Movement and Habitat Selection of Prairie Rattlesnakes in the Big Creek Drainage of the Frank Church River of No Return Wilderness in Central Idaho

A final report submitted to:
The DeVlieg Foundation and
The Taylor Ranch Wilderness Research Station
In fulfillment of the requirements of receiving a DeVlieg Undergraduate Research Scholarship

Prepared by:
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Abstract

Although widely distributed throughout much of western North America, the prairie rattlesnake has a limited distribution within Idaho. Previous studies of prairie and western rattlesnakes have indicated they are capable of long-distance movements to locate summer foraging habitat and receptive females for mating. However, the effect of mountainous topography on these movements remains largely unknown. The objectives of this study are to: (1) examine the movement patterns and distances and home range size and shape of prairie rattlesnakes in the Big Creek drainage, (2) characterize prairie rattlesnake habitat selection at the home range, mesohabitat, and microhabitat scales, and (3) determine how rattlesnake movement patterns and habitat selection are influenced by topography. I monitored the movements of 12 male prairie rattlesnakes using radio telemetry during the summer of 2006. I also collected vegetation data at some telemetry observations and at corresponding random points. I used these data to examine habitat selection at the meso- and micro-habitat scales and used a GIS vegetation cover map and digital elevation models to examine habitat selection and selection for topographic features at the landscape scale. Rattlesnakes moved a mean of 3.95 kilometers during this study and a mean of 1.30 kilometers, straight lined, from the hibernacula. Total distance moved and maximum distance moved from the hibernacula increased as the summer progressed. Movement directionality was low for most snakes, although were generally straighter during May than in June-August. Although rattlesnakes showed some selection for lower elevations and less steep slopes at the landscape scale, there was very little selection for these features at the home range scale. Rattlesnakes appeared to act as habitat generalists, although use was greatest for bunchgrass and riparian habitats. Habitat selection was weak at the meso- and micro-habitat scales although some selection for increased shrub cover was observed. Rattlesnake movements in this study were less than some distances reported in previous studies but comparable to others. This suggests that rattlesnakes are capable of extensive movements in mountainous landscapes. Low movement directionality and lack of clear habitat selection may be a result of evenly distributed prey resources.

Introduction

The prairie rattlesnake (*Crotalus viridis*) is a wide ranging pit-viper found throughout much of the Great Plains (Stebbins, 2003). Formerly classified as a sub-species of the western rattlesnake (*Crotalus oreganus*), the prairie rattlesnake has received full species status on the basis of molecular data (Ashton and de Queiroz, 2001). The prairie rattlesnake has a very limited distribution in Idaho, occurring only in the upper Salmon River drainage of Idaho, Lemhi, and Valley Counties (Nussbaum et al., 1983). Although the biology of the prairie rattlesnake has been widely studied in other parts of its range (e.g. Duvall et al., 1985; King and Duvall, 1990), very few studies have been conducted on the prairie rattlesnake in Idaho and as such, very little is currently known about their basic movement patterns and habitat use in Idaho. Previous research on prairie and western rattlesnakes in the western U.S. provide excellent examples with which to compare the ecology of prairie rattlesnakes in Idaho. Male and non-gravid female rattlesnakes in previously studied populations undertook long-distance, straight-line movements away from the dens after spring emergence (Duvall et al., 1985; King and Duvall, 1990; Cobb, 1994). These movements appeared to be directed at locating small mammal prey (Duvall et al., 1985; Duvall et al., 1990). Straight line movements are an efficient search pattern in locating spatially unpredictable resources (Duvall and Scheutt, 1997). Males also continued their movements in the late summer to locate mates (King and Duvall, 1990). Other populations of western rattlesnakes in southwestern Wyoming (Ashton, 2003) and northern Arizona (Reed and Douglas, 2003) were found to move shorter distances and exhibit smaller activity ranges than rattlesnakes in south-central Wyoming or eastern Idaho. These differences in movement distances may be due to more closely spaced resources (e.g. shelter sites, hibernacula, and prey, Asthon, 2003; Gregory 1984; Gregory et al., 1987; Reed and Douglas, 2003).

Although the availability of prey and receptive females can have a strong influence on the movement patterns of prairie and western rattlesnakes, other environmental factors may also influence these behaviors. The topography of the Big Creek drainage is characterized by narrow river and creek valleys and steep mountain ridges which have the potential to influence the movement of prairie rattlesnakes. It is possible that the steep, rugged topography of the Big Creek drainage acts as a barrier to rattlesnake movement, funneling the snakes along the narrow riparian corridors. Such an environment would prevent straight line movements and reduce the directionality of rattlesnake movements. Rugged topography may also act to reduce the distance moved over the course of the summer and reduce movement rates. The objectives of this study are to: (1) examine the movement patterns and distances and home range size and shape of prairie rattlesnakes in the Big Creek drainage, (2) characterize prairie rattlesnake habitat selection at the home range, mesohabitat, and microhabitat scales, and (3) determine how rattlesnake movement patterns and habitat selection are influenced by topography.

