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HABITAT USE AND MOVEMENTS OF KINGSNAKES (*LAMPROPELTIS GETULA HOLBROOKI*) IN A PARTIALLY ABANDONED AND REFORESTED AGRICULTURAL LANDSCAPE

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***Abstract.*—*Lampropeltis getula* is a species of conservation concern in several parts of its wide geographic range. I describe habitat use and movement patterns of *L. getula holbrooki* in an agricultural landscape, a portion of which has been brought out of agriculture and reforested. Both sexes strongly preferred vegetated shrubby levee habitats, and avoided active agricultural fields. There was no evidence that *L. getula* preferred more natural habitats such as oldfields or reforested areas over agricultural edge habitats. Adult males maintained larger home ranges than adult females. The home ranges of a juvenile male and a first-year adult male were similar to those of females. A small core use area centered on levee habitat was identified within the home range of each snake. A strong preference for vegetated shrubby microhabitats emphasizes the importance of maintaining structural heterogeneity in otherwise featureless agricultural landscapes for the conservation of *L. getula* populations.**

Key Words.—conservation; habitat selection; home range; kingsnake; *Lampropeltis getula;* movement; radiotelemetry

INTRODUCTION

The kingsnake, *Lampropeltis getula*, is a widely distributed species found in a variety of lowland and upland habitats throughout its range in the United States (Ernst and Barbour 1989). Although the popularity of *L. getula* in the pet trade has resulted in an enormous body of husbandry literature, the behavior and ecology of free-living *L. getula* remain poorly known. *Lampropeltis getula* is of conservation concern in Florida, Georgia, and South Carolina where it has declined precipitously in some localities (Means 1992; Krysko 2001, 2002; Krysko and Smith 2005; Winne et al. 2007; Stapleton et al. 2008). Both abundance and body mass of *L. getula* declined over the long term on a former agricultural site in South Carolina where entire communities had been protected and inaccessible to the public since the early 1950s (Winne et al. 2007). Considering that a thorough ecological knowledge of *L. getula* is needed to provide a biological basis for probable conservation measures, Winne et al. (2007) suggested that field studies of *L. getula* are needed where the species is still common, such as in eastern Tennessee (Jenkins et al. 2001) and more western localities such as Arkansas (Trauth et al. 2004).

The purpose of this paper is to describe the habitat use and movement patterns of *L. getula* in an agricultural landscape, a portion of which has been agriculturally abandoned and reforested. Compared to other terrestrial vertebrates, there are few examples of how reptiles respond to agricultural landscapes (e.g., Driscoll 2004; Berry et al. 2005; Wisler et al. 2008). To my knowledge, this paper provides the only comprehensive description of an ecological field study on *L. getula* west of the Appalachian Mountains and the first for the subspecies, *L. g. holbrooki*. In addition, the study should provide information useful for the application of knowledge-based conservation measures (Dodd 1993; Mullin and Seigel 2009) on declining populations of *L. getula*.

MATERIALS AND METHODS

Study area.—I studied kingsnakes on the Bald Knob National Wildlife Refuge (BKNWR) located in the floodplain (elevation ~61 m) of the White and Little Red Rivers near Bald Knob, White County, Arkansas. The approximate 6050 ha BKNWR, created from small tracts of bottomland hardwood forest bordering Overflow Creek and extensive areas of rice and soybean agricultural land, was formed in 1993 as part of the U.S. Fish and Wildlife Service (USFWS) North American Waterfowl Management Plan. The southern boundary of the refuge borders the Little Red River from which water is taken to supply an elaborate irrigation system that provides extensive managed habitat for waterfowl and shorebirds. Cleared in the 1960s, much of the area was farmed for 30+ years until acquired by USFWS. Reforestation with native hardwoods began in 1998. Current major habitat types include native bottomland closed-canopy hardwood forest (approx. 1600 ha), reforested abandoned agricultural fields of various successional ages (approx. 800 ha), a small stream (Overflow Creek), water-filled irrigation ditches with

