EFFECTS OF GRASSLAND MANAGEMENT ON SNAKE SPECIES DIVERSITY AND HABITAT USE, HOME RANGE AND MOVEMENTS OF WESTERN FOX SNAKES

BY

JOHN GRIESBAUM

THESIS

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Master’s Committee:

Affiliate Associate Professor Christopher A. Phillips, Adviser
Natural Resources and Environmental Sciences Department Head Jeffrey Brawn
Assistant Professor Robert L. Schooley
ABSTRACT

Prairies have become a globally endangered resource. In Illinois, the pervasiveness of agriculture has resulted in an almost complete loss of natural prairie. Wildlife associated with prairie and grassland has concomitantly declined or become critically imperiled. In Illinois, 12 snake species are associated with grassland habitat and; of these, three are of conservation concern. To prevent continued declines of grassland snakes, conservation efforts must realize how management techniques affect grassland snake diversity and understand habitat associations of grassland snakes. Little is known about the impact of prairie management techniques on ecology of grassland snakes. I studied community diversity in and around Allerton Park in east central Illinois on study sites managed with different techniques (i.e., burning, grazing, mechanical brush and woody vegetation removal, and herbicide application). Using drift fence arrays and funnel traps in 2008, I captured 186 individuals representing seven species. Species diversity of snakes was highly correlated ($r=0.74$) with the depth of the vegetation litter layer. Maintenance of a deep layer of vegetation may enhance the diversity of snakes in grasslands in the Midwest. The natural history of western fox snakes (*Elaphe v. vulpina*) is largely unknown. I radio-tracked nine adult western fox snakes (six male, three female) for one year to determine their home range sizes, core ranges, habitat use, and movements in and around Allerton Park, Piatt County, Illinois. This area included forest, grassland, agriculture fields, and roads. The active season for snakes extended from approximately mid-April to late-October. Males and females had similar activity levels throughout the active season. Average home ranges of males were larger than those of females. Average core ranges for males and females were similar in size. Although males had larger home ranges, females moved farther between locations and had greater total distances moved and maximum distances moved. Collectively, western fox snakes
avoided agricultural fields and used grassland and forest habitat more than expected based on availability. Roads were included in all snakes’ available habitat but only one road crossing was detected, suggesting that roads may be barriers to movement.
For my parents, without your help and support my academic accomplishments would simply not have been possible.

For my wife, your love, patience and understanding sustained me till the end.
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CHAPTER ONE
EFFECTS OF GRASSLAND MANAGEMENT ON SNAKE SPECIES DIVERSITY

INTRODUCTION

Prairies were once the largest vegetative zone in North America but are now a globally endangered resource with only 4% of an estimated original 68 million ha remaining (Rickletts et al., 1999; Steinauer and Collins, 1995). Loss of prairie has exceeded that of all other major ecosystems on the continent (Samson and Knopf, 1994, 2004; Noss et al., 1995). In Illinois, the pervasiveness of agriculture throughout the Grand Prairie Natural Division (Schwegman, 1973) has resulted in an almost complete loss of natural prairie. Only 0.1% remains of the estimated 8,900,000 ha of former native prairie (Illinois Department of Natural Resources 2005).

As this habitat declined, wildlife associated with grasslands has concomitantly declined or become critically imperiled (Samson and Knopf, 1994). Hence, federal, state and non-profit organizations have made grassland management (i.e. restoration, creation, protection) a long-term priority. Of the 38 species of snakes known to occur in Illinois, twelve are associated with grassland habitat and, of these, three are of conservation concern. To prevent continued declines of grassland snakes, conservation efforts must realize how management techniques may affect grassland snake diversity.

In Illinois, commonly implemented techniques to restore grasslands and manage extant grasslands include prescribed burning, cattle grazing, herbicide application and mechanical control (i.e. mowing, woody brush clearing). Prescribed burning is used to control woody encroachment, reduce litter buildup, recycle nutrients, destroy on-site
slash and prepare seed beds (Axelrod, 1985; Nyland, 1996; Smith et al., 1997; Stoddard, 1962; Van Lear and Waldrop, 1989; Walker, 1999). Cattle grazing, herbicide application and mechanical control promote grassland habitat by preventing woody encroachment or removing established woody and shrub species, maintaining open habitat. Because of the strong association of reptile diversity and vegetation structure (Weatherhead and Charland, 1985; Plummer and Congdon, 1994; Charland and Gregory, 1995), management practices have the potential to shape the diversity of reptile communities. Furthermore, snakes are ectothermic, regulating their body temperature behaviorally by habitat selection, body posture and timing of activity (Huey et al., 1989; Blouin-Demers and Weatherhead, 2001, 2002). The habitat characteristics that result from a management regime may alter the thermal properties of a site rendering it unsuitable for some grassland snakes.

Previous investigations that examined effects of grassland management on snake species diversity made simple comparisons of individual management techniques (e.g. burned vs. unburned; Cavitt, 2000; Moseley et al., 2000; Setser and Cavitt, 2003; Wilgers and Horne, 2007; Bock et al., 1990; Jones, 1981; Jones et al., 2000). This method ignores the varying types of microenvironments that are created within a site by a management technique. For example, the land cover of a site after a prescribed burn is rarely, if ever, homogenous. Subtle differences in soil moisture, vegetation type and density as well as the weather conditions during a burn (i.e. wind, relative humidity, and temperature) all affect the uniformity of a burn, resulting in sites that possess varying cover types available to snakes.
I investigated the vegetation structure and composition (e.g., grass, shrub, forb) that may result from alternative management techniques to identify underlying habitat characteristics potentially important to local snake species diversity. The objective of my study was to examine which underlying habitat characteristics are correlated with snake species diversity and may be important in snake species conservation.

