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Comparison of 2 methods to sample snake communities in early successional habitats

Victoria A. Kjoss and John A. Litvaitis

Abstract Landscape changes can affect species richness, population density, and condition of animals. We initiated an investigation of snakes in southeastern New Hampshire because we speculated that this taxon would be responsive to recent land-use changes. Species richness, relative abundance, and size distribution of snakes were the parameters we were interested in sampling by capturing snakes on a series of habitat patches. We considered various capture methods and compared the effectiveness of plastic cover sheets and drift fence-trap configurations to sample local snake populations. More species were captured with drift fence-trap configurations. Size distributions of snakes differed by method of capture, with cover sheets yielding proportionately more small-bodied snakes. Cover sheets were less expensive to construct, maintain, and remove than were drift fence-trap configurations. Additionally, fewer mortalities of snakes and nontarget vertebrates were associated with cover sheets. Microclimates under sheets likely attracted potential prey and snakes to cover sheets. Although cover sheets were effective to sample snakes in early successional sites, multiple techniques may be needed in more heterogeneous habitats.

Key words cover sheet, early successional habitat, New Hampshire, reptile, snake, trap

Researchers have relied on a variety of methods to sample snake populations, including focused searches of suitable microhabitats and hibernacula (Burger and Zappalorti 1988, Rosen 1991, Weatherhead and Prior 1992) and use of funnel or box traps in combination with drift fences (Fitch 1951; Plummer and Congdon 1994; R. Zappalorti, Herpetological Associates, personal communication). Most investigators using these methods were likely attempting to capture a subset of the snakes in an area and may not have been concerned with the inherent differences in capture success associated with each method. During an investigation of snake community structure in early successional habitats, we attempted to assess the abundance, species richness, and size distribution of snakes occupying habitat patches of different sizes. In doing so, we required a method of capture that would provide representative samples of all species of snakes that occupied a discrete patch of habitat.

Initial field efforts indicated that focused searches provided few captures. Drift fence-trap configurations yielded more captures than focused searches, but seemed biased toward larger snakes. Therefore, we developed a sampling method similar to the shelterboards used by DeGraaf and Yamasaki (1992) to sample the distribution of redback salamanders (*Plethodon cinereus*). Shelterboards apparently simulated fallen logs used by salamanders as cover, and DeGraaf and Yamasaki (1992) reported that these boards were very efficient in sampling abundance of salamanders in different habitats. We used sheets of black plastic similar to those used by horticulturists to limit weed

Authors' address: Department of Natural Resources, University of New Hampshire, Durham, NH 03824, USA; e-mail for Litvaitis: john@christa.unh.edu.

growth. Incidental observations by colleagues indicated that snakes congregated under such sheets, possibly attracted to the elevated temperature and moisture. In this paper, we report the relative efficiencies of plastic cover sheets and drift fence-trap configurations that were used simultaneously to sample the snake populations during 1998 and 1999.

Study area

We conducted our study within a 700-km^2 portion of Strafford County, New Hampshire (ca. 43°07'N, 71°00'W). Like many developing areas in southern New England, Strafford County is characterized by a mosaic of forests, farmland, and residential or industrial areas. The area covered by developed lands in this county increased from 12 to 27% between 1953 and 1983 (Befort et al. 1987). Topography was characterized by gently rolling hills with rocky soils. Dominant overstory vegetation included northern hardwoods (American beech [*Fagus grandifolia*], birches [*Betula* spp.], maples [*Acer* spp.]), and eastern white pine (*Pinus strobus*). Understory species included red maple (*Acer rubrum*), beaked hazelnut (*Corylus cornuta*), viburnums (*Viburnum* spp.), raspberry-blackberry (*Rubus* spp.), and eastern hemlock (*Tsuga canadensis*). We sampled patches ranging from approximately 5 to 120 ha of early successional habitat, including idle agricultural land and edges of industrial sites. These patches were dominated by grasses and forbs (primarily goldenrods [*Solidago* spp.]), with low shrubs. Common shrub species included *Rubus* spp., multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), steeplebush (*Spirea* spp.), blueberry (*Vaccinium* spp.), and juniper (*Juniperus communis*).