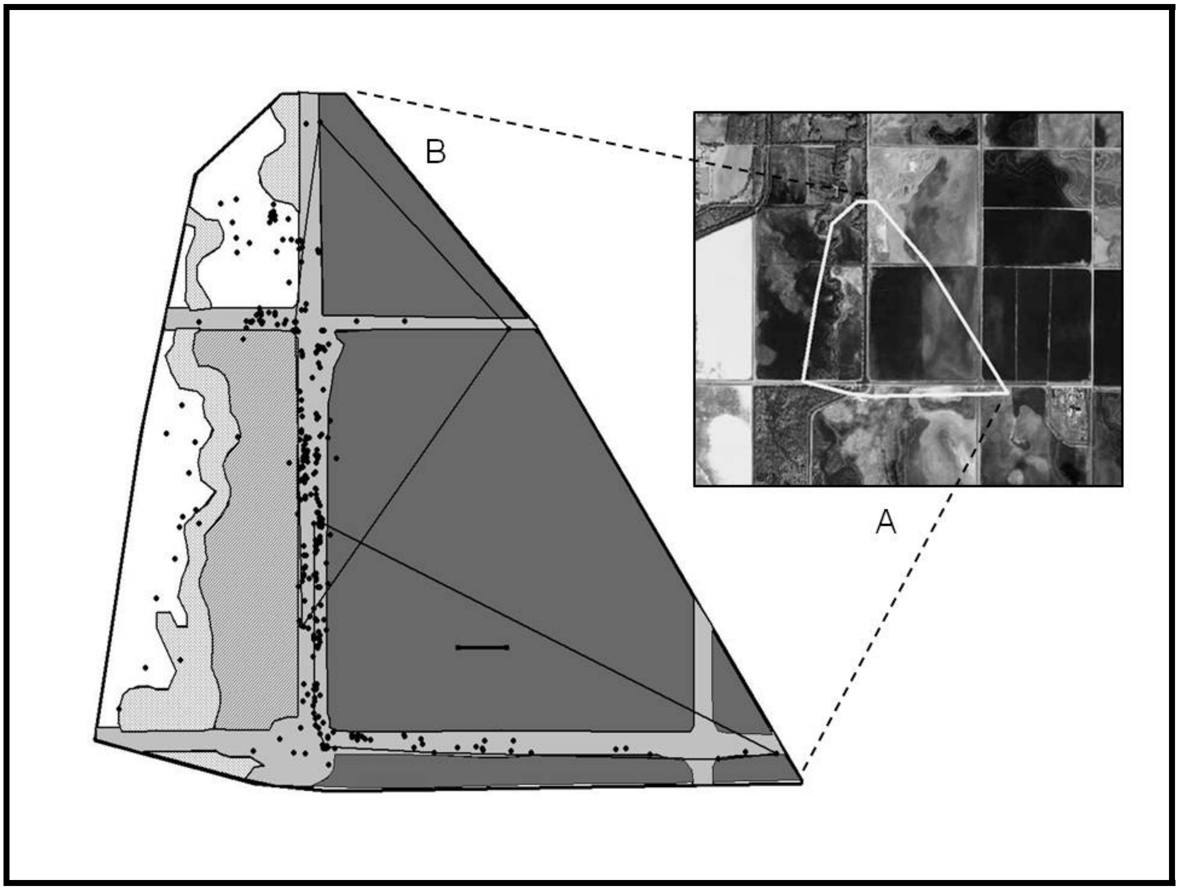

FIGURE 1. A.) An approximate 800 ha portion of the Bald Knob National Wildlife Refuge, Arkansas where *Lampropeltis getula* was radiotracked. Note checkerboard pattern of discrete habitat patches separated by levee roads and irrigation ditches. Dark areas indicate various amounts of water, the amount of which was determined largely by agricultural and waterfowl management practices, and which could change rapidly. Water levels were relatively high in this early-season photograph. The white polygon outline indicates the approximate 100 ha tracking area that contained all telemetry locations. B.) Sites of initial capture and subsequent telemetry locations of *Lampropeltis getula* on the study area. Dark gray = agricultural field, light gray = levee + canal, stippling = closed canopy forest, diagonal lines = abandoned agricultural field (oldfield), white = reforested agricultural field, horizontal bar = 100 m. Note clustering of points on levees. Also shown are the minimum convex polygon home ranges (black outline) of two snakes (nos. 4 and 7) illustrating the extensive unused areas contained within the MCP home ranges of some snakes.

adjacent levees, and abandoned and active agricultural fields (approx. 3650 ha). Much of the refuge is a checkerboard of crisscrossing irrigation ditches and shrub-covered levees that border discrete habitat patches approximately every 800 m (Fig. 1). Levee vegetation is maintained by periodic brush removal. The amount of water in any given habitat patch is determined largely by refuge management practices; consequently, water levels may change over time, sometimes rapidly. Temporal and spatial variation in reforestation has produced a variable-sized patchwork of discrete successional stages.

