Herpetofauna of Pitcher Plant Bogs and Adjacent Forests in Eastern Texas

Jeffrey A. Reid,[1] *College of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962*

R. Montague Whiting, Jr., *College of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962*

Abstract: Species composition and relative abundance of amphibians and reptiles were examined in 5 pitcher plant bogs and adjacent forests in eastern Texas. The herpetofaunal communities of the bogs and forests were compared and changes throughout a year were traced. Amphibians and reptiles were censused using drift fence arrays with funnel traps and 15-minute time-area searches. In the bogs, 407 individuals of 28 species were recorded; 468 individuals of 28 species were counted in the forests. More amphibian species and individuals were found in bogs ($P < 0.050$), and more reptile individuals ($P < 0.050$) were recorded in forests. Two amphibian and 5 reptile species comprised 87.1% of all individuals. The ground skink (*Scincella lateralis*) was the dominant species, representing 46.3% of all individuals. Ground skinks and six-lined racerunners (*Cnemidophorus sexlineatus*) preferred the forests ($P < 0.050$), coal skinks (*Eumeces anthracinus*) preferred the bogs ($P < 0.050$), and green anoles (*Anolis carolinensis*), dwarf salamanders (*Eurycea quadridigitata*), eastern narrowmouth toads (*Gastrophryne carolinensis*), and fence lizards (*Sceloporus undulatus*) showed no significant preferences.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 48:411–421

Within the Angelina National Forest in eastern Texas, small, hillside wetlands form unique ecological islands. The dominant plant species in these wetlands is the pale pitcher plant (*Sarracenia alata*), consequently the areas are referred to as "pitcher plant bogs" and are considered special management areas by the U.S. Forest Service. However, except for insect species associated with the pitcher plants, the fauna of the bogs is poorly known.

Previous studies in eastern Texas indicate that moisture and ground cover are important to the herpetofaunal community. During the dry summers that routinely occur in Texas, moisture provided by pitcher plant bogs may be espe-

[1] Present address: U.S. Fish and Wildlife Service, 701 N. First Street, Lufkin, TX 75901.

cially important to the forest faunal community. The objectives of this study were to examine and compare species composition and relative abundance of amphibians and reptiles in pitcher plant bogs and in adjacent forests and trace changes in the herpetofaunal communities of the bogs and forests throughout a year.

Assistance with data collection was provided by F. J. Chrismer, D. P. Fletcher, O. W. Gallaher, E. L. Naegeli, M. L. Poteet, and T. C. Swope. Guidance on statistical and herpetofaunal analyses was provided by R. R. Fleet. The study was funded by the College of Forestry, Stephen F. Austin State University, and the Southern Forest Experiment Station, U.S. Forest Service, Nacogdoches, Texas.

Methods

The study area was in the Boykin Spring region of the Angelina National Forest in Angelina and Jasper counties, Texas. Five pitcher plant bogs were selected on the basis of similarity, locality, and size. The bogs were generally characterized as marshy areas covered with sphagnum moss (*Sphagnum* spp.), pitcher plants, shrubs, and occasional pines. Vines, especially greenbrier (*Smilax* spp.), were prominent and frequently dominated portions of the canopy (Nixon and Ward 1986). The selected bogs averaged approximately 0.10 ha in size which accommodated the proposed arrangement of traps and were similar in vegetational and physiognomic characteristics and accessibility.

An adjacent forest site was situated in a randomly selected direction approximately 100 m from each bog. The 5 forest sites were similar to each other in stand age and structure. The forests were savannah-like with longleaf pine (*Pinus palustris*), shortleaf pine (*P. echinata*), and loblolly pine (*P. taeda*) dominating the overstory. The midstory was comprised of scattered shrubs such as American beautyberry (*Callicarpa americana*) and small hardwoods, primarily roughleaf dogwood (*Cornus drummondii*) and flowering dogwood (*C. florida*). Poison ivy (*Toxicodendron radicans*) dominated the understory and little bluestem grass (*Schizachyrium scoparium*) was the most common herbaceous component of the ground cover (Nixon and Ward 1986).

