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HABITAT USE AND HIBERNACULA OF THREE SPECIES OF SNAKES AT THE MIDDLE FORK FISH AND WILDLIFE AREA

FINAL REPORT FOR FY 99

Prepared by:

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HABITAT USE AND HIBERNACULA OF THREE SPECIES OF SNAKE AT THE MIDDLE FORK FISH AND WILDLIFE AREA, VERMILION COUNTY, ILLINOIS

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Final Report for FY 99 to the Illinois Wildlife Preservation Fund

Introduction

Due to their secretive behavior, snakes are difficult to study in the field and many important features of their ecology and natural history are not well known (Seigel et al. 1987; Seigel and Collins 1993). Accurate descriptions of habitat use, which are necessary for designing conservation plans, are available for few species (Reinert 1993). Snakes also are frequently considered vermin and often indiscriminately killed by humans (Dodd 1987, Greene 1997). As a result, many species of snakes are declining in numbers (Dodd 1987, Greene 1997). It is therefore important to identify and protect critical habitats and landscape features relevant to their conservation. Sites used as hibernacula are particularly important to the persistence of populations of many species of snakes (e.g., Burbrink et al. 1998). However, there is little information about sites used as hibernacula by snakes in agricultural regions of the midwestern United States.

Snakes also can have important ecological roles as predators. For example, gray rat snakes (*Elaphe obsoleta spiloides*) have been identified as significant predators of nests of the endangered red-cockaded woodpecker (Jackson 1974). Many species of songbirds show higher rates of nest predation near forest edges, possibly because some predators concentrate their activity along edges or forage more effectively there (e.g., Bider 1968). Black rat snakes (*E. obsoleta*) have been associated with habitat edges in Maryland (Durner and Gates 1993), and many researchers are beginning to recognize the importance of snakes as predators on songbird nests (e.g., Eichholtz and Koenig 1992). Studies of habitat use by species of snakes that are nest predators could help managers determine local manipulations of habitat features such as type of edge that could help improve nesting success for declining species of songbirds.

As part of a separate study examining patterns of songbird nest predation and predator activity at the Middle Fork Fish and Wildlife Area (MFFWA), we evaluated habitat use by three species of snakes (black rat snake - *Elaphe obsoleta*, fox snake - *E. vulpina*, blue racer - *Coluber constrictor*) that are potentially important predators of songbird nests. We also tracked snakes in the fall to determine habitats used as hibernacula by these snakes at MFFWA. Finally, we visited each hibernaculum several times in the spring to identify other species using the same sites to determine the importance of these sites for other, possibly rare species.

Methods

Study site: The study was conducted at the Middle Fork Fish and Wildlife Area (MFFWA) in Vermilion County, Illinois. The MFFWA includes about 1,235 ha along the Vermilion River; it stretches about 9.5 km north-south, and ranges from about 1 to 2.5 km wide as it follows the river. Prior to acquisition for public use in 1967 - 1971, the land was used primarily for farming and livestock grazing. The MFFWA currently is a mosaic of forested and open habitats (Cole 1986). Bottomland forests along the river (171 ha) are dominated by silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), sycamore (*Platanus occidentalis*), and walnut (*Juglans nigra*), whereas upland forests (340 ha) are dominated by oaks (*Quercus* sp.), hickories (*Carya* sp.), and sugar maple (*Acer saccharum*). Open habitats include old fields and prairie restorations (about 203 ha), wetlands (about 21 ha), and croplands (corn, soybeans, and sunflowers, *Helianthus annus*; 280 ha). About 110 ha are included in dedicated nature preserves and an archaeological site; habitats in these sites have not been inventoried. The remaining habitat includes treelines, hedgerows, narrow riparian corridors, patches dominated by upland shrubs, and areas appropriated for use by humans (roads and horse trails, campgrounds, ranger station, parking areas, dwelling). In addition to its conservation value, the MFFWA is heavily used for recreational and hunting activities. The region surrounding the MFFWA is dominated by row-crop agriculture.

