# Comparison of Methods for Monitoring Reptiles and Amphibians in Upland Forests of the Ouachita Mountains

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**We compared drift fence arrays (employing pitfalls and double-ended funnel traps), double-ended funnel traps without drift fences, and time-constrained searching as methods for capturing reptiles and amphibians in upland forests of the Ouachita Mountains, Arkansas. Taxonomic groups (anurans, salamanders, and squamates) were appraised for heterogeneity of susceptibility to capture among different methods. Also, capture success for types of funnel traps were compared across different size classes of squamates.**

**We sampled a total of 91 days during six trapping periods over the spring and summer months of 1993 and 1994. Eight-hundred eighty-six individuals representing 38 species of reptiles and amphibians were captured. Standardizing captures by common unit effort (captures/trap-day or captures/person-day) shows that time-constrained searching was overall the most efficient, followed by drift fence arrays, then stand-alone funnel traps. However, more herps can be captured by trapping (especially when associated with drift fences) than searching, because of personnel limitations. Pitfall traps more effectively captured most anurans, salamanders, lizards, and small snakes, while double-ended funnel traps effectively captured most large squamates. Funnel traps made of aluminum window screen were significantly better for catching small squamates than funnel traps made of hardware cloth because small individuals could pass through the larger mesh of the latter.** 

## INTRODUCTION

Multiple factors affect capture success, including animal body size, home range size, daily and seasonal activity patterns, trap avoidance behavior, and weather. For example, reptile and amphibian activity is often irregular and highly correlated with temperature and precipitation (*1-4*). Consequently, designing a sampling protocol that effectively captures all taxonomic groups can be difficult. Vogt and Hine (*5*) suggested using multiple short sampling periods during the activity season to obtain the most accurate estimates of species composition and abundance.

Drift fences in combination with pitfall and funnel traps are often used to determine the species richness of an area, detect the presence of rare or secretive species, estimate relative abundances, and determine habitat use by individual species (*4*, *6-9*). However, the ability of certain species to circumvent particular types of traps complicates the design of a comprehensive sampling protocol. For example, animals may be prone to burrow under or climb over drift fences (*7*). Several studies have suggested that drift fences and pitfalls alone are unable to adequately sample large snakes, turtles, and tree frogs (*1-3*). The accurate comparison of reptile and amphibian communities requires the knowledge of relative trap efficiencies. While several studies have compared the relative effectiveness of various capture methods used to sample reptiles and amphibians (*3*, *5-7*), few have focused on the upland herpetofauna of the central United States,

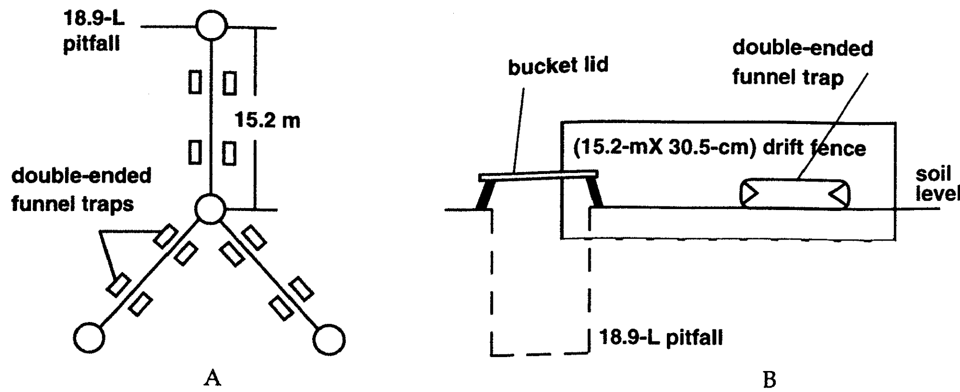


Figure 1. Design of drift fence arrays. (A) Configuration of drift fences, pitfall, and double-ended funnel traps. (B) Side view of an array segment showing the intersection of a pitfall trap with the drift fence.

and none has been conducted in the Ouachita Mountains. As part of a larger study comparing the effects of clearcutting and selective harvesting on herpetofaunal community composition in upland forests of the Ouachita Mountains of Arkansas, we compared overall capture success and differential susceptibility to capture of taxa among three different methods: drift fence arrays with pitfall and double-ended funnel traps, double-ended funnel traps alone, and time-constrained searching.