Pitcher plant bogs in eastern Texas are usually associated with the Willis and Catahoula geologic formations. The Willis formation is a deep sand which overlies an impermeable clay layer of the Catahoula formation. Percolation of rainfall through Willis sands provides a water source and the Catahoula clays provide an impermeable layer which causes lateral movement of water to small hillside seeps (Nixon and Ward 1986). Although the bogs are too small to be shown on soil survey maps, the bog soils appear to be in the Corrigan Series (Typic Albaqualfs) located at the contact between Willis and Catahoula formations (K. G. Watterston, pers. commun.). Soils of the forest sites were deep sands associated with the Willis formation (Dolezel and Holt 1988).

Data Collection

Herpetofauna were captured using drift fence arrays with funnel traps and during brief time-area searches (Bury and Raphael 1983). Three drift fences and 18 funnel traps were established in each bog and forest study site. At each site, the drift fences radiated from a common point; the angle between fences was 120° (Reid 1992). The drift fences were constructed of galvanized flashing and were 0.5 m high, 6.0 m long, and buried approximately 10 cm deep. Galvanized flashing rather than hardware cloth was chosen because small members of the herpetofaunal community could move through hardware cloth. To sample smaller amphibian and reptiles, 120 funnel traps were made of aluminum window screen. An additional 60 traps were made using hardware cloth to sample larger snakes that might avoid or escape the screenwire funnel traps. Both types of traps were approximately 15 cm in diameter and 46 cm long. One hardware cloth and 2 screen wire traps were placed along each side of each fence. Shade was placed over each trap to prevent desiccation of the captured individuals.

Amphibians and reptiles were sampled for 7 consecutive days each month throughout the year. During February, May, and August, sampling was conducted for 3 additional 7-day periods; thus, the sampling periods were approximately a month long. February and May were chosen to include peak breeding activity for amphibians and reptiles, respectively (Rakowitz 1983). The August period was chosen because that month is normally the driest (H. C. Reeves, pers. commun.). During each sample period, the funnel traps were checked and 15-minute time-area searches were conducted at least every other day.

Each new individual captured was identified to species and toe-clipped (amphibians, lizards, and turtles) or scale-clipped (snakes) for identification of recaptures. All individuals were released at the point of capture. During time-area searches, any individual that could be captured without injury to the animal or damage to its microhabitat was marked and released. If an individual was seen but not captured, it was recorded as observed and if positive identification was not made, it was not recorded. Searches were made to the perimeter of each bog; forest sites were searched up to 20 m from the drift fence arrays.

Data Analyses

Data gathered in all bogs were pooled by 7-day period and considered a single sample; data gathered in the forest sites were likewise pooled. Each of the 3 month-long sample periods was divided into 4 weekly samples. Weekly bog and forest totals of individuals for amphibians, reptiles, lizards, and selected species were compared using paired *t*-tests blocked by time.

Data collected in the bogs and forests during each month-long sample period also were pooled by week. For each month, the Pearson Chi-square test of homogeneity was used to examine differences between the bog and the forest communities, including differences in populations of some individual species.

In all cases, a null hypothesis of no difference between groups and a significance level of $P = 0.05$ were used.

Results

Excluding recaptures, 875 individuals representing 38 species were recorded during the year-long study. There were 407 individuals of 28 species recorded in the bogs and 468 individuals of 28 species located in the forests (Table 1). More amphibian species and individuals were recorded in the bogs, but more reptile species and individuals were recorded in the forests (Table 1).

Weekly Samples

Average numbers of species in the bogs and forests were 6.95 and 5.86, respectively ($P = 0.024$). More species were recorded in the bogs than in the forests during 13 of the 21 weekly samples. Generally, more species were encountered in both the bogs and the forests from March through October than during November through February (Fig. 1).

