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Travis J. Ryan
Butler University, tryan@butler.edu

Thomas Philippi

Yale A. Leiden

Michael E. Dorcas

T. Bently Wigley

See next page for additional authors

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Authors
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Monitoring herpetofauna in a managed forest landscape: effects of habitat types and census techniques

Travis J Ryan[1, a], Thomas Philippi[a], Yale A Leiden[2, a], Michael E Dorcas[3, a], T.Bently Wigley[b], J.Whitfield Gibbons[a]

[a] Savannah River Ecology Laboratory, Drawer E, Aiken, SC 29802, USA

[b] NCASI, P.O. Box 340362, Clemson, SC 29634, USA

Abstract

We surveyed the herpetofaunal (amphibian and reptile) communities inhabiting five types of habitat on a managed landscape. We conducted monthly surveys during 1997 in four replicate plots of each habitat type using several different methods of collection. Communities of the two wetland habitats (bottomland wetlands and isolated upland wetlands) were clearly dissimilar from the three terrestrial communities (recent clearcut, pine plantation, and mixed pine–hardwood forest). Among the three terrestrial habitats, the total herpetofaunal communities were dissimilar ($P<0.10$), although neither faunal constituent group alone (amphibians and squamate reptiles) varied significantly with regard to habitat. Three survey techniques used in the terrestrial habitats were not equally effective in that they resulted in the collection of different subsets of the total herpetofauna. The drift fence technique revealed the presence of more species and individuals in every habitat and was the only one to detect species dissimilarity among habitats. Nonetheless, coverboards contributed to measures of abundance and revealed species not detected by other techniques. We suggest that a combination of census techniques be used when surveying and monitoring herpetofaunal communities in order to maximize the detection of species.

Keywords: Amphibian; Conservation; Coverboard; Drift fence; Forest management; Herpetofauna; Landscape; Monitoring; Reptile; Surveying

1. Introduction

Because of apparent population declines and extinctions throughout the world, amphibians have garnered a central place in the concern of biodiversity loss among biologists (Alford and Richards, 1999) and the general public (Phillips, 1994). Recently, Gibbons et al. (2000) demonstrated that many reptile populations are experiencing declines of a similar magnitude as amphibians. Moreover, the declines are ostensibly due to the same suite of causes: habitat loss and degradation, unsustainable use, invasive species, environmental pollution, disease, and global climate change (Gibbons and Stangel, 1999).

Habitat loss appears to be the most serious threat to herpetofauna (Gibbons et al., 2000), and accordingly the impact of landscape alteration and forest management techniques on amphibian and reptile communities is a major concern (DeMaynadier and Hunter, 1995 and Block et al., 1998). The exact nature of the effects can be determined by a variety of factors, such as the type of forestry practice (Greenberg et al., 1994), the composition of the resident amphibian and reptile communities (Hanlin et al., 2000), and the spatial/temporal scales being evaluated (Petranka, 1994 and Ash, 1997). Likewise, a given forestry practice may have different effects on amphibian and reptile communities in terms of reduction or increase in the number of individuals or species present depending on its proximity to pristine or mature forests, wetlands, and other critical habitats. Perceptions of the effects may be determined in part by the design of monitoring programs (e.g. see Petranka et al., 1993 and Ash and Bruce, 1994) as well as the specific methods used to perform censuses (Heyer et al., 1994 and Hanlin et al., 2000), and the time period over which monitoring is conducted (Gibbons et al., 1997 and Pechmann et al., 1991).