## MATERIALS and METHODS

Study sites were located in Perry County, Arkansas, on the eastern edge of the Ouachita Mountains about 70 km north of Hot Springs. Vegetation in the region is a complex and variable combination of shortleaf pine (*Pinus echinata*) and upland hardwoods. All six stands had a predominately south, southeast, or southwest aspect and slopes of 5-20%. Two replicates of each of three treatments (young pine plantations; 80-year-old naturally regenerated, pine-hardwood stands; and selectively harvested pine stands) were sampled. Because we were interested in comparing capture methods apart from treatment effects, the results from these surveys were pooled for purposes of the present evaluation.

Three drift fence arrays were equally spaced along a central transect that angled down slope and bisected each timber stand. Arrays consisted of drift fences, pitfall traps, and double-ended funnel traps (Fig. 1). Arrays were positioned at least 100 m from any road, stream, or timber stand border. Arrays were spaced at 100-m intervals, making each central transect ~300 m in total length. Each array consisted of three 15.2-m X 30.5-cm sections of drift fence (galvanized metal flashing), originating from a central pitfall trap and radiating outward at 120° (Fig. 1a). Drift fences were buried ~5 cm below soil surface to prevent animals from burrowing under them. An 18.9-L pitfall trap (plastic paint bucket) was buried at the center and at the end of each wing. Drain holes were punched in the bottom of each pitfall. Pitfall traps were buried flush with the ground surface, and the drift fence overhung the lip of each pitfall trap (Fig. 1b). Two double-ended funnel traps were placed equidistant apart on each side of each arm of the arrays, for a total of 12 funnel traps per array. Six funnel traps were constructed of 0.64-cm mesh hardware cloth (*10*), and six were of 1.5-mm mesh aluminum window screen (*3*). Funnel traps were molded and positioned to fit as close to the drift fence as possible to prevent animals from moving between the traps and the fence. We attempted to make the transition from the substrate into the trap as smooth as possible by placing soil and detritus so that it led into the trap opening.

In each stand, 68 additional double-ended funnel traps of aluminum screen (*3*) were placed at 15-m intervals (17 per transect), along four transects, oriented parallel to and 25 and 50 m either side of the central array transect. These traps were positioned along fallen logs, rocky outcroppings, or in shallow depressions. Ten additional 0.64-cm mesh hardware cloth funnel

TABLE 1. Number (percent in parentheses) of captures by taxa for different sampling methods.[1]

| | Drift Fence Arrays | Funnel Traps | Time-constrained Searches | Total |
|---|---|---|---|---|
| Lizards | 358(61.1) | 138(23.6) | 90(15.4) | 586 (66.1) |
| Snakes | 53(52.5) | 22(21.8) | 26(25.7) | 101 (11.4) |
| Frogs/Toads | 155(89.1) | 1 (0.6) | 18(10.3) | 174 (19.7) |
| Salamanders | 2(10.5) | 1 (5.3) | 16(84.2) | 19 (2.1) |
| Turtles | 1(16.7) | 1(16.7) | 4(66.7) | 6 (0.7) |
| Total | 569(64.2) | 163(18.4) | 154(17.4) | 886(100.0) |

[1] $X^2 = 138.97$, $df = 8$, $P < 0.001$

traps (*10*) were placed at equal intervals along the center transect between the arrays.