The study area where I tracked animals was bounded by a minimum convex polygon encompassing all snake locations (Fig. 1). The major habitats in the 98.4 ha tracking area consisted of active agricultural fields (62%), levees and ditches (8%), reforested areas (10%), oldfields (13%), and forests (6%). During the course of the study, rice and soybeans were grown each year in the active agricultural fields of the study area. Crops were rotated yearly in a given agricultural field.

Methods.—After opportunistic hand-collection in early spring, I transported snakes to the laboratory where I determined sex with a cloacal probe, measured snout-vent length (SVL) and body mass, and calculated a body condition index (BCI = [body mass/SVL^3] X 10^5; Winne et al. 2007). I also classified each snake according to body size as a juvenile (< 80 cm SVL) or adult (≥ 80 cm SVL; Krysko 2002; Krysko and Smith 2005). Females in Arkansas are known to mature at < 70 cm SVL (Trauth et al. 1994); however, the smallest female with sufficient data for analysis in this study was 82 cm SVL.

I implanted snakes with Model LF1 transmitters (L.L. Electronics, Mahomet, Illinois), weighing < 5% of body mass, using techniques developed by Reinert (1992). I released snakes at their original capture location within three days of capture and tracked 2–3 non-consecutive days per week from April-September in 2006 and 2007. In March and April 2008, the study area was inundated by major flooding on the White River that for the most part prevented access until early May. Thus, except for two brief excursions by boat in March and April, I tracked snakes from May-September in 2008. All procedures followed the guidelines for use of live amphibians and reptiles in research published by the American Society of Ichthyologists and Herpetologists (available at http://www.asih.org/files/hacc-final.pdf).

I used open source MapWindow GIS desktop software (Version 4.5.2896; Geospatial Software Lab, Idaho State University, Pocatello, Idaho, USA) to quantify macrohabitats and plot daily snake locations on digital orthophoto quarter quads of the BKNWL obtained online from GeoStor, the State of Arkansas' Geospatial Data Clearinghouse maintained by the Arkansas Geographic Information Office (http://www.gis.arkansas.gov, accessed 12 July 2007). At each snake location, I recorded GPS coordinates (UTMs), habitat (active agricultural field, abandoned agricultural field [oldfield], reforested agricultural land, closed canopy forest, levee), snake position (exposed, concealed, underground), and snake behavior (coiled, moving, unknown). At a later date, I centered a 1 m^2 quadrat over each snake location and measured % leaf litter cover, % vegetation cover, % shrub cover, % grass cover, grass height, and shrub height in the quadrat. Finally, I measured canopy closure with a spherical densiometer, distance to nearest overstory tree (≥ 10 cm dbh) and distance to nearest understory tree (< 10 cm dbh).

For all analyses, I included snakes tracked a minimum of 90 days and having at least 35 telemetry locations, the approximate number of locations found for home range area of *L. getula* to stabilize. I estimated a minimum convex polygon (MCP) home range for each snake. Because the deterministic MCP home range model does not reflect repeated site use by snakes, I followed Row and Blouin-Demers' (2006) recommendation for analyzing habitat use by estimating 95% fixed kernel home ranges for each snake and adjusting the smoothing factor until the 95% kernel area equaled that of the individual's MCP home range. Minimum convex polygon and 95% kernel home ranges were estimated with Biotas™ (Ecological Software Solutions LLC, Version 1.03.1a, Hegymagas, Hungary). I then used compositional analysis (Aebischer et al. 1993; Jenkins et al. 2009) with Resource Selection for Windows software (Fred Leban©, Version 1, University of Idaho, Moscow, Idaho, USA) to determine if macrohabitat use differed from random. Habitat use was analyzed at two different scales; snake use compared to available habitats within the snake's home range and habitats within the home range compared to available habitats in the study area. Because the sampling unit for compositional analysis is the individual animal rather than individual telemetry locations, the problems of pseudoreplication and serial correlation that often accompany repeated measurements on individuals are avoided (Hurlbert 1984; Aebischer et al. 1993; Jenkins et al. 2009).