Average numbers of individuals in the bogs and forests were 19.38 and 22.29, respectively ($P = 0.116$). Generally, more individuals were recorded in the forests than in the bogs during spring and the first week of August. Conversely, more individuals were found in the bogs than forests during late summer; numbers were similar in the bogs and forest during the remaining weekly samples (Fig. 2).

Amphibians comprised 15.2% of the total individuals with 83 individuals of 11 species in the bogs and 50 individuals of 9 species in the forests. Average numbers of amphibian species per week in the bogs and forests were 2.14 and 1.38, respectively ($P = 0.012$). Average numbers of individuals were 3.95 and 2.38 in the bogs and forests, respectively ($P = 0.028$).

The reptiles included 324 individuals of 17 species in the bogs and 418 individuals of 19 species in the adjacent forests. In the bogs and forests, average numbers of species were 4.81 and 4.48, respectively ($P = 0.202$); average numbers of individuals were 15.43 and 19.90, respectively ($P = 0.009$). Of 742 individual reptiles, 92.5% were lizards and 299 of these were in the bogs and 387 were in the forests ($P = 0.009$).

Month-long Samples

During the May sample period, 14 species were found in the bogs as were 15 in the forests ($P = 0.591$); 97 and 132 individuals were recorded in the bogs and forests, respectively ($P = 0.031$). Amphibians comprised 13.5% of the herptiles; 67.7% of these were in the bogs and 32.3% were in the forests. Additionally, the 198 reptiles made up 86.5% of the individuals with 38.4% and 61.6% in the bogs and forests, respectively.

In August, 16 species were found in both the bogs and forests ($P = 0.931$); 186 individuals were recorded, 88 in the bogs and 98 in the adjacent forests

Table 1. Numbers of individual amphibians and reptiles by species as recorded in pitcher plant bogs and in adjacent forests during 21 weekly samples, March 1990 through February 1991 in the Angelina National Forest, Texas. Nomenclature follows Conant and Collins (1991).

Common name	Scientific name	Location		
		Bog	Forest	Total
Amphibians				
Dwarf salamander	*Eurycea quadridigitata*	39	24	63
Marbled salamander	*Ambystoma opacum*	—	1	1
Gulf Coast toad	*Bufo valliceps*	4	3	7
Woodhouse's toad	*Bufo woodhouseii*	2	—	2
Hurter's spadefoot	*Scaphiopus holbrookii*	—	1	1
Northern cricket frog	*Acris crepitans*	3	3	6
Spring peeper	*Pseudacris crucifer*	1	1	2
Upland chorus frog	*Pseudacris triseriata*	2	—	2
Southern leopard frog	*Rana utricularia*	5	1	6
Bronze frog	*Rana clamitans*	12	—	12
Bullfrog	*Rana catesbeiana*	1	—	1
Eastern narrowmouth toad	*Gastrophryne carolinensis*	13	15	28
Gray treefrog	*Hyla versicolor*	1	1	2
	Subtotal species	11	9	13
	Subtotal individuals	83	50	133
Reptiles				
Ground skink	*Scincella lateralis*	163	242	405
Coal skink	*Eumeces anthracinus*	60	14	74
Five-lined skink	*Eumeces fasciatus*	—	2	2
Broadhead skink	*Eumeces laticeps*	—	3	3
Green anole	*Anolis carolinensis*	25	47	72
Six-lined racerunner	*Cnemidophorus sexlineatus*	28	54	82
Fence lizard	*Sceloporus undulatus*	15	23	38
Slender glass lizard	*Ophisaurus attenuatus*	7	2	9
Three-toed box turtle	*Terrapene carolina*	2	1	3
Northern brown snake	*Storeria dekayi*	7	11	18
Redbelly snake	*Storeria occipitomaculata*	—	1	1
Rough earth snake	*Virginia striatula*	—	4	4
Eastern kingsnake	*Lampropeltis getula*	—	1	1
Buttermilk racer	*Coluber constrictor*	5	4	9
Southern ringneck snake	*Diadophis punctatus*	1	—	1
Rough green snake	*Opheodrys aestivus*	1	—	1
Eastern coachwhip	*Masticophis flagellum*	—	1	1
Texas rat snake	*Elaphe obsoleta*	1	—	1
Corn snake	*Elaphe guttata*	—	1	1
Eastern hognose snake	*Heterodon platyrhinos*	1	2	3
Western ribbon snake	*Thamnophis proximus*	4	—	4
Glossy crayfish snake	*Regina rigida*	1	—	1
Southern copperhead	*Agkistrodon contortrix*	—	4	4
Western cottonmouth	*Agkistrodon piscivorus*	1	—	1
Texas coral snake	*Micrurus fulvius*	2	1	3
	Subtotal species	17	19	25
	Subtotal individuals	324	418	742
	Total species	28	28	38
	Total individuals	407	468	875