Methods

Drift fence-trap configurations

In 1998, we placed 41 traps along 330 m of commercial siltation fence on 5 patches (approximately 1 to 2 traps/ha), and in 1999, we used 17 traps along 170 m of the original fences on 3 patches (approximately 2 traps/ha). Fences (30- and 60-m sections) were 90 cm tall and were erected in continuous straight lines. The lower 10 cm were spaded into the ground to limit movement of snakes under the fence. Initially, we placed cylindrical funnel traps (constructed from 1.3-cm mesh hardware cloth) parallel to and against each fence (Fitch 1951). We did not include pitfall traps (Gibbons and Semlitsch 1981) because soils were very rocky. Because these funnel traps captured few snakes, we replaced them with box traps (31 × 31 × 92 or 122 cm constructed from rough-cut lumber; R. Zappalorti, Herpetological Associates, Inc., personal communication) that were perpendicular to a fence. We inserted a funnel made of 0.6-cm mesh hardware cloth into one end of the trap and sealed the other end with hardware cloth. The funnel end was then inserted into a hole that was cut in the fence at ground level. Funnels and traps were lined with fly screening to reduce the chance of injury to captured snakes. Funnel and box traps were checked daily when temperatures exceeded approximately 26°C and every second day during cooler periods.

Captured snakes were placed into plastic bags and weighed to the nearest 0.5 g, and snout-to-vent length (SVL) was measured to the nearest 0.5 cm. In 1999, trap-caught snakes were marked by clipping 3 ventral scutes. All snakes were released ≥5 m from the fence. Traps were active on a patch for 30-55 days between July and September in 1998, and in 1999, all traps were operational for 90 days from May to mid-August.

Cover sheets

We used 1.5-m × 3-m × 0.1-mm black plastic sheets staked with 4-6 plastic pegs or metal sod staples on the same patches where drift fence-trap configurations were erected. In 1998, we distributed sheets ($n=108$) nonsystematically throughout each patch of habitat (ca. 3-8 sheets/ha). In 1999, we placed sheets ($n=79$) along transect lines within each patch (ca. 5-9 sheets/ha). In 1998, we sampled the 5 patches from July through September, and in 1999, we sampled the 3 patches from May through mid-August. In both years, all sheets were checked 6 times: 3 times during morning hours (between sunrise and 09:00) and 3 times in the evenings (between 16:00 and sunset). We restricted checks to these cooler hours because midday temperatures under a plastic sheet occasionally exceeded 40° C and periodic checks between noon and 14:00 indicated that snakes seemed to avoid sheets during these hot periods.

Sheet checks involved lifting up one-half of a sheet at a time and collecting all snakes found underneath. Initially, sheets were checked simultaneously by 2 observers to compensate for inexperience in capturing snakes. For most of the 1998 and all of the 1999 seasons, however, sheets were checked by an individual observer. Captured snakes were handled in the same manner as those captured in traps, and in 1999, sheet-caught snakes were marked by clipping 2 ventral scutes. Snakes that were observed but not captured were not included in the analyses. Our capture and handling procedures were approved by the University of New Hampshire Institutional Animal Care and Use Committee (Protocol 980804).

Data analysis

Because there was no way to effectively standardize the sampling effort of these 2 methods, we did not attempt to compare number of captures/method. We restricted comparisons to number of species caught, and size-class distributions by method of capture. We restricted comparisons of size-class distributions to garter snakes (*Thamnophis sirtalis*) because we caught too few individuals of other species. Garter snakes were partitioned by method of capture and placed into 5 SVL classes (<20, 20–30, 30.5–40, 40.5–50, and >50 cm). The number of recaptures in 1999 was low (n =23) and proportions of recaptures were approximately the same for each method of capture (sheets =0.12, traps=0.11); therefore, we included all captures in the analyses. Within a method, size distributions of garter snakes were compared between the 2 years using a chi-square test of independence (Zar 1999). Similar comparisons were made between methods, and results were considered significant at $\alpha=0.05$.

Results

Cover sheets captured 332 individuals of 4 species, compared to 168 individuals of 6 species captured with trap-fence configurations (Table 1). Smooth green snakes (*Liochlorophis vernalis*) were captured only in traps on these patches. Additionally, the only ribbon snake (*T. sauritus*) that we captured during this evaluation was in a trap.