To quantify the microhabitats available to each snake (Reinert 1993), I generated a random location within the snake's MCP home range by rolling a 10-sided die to determine compass bearing and distance within 50 m from each telemetry location. I centered a quadrat at each random location and measured the same habitat variables specified above for snake locations.

I used SYSTAT 12 (SYSTAT Software Inc., Richmond, California, USA) to compare home range areas of males and females with nonparametric Mann-Whitney tests and mixed-model two-way ANOVAs with microhabitat mean as the dependent variable, snake as a random factor, and location type as a fixed factor to compare microhabitat characteristics between snake locations and random locations. I used a BioSS (Biomathematics and Statistics, Scotland) Excel macro for a two-group randomization test to compare use and availability for each macrohabitat (Aebischer et al. 1993). Estimated probabilities for randomization tests were based on 1000 randomizations. Alpha was set at 0.05. Descriptive statistics are presented as mean ± 1 SE.

RESULTS

Fifteen *Lampropeltis getula* (9 males; 6 females) tracked over the course of three years yielded 693 radiotelemetry locations (Table 1). Unfortunately, five snakes were apparently lost to predators or their transmitters failed before the minimum requirement of 35 telemetry locations in 90 days had transpired. Thus, the following analyses are based on 542 telemetry locations taken on eight male and two female *L. getula*.

Macrohabitat use.—Levees were the most commonly used macrohabitat (82.3% of locations; Fig. 2). Of the 10.5% of telemetry locations I recorded in reforested habitat, most (68.4%) were by one juvenile male (snake no. 3). Extensive areas of rice and soybean fields occurred within the MCP home ranges of some snakes (Fig. 1), but I recorded few telemetry locations (0.6%) in either cropland type, regardless of the stage of crop

TABLE 1. Identification number, sex, age class (juvenile, adult), snout-vent length, and body mass of 15 *Lampropeltis getula* tracked at the Bald Knob National Wildlife Refuge, Arkansas. Also shown are the beginning and ending dates of annual tracking, span of days monitored, number of radiotelemetry fixes, minimum convex polygon home range area (MCP), and core use areas (50% fixed kernel home ranges). An asterisk (*) indicates snakes that were tracked in two different field seasons but had insufficient data for analysis in 2007 (no. 8) or 2008 (no. 11); home ranges for these two snakes were estimated each year to compare home range locations only.

Snake no.	Sex	Age class	SVL (cm)	Wgt (g)	Begin date	End date	No. days	No. fixes	MCP (ha)	Core (ha)
1	M	A	101.0	398	24 Apr 06	7 Sep 06	137	57	30.3	2.3
2	M	A	104.0	401	29 Mar 07	27 Jun 07	90	37	18.9	1.7
3	M	J	73.0	111	31 Apr 07	6 Sep 07	140	54	4.0	0.21
4	M	A	89.0	252	31 Mar 07	13 Sep 07	166	63	21.5	2.3
5	M	A	111.0	465	24 Apr 07	6 Sep 07	135	50	26.9	3.8
6	M	A	85.0	200	31 Mar 07	30 Aug 07	152	60	19.1	1.7
7	M	A	100.0	339	23 Mar 07	27 Sep 07	188	69	21.4	2.7
8	M	J	78.0	169	5 May 07	6 Jun 07	32	15	1.1*	--
8	M	A	82.0	204	3 May 08	21 Aug 08	110	44	1.9	0.12
9	M	A	90.0	290	3 May 08	9 Jul 08	67	29	--	--
10	F	A	93.0	275	12 Apr 06	9 May 06	27	15	--	--
11	F	A	87.0	250	23 Mar 07	27 Sep 07	188	69	2.9	0.16
11	F	A	88.0	249	16 Mar 08	16 Jun 08	92	20	3.4*	--
12	F	A	82.0	146	3 May 08	16 Jun 08	44	18	--	--
13	F	A	83.0	200	3 May 08	2 Jun 08	30	13	--	--
14	F	A	78.5	133	20 May 08	23 Jun 08	34	15	--	--
15	F	A	82.0	182	20 May 08	21 Aug 08	93	39	2.7	0.18

maturity. Variation among individual snakes in percentage macrohabitat use ranged from CV = 0.29% (levee) to CV = 2.2% (forest).