Study species: We radiotracked three species of snake: black rat snakes - *Elaphe obsoleta*, fox snakes - *E. vulpina*, and blue racers - *Coluber constrictor*. These species are all potential predators on songbird nests, and are large enough to be implanted with transmitters. Other species observed at MFFWA were prairie king snakes - *Lampropeltis calligaster*, eastern hognosed snakes - *Heterodon platyrhinos*, and eastern garter snakes - *Thamnophis sirtalis*, but these were all too small for transmitters.

We located snakes by searching extensively throughout the MFFWA, particularly in the mornings when snakes were most likely to be basking. We also occasionally drove slowly along roadways around and inside the MFFWA at dusk, and maintenance personnel at the MFFWA sometimes collected snakes for us that they encountered while working. We began our study in spring 1997, but found few snakes, perhaps because the early spring was unusually cold, reducing activity, and vegetation had already leafed out by the time it warmed. By tracking some snakes to hibernation sites in the fall of 1997, we were able to obtain a better supply of snakes in 1998 when they emerged in the spring. In all, we radiotracked 7 snakes in 1997 (3 black rat, 3 fox, 1 blue racer) and 17 snakes in 1998 (10 black rat, 2 fox, 5 blue racers).

Captured snakes were transported to the University of Illinois, where they were implanted with radiotransmitters (Advanced Telemetry Systems, Isanti, MN). Snakes were anesthetized with isoflurane gas, and transmitters were surgically implanted in the body cavity with a 24-cm whip antenna positioned subdermally along the side of the snake. All surgery was performed with the assistance of a veterinarian, and snakes were kept in captivity for 1 week following surgery to monitor recovery. When snakes appeared recovered, they were returned to the MFFWA and released at their capture site.

After release in the field, radioimplanted snakes were located at least once per week, and usually three times per week, during the main songbird nesting season (May - July). Snakes were located on foot via hand-held, 3-element Yagi antennae. When a snake was located, we marked its position on an aerial photo of the MFFWA and described in data logs its position relative to obvious landscape features. We also recorded the habitat in which the snake occurred, whether the snake was below ground, on the soil surface, or arboreal, the soil surface temperature, and time of day. We noted if a snake was within 10 m of the canopy edge of the nearest forest, which we referred to as a forest-field edge.

After July, we located snakes about once per week until either transmitters failed, we lost the snake, or snakes returned to hibernation sites in November. We described sites used as hibernacula, and marked their locations on maps of the MFFWA. In the spring of 1999, we returned to each hibernaculum six times as the weather warmed. On each visit, we searched the areas around hibernacula for basking snakes, and recorded species and numbers of any snakes observed.

Locations of radiotracked snakes were mapped onto aerial photos in a GIS (geographic information system; ArcView or ArcInfo) platform. We digitized aerial photos of areas where each snake occurred, and classified the resulting polygons by general habitat type: upland forest, bottomland forest, prairie, old fields, agricultural fields, and "other" (including anthropogenic features like roads and railroad berms). Habitat selection was analyzed by comparing observed use to availability of different habitat types, with data for each snake analyzed separately. For each snake, we estimated available habitat by using ArcInfo to describe a circle with 100-m radius around each location for that snake, then summed the area of each habitat type included in the circles. We assumed that because snakes sometimes moved several hundred meters between locations, a 100-m buffer would include a conservative sample of the habitats that the snake could choose among. We then compared the numbers of locations in each habitat type to the available proportions of each habitat type using a Friedman test (White and Garrott 1990). Similarly, we determined availability of edge habitat by using ArcInfo to measure the total area $\leq$10 m on either side of all forest-field edges included in the 100-m radius circles around each location. We then used chi-squared tests of independence to compare the number of observed locations $\leq$10 m from a forest-field edge to that expected based on the proportion of the total area considered edge habitat for each snake. Finally, we used a Monte Carlo test to compare the use of vertical habitat (numbers of locations underground, on the soil surface, $<$3 m above ground, $>$3 m above ground) among the three species. Because numbers of locations varied considerably among snakes, we first calculated a frequency distribution for use of the four vertical habitats for each snake, then averaged the frequencies for all individuals in each species. This weighting procedure assured that no individual snake biased the analysis, and the results are representative of the species as a whole.