METHODS

Study Site

All sampling occurred during 2008 at seven sites within Robert Allerton Park, Upper Sangamon River Land and Water Reserve, and Heartland Pathways, Piatt County, Illinois (Fig. 1). Allerton Park, located SW of Monticello IL, was donated to the University of Illinois by Robert Henry Allerton in 1946 for use as an educational and research center. The park’s 607 ha contain woodland, riparian and prairie areas of such high quality they have been designated a National Natural Landmark. The 259-ha Upper Sangamon River Land and Water Reserve was dedicated in 2003. Eastern massasauga (Sistrurus catenatus) and Kirtland’s water snake (Clonophis kirtlandii) either occur or have historic records within its boundaries. Heartland Pathways is an 85 km, 133 ha, out-of-service railroad right-of-way containing sections of remnant prairie. The park, reserve, and pathway are managed to improve, maintain or restore their natural qualities. Prescribed fire is implemented on three of my study sites (Fig. 1): alternating halves of site D are burned every other year, site E was burned in 2007, and site G is burned opportunistically and was last burned in 2005. Herbicide application occurs on two of my study sites (Fig. 1): site F and C had herbicide applied in 2007 to control exotic and
invasive weeds. Cattle grazing occurs March - November on two sites (Fig. 1), A and B, with the cattle owner moving the herd to adjacent pastures as needed.

**Habitat Characterization**

To characterize vegetative structure and composition, I measured five habitat variables (Table 1) at 20 random locations within each site every two weeks from May – August 2008: Visual obstruction rating (VOR), litter layer depth (LILA), percent cover type (grass, forb shrub, litter, bare ground, other) (%COV), substrate temperature (STEMP), and area (AREA). Visual obstruction rating is a correlative measure of vegetation height and density with units in decimeters (Robel et al., 1970). Visual obstruction rating predominantly assesses the current season’s vegetative growth and provides a general view of the vegetative structure resulting from a specific management technique. Litter layer depth is the depth (dm) of the surface layer of vegetation and differs from VOR in that LILA is predominantly composed of previous seasonal growth and increases over time. Percent cover type was measured at each of the 20 locations, within 1-m² plots, using an ocular tube haphazardly pointed at the ground and recording 50 readings of the vegetation type (grass, forb, shrub, litter, bare ground) per 1-m² and converting to a proportion. To reduce the number of values in the %COV variable, I conducted principal components analysis (PCA) with a varimax rotation to reduce the five quantities into fewer components. Substrate temperature (Celsius) was measured by randomly placing five ibutton thermochrons (Maxim Integrated Products) on the ground surface at each site and recording temperature every hour continuously over the active season (mid-April to mid-September). The area of a site (m²) was measured using 2008 aerial photographs in ArcGIS 9.2.
Snake Diversity

I measured sampling effort by the number of nights traps were open to catch individuals (i.e. trap nights). Sampling units were the individual grasslands where trapping occurred. I captured snakes using eight double-sided funnel traps placed along a 30-m drift fence array that was installed at each study site in early spring prior to the start of the active season (mid-April to mid-September). To avoid counting individuals more than once, snakes were individually marked by implanting passive integrated transponder (PIT) tags subdermally. I used ventral scale clipping (Brown and Parker 1976) to mark individuals too small for PIT tags.

I estimated snake species diversity at each study site using $\alpha$, from the log series diversity index (Fisher et al., 1943). I refrained from using species richness (S) as my measure of diversity because richness alone can mask variation in the evenness or dominance of the species distribution (Magurran, 1988). Moreover, S is sensitive to sampling and will increase as the sampling area is extended or as the number of samples taken increases (Magurran, 1988). Other popular diversity indices (i.e. Simpson and Shannon) have been shown to be more sensitive to sample size than $\alpha$. The only disadvantage of $\alpha$ is that it is based purely on S (species richness) and N (number of individuals). Thus, $\alpha$ can’t discriminate situations where S and N remain constant, but performs well when there is a change in evenness. This concern is largely academic due to the unlikely probability that field data would behave in this manner. The large number of investigations into the behavior of $\alpha$ and its satisfactory performance in a wide range of circumstances make it an excellent candidate for a universal diversity statistic (Taylor et al., 1976; Southwood, 1978; Magurran, 1988; Buzas and Hayek, 2005). After
estimating \( \alpha \), I calculated the Pearson correlation coefficient \( r \) using the Systat 11 software package to determine the strength of the relationship between snake species diversity and each of the habitat variables.

**RESULTS**

Sampling occurred for 648 trap nights per site. I captured 186 individuals representing seven species (Table 2). The minimum \( (\alpha) \) value (0.525) was estimated at site B and maximum (2.759) occurred at site E (Table 2). The most abundant snake species across all sites were the common garter snake (*Thamnophis sirtalis*) and Dekay’s brownsnake (*Storeria dekayi*). Alpha values per management technique were: herbicide application (0.876, 0.939), grazing (0.525, 1.240), older burn (1.057), newer burns (1.830, 2.759).

Two principal components explained 82.3% of the sample variation in proportional cover type (Table 3). The PC1 parameter separated grasslands that had a greater proportion of the categories “other” (i.e. coarse woody debris, rock, log, etc.) and “bare ground” and smaller proportions of “grass” and “forbs”. The PC2 parameter separated grasslands that had larger proportions of the categories “grass” and “forb” and smaller proportions of “bare ground” and “other”.

Depth of litter layer (LILA) had the strongest correlation \( (r=0.745, \text{ Table 4}) \) with species diversity of snakes. Diversity was related positively to litter depth (Fig. 2). The PC2 parameter had the next highest correlation with snake diversity \( (r=0.689, \text{ Table 4}) \). All remaining variables had \( r \) values <0.6.
DICUSSION

Depth of the litter layer had the strongest correlation with snake species diversity across my intensively managed grassland sites. The habitat variable PC2 also correlated with snake species diversity. Site E had the highest alpha value and deepest litter layer and is managed using prescribed fire. Fire acts to suppress woody vegetation (e.g., Bragg and Hulbert, 1976), alters vegetation composition (Gibson and Hulbert, 1987), and productivity (Collins and Gibson, 1990). Site E was burned the year prior to my study (2007) so it appears that a single growing season can be sufficient to rebuild a suitable litter layer. Snakes at the Konza Prairie in Kansas used recently burned grasslands (burned that year) less than grasslands not recently burned (Cavitt, 2000). This result may be due to grassland snakes’ susceptibility to aerial predation (Wilgers and Horne, 2007). A developed litter layer would offer larger bodied snakes (i.e. blue racer (C. c. foxii), western fox snake (E. v. vulpina), eastern hognose (H. platirhinos), and prairie kingsnake (L. c. calligaster)) greater protection for carrying out daily activities (i.e. basking, and foraging), whereas smaller bodied snakes (i.e. Dekay’s brownsnake (S. dekayi), Kirtland’s snake (C. kirtlandii), and common garter snake (T. sirtalis) could remain obscured with a shallower litter layer. However, Site G was burned in 2005 and had the second highest litter layer depth yet only a moderate diversity value relative to my other study sites. This may be due to increased levels of woody vegetation at site G due to infrequent fires and grassland snakes preferring open habitats.