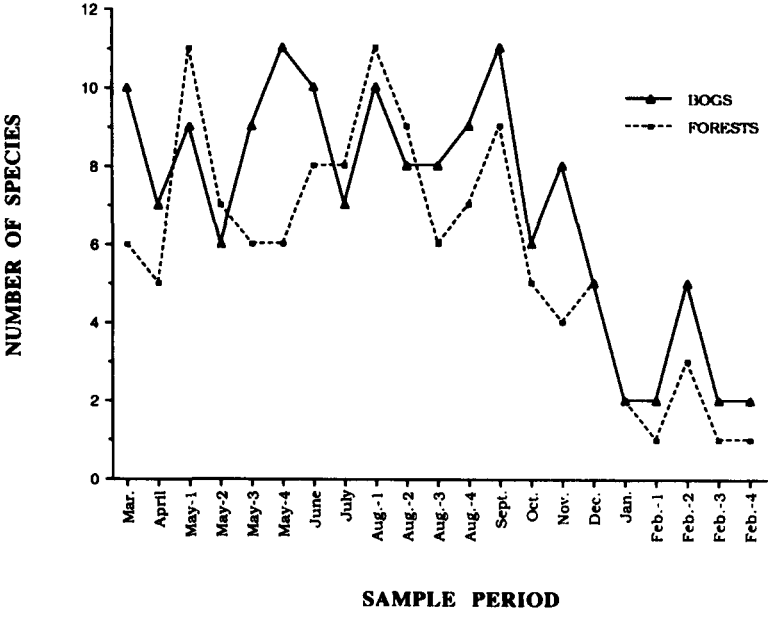

Figure 1. Numbers of species of amphibians and reptiles recorded in pitcher plant bogs and in adjacent forests during 21 weekly samples.

($P = 0.098$). Amphibians made up 10.8% and reptiles comprised 89.2% of the individuals recorded. Among the amphibians, 55.0% were in the bogs and 45.0% were in the forests; for reptiles, 46.4% were in the bogs and 53.6% in the forests.

During February only 31 herptiles were recorded. Due to the low numbers, no statistical comparisons were made. One salamander, 3 frog, 3 lizard, and 3 snake species were recorded. Amphibians comprised 15.8% and 8.3% and reptiles 84.2% and 91.7% of the bog and forest communities, respectively.

Analysis of Selected Species

Two amphibian and 5 reptile species comprised 87.1% of all individuals recorded during the study. Dominant amphibians were the dwarf salamander and the eastern narrowmouth toad. Dominant reptiles, all of which were lizard species, collectively comprised 76.7% of all individuals. The ground skink represented 46.3% of all amphibians and reptiles. Other abundant lizard species included the six-lined racerunner (9.4%), the coal skink (8.5%), the green anole (8.2%), and the fence lizard (4.3%).