There were no between-year differences in size classes of snakes caught using traps (χ^2_4=7.08, P= 0.131). There were between-year differences in size classes of snakes caught using cover sheets (χ^2_4 =25.0, P<0.001). However, this was a consequence of the large number of neonatal garter snakes caught during the end of the 1998 field season. When the first size class (SVL<20 cm) was removed from the analysis, there were no between-year differences among snakes caught with cover sheets (χ^2_3=0.22, P=0.974). Therefore, we pooled the data by method of capture. Size-class distributions of garter snakes differed substantially by method of capture (χ^2_4=91.3, P<0.001, Figure 1).

Table 1. Number of snakes captured using plastic cover sheets and drift fence–trap configurations in southeastern New Hampshire during 1998 and 1999. Totals for each species by method include initial captures and recaptures.

	Species of snakes					
	Garter	Brown	Redbelly	Milk	Green	Ribbon
Sheets	220	75	34	3		
Traps	153	2	2	5	5	1

Cover sheets were apparently more effective in sampling smaller-bodied snakes. The 2 largest individuals (milk snakes, *Lampropeltis triangulum*) captured in traps and under sheets in this evaluation were approximately the same size (~200 g, 90-cm SVL). However, the smallest individual found in a trap was 1 of only 2 neonatal garter snakes (5 g, 18-cm SVL), whereas the smallest snake caught under a sheet was a neonatal redbelly snake (*Storeria occipitomaculata*), 0.5 g, 6-cm SVL. Neonates accounted for 26% of garter snakes caught under sheets, but only 0.1% of garter snakes found in traps.

Discussion

We were unable to compare the samples obtained by these 2 methods to the actual composition of resident communities; however, of the 11 species of snakes reported for New Hampshire

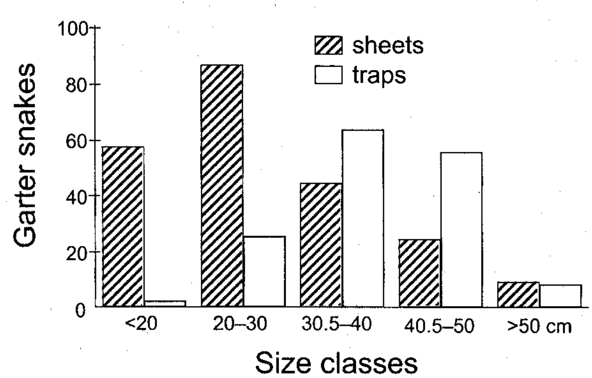

Figure 1. Size classes (snout-to-vent lengths) of eastern garter snakes captured using plastic-cover sheets and drift fence–trap configurations in southeastern New Hampshire, 1998 and 1999.

(Taylor 1993), we captured 6 species during our evaluation. Two of the other species (timber rattlesnake [*Crotalus horridus*] and eastern hognose [*Heterodon platirhinos*]) lacked confirmed sightings in our study area (Taylor 1993), and 2 species (ringneck [*Diadophis punctatus*] and water snake [*Nerodia sipedon*]) were not considered common in early successional habitats (Conant and Collins 1991). Racers (*Coluber constrictor*) were not captured during this evaluation, but were captured with cover sheets, as were smooth green snakes and ribbon snakes while sampling additional patches of habitat (Kjoss and Litvaitis 2001).

Although traps sampled more species in this evaluation, this may have been simply a function of sampling intensity. Whereas each sheet was visited only 6 times during a field season, each trap was checked at least every other day during the same period. Therefore, the chance of encountering a rare species may have been greater in a trap.

For studies in demographics, it may be necessary to be aware of size distributions to infer age structure of a population. Methods of capture that rely on artificial cover may provide a more representative sample of each size- (and, by inference, age-) class within a population (Bonnet et al. 1999). In our study, relying only on traps would have resulted in an adult-biased sample of garter snakes. Moreover, unlike sheets, traps did not yield captures of neonatal redbelly or brown snakes. Fitch (1992) also observed that smaller-bodied snakes were captured more frequently under sheets of corrugated metal than in drift fence–trap configurations.