In this study, we examined the differences in herpetofaunal (amphibian and reptile) community composition among five different habitat types within the Woodbury Tract, a large, managed landscape in South Carolina that supports more than 70 species of amphibians and reptiles (Leiden et al., 1999). We used a variety of sampling methods in all habitat types to document the abundance and diversity of amphibians and reptiles during 1996–1998 (Leiden et al., 1999). In the present paper, we describe the results of a systematic, replicated monthly sampling effort made in 1997 within five distinct habitat types. Two wetland habitats were sampled, but we focus primarily on the differences in herpetofaunal abundance and diversity among the three terrestrial habitat types, all of which were under some degree of forestry management. Also, we compare the efficacy of three survey techniques within the different terrestrial habitats. Our goals in this paper are triune: (1) to compare herpetofaunal community dissimilarities between wetland and terrestrial habitats; (2) to compare herpetofaunal community dissimilarities among three terrestrial habitats common to forest-managed landscapes of the southeast; and (3) to compare the effectiveness of different surveying techniques.

2. Materials and methods

2.1. Study site and survey methodology

This study was conducted on the 8000 ha Woodbury Tract, located in Marion County, SC. A variety of coastal plain wetlands (e.g. river swamps, Carolina bays, oxbow lakes, streams) and upland habitats (e.g. sandhills, pine plantations and flatwoods, mixed pine–hardwood forests) are found on the Woodbury Tract. The landscape has been altered by a variety of human activities, past and present. Some recent examples include forestry practices that have resulted in numerous even-aged pine plantations, clearcuts, annually tilled wildlife food plots, and a powerline right-of-way through the center of the tract (Leiden et al., 1999). We surveyed plots monthly throughout 1997.

The two wet habitat types were (1) bottomland wetlands (i.e. in the Pee Dee River floodplain) and (2) isolated upland freshwater wetlands (e.g. Carolina bays). The three terrestrial habitat types were (1) clearcut areas that had been harvested 0–3 years previously; (2) mixed pine–hardwood habitats harvested 25–40 years ago; and (3) loblolly pine plantations, now 10–15 years old. For each of the three terrestrial habitat types, four 0.8 ha plots were established, with each replicate located in a unique stand. The plots were located within stands measuring a minimum of 5 ha.

To document the presence of herpetofauna, we sampled each plot for 1 week each month using three census methods: time-constrained searches, coverboards, and drift fences with pitfall and funnel traps. Time-constrained searches were conducted during daylight hours, involved one researcher-hour/week, and included turning cover objects other than coverboards. All animals collected were identified and released within the plot immediately unless further documentation (e.g. photographs, pit-tag identification codes) was required. We placed an array of 20 coverboards ($60\ cm \times 120\ cm \times 1.25$ cm plywood; Grant et al., 1992) located 10 m apart in each plot. The coverboard arrays lined three of the sides of each plot and were checked twice weekly. We installed a plus-shaped drift fence array (Gibbons and Semlitsch, 1981) in each plot. A box trap was at the center of the array (Leiden et al., 1999), and along each 15.3 m wing of the fence we set three pairs of pitfall traps (19 l buckets flush with the ground) and two pairs of double-ended funnel traps. During each sample period we checked the pitfall traps four consecutive days and disabled the traps when plots were inactive.

Four replicates of each wetland habitat were sampled by using minnow traps and baited turtle traps in addition to coverboards and time-constrained searches. Drift fences were not used at the wetland sites