Amphibians—Sixty-three dwarf salamanders were recorded, 39 in the bogs and 24 in the forests ($P = 0.363$); these individuals comprised 47.4% of all amphibians. The October sample period contained 47.3% of all dwarf salamanders. During that month, 20 individuals were recorded in the bogs as were 10 in the

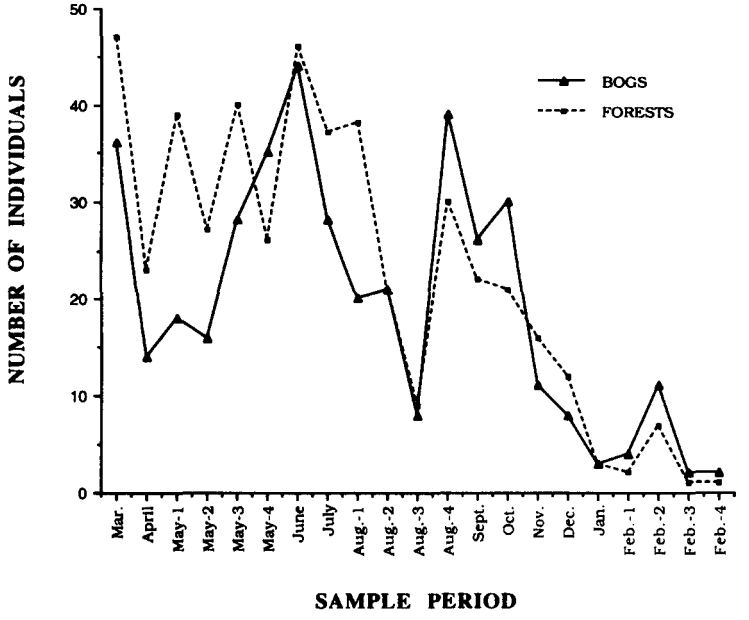

Figure 2. Numbers of individual amphibians and reptiles recorded in pitcher plant bogs and in adjacent forests during 21 weekly samples.

forests. Twenty-eight narrowmouth toads were recorded, 13 in the bogs and 15 in the forests ($P = 0.456$); these individuals comprised 21.1% of the amphibians. Distributions of numbers of narrowmouth toads showed bell-shaped curves with the peaks in the forests in July and early August and in the bogs from late May to late August (Reid 1992).

Reptiles—Ground skinks were recorded in the bogs and forests in every sample period. This skink comprised 54.5% of all reptiles with 163 and 242 individuals in the bogs and forests, respectively ($P = 0.009$). There were more ground skinks in the forests than in the bogs during the March, April, and May sample periods; thereafter, numbers were similar (Reid 1992).

Sixty coal skinks were recorded in the bogs as were 14 in the forests ($P = 0.021$). In the bogs, coal skinks were recorded in every month except October and December; numbers peaked in March and July. Coal skinks were recorded in the forest only from March to mid-August.

The six-lined racerunner was the second most abundant species; 82 individuals were recorded, 28 in the bogs and 54 in the forests ($P = 0.045$). Racerunners were recorded only in the May through September sample periods.

Green anoles and fence lizards, both predominantly arboreal lizard species, were generally recorded during March through December. Seventy-two green anoles were recorded, 25 in the bogs and 47 in the forests ($P = 0.058$). Of the 38 fence lizards, 15 were in the bogs and 23 in the forests ($P = 0.425$).

Discussion

Higher numbers of amphibians in the bogs than in the forests are not surprising. The bogs provided standing water which is required for survival by upland chorus frogs (*Pseudacris triseriata*), bronze frogs (*Rana clamitans*), and bullfrogs (*R. catesbeiana*). Although Woodhouse's toads (*Bufo woodhouseii*) were found only in the bogs, this was probably due to breeding activity because the species does inhabit drier habitats (Conant and Collins 1991). Species such as the gulf coast toad (*Bufo valliceps*) and the eastern narrowmouth toad, which have adapted to forest habitats but require standing water for reproduction, were found in both types of habitat. Two species, the marbled salamander (*Ambystoma opacum*) and the Hurter's spadefoot (*Scaphiopus holbrookii*) complete their life cycles in forest habitats (Garrett and Barker 1987) and were recorded only in the forests.

Amphibian activity is centered around the breeding process and thus amphibian abundance is strongly tied to occurrence of water suitable for breeding (Rakowitz 1983). However, our results support observations of Fisher and Rainwater (1978) that the occurrence of some amphibian species is associated with shelter rather than moisture. The fact that most amphibians require standing water was reflected by their preference for the bogs, however.

