated that significantly more animals were encountered beneath plywood than tin (Grant et al., 1992). In addition, amphibian numbers were proportionally higher under plywood coverboards, presumably because the average percentage of litter mass due to water was 30% higher beneath wood than tin (Grant et al., 1992). We compared 1) the taxonomic composition of the herpetofauna and 2) encounter frequency between coverboard types to assess potential differences between plywood versus tin transects at the Farm Ridge. Our comparisons also revealed a much higher incidence of frogs and salamanders beneath plywood than tin (Fig. 2), but yielded a comparable encounter frequency between coverboard types (24.8 and 23.7 encounters per 100 plywood and tin coverboards, respectively, averaged over all site checks). Similar encounter frequencies between coverboard types at the Farm Ridge versus significantly different frequencies at the Carolina bay (Grant et al., 1992) may reflect microclimatic features associated with the closed canopy of a mature ridge forest compared to a more open understory at the Carolina bay.

Potential impact of flooding: Clearly, more species were observed at ridge sites (n = 25) than levee forest sites (n = 4). These differences likely represented fundamental habitat differences with respect to both plant community types and hydric regimes (Rice and Peet, 1997). An obvious correlate with this pattern is the greater incidence, duration, and intensity of flooding at the levee sites (Townsend, 1997). A question raised by this study is whether the protracted flooding documented for levee forests and adjacent cypress-tupelo forests (Townsend, 1997), as a function of activities of the Roanoke Rapids Dam upstream, has altered the herpetofaunal community within the levee forest and brownwater backswamp habitats of the lower Roanoke River. If flooding negatively affects terrestrial reptiles or the terrestrial phase of certain amphibians by protracted habitat disturbance, lower diversities might be expected, even within floodplain habitats like the levee and cypress-tupelo forests.

Future studies need to address the hypothesized connection between protracted flooding and possible herpetofaunal impact. Such data will be important to collect because our survey demonstrates how herpetofaunal community structure may serve to indicate levels of impact of wetlands hydrology. Most wetland studies only examine botanical indicators, but our data suggest that information on herpetofaunal biodiversity might provide further insight to wetlands function. Additionally, our data suggest that the management of terrestrial herpetofaunal biodiversity may be more closely linked to watershed management than is commonly recognized.

Working list of the lower Roanoke herpetofauna: Through collective sampling efforts, we documented the presence of 19 amphibian and 22 reptile species, or 41 species overall, in the lower Roanoke River basin (Table 4). Our survey list is preliminary and should be viewed as a first-pass compilation. That perceptions of herpetofaunal diversity are strongly dependent on survey effort has been clearly documented by four decades of sampling on the Savannah River Site (Gibbons et al., 1997). Nonetheless, our survey provides an important baseline from which patterns of herpetofaunal distribution and abundance can be expanded and refined. We endorse undertaking additional biotic surveys for the essential roles they will play in effective long-term management of the lower Roanoke River basin.

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REFERENCES CITED

CONANT, R., AND J. T. COLLINS. 1991. A Field Guide to the Reptiles and Amphibians: Eastern and Central North America. Houghton Mifflin Co., Boston, MA. 450 pp.

GIBBONS, J. W. 1988. The management of amphibians, reptiles and small mammals in North America: the need for attitude adjustment. Pp. 4–10 in R. C. Szaro, K. E. Severson, and D. R. Patton, Management of amphibians, reptiles and small mammals in North America. U.S. Forest Serv. Gen. Tech. Rept. RM-166. Ft. Collins, Colo.

———, V. J. BURKE, J. E. LOVICH, R. D. SEMLITSCH, T. TUBERVILLE, J. L. GREENE, P. NIEWIAROSKI, H. WHITEMAN, J. KRENZ, J. H. K. PECHMANN, D. E. SCOTT, M. S. MILLS, K. A. BUHLMANN, J. LEE, N. B. FRAZER, J. D. CONGDON, M. H. SMITH, R. SEIGEL, A. TUCKER, T. MILLS, T. LAMB, M. DORCAS, D. H. NELSON, B. M. DIETSCH, H. HANLIN, AND J. A. OTT. 1997. Perceptions of species abundance, distribution, and diversity: lessons from four decades of sampling on a government-managed reserve. Env. Mgt. **21**:259–268.

GRANT, B. W., A. D. TUCKER, J. E. LOVICH, A. M. MILLS, P. M. DIXON, AND J. W. GIBBONS. 1992. The use of coverboards in estimating patterns of reptile and amphibian biodiversity. Pp. 379–403 in D. R. McCullough, and R. H. Barrett (eds.), Wildlife 2001. Elsevier Science Publ., Inc., London, UK.

HEYER, W. R., M. A. DONNELLY, R. W. MCDIARMID, L. C. HAYEK, AND M. S. FOSTER. 1994. Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. Smiths. Inst. Press, Wash., DC 364 pp.

PALMER, W. M., AND A. L. BRASWELL. 1995. Reptiles of North Carolina. Univ. of No. Carolina Press, Chapel Hill. 412 pp.

PIELOU, E. C. 1977. Mathematical Ecology. John Wiley & Sons, New York, NY. 385 pp.

RICE, S. K., AND R. K. PEET. 1997. Vegetation of the Lower Roanoke Floodplain. Component Report in *The Roanoke River BioReserve: A Preliminary Assessment of Flow Modifications on Hydrology, Geomorphic Processes, and Vegetation.* The Nature Conservancy Ecosyst. Res. Progr., Arlington, Va. 154 pp.

SEIDEL, M. E. 1994. Morphometric analysis and taxonomy of cooter and red-bellied turtles in the North American genus *Pseudemys* (Emydidae). Chelonian Conser. Biol. **1**:117–130.

SMITH, I. K., H. E. LEGRANDE, S. P. HALL, Z. E. MURRELL, C. W. NORDMAN, AND M. SCHAFALE. 1993. *Regional Inventory for Critical Natural Areas, Wetland Ecosystems, and Endangered Species Habitats of the Albemarle-Pamlico Estuarine Region: Phase 3.* NC Natural Heritage Program, Div. Parks Recreation, Dept. Env., Health, Nat. Resour., Raleigh, NC. 666 pp.

TOWNSEND, P. A. 1997. Environmental gradients and vegetation patterns on the Roanoke River floodplain, North Carolina. Ph.D. dissertation, University North Carolina, Chapel Hill. 695 pp.

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