2.2. Analyses

We used an analysis of dissimilarity (ANOSIM; Clarke, 1993, Smith, 1998 and Philippi et al., 1998) to compare herpetofaunal community composition among the habitat types. We used two methods of estimating dissimilarities in species composition between the habitats, each emphasizing a different aspect of community structure: Bray–Curtis method accounts for evenness among species within samples while the Jaccard method evaluates the presence/absence (not found) of species in each sample. We calculated dissimilarities between all pairs of samples using both methods. If two habitat types support different communities, then the dissimilarities between pairs of samples of different habitats should be larger than the dissimilarities between pairs of samples within one or the other habitat. The magnitudes of the dissimilarities between habitat versus within habitat pairs were tested using a Kruskal–Wallis test (non-parametric one-way analysis of variance), with significance determined by a Mantel test permuting the habitat labels on the samples. With four replicate samples in each habitat type, a given comparison had 16 between habitat dissimilarities (four samples from one habitat contrasted with each of four samples from another habitat) and 12 within habitat dissimilarities (six unique within habitat comparisons in each of two habitats). However, there were only 35 unique label permutations (e.g. see Philippi et al., 1998), so even for the largest possible difference (i.e. all between habitat dissimilarities larger than the largest within habitat dissimilarity) the most significant result possible was P=1/35=0.029. Because the lower limit of significance is severely truncated (from infinity), we set α=0.1. Finally, we generated non-metric multidimensional scaling (MDS) figures from the pairwise Bray–Curtis dissimilarities. The two dimensions in the MDS figures are determined by undefined factors, which likely include environmental and microgeographic variables such as proximity to water, distance to edge of the habitat, availability of suitable cover objects, and vegetative cover. We used Chi-square test of association to determine whether the number of species detected in the different habitats departed significantly from parity. We then used Chi-square goodness-of-fit tests to evaluate the number of species and individuals detected (1) in the different habitats and (2) by the different techniques; because we caught far more individual amphibians than reptiles (626 and 348, respectively), we analyzed the two groups separately.

3. Results

During this study, 41 (57%) of the 72 species known from the area (Leiden et al., 1999) were captured and used in the analyses: 13 of the 19 species of anurans known to be present on the site, 7 of the 8 salamanders, 5 of the 8 lizards, and 16 of the 28 snakes (Table 1). Turtles were excluded from the analyses because they were captured only in aquatic traps that were not used at the terrestrial sites. A total of 1752 anurans, salamanders, lizards, and snakes were captured on the 20 replicate plots within the five habitats (Table 2).

Herpetofaunal communities in the two wetland habitats were clearly dissimilar from those in the three terrestrial habitats (P<0.0001, Fig. 1). When considering only the three terrestrial habitats, we found that while replicate sites of each habitat clustered together (Fig. 2), only in two of the pairwise comparisons were the dissimilarities significant (Table 3). When we divided the herpetofauna into the main taxonomic groups (amphibians and squamate reptiles), a similar pattern was evident; there was clear separation among habitat types (Fig. 3), but the dissimilarities lacked statistical significance (all P>0.10). There was no relationship between the number of amphibian and reptile species and the different habitat types (test of association: χ^2=0.43, P=0.8057, Table 2). Amphibians were unevenly distributed among the habitats (goodness-of-fit: χ^2=18.37, P=0.000103, Table 2), being most common in the clearcuts. Reptiles were least numerous in clearcuts and most common in the mixed forests (goodness-of-fit: χ^2=12.62, P=0.0018, Table 2).

Drift fences were clearly superior to other techniques used: drift fences caught 30 (97%) of the 31 species collected in terrestrial habitats, and was the sole technique responsible for capture of 18 species (58%). Drift fences revealed the presence of more species (Table 2) and also captured a disproportionate number of both amphibians (goodness-of-fit: χ^2=1106.61, P<0.0001, Table 2) and reptiles (goodness-of-fit: χ^2=107.60, P<0.0001, Table 2). Furthermore, only the drift fence technique revealed herpetofaunal community differences among habitats (Table 3).

4. Discussion

Our study on the Woodbury Tract provides insight into the application of a 1-year sampling program in the comparison of herpetofaunal communities among habitats and the use of different field survey techniques in the assessment. We found that the herpetofaunal communities inhabiting wetland habitats were very different from communities in the terrestrial habitats. Not unexpectedly, the wetland habitats support a significantly different subset of the herpetofauna than do the dry upland habitats, although many pond- and stream-breeding amphibians may stray more than 100 m from the edge of wetland habitats (Semlitsch, 1998 and Semlitsch and Ryan, 1998).

Excluding the wetland habitats from the sampling comparisons, the herpetofaunal communities inhabiting terrestrial habitats (31 species) were dissimilar, although the differences were not statistically significant at conventional levels (i.e. α=0.05). However, because the level of probability in our tests have a lower boundary of P=0.029, as opposed to infinity, we suggest that differences often considered marginally significant (e.g. P<0.10) may indicate biological significance in this context. That is, the dissimilarities among upland habitat types reflect the differential distribution of the herpetofauna on the Woodbury Tract.