As a group, reptiles are not as strongly tied to water as are amphibians and higher numbers in the forests are not unexpected. However, the bogs provided water upon which several species, including coal skinks and several snake species, are dependent.

The presence of dwarf salamanders in both bogs and forests is contrary to the findings of Jackson (1973) and Pearson et al. (1987). In those studies, dwarf salamanders were found only in wet areas. We found 36.2% of the dwarf salamanders in the forests and of these, 72.0% were recorded in March and October. Their presence in the forest was probably a result of breeding activity (Behler and King 1979).

Approximately equal numbers of eastern narrowmouth toads were found in the bogs and forests. These results are similar to those of Jackson (1973) and Pearson et al. (1987). Most narrowmouth toads were recorded between May and September. This species breeds from April to October with courtship activity triggered by rains (Behler and King 1979). The peak of breeding activity may occur from May through August.

Ground skinks breed from January through August and lay up to 5 clutches per season (Mather 1968). As a result of this reproductive strategy and the abundance of food and cover in the southern pine forest, the ground skink is the dominant species in most reptile studies in eastern Texas (Jackson 1973, Rakowitz 1983). Its abundance in the bogs and forests reflect the ubiquitous nature of this species. However, higher numbers in the forests reflect the preferred habitats (Garrett and Barker 1987). Although both habitats provided ample litter required by the species (Fisher and Rainwater 1978), more individuals were re-

corded in the forests because food was probably more plentiful there. The saturated conditions of the bogs may not provide optimum habitat for terrestrial insects which are the mainstay of the ground skink's diet.

There also were seasonal differences in numbers of ground skinks. During May and August, 115 and 82 were recorded, respectively ($P = 0.023$), indicating a major reduction in the population from spring to summer. However, the reduction was in the forests where May to August numbers declined from 79 to 44. Numbers increased during the same period from 36 to 38 in the bogs. Rather than a reduction in the population from spring to summer, the change was probably in activity, especially in the forests. Ground skinks become less active when ground temperatures exceed approximately 30 C (Mather 1968, Jackson 1973). Ground skinks may become inactive and probably fossorial in the forests. Conversely, during the dry summer months, water in the bogs may provide a moist and relatively cool microclimate which may allow ground skinks to remain active.

Conant and Collins (1991) describe coal skink habitat as "hillsides within the vicinity of springs." The sandy rolling hills and bogs of the study area appear to reflect that habitat. Coal skinks were recorded in the forest only from March to August but in the bogs they were recorded in all but the October and December sample periods. The species mates during the spring and early summer (Garrett and Barker 1987) and lays eggs in dry, sandy areas. Since bogs do not provide suitable nesting habitat, its presence in the forest may represent individuals searching for nesting sites. Coal skinks may occupy the bogs for food and shelter and utilize the forests for nesting.

Six-lined racerunners prefer areas containing high percentages of sandy, bare ground (Rakowitz 1983) which allows them to escape predators by running or burrowing (Smith and Brodie 1982). This species showed a distinct preference for forest sites which had sandy soils and a history of prescribed burns. Both Jackson (1973) and Pearson et al. (1987) found racerunners only in dry upland sites.

The green anole and the fence lizard were recorded in both bogs and forests. These arboreal species feed on small terrestrial and flying insects. Although vegetation in the bogs provided vertical structure required by these species in the form of pitcher plants, greenbrier vines, and occasional longleaf pines, higher numbers in the forests suggests the bogs did not provide suitable habitat. These species prefer relatively dry forests with good understory development for perching and are common in uplands (Fisher and Rainwater 1978). Our findings are similar to those of Jackson (1973) and Pearson et al. (1987).