Results and Discussion

A summary of the snakes of each species, the first and last dates of radiotracking for each individual, and the numbers of locations obtained is given in Table 1. A summary of the numbers of locations of each snake in each habitat type is given in Table 2, with "edge" separated as a distinct category; in actual analyses of habitat use, "edge" locations were reassigned to the type of habitat in which the snake was found (i.e., as snake 10 m from the edge but in an old field was assigned to old field habitat). Because of small numbers of locations or erratic behavior by some snakes, statistical analysis of habitat use was based on 10 black rat snakes, 5 fox snakes, and 5 blue racers.

The total number of locations for each species of snake (data from all radiotracked snakes pooled) is given in Fig. 1. Although black rat snakes were found mostly in forest habitats and both fox snakes and blue racers were found mostly in open habitats, these data alone can not demonstrate habitat selection. However, when a selection index based on calculations for the Friedman test is made that takes into consideration the relative availability of each habitat type (Fig. 2), the pattern remains. Black rat snakes used forested habitats more frequently than expected based on availability of these habitats, and open habitats less frequently than expected based on availability of these habitats. Fox snakes and blue racers were very similar in their pattern of habitat use (Fig. 2). Both species used old fields and prairie restorations more frequently than expected based on availability of these habitats, and avoided agricultural fields and forests. The Friedman test indicated that use of habitat by each species was significantly non-random (black rat:

$\chi^2 = 13.96$, df = 5, $P < 0.05$; fox snake: $\chi^2 = 17.88$, df = 5, $P < 0.01$; blue racer: $\chi^2 = 14.21$, df = 5, $P < 0.05$).

Numbers of locations for each snake in relation to the vertical habitat categories are given in Table 3. Fox snakes and blue racers were primarily terrestrial, whereas black rat snakes used all categories of vertical space but were most frequently located up in the forest canopy (Fig. 3). Almost 50% of the locations of black rat snakes were up in the trees. Differences among the species in use of vertical habitat were significant (Monte Carlo estimate of $\chi^2 = 183.3$, $P < 0.0005$), but the difference was clearly due to the distinction between black rat snakes and the other two species. Fox snakes and blue racers only differed in that 5 records of blue racers were in branches of vegetation <3 m above the soil surface.

In contrast to some previous studies (e.g., Durner and Gates 1993), we did not find a significant association with forest-field edges for most snakes (Table 4). Some snakes were positively associated with edges, some were negatively associated with edges, and many showed random use of edge versus non-edge habitat. All three species appeared similar in this respect.

We tracked 11 snakes (7 black rat, 2 fox snakes, 2 blue racers) back to presumed hibernation sites (most were known hibernation sites, but in a few cases transmitters failed before hibernation actually began, Table 1). Three hibernation sites were located. One black rat snake hibernated in an old dumpsite on a steep hillside above a swampy bottomland area (hereafter, "dump"). One black rat snake hibernated in a steep slope that was very rocky and had several discarded slabs of concrete, located near a campground and parking area (hereafter, "camp"). All other snakes hibernated in an abandoned railroad berm and trestle that crossed the river (hereafter, "RR trestle"). This latter site appeared critically important to snakes at the MFFWA, as some snakes moved distances of over 1000 m from this site to their summer ranges. Exact locations of sites will not be included in this report because of possible sabotage, but will be reported to managers at the MFFWA and appropriate IDNR personnel.

The three hibernation sites were visited six times in the spring and early summer of 1999 (Table 5). Early in the season, black rat snakes emerged from two of the sites (camp, RR trestle) and could be seen basking on the branches of nearby trees. On some visits, up to 10 black snakes were seen in branches of large trees at the RR trestle. Few snakes other than black rats were seen, but three blue racers and one hognosed snake were also seen basking on the ground near these sites (Table 5). Apparently, fox snakes emerge later, or are more secretive upon emergence, as none were seen near the hibernacula in spring but we know that at least two fox snakes hibernated in the RR trestle.

Finally, some movements by radiotracked snakes were noteworthy. Sometimes a snake remained in the same location for several days, and at other times we recorded movements of over a kilometer in a few days (i.e., between successive locations). Several snakes moved back and forth across the river repeatedly.