While overall herpetofaunal community composition was dissimilar between terrestrial and wetland habitats, the constituent groups (amphibians and squamate reptiles) in the three terrestrial habitats were more similar than the herpetofauna as a whole. This may be because both the amphibians and squamates sampled in the terrestrial habitats represent relatively small subsets of species (14 and 17, respectively, of 72 possible species), thereby reducing the possible degree of dissimilarity. Each of the habitats studied on the Woodbury Tract has a history of alteration, and therefore we cannot interpret our results in terms of how different management techniques directly affect herpetofaunal community composition. Nonetheless, our results indicate that the pine plantation habitat supports a different subset of the herpetofaunal diversity (and also proportionally fewer individuals) than does either the clearcut or the mixed hardwood habitats, as revealed by drift fence sampling. It is worth noting that the differences are significant only for the Jaccard method, which evaluates differences in presence/absent (not present) of species in a sample and not Bray–Curtis method, which evaluates the evenness of species. The difference between the habitats is likely due to the greater number of species present in the clearcut plots as compared to the pine plots (i.e. more present in the former versus the latter), and due to the presence of different species assemblages in the mixed and pine communities, which were similar in terms of total number of species present. Of additional interest is that the dissimilarities are significant only for the drift fence captures.

In our study, drift fences were superior to the other methods in terms of capturing both species and individuals. Our results support the contention that drift fences are the preferred method for revealing the presence of poorly represented species and in capturing significantly larger sample size of more abundant species (Gibbons and Semlitsch, 1981). However, coverboard arrays are frequently viewed as preferable to drift fences and time-constrained searches (Grant et al., 1992) because they are relatively inexpensive when compared to the cost of construction and maintenance of drift fences (when measured in both time and dollars). Also, in our study the coverboards revealed the presence of one species (*Eumeces laticeps*) not captured by the drift fence method (Table 1). The cost of time-constrained searches in terms of person–hours makes this technique the least worthwhile as no species were added, and the smallest number of species and individuals were captured. Visual searches by experienced personnel, however, are likely to contribute to estimates of presence and abundance (Corn and Bury, 1990).

Based on the results of the present study, we suggest that for a short-term monitoring program, drift fences are an indispensable survey tool. The most rigorous monitoring program in species-rich terrestrial habitats should also include coverboards and time-constrained searches, as no single sampling method is likely to reveal the presence of all species of herpetofauna inhabiting a particular region.

Developing an effective monitoring program requires determining the amount of time necessary to effectively sample the herpetofauna in terms of both species presence/absence (not detected) and abundance. Leiden et al. (1999) demonstrated that the number of species collected throughout the Woodbury Tract rapidly increased logarithmically, resulting in more than 66% of the total species being observed on the tract within the first 75 days of the monitoring program, but an additional 325 days were required to collect 90% of the total number of species. Nonetheless, some species were represented by a single observation, a consequence of the clandestine nature of many species of reptiles and amphibians, resulting in low detectability levels. Confirmation of species presence in small plots like those used in the present comparative study of habitats would presumably require a much longer monitoring period. Also, variation in the seasonal activity patterns of different members of the herpetofaunal community needs to be accounted for when determining the length of the monitoring program.

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1 Present address: Department of Biological Sciences, Butler University, Indianapolis, IN 46208, USA.