The inadequate sample size of specific management techniques limits the inferential scope of my study. Future studies should build on the generality of my results. However, based on the observations of this study, basic recommendations can be made.
A 2-4 year burn rotation for grassland sites in the Midwest appears to maximize local diversity of snakes. This management should allow a suitable litter layer to develop. On sites where woody invasive vegetation is a management concern, a burn rotation closer to two years would be advisable to maintain open habitat. On sites where moderate to high quality grassland exist, a burn rotation of 3 to 4 years would be advisable to promote and stimulate native vegetation, maintain open habitat and allow the litter layer to develop.

Livestock grazing is practiced on two of my study sites, A and B. These two areas were among the lowest in litter layer depth and snake species diversity. At moderate stocking rates, activities of cattle such as selective grazing, nutrient deposition (i.e. urine and dung patches) and soil disturbance (i.e. trampling and wallowing) enhance grassland quality by increasing heterogeneity in resource availability and altering species composition and community structure (Steinauer and Collins, 1995; 2001; Augustine and Frank, 2001). Previous research to examine the relationship between reptiles and livestock grazing has shown that diversity is lower in areas where grazing occurs due to the reduction of the litter layer (Busack and Bury, 1974; Jones, 1981; Bock et al., 1990). These studies occurred in the desert grasslands of Arizona. Climatic differences between Arizona and central Illinois could lead to grasslands that are more resilient to grazing in the Midwest. Moreover, stocking rates were not reported in these studies. Stocking rates on my sampling sites during the time of my study (2008) were ~0.5 cow/ha. Moderate stocking rates enhance structure, composition and diversity of grassland vegetation (Towne et al., 2005). Therefore, I recommend a light to moderate stocking rate. However, it is important to note that optimal stocking rates for grasslands can vary due to the amount of forage the particular animal or group of animals will consume and
availability of forage (Pratt and Rasumussen, 2001). A moderate stocking rate will maintain the ideal structure and composition and accommodate the largest number snake species possible.

Two of my study sites, C and F, are managed using herbicide application and mechanical removal of woody vegetation. Grassland snake abundance can positively respond to herbicide application (Jones et al., 2000) due to the maintenance of open habitat with little to no over-story. Site F was managed using chemical controls of invasive woody and herbaceous vegetation. However, Site F was among the lowest of my study sites in species diversity and hiding cover. Site F was an old field that was planted in redtop (Agrostis gigantea). This cool season grass is relatively short and sparse, providing an insufficient litter layer for certain species of grassland snakes. Increasing the heterogeneity of vegetation to include other species of native grasses and forbs may increase habitat suitability for grassland snakes. Mechanical control was used on site C to control invasive herbaceous vegetation. Site C was a successional grassland that is being restored to an upland oak-hickory (Quercus-Carya) forest. Herbaceous vegetation was mowed once a year. Therefore, the litter layer was the lowest of all my study sites. However, snake species diversity was moderate when compared to my other study sites. The site is typically mowed over several weeks, beginning in mid-summer thru mid-fall leaving large unmowed areas adjacent to relatively small mowed areas. The mosaic of mowed, recently mowed and unmowed habitat could create suitable habitat for grassland snakes.

Variation in the body temperature ($T_b$) of ectotherms affects their physiology (Christian and Tracy, 1981; Hertz et al., 1982; Arnold and Bennett, 1984). Therefore,
virtually all aspects of reptile ecology are affected by \( Tb \) variation, and \( Tb \) ultimately has an impact on fitness (Huey et al., 1989). Because behavioral thermoregulation is such an important component of thermoregulation for terrestrial squamates, the thermal properties of a site are thought to be the single most important proximate factor influencing habitat selection (Reinert, 1993). However, there was no correlation between snake species diversity and substrate temperature (\( R = -0.090 \)) at my study sites. However, mean STEM varied among my sites by \(<5^\circ°C\). This gradient in surface soil temperature may encompass the entire preferred temperature range favored by grassland snakes at my study sites.

The community species-area relation, describing the increase of species number with increasing area, is one of ecology's most pervasive regularities. Reptiles are no exception to this rule (Schoener et al., 2001; Losos, 1986; Jones et al., 1985). However, the area of my study sites explained little of the variance in diversity (\( R^2 = -0.288 \)), indicating a weak to non-existent relationship between snake species diversity and area. Area of my sites ranged from 4.7 – 34.3 ha. Other studies to examine the species area relationship of reptiles have collected diversity information from study sites that were thousands of hectares in size (Jones et al., 1985). Variability in the spatial extent of my study sites may have been too small to observe differences in species diversity.
**Figures & Tables**

**Figure 1:** Aerial photograph showing location of three preserves with the seven individual study sites denoted by letters (A - G). All preserves and study sites were located in Piatt County, Illinois.
**Table 1:** Habitat variables measured at grasslands in east central Illinois managed using differing techniques

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Obstruction Rating</td>
<td>VOR</td>
<td>Correlative measure of vegetation height and density (Robel et al. 1970)</td>
</tr>
<tr>
<td>Litter Layer</td>
<td>LILA</td>
<td>Depth of the litter layer of vegetation</td>
</tr>
<tr>
<td>Percent Cover Type</td>
<td>%COV</td>
<td>Percent grass, forb, shrub, bare ground, other - per m², sighted through an ocular tube</td>
</tr>
<tr>
<td>Substrate Temperature</td>
<td>STEMPE</td>
<td>Measured, once per hour, continuously at each site throughout the active season at five random locations at each site</td>
</tr>
<tr>
<td>Area</td>
<td>AREA</td>
<td>Area of Grassland (ha)</td>
</tr>
</tbody>
</table>
Table 2: Snake species captured, abundances, diversity, vegetative characteristics and area of grasslands, by site, in east central Illinois between May and August 2008. Means are reported for vegetation data with standard deviations in parentheses.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Latin Name</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kirtland's snake</td>
<td><em>Clonophis kirtlandii</em></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Blue racer</td>
<td><em>Coluber constrictor</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Western fox snake</td>
<td><em>Elaphe vulpina</em></td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Eastern hognose</td>
<td><em>Heterodon platirhinos</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Prairie kingsnake</td>
<td><em>Lampropeltis calligaster</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Little brown snake</td>
<td><em>Storeria dekayi</em></td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Common garter snake</td>
<td><em>Thamnophis sirtalis</em></td>
<td>19</td>
<td>3</td>
<td>19</td>
<td>28</td>
<td>5</td>
<td>21</td>
<td>10</td>
</tr>
</tbody>
</table>