Cover sheets may have resulted in more captures for several reasons. First, sheets were distributed throughout a patch of habitat and probably sampled a larger proportion of the habitat than did drift fences. Additionally, the temperature and moisture differences under sheets may have attracted snakes or their potential prey. Invertebrates (especially gastropods, spiders, and various insects), amphibians, and small mammals were observed frequently on or under cover sheets. Invertebrates are important prey of small snakes (Wright and Wright 1957). Large snakes (e.g., racers, milks, and large garters) are known to prey on small mammals, amphibians, smaller snakes, and even young conspecifics (racers: Fitch 1963, milks: Dyrkacz 1977, garters: Rossman et al. 1996); therefore, presence of smaller snakes also could have attracted larger snakes to the sheets.

Recently, Sutton et al. (1999) compared effectiveness of cover sheets made from plywood and drift fences with pitfall traps to sample habitats for sand skinks (*Neoseps reynoldsi*). Here, the investigators compared the ability of both methods to detect skinks based on tracks under cover boards and captures in pitfall traps. Cover sheets were more effective in detecting presence of skinks, and the authors indicated that the sheets were less expensive than drift fences. In our study, plastic cover sheets were much less expensive than drift fences–trap configurations (US \$4–6/roll of plastic that yielded 5 sheets versus approximately \$50 for 60 m of fencing and \$40 for 6 associated traps) and required much less time and effort to deploy and dismantle. Unlike traps, cover sheets did not require constant attention and could be left in the field for several days without checking. Plastic sheets are less cumbersome to distribute than sheets of plywood (Durner and Gates 1993, Sutton et al. 1999), corrugated metal (Fitch 1992), or slabs of concrete (Bonnet et al. 1999) that were used by other researchers.

Another major advantage of plastic cover sheets was limited injuries to target and nontarget vertebrates. With one exception, no nontarget vertebrates were injured or killed because of contact with cover sheets. The only vertebrate mortalities associated with cover sheets were 6 neonatal garter snakes and 1 meadow jumping mouse (*Zapus hudsonius*) that had evidently drowned in small pools of water that accumulated on the sheets during rainstorms. In contrast, we captured 15 small or medium-sized mammals (as large as a juvenile opossum, *Didelphis virginianus*), 7 birds, and numerous amphibians in traps. Several of these animals were incidentally injured or killed. Also, 17 garter snakes were injured or killed while attempting to escape from traps.

Cover sheets may not be effective under all conditions. During the hottest periods of summer, daytime temperatures were high (often >27° C) and snakes apparently avoided cover sheets. Additionally, when air temperatures were cool (<17° C), we captured few snakes under cover sheets because they apparently retreated beneath the matted vegetation under the sheets where they could not be captured. Diurnal differences in capture success also may have been related to ambient temperatures. For example, in 1999, we caught more garter snakes >20-cm SVL ($n=134$) during evening checks than during morning checks ($n=32$ garter snakes) despite equal effort. Cover sheets are probably most effective in open-canopy habitats similar to those that we sampled. In closed-canopy forests, the thermal attraction is likely reduced or eliminated and other forms of concealment cover (e.g., fallen logs and rocks, leaf litter) are usually abundant.

In summary, plastic cover sheets seemed to be an effective method to sample snake populations in open habitats. They sampled a greater range of individual sizes of snakes, were less expensive and required less time to monitor, and resulted in fewer injuries and deaths than did drift fence-trap configurations. However, in varied landscapes it may be necessary to rely on a variety of capture methods to obtain representative samples (e.g., Jones 1986, Fitch 1992).

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Victoria A. (Vicky) Kjoss is a research technician at McMaster University in Hamilton, Ontario. She received her B.S. degree in forestry and her M.S. in wildlife ecology at the University of New Hampshire (UNH). Vicky has studied badgers in Germany and beavers in France. Her research interests include reptile–habitat relationships and issues in conservation biology. ***John A. Litvaitis*** is professor of wildlife ecology at UNH. John obtained a B.S. from UNH, M.S. from Oklahoma State, and Ph.D. from the University of Maine. He has served as chairman of The Wildlife Society's (TWS) Publications Committee and just completed a tour as Editor of *Northeast Wildlife*, a regional journal published by the Northeast Section of TWS. John's research interests include an examination of vertebrate responses to landscape change, especially the decline of vertebrate populations that are dependent on early successional habitats in eastern forests.

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