2 Present address: Quail Unlimited, P.O. Box 610, Edgefield, SC 29824, USA.

3 Present address: Department of Biology, Davidson College, Davidson, NC 28036, USA

References

R.A Alford, S.J Richards. Global amphibian declines: a problem in applied ecology. Ann. Rev. Ecol. Systematics, 30 (1999), pp. 133–165

A.N Ash. Disappearance and return of plethodontid salamanders to clearcut plots in the southern blue ridge mountains. Conserv. Biol., 11 (1997), pp. 983–989

A.N Ash, R.C Bruce. Impacts of timber harvesting on salamanders. Conserv. Biol., 8 (1994), pp. 300–301

W.M Block, M.L Morrison, P.E Scott. Development and evaluation of habitat models for herpetofauna and small mammals. For. Sci., 44 (1998), pp. 430–437

K.R Clarke. Non-parametric multivariate analysis of changes in community structure. Aust. J. Ecol., 18 (1993), pp. 117–143

Corn, P.S., Bury, R.B., 1990. Sampling methods for terrestrial amphibians and reptiles. US Department of Agriculture, Forest Service, General Technical Report, PNW-GTR-256.

P.G DeMaynadier, M.L Hunter Jr. The relationship between forest management and amphibian ecology: a review of the North American literature. Environ. Rev., 3 (1995), pp. 230–261

J.W Gibbons, R.D Semlitsch. Terrestrial drift fences with pitfall traps: an effective technique for quantitative sampling of animal populations. Brimleyana, 7 (1981), pp. 1–16

Gibbons, J.W., Stangel, P.W., 1999. Conserving amphibians and reptiles in the new millennium. In: Proceedings of the Partners in Amphibian and Reptile Conservation (PARC) Conference, 2–4 June 1999, Atlanta, GA. Aiken, SC: Savannah River Ecology Laboratory. Herp Outreach Publication No. 2

Gibbons, J.W., Burke, V.J., Lovich, J.E., Semlitsch, R.D., Tuberville, T.D., Bodie, J.R., Greene, Niewiarowski, P.H., Whiteman, H.H., Scott, D.E., Pechmann, J.H.K., Harrison, C.R., Bennett, S.H., Krenz, J.D., Mills, M.S., Buhlmann, K.A., Lee, J.R., Seigel, R.A., Tucker, A.D., Mills, T.M., Lamb, T., Dorcas, M.E., Frazer, N.B., Congdon, J.D., Smith, M.H., Nelson, D.H., Dietsch, M.B., Hanlin, H.G., Ott, J.A., Karapatakis, D.J., 1997. Perceptions of species abundance, distribution, and diversity: lessons from four decades of sampling on a government-managed reserve, Environ. Manage. 21, 259–268.

J.W Gibbons, D.E Scott, T.J Ryan, K.A Buhlmann, T.D Tuberville, B Metts, J.L Greene, T.M Mills, Y.A Leiden, S.M Poppy, C.T Winne. The global decline of reptiles, deja' vu amphibians. Biol. Sci., 50 (2000), pp. 653–666

Grant, B.W., Tucker, A.D., Lovich, J.E., Mills, A.M., Dixon, P.M., Gibbons, J.W., 1992. The use of coverboards in estimating patterns of reptile and amphibian biodiversity. In: McCullough, D.R., Barrett, R.H. (Eds.), Populations in 2001. Elsevier, New York, pp. 379–403.

C.H Greenberg, D.G Neary, L.D Harris. Effect of high-intensity wildfire and silvicultural treatments on reptile communities in sand-pine scrub. Conserv. Biol., 8 (1994), pp. 1047–1057

H.G Hanlin, F.D Martin, L.D Wike, S.H Bannett. Terrestrial activity, abundance and species richness of amphibians in managed forests in South Carolina. Am. Midland Naturalist, 143 (2000), pp. 70–83

Heyer, R.W., Donnelly, M., Wake, D.B., McDiarmid, R.W., 1994. Measuring and Monitoring Biodiversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC.