# Species                  | 4   | 1   | 3   | 7   | 4   | 3   | 3   |
# Individuals              | 30  | 3   | 22  | 81  | 9   | 26  | 17  |

<table>
<thead>
<tr>
<th>Site</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>1.240</td>
<td>0.525</td>
<td>0.939</td>
<td>1.838</td>
<td>2.759</td>
<td>0.876</td>
<td>1.057</td>
</tr>
</tbody>
</table>

| Visual Obstruction Rating (VOR) | 3.9 (1.17) | 3.8 (1.4) | 3.1 (2.1) | 5.4 (2.1) | 6.3 (3.1) | 5.7 (2.1) | 6.0 (2.5) |
| Litter Layer (LILA)           | 2.1 (0.71) | 2.1 (2.5) | 1.4 (0.8) | 2.5 (1.6) | 3.6 (2.4) | 2.3 (1.5) | 3.0 (2.5) |
| Substrate Temp (STEMP)        | 21.2 (5.9) | 21.5 (4.4) | 23.8 (7.5) | 21.7 (4.9) | 21.1 (4.8) | 20.4 (4.4) | 20.0 (3.9) |
| % Grass                     | 99.1 (4.71) | 92.1 (15.9) | 25.8 (25.8) | 50.6 (29.1) | 26.7 (28.4) | 80.5 (27.9) | 61.7 (24.5) |
| % Forb                      | 0.9 (4.71) | 6.1 (12.4) | 38.6 (29.3) | 43.1 (27.1) | 73.1 (28.3) | 19.4 (27.8) | 28.9 (18.6) |
| % Shrub                     | 0.0 | 0.3 (1.1) | 0.5 (1.5) | 2.7 (6.1) | 0.1 (0.5) | 0.1 (0.5) | 9.0 (23.2) |
| % Other                     | 0.0 | 0.0 | 28.2 (28.0) | 3.1 (8.4) | 0.0 | 0.0 | 0.3 (1.5) |
| % Bare Ground               | 0.0 | 0.1 (0.51) | 7.1 (14.6) | 0.4 (2.4) | 0.1 (0.5) | 0.0 | 0.0 |
| Area (ha)                   | 14.2 | 4.7 | 30.0 | 14.2 | 7.3 | 34.6 | 6.5 |

|        | 2   |
| Site   |     |

13
Table 3: Factor loadings from principal components analysis (PCA) of proportional vegetative cover measured between May and August 2008 in grasslands with differing management techniques

<table>
<thead>
<tr>
<th></th>
<th>PC1</th>
<th>PC2</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of variance explained</td>
<td>42.82</td>
<td>39.49</td>
</tr>
<tr>
<td>grass</td>
<td>-0.383</td>
<td>-0.92</td>
</tr>
<tr>
<td>forb</td>
<td>0.023</td>
<td>0.943</td>
</tr>
<tr>
<td>shrub</td>
<td>-0.455</td>
<td>0.351</td>
</tr>
<tr>
<td>litter</td>
<td>0.941</td>
<td>0.249</td>
</tr>
<tr>
<td>bare ground</td>
<td>0.949</td>
<td>0.234</td>
</tr>
</tbody>
</table>
Table 4: Pearson correlation coefficients (r) of habitat variables relative to snake species diversity measured in grasslands in east central Illinois.

<table>
<thead>
<tr>
<th>Variable</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICAN</td>
<td>0.745</td>
</tr>
<tr>
<td>PC2</td>
<td>0.689</td>
</tr>
<tr>
<td>VOR</td>
<td>0.572</td>
</tr>
<tr>
<td>STTEMP</td>
<td>-0.091</td>
</tr>
<tr>
<td>PC1</td>
<td>-0.260</td>
</tr>
<tr>
<td>Area</td>
<td>-0.288</td>
</tr>
</tbody>
</table>

VOR = Correlative measure of vegetation height and density, units in decimeters (Robel et al., 1970)
LILA = Depth of the litter layer of vegetation
STTEMP = Substrate temperature, measured once per hour, continuously at each site throughout the active season at five random locations at each site
Area = Area of grassland (ha)
PC1 = principal component 1, which separated grasslands that had greater amounts of other and bare ground and smaller amounts of grass and forbs
PC2 = principal component 2, which separated grasslands that had larger amounts grasses and forbs and smaller amounts of bare ground and other
Figure 2: Relationship between snake species diversity ($\alpha$) and litter layer depth (decimeters) for grasslands in east central Illinois. Each dot represents a sampling site.
CHAPTER TWO
HABITAT USE, HOME RANGE AND MOVEMENTS OF WESTERN FOX SNAKES

INTRODUCTION

Because many snake species are declining in numbers (Dodd, 1987; Greene, 1997), it is important to identify and protect habitats and landscape features critical to their survival before additional snake species become critically imperiled. The greatest constraint in conservation planning for snakes is the lack of basic biological information for most species (Dodd, 1987, 1993; Reinert, 1993). Implementing a conservation program without regard to, or in ignorance of, the specific habitat use, home range and movement patterns of a given species has little chance of success (Dodd and Seigel, 1991; Scott and Seigel, 1992). For example, although a thorough knowledge of the use of space is important to understanding the ecology of any mobile species (Brown and Orians, 1970), our knowledge of spatial use for most snake species is sparse (Reinert, 1993) and our interpretations of habitat use, home range and movement estimates may vary with geography (Shine, 1987; Plummer and Congdon, 1994) and methodology (Gregory et al., 1987).