Arrays were installed during March 1993, about two months prior to initial trapping. Traps were opened during three periods in 1993 (22 May-6 June, 15-30 June, and 15-25 July) and three periods in 1994 (6-21 March, 14-29 May, and 15-29 June) and checked on alternate days. When pitfall traps were not in use, they were closed with tight-fitting snap lids; funnel traps were closed by lodging a plug of aluminum foil in the entrance of each. During sampling periods, a square section of asphalt shingle was draped over each funnel trap to provide shade. Pitfall traps were shaded using small sticks to prop the lids 10-15 cm above the container (Fig. 1b). These measures helped minimize animal mortality due to overheating and desiccation.

Time-constrained searches also were conducted to identify the presence of sedentary species or those that are otherwise difficult to trap. We opportunistically conducted six person-hours of time-constrained searching within each stand during the study. Searches consisted of turning cover objects (rocks, logs, and bark), probing crevices, and visually looking for animals. Animals captured by each method were identified to species and released at the point of capture.

Capture success was converted to captures per common unit effort for the three methods and compared for all taxa combined. Chi-square contingency table analyses were used to compare susceptibility to capture of taxonomic groups among capture methods.

Capture success for types of funnel traps were compared across different size classes of snakes and lizards. This test was used to detect any trap bias toward capture of larger individuals by the hardware cloth traps. Because these funnel traps were constructed of 0.64-cm mesh hardware cloth, it was possible that small snakes and lizards with a maximum body diameter less than the mesh size could escape. Using preserved specimens from the vertebrate collection of Oklahoma State University, we determined that small individuals of some species could potentially pass through the 0.64-cm mesh of our hardware cloth funnel traps. Because we had measured only snout-vent length (SVL) of our field specimens, we used preserved specimens to estimate maximum body diameter (usually head width) based on SVL. We estimated that small snakes (except for viperids) with SVL <340 mm and lizards with SVL < 40 mm could possibly pass through the hardware cloth. Consequently, snakes and lizards captured in both screen and hardware cloth funnel traps were grouped into small and large size-classes according to these thresholds of SVL. We then used chi-square analysis to test the null hypothesis that proportions of captures were the same for small and large squamates (snakes and lizards pooled) in both types of funnel traps.

## RESULTS

During a total of 91 days of trapping over the spring and summer of 1993 and 1994, we captured 886 individuals representing 38 species of reptiles and amphibians (Appen. 1). Capture success was significantly different for various taxa among the sampling methods tested (Table 1). Lizards were captured most frequently during both years, representing 66% of total captures.

TABLE 2. Number (percent in parentheses) of captures by taxa for different kinds of traps associated with drift fence arrays.

| | Pitfall Traps (N=72) | Funnel Traps: Aluminum Screen (N=108) | Funnel Traps: Hardware Cloth (N=108) | Total |
|---|---|---|---|---|
| Lizards | 270 (75.4) | 65 (18.2) | 23 (6.4) | 358(62.9) |
| Snakes | 19 (35.9) | 20 (37.7) | 14(26.4) | 53 (9.3) |
| Frogs/Toads | 148 (95.5) | 5 (3.2) | 2 (1.3) | 155(27.2) |
| Salamanders | 2 (100.0) | 0 (0.0) | 0 (0.0) | 2 (0.4) |
| Turtles | 0 (0.0) | 1(100.0) | 0 (0.0) | 1 (0.2) |
| Total | 439 (77.2) | 91 (16.0) | 39 (6.9) | 569(100.0) |

*Sceloporus undulatus* and *Scincella lateralis* were the most common species, representing 42 and 25% of all lizards, respectively (Appen. 1). Drift fences (Table 1), and especially pitfall traps associated with drift fences (Table 2), were the most effective methods for capturing lizards. Time-constrained searching and funnel traps made of hardware cloth were the least effective methods.