Y.A Leiden, M.E Dorcas, J.W Gibbons. Herpetofaunal diversity in coastal plain communities of South Carolina. J. Elisha Mitchell Sci. Soc., 115 (1999), pp. 270–280

J.H.K Pechmann, D.E Scott, R.D Semlitsch, J.P Caldwell, L.J Vitt, J.W Gibbons. Declining amphibian populations: the problem of separating human impacts from natural fluctuations. Science, 253 (1991), pp. 892–895

J.W Petranka. Response to impact of timber harvesting on salamanders. Conserv. Biol., 8 (1994), pp. 302–304

J.W Petranka, M.E Eldridge, K.E Haley. Effects of timber harvesting on southern Appalachian salamanders. Conserv. Biol., 7 (1993), pp. 363–370

T Philippi, P.M Dixon, B.E Taylor. Detecting trends in species composition. Ecol. Appl., 8 (1998), pp. 300–308

Phillips, K., 1994. Tracking the Vanishing Frogs: An Ecological Mystery. St. Martin Press, New York.

R.D Semlitsch. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conserv. Biol., 12 (1998), pp. 1113–1119

Semlitsch, R.D., Ryan, T.J., 1998. Migration, amphibian. In: Knobil, E., Neill, J.D. (Eds.), Encyclopedia of Reproduction. Academic Press, New York, pp. 221–227.

E.P Smith. Randomization methods and the analysis of multivariate ecological data. Environmetrics, 9 (1998), pp. 37–51

Table 1.
Amphibians and reptiles collected during sampling of five habitat types (each with four replicate plots) on the Woodbury Tract, SC in 1997a

Taxon	Common name	Habitat		Single	Method		
		W	T		D	C	S
Class Amphibia							
Order Caudata—salamanders							
Amphiuma means	Two-toed amphiuma	X		X			
Siren lacertian	Greater siren	X					
Ambystoma opacum	Marbled salamander		X		X		
Notophthalmus viridescens	Red-spotted newt	X	X		X		
Eurycea guttolineata	Three-lined salamander	X					
Eurycea quadridigitata	Dwarf salamander	X					
Order Anura—frogs and toads							
Scaphiopus holbrooki	Eastern spadefoot toad		X		X		
Bufo quercicus	Oak toad		X		X		X
Bufo terrestris	Southern toad	X	X		X	X	X
Acris gryllus	Southern cricket frog	X	X		X		
Hyla chrysoscelis	Gray treefrog		X	X	X		
Hyla cinerea	Green treefrog		X	X	X		
Hyla femoralis	Pine woods treefrog	X	X		X		
Hyla squirella	Squirrel treefrog		X	X	X		
Pseudacris crucifer	Spring peeper	X					
Gastrophryne carolinensis	Narrow-mouthed toad		X		X	X	
Rana catesbeiana	Bullfrog	X	X		X		
Rana sphenocephala	Southern leopard frog	X	X		X		
Rana virgatipes	Carpenter frog	X	X		X		
Class Reptilia							
Order Squamata—snakes and lizards							
Suborder Lacertilia—lizards							
Anolis caolinensis	Green anole	X	X		X	X	X
Cnemidophorus sexlineatus	Six-lined race runner		X		X	X	X
Eumeces inexpectatus	Southeastern five-lined skink	X	X		X	X	X
Eumeces laticeps	Broadhead skink		X	X		X	
Scincella lateralis	Ground skink	X	X		X	X	X
Suborder Serpentes—snakes							
Carphophis amoenus	Worm snake		X		X	X	
Cemophora coccinea	Scarlet snake		X		X		
Coluber constrictor	Black racer	X	X		X	X	X
Diadophis punctatus	Ringneck snake	X					
Farancia abacura	Mud snake		X		X		
Heterodon platyrhinos	Eastern hognose snake		X		X	X	
Heterodon simus	Southern hognose snake		X	X	X		

Lampropeltus getula	Common kingsnake	X	X		X		
Masticophis flagellum	Coachwhip		X		X	X	
Nerodia erythrogaster	Red-bellied water snake	X	X		X		X
Nerodia fasciata	Southern banded water snake	X	X		X		
Nerodia taxispilota	Brown water snake	X		X			
Seminatrix pygaea	Black swamp snake	X		X			
Virginia valeriae	Smooth earth snake	X		X			
Agkistrodon contortrix	Copperhead		X	X	X		
Croatlus horridus	Canebrake rattlesnake		X	X	X		

a Habitat refers to either wetlands (W: Carolina bays and floodplains) or terrestrial (T: recent clearcut, pine plantation, and mixed hardwood). Single indicates only a single individual was captured; method refers to census methods used in the terrestrial habitats (D: drift fence, C: coverboard, and S: time-constrained searches).