Summary: Our telemetry data revealed that these three species of snakes, all of which are known nest predators, used habitats at the MFFWA differently. The most abundant species at the MFFWA, the black rat snake, was most likely to be found in forested habitats, was also common near edges and occasionally in the open habitats, although less frequently than expected based on habitat availability. Fox snakes and blue racers were more frequently associated with prairies and old fields. Our data largely support the opinions of Smith (1961), who did not have quantitative data on habitat use. This complementary use of habitats also underscores the conclusions of S. K. Robinson, E. J. Heske, and J. D. Brawn (personal communication) that there are no clear refuges from nest predation in this heterogeneous landscape. Snakes made minimal use, if any, of agricultural areas. The few records reported as "agricultural" were made in a field of sunflowers planted to attract mourning doves.

Dodd (1987) identified loss of critical habitat features as the most important factor contributing to the declining numbers of endangered species of snakes. A key habitat feature for many species is the availability of suitable hibernacula. Although the focal species of our study are not endangered, many snake species hibernate in aggregations with other species (e.g., Gibbons and Semlitsch 1987), and rarer species may thus benefit from the identification and protection of these sites. Our study provided descriptions of three sites used as hibernacula at the MFFWA, in a region dominated by row-crop agriculture where natural habitat is scarce and few studies of this nature have been conducted. Of particular interest, an abandoned railroad berm and trestle appears to be a major center for hibernating snakes, and was frequently used as a basking site. Snakes of at least four species hibernated in this structure, with black rat snakes hibernating there in large numbers. This site should certainly be protected and maintained as an important landscape feature at the MFFWA.

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Table 1.-- Summary of snakes implanted with radio transmitters, first and last dates of radiotracking for each snake, numbers of telemetry locations, and fates of snakes.

Species	First Record	Last Record	Number of locations	Fate
1997				
Black Rat 316	2 July	7 November	40	No signal after Nov. 7; in hill near camp
Black Rat 418	16 July	7 November	36	No signal after Nov. 7; in old dump
Black Rat 792	17 July	15 November	36	Tracked to hibernation site; in RR trestle
Fox 267[1]	7 July	5 August	12	Transmitter removed; rehab. and released
Fox 367[1]	16 July	23 July	6	Transmitter removed; snake euthanized
Fox 842[1]	30 July	20 August	12	Snake recaptured to treat wound; signal lost
Blue Racer 869	18 September	15 November	9	Tracked to hibernation site; in RR trestle
1998				
Black Rat 792	23 April	14 May	14	Emerged from hib., but re-entered and died
Black Rat 616	23 April	12 August	27	Signal lost in field
Black Rat 891	23 April	20 July	29	Signal lost in field
Black Rat 515	23 April	15 October	24	Signal lost in field; snake underground
Black Rat 716	23 April	18 November	36	Tracked to hibernation site; in RR testle
Black Rat 964	4 May	15 October	28	Signal ceased at hibernation site
Black Rat 742	4 May	6 May	4	Removed due to illness
Black Rat 813	10 June	18 November	16	Tracked to hibernation site; in RR trestle
Black Rat 919	19 June	18 November	24	Tracked to hibernation site; in RR trestle
Black Rat 868	17 July	14 September	12	Signal lost in field
Fox 062	19 June	15 October	20	Signal ceased at hibernation site
Fox 050	17 July	15 October	15	Signal ceased at hibernation site
Blue Racer 669	23 April	12 August	27	Signal lost in field
Blue Racer 465	23 April	6 September	31	Signal ceased while moving to hib. site
Blue Racer 941	4 May	14 September	28	Signal lost in field
Blue Racer 028	4 May	6 May	4	Signal lost in field
Blue Racer 566	4 May	27 July	26	Transmitter shed with eggs!

[1]original transmitters proved too large for fox snakes and had to be removed from these animals

Table 2.-- Numbers of locations of radioimplanted snakes in various habitat types. Edge locations were considered locations within 10 m of a forest-field edge. EO = black rat snake (*Elaphe obsoleta*), EV = fox snake (*Elaphe vulpina*), CC = blue racer (*Coluber constrictor*).