Snakes composed 11% of the total captures (Table 1). The most commonly encountered species were *Agkistrodon contortrix* and *Coluber constrictor,* representing 21 and 20% of all snakes, respectively (Appen. 1). Snakes were more effectively sampled using the drift fence arrays (Table 1), where captures were nearly equally divided among pitfall traps, screen, and hardware cloth funnel traps (Table 2).

Small snakes and lizards were caught significantly less frequently in hardware cloth funnel traps than in screen traps ($X^2 = 7.62$, $df = 1$, $P = 0.006$).

Anurans were the second most frequently captured taxon, representing 20% of total captures (Table 1). More than 89% of anurans were captured along drift fences (Table 1), and more than 95% of these in pitfall traps (Table 2). *Bufo americanus* and *Gastrophryne carolinensis* were the most commonly encountered species, representing 70 and 25% of all anurans captured, respectively (Appen. 1).

Nineteen salamanders were captured during the study (Table 1). Fourteen of the 19 salamanders encountered were *Eurycea multiplicata,* captured during time-constrained searches (Appen. 1). Salamanders vere most often found by turning over rocks or logs. One each of *Amibystoma talpoideum* and *A. opacum* were captured in pitfall traps associated with the arrays, and both captures occurred after rains (Table 2).

Two terrestrial turtle species were encountered, two *Terrapene ornata* and four *T. carolina* (Appen. 1). Four of these individuals were encountered during time-constrained searches, one was captured in a screen funnel trap on a transect, and one was captured in a screen funnel trap along a drift fence (Table 1).

## DISCUSSION

Our findings suggest that a comprehensive sampling design is important to adequately survey amphibian and reptile communities. In agreement with other authors, we recommend incorporating several trapping strategies to sample animals with a wide variety of habits. Within the array design itself, the pitfall traps performed well by capturing most frogs and toads, salamanders, lizards, and small snakes. Bury and Corn (*4*) and Greenburg and coworkers (*9*) also reported high numbers of anurans and lizards captured by pitfall traps. Pitfalls were not effective at capturing large snakes. These results are similar to those of others (*2,4-6,9*), where funnel traps were responsible for the capture of most large squamates. The hardware cloth funnel traps positioned along the drift fences in particular contributed most by capturing medium and large snakes and large lizards; smaller individuals apparently escaped through the mesh of these traps. Screen funnel traps mostly captured small snakes and lizards, as was reported by Greenburg and coworkers. (*9*).

Anurans were especially abundant immediately after rains in June and July and, more than any other taxon, tended to be captured in pitfall traps, even though some species probably were able to climb or hop over the drift fence (*7*). Anurans may have been attracted to shallow, standing water in the bottom of some pitfall traps, as they were often found in those containing water. Shields (*11*) observed preferential use of pitfall traps by *Rana utricularia*.

Although we caught few turtles in our study, most were captured by hand, which suggests that turtles, like salamanders, may be more effectively sampled by this method. No turtles were captured in pitfall traps, which may have been due to avoidance behavior (*2*).

Because terrestrial and semi-aquatic salamanders are often restricted to moist habitats and are active only under narrow sets of environmental conditions, they are most effectively sampled by hand-collecting (*12-14*), except at breeding sites.

Reptile and amphibian activity is often irregular and highly correlated with temperature and precipitation (*1-4*), and the presence of water is an important determinant in the distribution of amphibians (*12*,*15*). Therefore, because of higher temperatures, lower relative humidity, and greater insolation associated with south-facing slopes, we expected to capture fewer amphibians. Unlike amphibians, reptiles generally prefer the warm, dry conditions that are common during summers in the uplands of the Ouachitas. Reptiles were especially abundant in the open sunny habitats of clearcut stands.

Capture success of both reptiles and amphibians generally declined over the study. One possible reason for this may be the accelerated regrowth of early successional plants near the arrays during the second year. This may have reduced trapping success by deterring small snakes, lizards, or frogs away from the fence. We observed that grasses and forbs were especially dense where disturbance occurred during installation of the trapping arrays. To maintain good capture success of drift fence installations, vegetation should be kept clear of the fence.