Compositional analysis revealed that percentage of macrohabitats in the 95% kernel home ranges differed significantly from the percentage of macrohabitats expected based on availability in the study area (λ = 0.1324; P < 0.05). Levees were used more than their availability and agricultural fields were used less than their availability (Fig. 2A). Only about 8% of the study area consisted of levee habitat, but levees comprised ~48% of 95% kernel home ranges. About 62% of the study area consisted of agricultural fields but agricultural fields comprised only ~20% of 95% kernel home ranges (Fig. 2A). There were no differences between use and availability for oldfield, reforest, and forest (Fig. 2A). Habitats ranked by use were levee >>> oldfield > ag field > reforest > forest (">>>" indicates a significant difference between two consecutively ranked habitat types).

Similar results from compositional analysis were found at the individual use scale. Percentage of macrohabitats used by individual snakes differed significantly from percentage of macrohabitats expected based on availability in their respective 95% kernel home ranges (λ = 0.0289; P < 0.001; Fig. 2B). The most striking differences were that levee home range was used more than expected and agricultural field and oldfield home range was used less than expected. About 48% of the 95% kernel home ranges consisted of levee habitat but levees contained ~86% of snake locations. About 20% of the 95% kernel home ranges consisted of agricultural fields but agricultural fields contained < 1% of snake locations. About 14% of the 95% kernel home ranges consisted of oldfields but oldfields contained < 1% of snake locations (Fig. 2B). There were no differences between use and availability for reforest and forest (Fig. 2B). Habitats ranked by use were levee >>> reforest > forest > ag field > oldfield.

Microhabitat use.—Microhabitats used by snakes had significantly greater litter, total vegetation, and shrub cover than microhabitats at random sites within the snakes' home ranges (Table 2). Microhabitats used by snakes had significantly less grass cover than microhabitats at random sites (Table 2). There were no differences between used and random sites for shrub and grass height, canopy closure, and distance to overstory and understory trees. Individual variation (CV) in microhabitat variables was generally high, ranging up to 73.5%. The lowest CVs were found for variables important in microhabitat selection by snakes (e.g., vegetation cover 16.0%; shrub cover 23.8%).

The total vegetational cover of selected microhabitats afforded concealment to snakes and was augmented by numerous subterranean shelters created by burrowing mammals and the root systems of trees and shrubs. I recorded only 20.3% of located snakes as exposed whereas 79.7% were classified as underground or concealed (snake not seen, but it could not be determined if the snake was above or below ground due to surface vegetation and litter).