Species	Habitat Type							
	Old Field	Agric. Field	Prairie Rest.	Upland Forest	Bottomland Forest	RR Berm	Edge	Total
1997								
EO 316	1	0	0	11	0	0	28	40
EO 418	0	0	0	31	0	0	2	33
EO 792	0	0	1	0	32	4	0	37
EV 267	0	4[1]	7	0	0	0	1	12
EV 367	2	0	0	1[2]	0	0	3	6
EV 842	11	0	0	0	0	0	0	11
CC 869	3	0	0	0	0	6	0	9
1998								
EO 792[3]	0	0	0	0	0	13	0	13
EO 616	2	0	0	3	20	0	2	27
EO 891	1	0	1	3	19	0	5	29
EO 515	0	0	0	2	19	0	3	24
EO 716	0	0	0	0	25	4	5	29
EO 964	0	0	0	1	19	6	0	26
EO 742[4]	3	0	0	0	0	1	0	4
EO 813	2	0	0	0	14	2	0	18
EO 919	0	0	3	0	15	3	2	23
EO 868	1	0	2	0	0	0	9	12
EV 062	5	0	6	0	0	1	3	15
EV 050	6	0	12	0	0	4	0	22
CC 669	2	0	9	0	2	8	7	28
CC 465	14	0	10	0	0	3	5	32
CC 941	3	0	10	0	2	5	7	27
CC 028	0	0	0	0	0	4	0	4
CC 566	5	0	20	0	0	0	0	25

[1]sunflower field
[2]along trail
[3]snake emerged from hibernation site in RR trestle, remained in area, then went back underground and died
[4]snake appeared ill and did not move much after release; transmitter removed and snake rehabilitated

Table 3.-- Numbers of locations of radioimplanted snakes in relation to substrate. EO = black rat snake (*Elaphe obsoleta*), EV = fox snake (*Elaphe vulpina*), CC = blue racer (*Coluber constrictor*).

Species	Location of Snake			
	Underground	On Soil Surface	< 3m Above Ground	> 3m Above Ground
1997				
EO 316	4	5	19	12
EO 418	4	3	18	8
EO 792	5	2	16	14
EV 267	7	5	0	0
EV 367	2	4	0	0
EV 842	0	11	0	0
CC 869	7	1	1	0
1998				
EO 792[1]	11	1	0	1
EO 616	0	3	2	22
EO 891	8	5	2	14
EO 515	2	2	1	19
EO 716	6	6	7	15
EO 964	4	1	2	19
EO 742[2]	0	4	0	0
EO 813	3	3	0	12
EO 919	8	1	1	13
EO 868	1	11	0	0
EV 062	13	9	0	0
EV 050	11	13	0	0
CC 669	7	18	2	1
CC 465	11	20	0	1
CC 941	2	25	0	0
CC 028	0	4	0	0
CC 566	13	12	0	0

[1]snake emerged from hibernation site, remained in area, then went back underground and died
[2]snake appeared ill after release and did not move much from release site; transmitter removed and snake rehabilitated

Table. 4.-- Use of edges (< 10 m from canopy edge) by three species of snakes radiotracked at the Middle Fork Fish and Wildlife Area. Numbers indicate how many snakes were significantly ($P < 0.05$) positively or negatively associated with edges, after comparing observed numbers of locations near edges to the number expected based on availability of edge habitat via chi-squared tests.

	Association with Forest-Field Edges		
Species	Positive	No Association	Negative
Black Rat	1	4	5
Fox Snake	1	3	1
Blue Racer	2	2	1

Table 5.-- Snakes observed at hibernation sites at the Middle Fork Fish and Wildlife Area in spring 1999.

Date of visit	Hrs. at sites	Site	Number of snakes and species
April 12	3	trestle	none seen
		camp	none seen
		dump	none seen
April 19	3	trestle	10 black rat, 1 blue racer
		camp	none seen
		dump	none seen
April 23	3 (cold day)	trestle	none seen
		camp	none seen
		dump	none seen
April 29	3	trestle	6 black rat, 1 racer
		camp	2 black rat
		dump	none seen
May 4	3	trestle	1 black rat, 1 hognosed
		camp	2 black rat, 1 racer
		dump	none seen
June 3	4	trestle	none seen
		camp	none seen
		dump	none seen

Figure legends

Fig. 1.-- Numbers of locations of three species of snakes (data from all individuals pooled) in six habitat categories at the Middle Fork Fish and Wildlife Area, 1997-1998.