The presence of the bogs increased the species composition and the size of the amphibian and reptile community in the overall forest community. Two amphibian (bullfrog, bronze frog) and 2 reptile (coal skink, western cottonmouth) species may have been absent had the bogs not been present. Numbers of several other species may well have been reduced. If the bogs had not been present, it is very unlikely that coal skinks would have achieved such a

dominant position in the overall upland forest community. Higher numbers of these species were recorded in this study than in Rakowitz's (1983) study which spanned 3 years.

February was selected to sample amphibians during the peak of breeding activity. However, more amphibians were recorded in a single week in March than during all of February. This suggests that the peak of breeding for amphibians occurred during March. Future studies in eastern Texas should probably be conducted during late February and early March.

Pitcher plant bogs are fragile ecosystems which have a successional gradient towards a sedge-woody vegetative community. Concerns about the disappearance and lack of management of the bog vegetative community are prominent in the literature (Nixon and Ward 1986). The most important management tool in maintaining the bog vegetative community is fire (Folkerts 1982) but other land use and forest management may impact these fragile wetlands. Practices such as stand regeneration, thinning, periodic burning, grazing, and well drilling should be studied to evaluate the impacts on the bogs. If the herpetofaunal community is monitored in relation to land use practices, it may be an ideal indicator of proper management and forest health.

Literature Cited

Behler, J. L. and F. W. King. 1979. The Audubon Society field guide to North American reptiles and amphibians. Alfred A. Knopf, New York, N.Y. 743pp.

Bury, R. B. and M. G. Raphael. 1983. Inventory methods for amphibians and reptiles. Pages 416–419 *in* J. F. Bell and T. Atterbury, eds. Renewable resource inventories for monitoring changes and trends. Coll. For., Ore. State Univ., Corvallis.

Conant, R. and J. Collins. 1991. A field guide to reptiles and amphibians of eastern and central North America. Houghton Mifflin Co., Boston, Mass. 450pp.

Dolezel, R. and T. Holt. 1988. Soil survey of Angelina County, Texas. U.S. Dep. Agric., Soil Conserv. Serv., Nacogdoches, Texas. 203pp.

Fisher, C. D. and F. L. Rainwater. 1978. Distribution and relative abundance of amphibians and reptiles in forest communities of Big Thicket National Preserve. Dep. Bio., Stephen F. Austin State Univ., Nacogdoches, Texas. 60pp.

Folkerts, G. W. 1982. The Gulf Coast pitcher plant bogs. Am. Sci. 70:260–267.

Garrett, J. M. and D. G. Barker. 1987. A field guide to reptiles and amphibians of Texas. Texas Monthly Press, Austin. 255pp.

Jackson, R. L. 1973. A study of amphibians and reptiles of the Stephen F. Austin Experimental Forest. M.S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Texas. 61pp.

Mather, C. M. 1968. Home range and reproduction of the ground skink *Lygosoma laterale.* M.S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Texas. 36pp.

Nixon, E. S. and J. R. Ward. 1986. Floristic composition and management of east Texas pitcher plant bogs. Pages 283–287 *in* D. L. Kulhavy and R. N. Conner, eds. Wilderness and natural areas in the eastern United States: A management challenge. School For., Stephen F. Austin State Univ., Nacogdoches, Texas.

Pearson, H. A., R. R. Lohoefener, and J. L. Wolfe. 1987. Amphibians and reptiles on longleaf-slash pine forests in southern Mississippi. Pages 157–165 *in* H. A. Pearson,

F. E. Smeins, and R. E. Thill, compilers. Ecological, physical, and socioeconomic relationships within southern national forests. U.S. For. Serv. Gen. Tech. Rep. SO-68.

Rakowitz, V. A. 1983. Comparison of the herpetofauna of four different-aged stands in the loblolly-shortleaf pine-hardwood ecosystem of east Texas. M.S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Texas. 127pp.

Reid, J. A. 1992. Herpetofauna of pitcher plant bogs and adjacent pine forests in east Texas. M.S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Texas. 77pp.

Smith, H. M. and E. D. Brodie, Jr. 1982. A guide to field identification reptiles of North America. Western Publ. Co., Racine, Wis. 240pp.