Snakes also can have important ecological roles as predators. For example, the western fox snake, *Elaphe v. vulpina*, has been identified through videotape as a predator of grassland bird nests in Wisconsin (Renfrew and Ribic, 2003). Many species of songbirds have higher rates of nest predation near forest edges, possibly because some predators concentrate their activity or forage more effectively along edges (Yahner, 1988, Paton, 1994, Andren, 1995, Richardson et al., 2006). Studies of habitat use of snakes that
are nest predators could help land managers determine whether local manipulations of
habitat could improve nesting success for declining species of grassland birds.

The western fox snake, abundant in the Grand Prairie Natural Division of Illinois,
occurs in open habitats including intensively cultivated fields and pastures in the northern
half of Illinois (Phillips et al., 1999). The western fox snake is a widely distributed and
common snake throughout much of its range, yet information regarding its spatial
ecology is sparse. The only spatial study to examine *Elaphe v. vulpina* that I am aware of
occurred at Middle Fork Fish and Wildlife Area, Vermillion County, Illinois (Keller and
Heske, 2000). However, this study did not measure home range, core range or
movements. The objective of this study was to estimate home range and core range sizes,
and describe habitat use, and movement patterns of *E. v. vulpina* in east central Illinois.

**METHODS**

**Study Site**

The study site included Robert Allerton Park, Upper Sangamon River Land and
Water Reserve, and Heartland Pathways, Piatt County, Illinois (Fig. 3). Allerton Park,
located SW of Monticello II, was donated to the University of Illinois by Robert Henry
Allerton in 1946 for use as an educational and research center. The park’s 607 ha contain
woodland, riparian and prairie areas of such high quality they have been designated a
National Natural Landmark. The 259 ha Upper Sangamon River Land and Water
Reserve was dedicated in 2003 with two state-listed snake species either occurring or
having historic records within its boundaries. Heartland Pathways is a 33 mile, 330 acre,
out-of-service railroad right-of-way containing sections of remnant prairie. The study
area is composed of the following macro-habits (i.e. cover types): forest, grassland, mowed grass, and agricultural field.

**Telemetry Methods**

Holohil Systems Ltd. model SB-2 transmitters were surgically implanted by University of Illinois veterinarians, using methods of Reinert and Cundall (1982) and Blouin-Demers and Weatherhead (2001). Snakes were housed at the Natural Resources Building on the campus of the University of Illinois Urbana-Champaign and released 5-7 days after the implantation procedure. I sampled snake movements and habitat use for 12 months or until transmitter failure or snake mortality was documented. Individual snake locations were considered unique if they were >1 m from the previous location. Snakes were located every other day until they began winter dormancy. A snake was considered to be in winter dormancy when it did not move locations for 14 consecutive days and telemetry indicated it was underground (i.e. in a hibernaculum). Tracking occurred at varying times during daylight hours to capture variation in activity and habitat use that may have occurred throughout the day. Upon locating a snake, I recorded GPS coordinates and macro-habitat type.

**Home Range and Core Range**

I estimated individual home range and core range sizes using ABODE (Laver, 2006) within ArcGIS 9.2. Core ranges reflect areas of concentrated use and may indicate essential resources or biologically important areas. Home range size was estimated using a Fixed, Bi-weight Kernel Density estimator (Silverman, 1986), a least squares cross validation (LSCV) for bandwidth selection, and unit variance standardization. Volume contouring and delineation was 95% (Appendix A). LSCV was used due to its
superior performance in selecting a smoothing parameter (Seaman and Powell, 1996). Unit variance was arbitrarily selected for standardization. Unit variance and X variance provide equivalent results (Rodgers and Carr, 1998; Laver, 2005). ABODE estimates core ranges following Horner and Powell (1990) and Powell (2000) with volume contouring and delineation dependent on the individual snake’s utilization distribution.

Laver (2005) describes this core estimation technique as follows:

“The use of a plot of the percentage of home range area against the probability of use. The probability of use is plotted on the x-axis, scaled by the maximum probability of use (the highest probability of use occurs at 100%). The percentage of the home range area at a specified probability of use is plotted on the y-axis, scaled by the maximum area. In theory, random space use would result in a straight line plot. ‘Even’ use of space would result in a convex curve. Clumped use of space should result in a concave curve. The core should be contoured at the probability of use where the curve has a slope equal to that for random use (m = -1), this is equivalent to the point on the graph farthest (in vertical distance) from the slope m = -1” (Fig. 4).

This method has been recommended as way to standardize core range estimation (Laver and Kelly, 2008). Due to small sample size, only descriptive statistics of home range and core range are provided.

To ensure that I collected enough locations from each individual snake to reasonably estimate home range, I performed an asymptote analysis on each snake’s location dataset using ‘area-observation plots’ (Harris et al., 1990; Otis and White, 1999). I accomplished this using ABODE, running 20 simulations for each snake. Each simulation was calculated by incrementally adding locations randomly and recalculating
the home range area until all locations for an individual had been added. I determined whether 20 simulations were sufficient to provide an accurate and precise mean asymptote by assessing the stabilization of the cumulative mean and standard deviation of the home range estimates with increasing number of simulations (Laver, 2005). An asymptote was achieved when an individual’s cumulative mean home range area (obtained from the estimates) fell within a specified limit of that individual’s final kernel home range size (as calculated using all unique location estimates for an individual). This limit was chosen as 10% of the mean home range size (Laver and Kelly, 2008). The mean home range size was defined both in terms of its accuracy and its precision such that the entire confidence interval (CI for \( \alpha = 0.05 \)) for the mean had to fall within this accuracy limit. Home range and core range values are reported only for snakes whose location dataset achieved an asymptote with a confidence interval that was less than 10% of the mean home range area for each snake.

**Movement Patterns**

For each radio-marked snake, I calculated maximum distance moved, mean distance moved per day, percentage of locations >1 m from previous locations, and total distance moved. These values were calculated in ArcView 3.2 using the Animal Movement extension v2.0 (Hooge and Eichenlaub, 2000). Due to small sample size only descriptive statistics of movement patterns are provided.