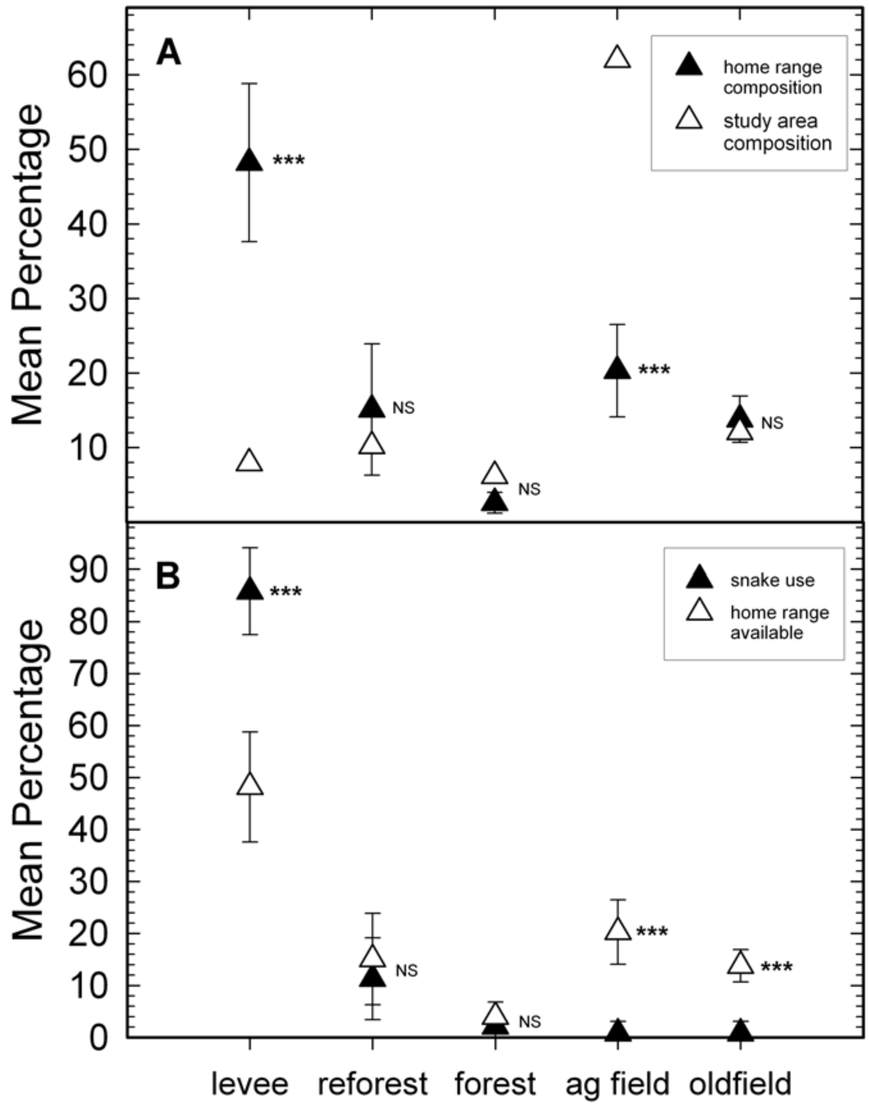

FIGURE 2. A.) The percentage of the study area occupied by each macrohabitat compared to the percentage of the 95% kernel home ranges used by radiotracked *Lampropeltis getula* on the Bald Knob National Wildlife Refuge, Arkansas. B.) The percentage of the 95% kernel home ranges available for each macrohabitat compared to the percentage of macrohabitats used by *L. getula*. Error bars represent ± 1 SE. Three asterisks (***) indicates significant differences (P < 0.001) between used and available microhabitats.

Home range and movements.—*Lampropeltis getula* moved an average distance of 121 ± 7.7 m between locations when instances of no movement (29.5% of locations) were removed. Periods of inactivity averaged 5.0 ± 0.39 (range 2-19) days. When snakes moved (70.5% of locations), the movements were restricted to a prescribed area (= home range) in which certain locations were used repeatedly. Maximum distance between successive locations averaged 570 ± 91 m (range 228–979 m).

Minimum convex polygon home range area averaged 20.0 ± 3.41 ha for seven adult males and 2.8 ± 0.10 ha (range 2.7–2.9 ha) for two adult females (Table 1; U = 2.00, P > 0.10). A juvenile male had a home range of 4.0 ha (Table 1). The maximum length of MCP home ranges along narrow linear environmental features (roads, levees, irrigation ditches) averaged 1012 ± 120 m for adult males and 622 ± 92 m for adult females. The annual MCP home ranges overlapped extensively for a male and a female over two consecutive years.

From 1–4 (mean 1.9 ± 0.38) core areas were identified for each snake (Table 1). Core area averaged 2.0 ± 0.45 ha for adult males and 0.17 ± 0.01 ha for adult females. A juvenile male had a core area of 0.21 ha. All core

TABLE 2. Characteristics of microhabitats used by individual *Lampropeltis getula* compared to those in available microhabitats within the snake's home range on the Bald Knob National Wildlife Refuge, Arkansas. Shown are the mean ± 1 SE for microhabitat variables and the results of mixed-model two-way ANOVAs using Type III sums of squares.