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APPENDIX 1. Captures of species by month employing drift fences, funnel traps, and time-constrained searches.

| Species | 1993 May | 1993 Jun | 1993 Jul | 1994 Mar | 1994 Apr[1] | 1994 May | 1994 Jun | Total (%) |
|---|---|---|---|---|---|---|---|---|
| **Anurans** | | | | | | | | |
| *Gastrophryne carolinensis* | 2 | 16 | 15 | 0 | 0 | 3 | 8 | 44 (5.0) |
| *Bufo americanus* | 26 | 32 | 32 | 1 | 9 | 16 | 5 | 121 (13.7) |
| *Rana clamitans* | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 (0.7) |
| *Rana catesbeiana* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 (0.2) |
| *Rana utricularia* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.1) |
| **Salamanders** | | | | | | | | |
| *Ambystoma opacum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 (0.1) |
| *Ambystoma talpoideum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 (0.1) |
| *Eurycea multiplicata* | 2 | 0 | 0 | 11 | 1 | 0 | 0 | 14 (1.6) |
| *Plethodon albagula* | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 3 (0.3) |
| **Turtles** | | | | | | | | |
| *Terrapene carolina* | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 4 (0.5) |
| *Terrapene ornata* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 (0.2) |
| **Lizards** | | | | | | | | |
| *Anolis carolinensis* | 3 | 5 | 0 | 1 | 1 | 1 | 1 | 12 (1.4) |
| *Cnemidophorus sexlineatus* | 12 | 14 | 14 | 0 | 1 | 16 | 6 | 63 (7.1) |
| *Sceloporus undulatus* | 55 | 36 | 6 | 95 | 6 | 39 | 9 | 246 (27.8) |
| *Scincella lateralis* | 23 | 53 | 4 | 23 | 13 | 15 | 18 | 149 (16.8) |
| *Eumeces fasciatus* | 11 | 20 | 12 | 7 | 5 | 7 | 2 | 64 (7.2) |
| *Eumeces laticeps* | 5 | 6 | 3 | 0 | 1 | 4 | 4 | 23 (2.6) |
| *Eumeces anthracinus* | 0 | 0 | 0 | 23 | 1 | 3 | 2 | 29 (3.3) |
| **Snakes** | | | | | | | | |
| *Thamnophis sirtalis* | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 3 (0.3) |
| *Thamnophis proximus* | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 5 (0.6) |
| *Virginia valeriae* | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 (0.2) |
| *Storeria occipitomaculata* | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 4 (0.5) |
| *Storeria dekayi* | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 6 (0.7) |
| *Heterodon platyrhinos* | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 3 (0.3) |
| *Diadophis punctatus* | 0 | 0 | 0 | 1 | 5 | 0 | 1 | 7 (0.8) |
| *Carphophis amoenus* | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 4 (0.5) |
| *Opheodrys aestivus* | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 (0.5) |
| *Coluber constrictor* | 3 | 6 | 1 | 2 | 1 | 5 | 2 | 20 (2.3) |
| *Masticophis flagellum* | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 3 (0.3) |
| *Elaphe guttata* | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 4 (0.5) |
| *Elaphe obsoleta* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 (0.1) |
| *Cemphora coccinea* | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 5 (0.6) |
| *Lampropeltis triangulum* | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 4 (0.5) |
| *Lampropeltis calligaster* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.1) |
| *Lampropeltis getula* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.1) |
| *Agkistrodon contortrix* | 3 | 6 | 2 | 5 | 1 | 3 | 1 | 21 (2.4) |
| *Sistrurus miliarius* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 (0.1) |
| *Tantilla gracilis* | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 (0.2) |
| **Total** | 162 | 209 | 97 | 175 | 51 | 118 | 74 | 886 (100.0) |

[1]Time-constrained searching was the only capture method employed during April.