**Habitat Use**

For each snake, I buffered each of its locations by the maximum observed distance moved between radiolocations for that individual using ArcGIS 9.2. Maximum distance moved was chosen because snakes could have made such a move from any
location. For each snake, I classified the area within the outer-most boundary of its merged buffers as available habitat (Appendix B). Using ArcGIS 9.2 and a 2005 aerial photography layer, I divided each snake’s available habitat into the macro-habitat types identified above. Using compositional analysis (Aebischer et al., 1993), I analyzed the proportional macro-habitat use of each snake to determine which habitat types were over-used and under-used based on availability. For each snake, I used the proportion of available and the proportion of used macro-habitats to calculate the difference in log ratios for each macrohabitat pair. Differences in log ratios of use vs. availability between macro-habitat pairs were used to establish rankings in macro-habitat use for each individual snake (Aebischer et al., 1993). A t-test was then used to determine if each habitat pair differs significantly from zero and those results were used to rank habitats. Rankings ranged from zero to four (number of habitat types) with larger ranks representing higher use than smaller ranks. This method is preferred because it considers individual animals as the sampling units, and not the individual radiolocations, and yields rankings among macro-habitat types.

**RESULTS**

Eleven snakes were tracked from 21 May 2008 to 27 June 2009. Snakes were on air for a mean of 228 days (SD=134.01; range = 15 – 355 days; Table 5). Three of the eleven snakes were lost to predation prior to winter dormancy in 2008. Snakes entered hibernacula from the first week of September through the first week of November 2008, with most snakes ingressing late September through early October. Of the eight hibernacula identified, five were located in grassland and three in forest habitat. All snakes hibernated in burrows that, from the surface, had no observable difference from
burrows used during the active period. Of the eight snakes that survived until dormancy, five were confirmed to have successfully egressed the following spring in 2009. Three transmitters failed during winter dormancy, so the fates of these three snakes could not be determined.

Nine (3 female, 6 male) snakes met the requirement of mean home range area and SD stabilizing within 20 simulations (Fig. 5). All subsequent movement analyses were carried out on these nine snakes.

**Home Range and Core Range**

Home range estimates for male snakes ($\bar{x} = 7.36$ ha, $SD = 4.38$ ha) were larger than for female snakes ($\bar{x} = 5.35$ ha, $SD = 0.69$ ha; Figs. 5 and 6). Estimates of core range size for males ($\bar{x} = 2.16$ ha, $SD = 1.71$ha) were about the same as for females ($\bar{x} = 2.22$ ha, $SD = 0.11$ ha). Male core ranges were delineated at a mean ($\bar{x} = 54\%$ of the volume, $SD = 9.60\%$) that was smaller for females ($\bar{x} = 68\%$ of the volume, $SD = 7.64\%$; Table 6)

**Movement Patterns**

Overall, movement patterns of males and females were similar throughout the activity season (Fig. 7). A noteworthy difference occurred in October when movements for females were ~25% greater than for males (Fig. 7). Percentage of locations >1m from previous over the entire tracking period showed males moved less ($\bar{x} = 64.5\%$, $SD = 20.0\%$) than females ($\bar{x} = 73.4\%$, $SD = 16.4\%$). With both sexes pooled for the entire tacking period, snake locations were >1m from their previous sites 69% of the time. Maximum distances moved for males ($\bar{x} = 364.2$ m, $SD = 240.0$ m) were shorter than for females ($\bar{x} = 463.1$ m, $SD = 96.4$ m). Total distances moved for males ($\bar{x} = 2427.4$ m, $SD = 208.0$ m) were shorter than for females ($\bar{x} = 3080.2$ m, $SD = 960.0$ m).
were shorter than for females ($\bar{x} = 3116.2$ m, $SD = 863.5$ m). Mean distance moved per location for males ($\bar{x} = 43.6$ m, $SD = 13.8$ m) were shorter than for females ($\bar{x} = 52.2$ m, $SD = 10.4$ m; Table 7).

**Habitat Use**

Macrohabitat was determined for 560 snake locations (differences between sexes were not analyzed because of small number of individual snakes). Compositional analysis revealed use of macrohabitats by fox snakes was nonrandom ($\lambda = 0.059$, $F_{4,10} = 27.5$, $p=0.0002$). The grassland category was ranked highest (Table 8). Grassland was used more than forest ($t=2.65$, $df= 10$, $p=0.029$), agriculture ($t=9.59$, $df=10$, $p=0.001$) and mowed grass ($t=10.02$, $df=10$, $p=0.001$). Forest was used more than agriculture ($t=2.85$, $df=10$, $p=0.025$) and mowed grass ($t=3.12$, $df=10$, $p=0.013$).

**DISCUSSION**

Home range sizes in this study fall into the range of reported values of 33 snake species in 45 studies reviewed by Macartney et al. (1988) and are smaller than those reported for *Coluber constrictor* in South Carolina (male and female $\bar{x} = 12.2$ ha, Plummer and Congdon, 1994), *Pituophis melanoleucus* in Tennessee (male and female $\bar{x} = 59.9$ ha, Gerald et al., 2006) and *Pantherophis obsoleta* in Maryland (male and female $\bar{x} = 9.49$ ha, Durner and Gates, 1993). However, caution should be used when comparing home ranges among studies because of differences in the methods used to estimate home ranges, differences in sample sizes, variation in the duration of various studies (Gerald et al., 2006) and differences in habitat structure and vegetation composition.

The frequency of movement for individual *E. v. vulpina* (69%) in my study was higher than an average for eight snake species (60%; Fitch and Shirer, 1971), and less
than values reported for other telemetered snake species (*Coluber constrictor*, 72-80%, Plummer and Congdon, 1994; *Masticophis flagellum*, 76%, Secor, 1992) and identical to *Sistrurus catenatus* (69%, Johnson, 1995). In my sample, males tended to move the same as females throughout the active season until October when male activity decreased compared to female activity. This difference could be due to females continuing to forage heavily in an effort to replenish fat reserves that had been metabolized during gestation. A midsummer decrease in male activity has been reported in other snake species (e.g., Feaver, 1977; Madsen, 1984; Plummer, 1985; 1991).