Microhabitat characteristic	Snake locations	Random locations	F ratio	*P*
Litter cover (%)	11.8 ± 0.99	8.0 ± 0.83	6.51	< 0.05
Vegetation cover (%)	82.9 ± 1.16	52.4 ± 2.16	39.56	< 0.001
Shrub cover (%)	74.7 ± 1.65	26.9 ± 1.89	44.38	< 0.001
Grass cover (%)	22.3 ± 1.57	34.3 ± 2.25	9.24	< 0.05
Shrub height (cm)	65.6 ± 3.57	136.9 ± 11.51	0.16	> 0.70
Grass height (cm)	40.2 ± 1.85	47.7 ± 1.87	0.38	> 0.50
Canopy closure (%)	21.9 ± 1.52	25.1 ± 1.65	0.09	> 0.70
Dist. to overstory tree (m)	12.1 ± 0.60	6.4 ± 0.25	2.09	> 0.10
Dist. to understory tree (m)	8.1 ± 0.36	5.2 ± 0.25	0.18	> 0.60

areas were located in levee habitat. Core areas were identifiable both quantitatively (50% kernel home ranges) and qualitatively as *L. getula* spent substantial amounts of time in them and repeatedly left and returned to them during the active season, often returning to an exact location (e.g., same mammal burrow, same root system).

DISCUSSION

Habitat use.—*Lampropeltis getula* may be found in a variety of upland and lowland habitats within its extensive geographic range (Ernst and Barbour 1989). At BKNWR, *L. getula* strongly preferred levees, avoided agricultural fields and oldfields, and used forest and reforested areas in proportion to their availability. An important factor in microhabitat selection by *L. getula* at BKNWR was the presence of concealing ground cover, especially shrubs. While *L. getula* is often regarded as a habitat generalist (Wund et al. 2007), the presence of sufficient ground vegetation, leaf litter, or other ground cover seems to be a necessary component of the various habitats chosen by *L. getula* in different parts of its range (Tennessee, Jenkins et al. 2001; New Jersey, Wund et al. 2007; Georgia, Steen et al. 2010; Arkansas, present study). Microhabitats offering surface concealment may occur where the canopy is sufficiently open to permit growth of ground vegetation, in forests where leaf litter and fallen logs accumulate, and at ecological edges. The narrow levees at BKNWR were periodically disturbed by brush removal and consisted entirely of ecological edges.

Lampropeltis getula is often found in the vicinity of water in soils in which they can burrow (e.g., Wright and Bishop 1915; Carr 1940; Enge, K.M. 1997. Habitat occurrence of Florida's native amphibians and reptiles, Technical Report No. 16. Florida Game and Fresh Water Fish Commission. Tallahassee, Florida.). The use of near-water levee habitat on the BKNWR by *L. getula* appears similar to how *L. getula* uses the banks of the extensive canal and levee system of South Florida (Godley 1982; Wilson and Porras 1983; Krysko 2001, 2002). It may be that levees attract *L. getula* because of their physical structure and because they provide readily available prey for the primarily ophiophagous *L. getula*. Aquatic snakes constituted 79% of the snake prey for *L. getula* in South Carolina and turtles and turtle eggs are readily eaten by *L. getula* (Ernst and Barbour 1989; Jenkins et al. 2001; Winne et al. 2007). Several known snake prey of *L. getula* were common and abundant in and around the irrigation ditches of the BKNWR, such as three species of water snakes (*Nerodia fasciata, N. rhombifera, N. erythrogaster*), Cottonmouths (*Agkistrodon piscivorous*), and two species of garter snakes (*Thamnophis sirtalis, T. proximus*). During the course of the study, I observed telemetered one *L. getula* eating a *T. proximus* and another eating a *Coluber constrictor*. Several species of turtles, especially *Trachemys scripta*, also were abundant in the BKNWR irrigation ditches. On the levees, I frequently observed both depredated turtle nests with nearby scattered empty eggshells as well as excavated nests lacking eggshells, suggesting snake predation.

Home range and movements.—Home ranges of *L. getula* at BKNWR were stable in location over years and were similar in size to MCP areas reported for snakes in general (McCartney et al. 1988) and *L. getula* in New Jersey (Wund et al. 2007). The areas actually used by *L. getula* at BKNWR were considerably less than what the MCP home ranges indicated. The MCP home range model has been used to compare home range areas among various species of snakes (Gregory et al. 1987) and is generally recommended for calculating home range areas for most snakes (Gregory et al. 1987; Row and Blouin-Demers 2006). However, it has the disadvantage, depending on the particular patterns of movement observed, of including areas not used by the individuals being tracked (Powell 2000). This was indeed the case with *L. getula* whose MCP home ranges contained extensive areas of agricultural fields, a habitat not used by snakes.