Fig. 2.-- Values of a selection index (White and Garrott 1990) for habitat use by three species of snake at the Middle Fork Fish and Wildlife Area. Positive values indicate the habitat was used more frequently than expected based on availability, negative values indicate habitat was avoided.

Fig. 3.-- Frequency distribution of locations of radiotracked snakes in four categories of vertical habitat at the Middle Fork Fish and Wildlife Area.

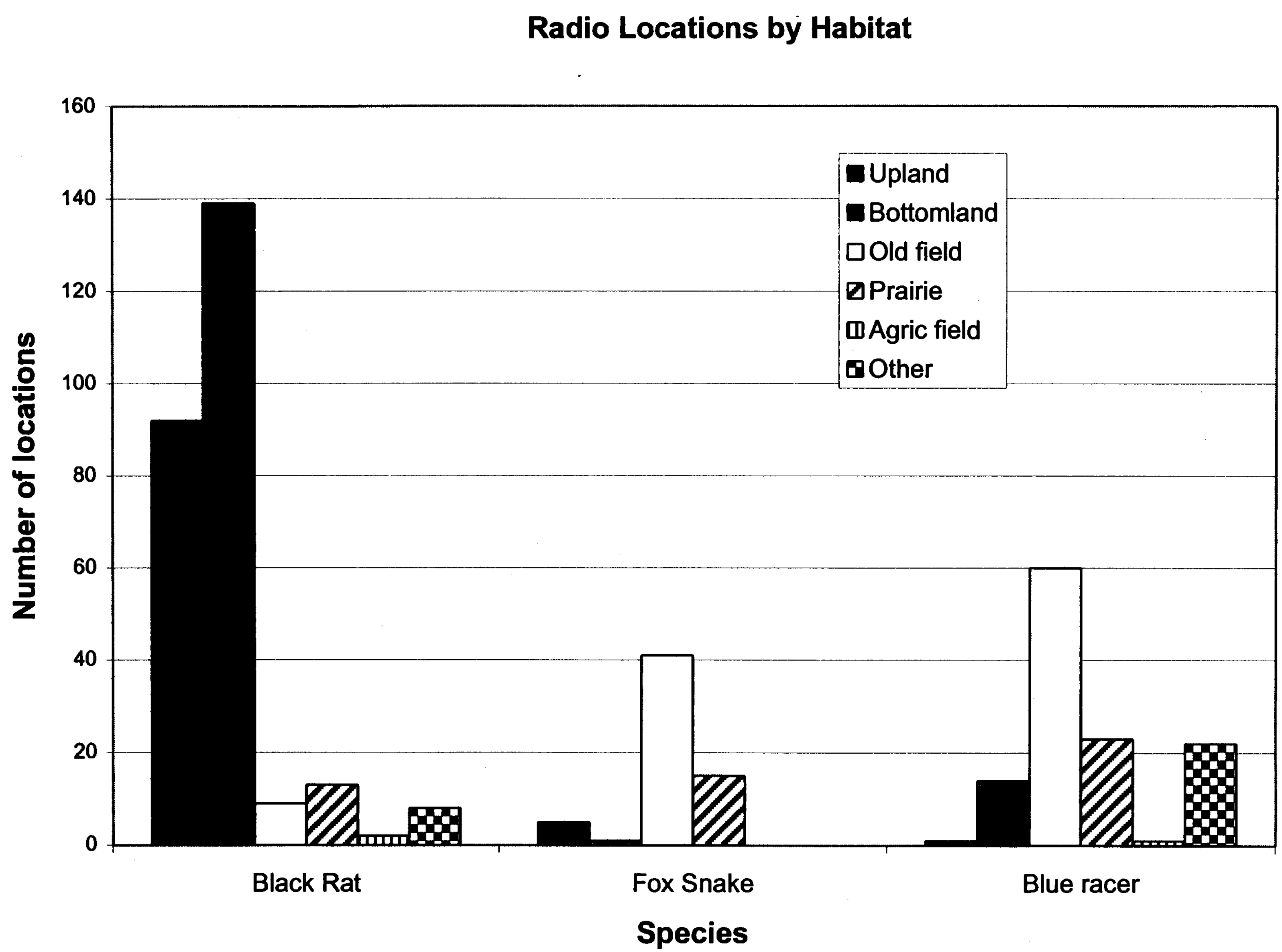
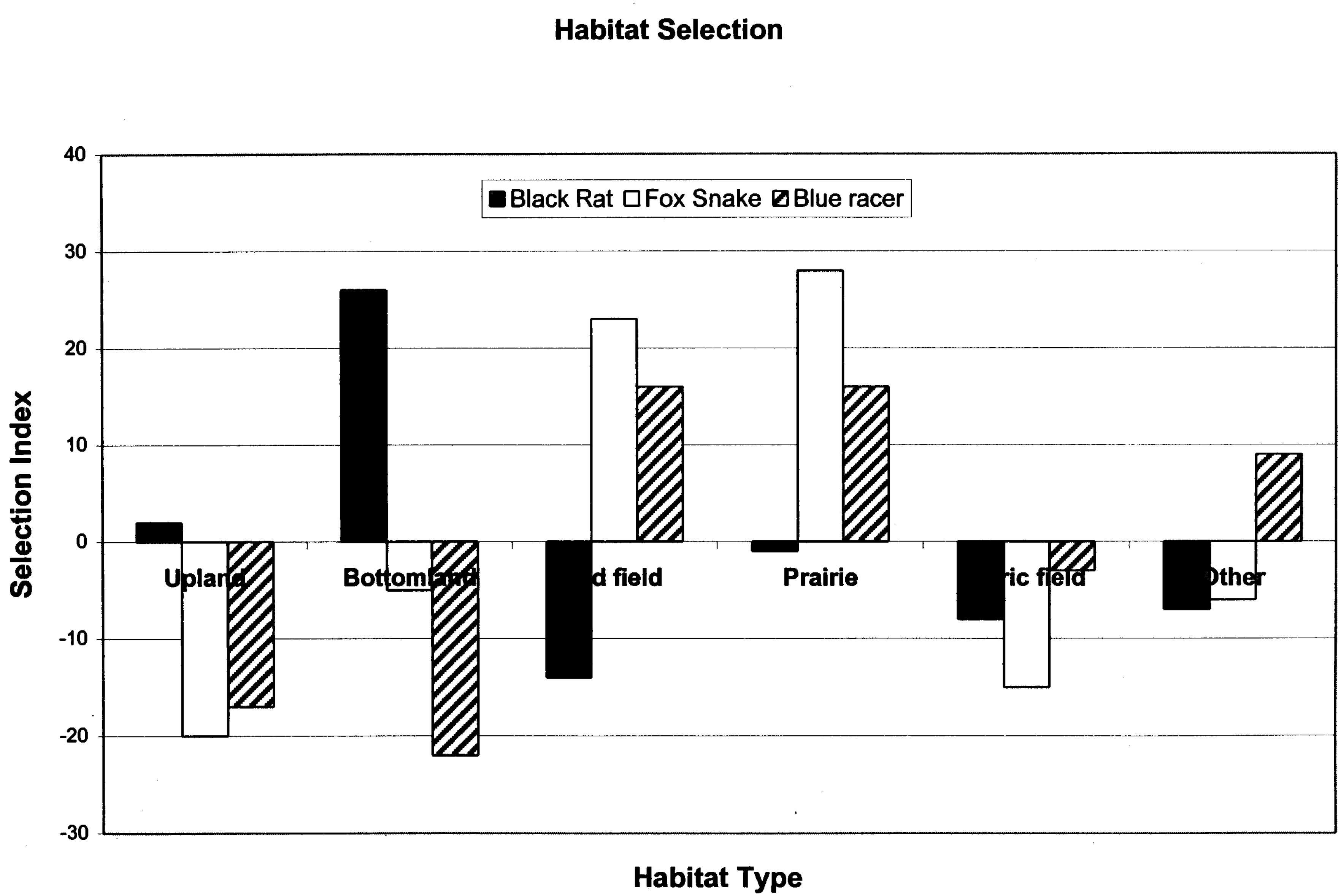