During the active season at my study sites (April–October), *E. v. vulpina* used grassland, edge, and forest habitats more frequently than expected based on availability. The grasslands at my study sites are old-fields, prairie restorations and prairie relicts located on mesic upland sites and have a dense ground layer of grass and other herbaceous vegetation. The forests are located on mesic upland sites with oak (*Quercus*) and hickory (*Carya*) dominating the canopy. The fox snakes did not use row-crop agriculture. Fox snakes in Keller and Heske’s (2000) Illinois study used old fields and prairie restorations more frequently based on availability and avoided row crop and forest habitat. Black rat snakes (*Pantherophis obsoleta*) in Maryland also avoided row crops (Durner and Gates, 1993), whereas black rat snakes in Ontario used row-crop fields early in the season, but used deciduous forest and old-field habitats in proportion to their availability later in the season (Weatherhead and Charland, 1985). Durner and Gates (1993) reported that black rat snakes in Maryland used herbaceous/brush habitat and deciduous forest more often than expected based on availability. Plummer and Congdon (1994) reported that racers (*Coluber constrictor*) in South Carolina were located in
shrubby habitats or thickets 50% of the time, in grassland habitats 25% of the time, and in forested habitat 25% of the time, but did not compare habitat use to availability. As noted by Weatherhead and Prior (1992) in regard to the eastern massasauga rattlesnake (*Sistrurus c. catenatus*), habitat use may vary in different parts of the geographic range of a species. Types and relative abundance of habitats also differed among the studies cited above.

Smith (1961) stated that in Illinois, *Elaphe v. vulpina* are terrestrial and Keller and Heske’s (2000) fox snakes were exclusively terrestrial even though their study site was predominantly forested. My results did not support these conclusions. Middle Fork Fish and Wildlife Area is located in and around the Middle Fork Vermillion River. The topographic gradient, amount of edge habitat and juxtaposition of grassland, forest and old field habitat could all lead to differential habitat use between the two sites. Fox snakes in my study occasionally used forest habitat and appeared to be efficient climbers. I observed multiple individuals using vines and epicormic sprouts to ascend into tree cavities (Fig. 8 and 9), most likely in an effort to raid bird or small mammal nests. Grassland bird nest predation by fox snakes is documented (Renfrew and Ribic, 2003). Incidences of nest predation of forest bird species by fox snakes have not been recorded. Fox snakes could be efficient and important nest predators and could significantly impact nest success. This is the first study to demonstrate that *Elaphe v. vulpina* use arboreal habitats.

*Elaphe v. vulpina* appear to hibernate individually. This finding could reflect an abundance of good hibernation sites but may also be related to burrow preference. Two snakes hibernated in burrows ~10 m apart indicating some type of subsurface feature may
be preferred. There is little information available about hibernation sites used by *E. v. vulpina*. Smith (1961) stated that *E. v. vulpina* may overwinter in old wells, and Ernst and Barbour (1989) stated that *E. vulpina* might hibernate in animal burrows, rock crevices, or cisterns. Hibernation locations used by snakes in my study appeared to be burrows of small mammals, excavated into mineral soil. From the surface, burrows used for hibernacula did not appear large enough to accommodate multiple snakes. Several of the burrows had water visible from the entrance. I could not determine if the snakes were hibernating in water or located in a subsurface air pocket. No hibernacula were found in rock or log piles, bluffs or rocky outcrops, cisterns or old wells.

Agricultural drainage ditches, creeks and roads intersected available habitat for each of the snakes in my study (for which available habitat was mapped). All snakes that encountered waterways successfully traversed them, so it appears that these habitats do not pose a barrier to movement. However, I documented only one instance of a snake crossing a road. Roads could be barriers to movement for snakes (Richardson et al., 2006; Shepard et al., 2008 a, b). Due to the highly fragmented nature of Illinois grasslands by roads, further research should be conducted to determine the extent of the relationship between snakes and roads.
Figures and Tables

Figure 3: Aerial photograph showing location of three preserves with individual study sites denoted by letters (A-F). All preserves and study sites were located in Piatt County, Illinois.
Figure 4: Core area determination following Powell (2000) and Horner and Powell (1990), with random (a), even (b) and clumped (c) use of space (from Laver, 2005)
Table 5: Tracking duration information for fox snakes radio-tracked in east central Illinois.

<table>
<thead>
<tr>
<th>Snake</th>
<th>Sex</th>
<th>Days on Air</th>
<th>Dates</th>
<th>Total</th>
<th>Unique</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>M</td>
<td>51</td>
<td>5/21/2008 - 7/10/2008</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>002</td>
<td>F</td>
<td>15</td>
<td>5/21/2008 - 6/4/2008</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>004</td>
<td>M</td>
<td>355</td>
<td>6/13/2008 - 6/2/2009</td>
<td>83</td>
<td>43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># Locations</th>
<th>mean</th>
<th>SD</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>228</td>
<td>134.01</td>
<td>15 - 355</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24.76</td>
<td>4 - 44</td>
</tr>
</tbody>
</table>
**Figure 5:** The mean and standard deviation of home range size for each of nine individuals, as a function of increasing number of simulations. A home range simulation was one home range estimate for a particular snake, using randomly added location estimates from the set of location estimates. Each simulation was calculated by incrementally adding location estimates randomly and recalculating the aerial extent until all location estimates for an individual had been added to the set.
Figure 6: Home range asymptote analysis for snake ‘004’. Twenty simulations (thin gray lines) using randomly added points and their mean (95% CI) function (red vertical lines). Kernel cumulative mean home range (red) did reach an asymptote, with a mean value consistently within 10% (dashed black line) of the final home range size (thick black line) at 43 locations.
Table 6: Home range sizes, core range sizes, and core range contour % for male and female fox snakes in east central Illinois.