Conversion of natural habitats to agriculture can potentially affect a species' behavioral ecology (Lima and Zollner 1996, Yahner and Mahan 1997), such as movement speed and habitat selection (Gehring and Swihart 2003, 2004), presumably resulting from greater visual exposure and risk of predation. Radiotelemetric studies have demonstrated that some reptiles avoid moving in active agricultural fields (Doroff and Keith 1990; Durner and Gates 1993; Keller and Heske 2000; Richardson et al. 2006) whereas others readily use them, at least temporarily (Wisler et al. 2008). For example, Grass Snakes (*Natrix natrix*) may avoid agricultural monocultures but will move through them to reach preferred edge habitats (Madsen 1984). Whether *L. getula* actually traversed either rice or soybean fields may be open to question, but, if the movements did in fact occur, more frequent telemetry locations would likely be necessary to detect them, especially if the movements were hurried.

The results of radiotelemetric studies on *L. getula* in New Jersey (Wund et al. 2007), eastern Tennessee (Jenkins et al. 2001), southwestern Georgia (Linehan et al. 2010; Steen et al. 2010), and preliminary work in Arkansas (Trauth et al. 2004) were generally similar to the present study in terms of daily activity levels, burrow use, habitats used, and site fidelity. However, the pattern and extent of movements vary among populations. For example, there was no sexual difference in MCP home range size for *L. getula* in New Jersey (Wund et al. 2007) and Georgia (Linehan et al. 2010) and average MCP home range size varied from < 2 ha in Tennessee (Jenkins et al. 2001) to ~50 ha in Georgia (Linehan et al. 2010).

Several aspects of the ecology of *L. getula* are similar to those of the closely related *L. calligaster* (Richardson et al. 2006). For example, *L. calligaster* spends about 75% of its time underground, strongly prefers habitat edges, avoids agricultural fields, and exhibits sexual differences in movement and home range size (Richardson et al. 2006). Previous workers have reported sexual differences in movement patterns and home range size in numerous snakes (Gibbons and Semlitsch 1987). Male *L. getula* are opportunistically encountered more frequently than females (Krysko 2002; Steen et al. 2010) probably because males move more when seeking mates or because females have smaller home range sizes. These differences likely contributed to the difficulty I and others (e.g., Linehan et al. 2010) had in finding a sufficient number of females to track.

Conservation.—Although *L. getula* is geographically widespread, found in a wide variety of upland and lowland habitats, and historically common (Ernst and Barbour 1989), populations in some areas have declined precipitously, especially those in the southeastern most parts of its range (Means 1992; Krysko 2001, 2002; Krysko and Smith 2005; Winne et al. 2007; Stapleton et al. 2008). The purpose of this study did not include assessing the status of the population of *L. getula* at BKNWR; however, anecdotal observations suggest it is not in serious trouble. For example, my students, knowledgeable BKNWR employees, and I have regularly encountered *L. getula* in central Arkansas and on the BKNWR over the last 15 years. In addition, the body condition of telemetered BKNWR *L. getula* (BCI = 33.0 ± 1.24) was comparable to that of pre-population decline *L. getula* in South Carolina (estimated from Fig. 3A in Winne et al. 2007).

Both natural and human-induced habitat changes may be of concern in the conservation of snake populations. For example, natural succession from open habitats to relatively closed canopy forest has been implicated in declines of several snake species including *L. calligaster*, *L. triangulum,* and *L. getula* on former agricultural areas (Fitch 1999; 2006a; 2006b; Winne et al. 2007). Alternatively, human conversion of natural habitats to agriculture has been identified as a source of reptile species loss (Driscoll 2004 and references therein) although it has not been implicated *per se* as an underlying cause of *L. getula* decline (Krysko 2002; Krysko and Smith 2005; Winne et al. 2007). Maintaining heterogeneous vegetation structure to promote reptile conservation in agricultural landscapes has been recognized (Driscoll 2004; Wisler et al. 2008; Shoemaker et al. 2009). Despite the avoidance of agricultural fields by BKNWR *L. getula*, agricultural landscapes seem to be compatible with the species' persistence. However, the near complete restriction to densely vegetated edges and the strong response to shrubby ground cover highlight the importance of maintaining structural heterogeneity at both the macrohabitat and microhabitat scales in otherwise featureless agricultural landscapes for the conservation of *L. getula* populations.

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