Table 2.

Number of species (S) and individuals (I) of amphibians and reptiles (excluding turtles and alligators) captured during sampling of five habitat types (each with four replicate plots) on the Woodbury Tract, SC in 1997a

Taxon	Wetlands 8 sampling sites		Terrestrial 12 sampling sites		Both 20 sampling sites	
General habitat types	S	I	S	I	S	I
All herpetofauna						
Reptiles	25	778	31	974	41	1752
Lizards	12	22	17	348	21	370
Snakes	4	9	5	287	5	296
Amphibians	8	13	12	61	16	74
Frogs	13	756	14	626	20	1382
Salamanders	8	241	12	623	13	864
	5	515	2	3	7	518
	Clearcut		Mixed		Pine	
Terrestrial habitats only	S	I	S	I	S	I
All herpetofauna						
Reptiles	24	343	17	345	15	286
Lizards	14	88	11	142	8	118
Snakes	3	61	5	128	4	98
Amphibians	11	27	6	14	4	20
Frogs	10	255	6	203	7	168
Salamanders	9	253	6	203	6	167
	1	2	0	0	1	1
	Drift fence		Coverboard		Searches	
Sampling techniques in terrestrial habitats	S	I	S	I	S	I
All herpetofauna						
Reptiles	30	796	11	132	8	46
Lizards	16	195	9	116	6	37
Snakes	4	146	5	106	4	35
Amphibians	12	49	4	10	2	2
Frogs	14	601	2	16	2	9
Salamanders	12	598	2	16	2	9
	2	3	0	0	0	0

a Captures are displayed as a function of general habitat types, management practices in the terrestrial habitat, and sampling methods in the terrestrial habitat (drift fence includes captures alongside the fence; searches includes other incidental captures)

Table 3.
Pairwise comparisons of dissimilarities of herpetofaunal communities inhabiting three terrestrial habitats on the Woodbury Tract, SC in 1997a

Comparison	Census method	Bray–Curtis	Jaccard
Clearcut vs. mixed	Coverboard	0.7714	0.2571
	Time-constrained search	0.8571	1
	Drift fence	0.2571	0.2286
Clearcut vs. pine	Coverboard	0.9429	0.7143
	Time-constrained search	0.82286	0.8286
	Drift fence	0.2	0.0571*
Mixed vs. pine	Coverboard	0.6	0.4857
	Time-constrained search	0.4286	0.3429
	Drift fence	0.3714	0.0857*

a The significance of Kruskal–Wallis non-parametric t-tests based on Bray–Curtis and Jaccard dissimilarities is reported for each census technique.

*Significant comparisons (P<0.10).

Fig. 1.

Multidimensional scaling representation of Bray–Curtis distances among herpetofaunal communities in five habitats on the Woodbury Tract, SC. Symbols are as follows: open squares (B): bottomland wetlands; closed circles (C): clearcuts; closed triangles (M): mixed pine–hardwood forests; closed squares (P): pine plantations; open diamonds (U): isolated upland wetlands.

Fig. 2.

Multidimensional scaling representation of Bray–Curtis distances among herpetofaunal communities in three terrestrial habitats on the Woodbury Tract, SC. Symbols are as in Fig. 1.

Fig. 3.

Multidimensional scaling representation of Bray–Curtis distances among amphibians and squamate reptiles assemblages in three herpetofaunal communities in three terrestrial habitats on the Woodbury Tract, SC. Symbols are as in Fig. 1.