Radio Locations by Habitat
Number of locations
160
140
120
100
80
60
40
20
0
Upland
Bottomland
Old field
Prairie
Agric field
Other
Black Rat
Fox Snake
Blue racer
Species

Fig. 1



Habitat Selection
Black Rat
Fox Snake
Blue racer
40
30
20
10
0
-10
-20
-30
Selection Index
Upland
Bottomland
d field
Prairie
ric field
Other
Habitat Type

Fig 2

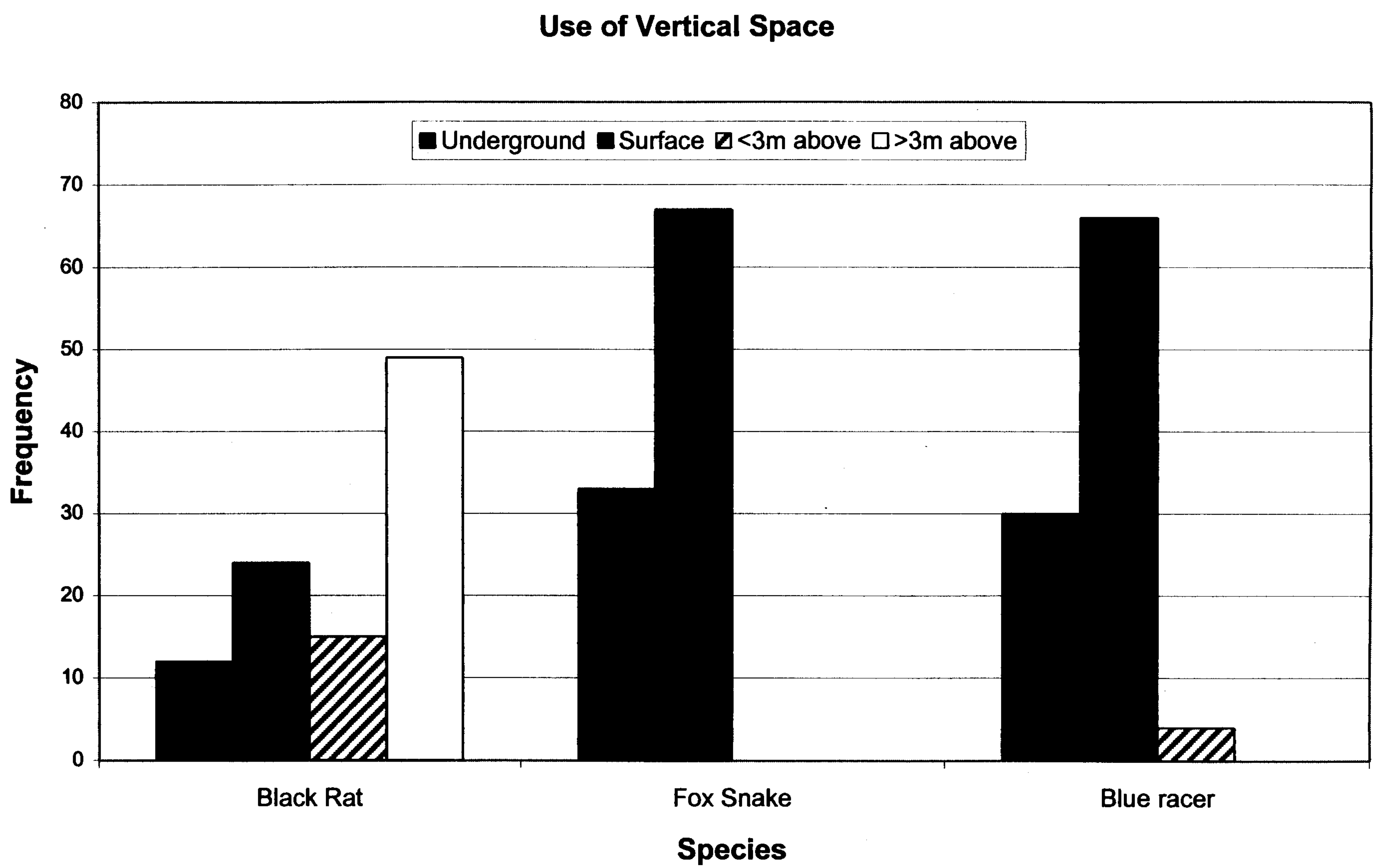

Use of Vertical Space
Underground
Surface
<3m above
>3m above
80
70
60
50
40
30
20
10
0
Frequency
Black Rat
Fox Snake
Blue racer
Species

Fig. 3