<table>
<thead>
<tr>
<th>Snake #</th>
<th>sex</th>
<th>Range size (ha)</th>
<th>core size (ha)</th>
<th>core %</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>M</td>
<td>6.54</td>
<td>1.42</td>
<td>40</td>
</tr>
<tr>
<td>004</td>
<td>M</td>
<td>13.81</td>
<td>5.14</td>
<td>64</td>
</tr>
<tr>
<td>007</td>
<td>M</td>
<td>11.30</td>
<td>3.21</td>
<td>60</td>
</tr>
<tr>
<td>008</td>
<td>M</td>
<td>4.60</td>
<td>1.40</td>
<td>62</td>
</tr>
<tr>
<td>010</td>
<td>M</td>
<td>5.90</td>
<td>1.33</td>
<td>50</td>
</tr>
<tr>
<td>011</td>
<td>M</td>
<td>2.03</td>
<td>0.47</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Mean =</strong></td>
<td><strong>2.16</strong></td>
<td><strong>54</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>STDEV =</strong></td>
<td><strong>1.71</strong></td>
<td><strong>9.60</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Snake #</th>
<th>sex</th>
<th>Range size (ha)</th>
<th>core size (ha)</th>
<th>core %</th>
</tr>
</thead>
<tbody>
<tr>
<td>005</td>
<td>F</td>
<td>6.14</td>
<td>2.10</td>
<td>60</td>
</tr>
<tr>
<td>006</td>
<td>F</td>
<td>4.90</td>
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<td>75</td>
</tr>
<tr>
<td>007</td>
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<td>5.00</td>
<td>2.32</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Mean =</strong></td>
<td><strong>2.22</strong></td>
<td><strong>68</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>STDEV =</strong></td>
<td><strong>0.11</strong></td>
<td><strong>7.64</strong></td>
</tr>
</tbody>
</table>
Figure 7: Percentage of locations moved >1 m during the active season for male and female fox snakes in east central Illinois. Sample sizes for locations in parentheses.
Table 7: Movement parameters for fox snakes radio tracked in east central Illinois. Distances reported are for entire period animal was tracked (12 months or until transmitter failure).

<table>
<thead>
<tr>
<th>Snake</th>
<th>Sex</th>
<th>Max Dist. (m)</th>
<th>Total Dist. (m)</th>
<th>Mean Dist. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>M</td>
<td>245.2</td>
<td>1488.8</td>
<td>57.3</td>
</tr>
<tr>
<td>004</td>
<td>M</td>
<td>587.6</td>
<td>3117.9</td>
<td>38.0</td>
</tr>
<tr>
<td>007</td>
<td>M</td>
<td>742.5</td>
<td>4180.8</td>
<td>63.3</td>
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<td>008</td>
<td>M</td>
<td>244.7</td>
<td>1893.9</td>
<td>35.1</td>
</tr>
<tr>
<td>010</td>
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<td>200.7</td>
<td>2409.8</td>
<td>40.8</td>
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<tr>
<td>011</td>
<td>M</td>
<td>164.6</td>
<td>1473.2</td>
<td>27.3</td>
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<tr>
<td>Mean</td>
<td></td>
<td>364.2</td>
<td>2427.4</td>
<td>43.6</td>
</tr>
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<td>STDEV</td>
<td></td>
<td>240.0</td>
<td>1060.9</td>
<td>13.8</td>
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</table>

<table>
<thead>
<tr>
<th>Snake</th>
<th>Sex</th>
<th>Max Dist. (m)</th>
<th>Total Dist. (m)</th>
<th>Mean Dist. (m)</th>
</tr>
</thead>
<tbody>
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<td>005</td>
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<td>472.8</td>
<td>3914.3</td>
<td>64.2</td>
</tr>
<tr>
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<td>F</td>
<td>554.2</td>
<td>3234.8</td>
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</tr>
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<td>012</td>
<td>F</td>
<td>362.2</td>
<td>2199.5</td>
<td>46.8</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>463.1</td>
<td>3116.2</td>
<td>52.2</td>
</tr>
<tr>
<td>STDEV</td>
<td></td>
<td>96.4</td>
<td>863.5</td>
<td>10.4</td>
</tr>
</tbody>
</table>
Table 8: Compositional analysis output table showing proportional habitat use for fox snakes in east central Illinois. Triple pluses and minuses indicate statistically significant over-use or under-use verses availability. Habitats are listed in order of use.

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Grass</th>
<th>Edge</th>
<th>Forest</th>
<th>Ag</th>
<th>Mowed Grass</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass</td>
<td>.</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>3</td>
</tr>
<tr>
<td>Forest</td>
<td>---</td>
<td>-</td>
<td>.</td>
<td>+++</td>
<td>+++</td>
<td>2</td>
</tr>
<tr>
<td>Ag</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>+</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Mowed Grass</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-</td>
<td>.</td>
<td>0</td>
</tr>
</tbody>
</table>

Compositional Analysis
Figure 8: Western fox snake utilizing vines and epicormic sprouts to ascend a tree.
Figure 9: Western fox snake stalking/foraging in an arboreal environment
SUMMARY

Prairie and grassland habitats are rare and declining fast. How grassland management affects animal populations and communities is therefore important information for land managers. As restoration, preservation, and management continue to be used to modify and maintain natural areas it will be important to understand and monitor how different taxa respond to these actions. The data that I present here suggest that the depth of the litter layer of vegetation is important to grassland snake species diversity. This project only identifies general trends. Future research will need to examine the effect of grassland management on a broader scale and across taxonomic boundaries.

Information regarding habitat associations is crucial for conservation and to identify the role of snakes in interspecific interactions. However, basic natural history information is lacking for many species of snakes. While the western fox snake is not a species of conservation concern, it occurs in and utilizes grassland habitat, which is one of the rarest and fastest declining habitat types in Illinois and North America. Future research should confirm the microhabitat utilization patterns and determine the extent of the effect roads have on the movement of fox snakes. Previous studies have shown a pattern of behavior between snakes and roads with roads possibly restricting movement. Because natural habitat in Illinois is being replaced with agriculture and urbanization, and becoming increasingly fragmented, future research needs to be conducted so that conservation efforts can act in a proactive instead of reactive manner.
REFERENCES


APPENDIX A

HOME RANGE AND CORE RANGE MAPS

Snake 001 Home and Core Range Map

Legend
- Sangamon River
- Allerton Park
- Snake 001
- 001 Home Range (95%)
- 001 Core Range (40%)
APPENDIX B
AVAILABLE HABITAT MAP

Snake 004 Available Habitat Map

Legend
- Snake 004
- Upper Sangamon River LWR
- Allerton Park
- Available Habitat
  - Agriculture
  - Forest
  - Grassland
  - Mowed Grass

South Bridge Road
South Allerton Road (CR 1450 N)

Kilometers