Study Area

I conducted this study in the Big Creek drainage of the Frank Church River of No Return Wilderness in central Idaho (Figure 1). Big Creek is a major tributary to the Middle Fork of the Salmon River. My field efforts were based out of the University of Idaho Taylor Ranch Wilderness Field Station (TRWFS, elevation 1200 meters). Three tributary creeks, Cliff, Pioneer, and Rush Creek, join Big Creek within 2 kilometers of the TRWFS (Figure 2). The topography of the Big Creek drainage is characterized by steep river and creek valleys and high mountain ridges. Exposed rocky outcrops and bare talus slopes are widespread along the sides of the Big Creek valley and its tributary valleys. This complex landscape results in a wide diversity of habitats and vegetation classes. Southerly aspects support several species of shrubs and grasses including mountain mahogany (*Cercocarpus ledifolius*), big sagebrush (*Artemisia tridentata*), Idaho fescue (*Festuca idahoensis*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). Cooler, northerly aspects support Douglas fir (*Pseudotsuga menziesii*) and mallow ninebark (*Physocarpus malvaceus*). Riparian habitats are located along Big Creek and its tributaries and the vegetation in these habitats includes black cottonwood (*Populus tricocarpa*), Rocky Mountain maple (*Acer glabrum*), alder (*Alnus* spp.), chokecherry (*Prunus virginiana*), raspberry (*Rubus idaeus*), thimbleberry (*Rubus parviflorus*), rose (*Rosa* spp.) and other shrub species. Exotic plant species, such as cheatgrass (*Bromus tectorum*) and knapweed (*Centaurea* spp.), are also present near the TRWFS. Large fires swept through much of the Big Creek drainage in the summer of 2000, burning most of the forested habitat near the TRWFS. Although vegetation regrowth has been substantial, the effects of the fire can still be clearly seen.

I focused my efforts on two rattlesnake hibernaculum complexes near the TRWFS, located north and south of Big Creek (Figure 2). The southern hibernaculum complex (hereafter referred to as the Pioneer Creek complex) consists of a series of small talus patches and scattered rock outcrops in the lower Pioneer Creek valley on an east aspect. The surrounding vegetation includes bunchgrass slopes and scattered patches of Douglas fir. The Pioneer Creek complex is about 1408 meters in elevation. The northern hibernaculum complex (hereafter referred to as The J complex) is located on bunchgrass slopes immediately north of the TRWFS. This complex consists of two separate hibernacula. The first hibernaculum (hereafter referred to as The J) is a large talus patch located on an open bunchgrass slope with a southwest aspect. There are several small, scattered rock piles within about 50 meters of this hibernaculum. The second hibernaculum in northern complex is about 150 meters northeast of The J on a southeast aspect. This hibernaculum (hereafter referred to as The Upper J) is a small talus complex containing scattered shrubs located on an open bunchgrass slope. The J and The Upper J are 1288 and 1321 meters in elevation, respectively.

Methods

Between 10 August and 17 August 2005, I searched for rattlesnakes opportunistically along Big Creek and the area surrounding the TRFWS. My objective was to mark several snakes with radio transmitters and monitor their movements during the late summer and fall to locate over-wintering sites from which to collect additional snakes for this study. I captured all rattlesnakes encountered using snake tongs. Each rattlesnake was weighed, measured (snout-vent [SVL] and tail length [TL]), sexed by the presence of hemipenes, and marked with an individually unique Passive Integrated Transponder (PIT) tag (Biomark Inc., Boise, Idaho). The basal rattlesnake segment was painted with an acrylic craft paint to identify marked snakes in the field and determine the frequency of ecdysis. Blood samples were taken from the caudal vein of each snake for future genetic analysis. Snakes marked only with PIT tags are hereafter referred to as marked snakes.

In August 2005, I captured two male rattlesnakes that were large enough to receive surgically implanted radio transmitters. I implanted a 13.5 gram SI-2T temperature sensitive transmitter (Holohill Systems Ltd., Ontario, Canada) into each snake. Snakes were anesthetized using Sevoflurane following the procedures described in Reinert (1992). Transmitters were implanted using the methods described in Reinert and Cundall (1982). Each snake was held for 24 hours before being released at their respective capture sites. These snakes were monitored over the winter to locate the two hibernaculum complexes used in this study. Between 28 April and 1 May 2006, I searched each hibernaculum complex to locate additional rattlesnakes as the snakes were beginning to emerge from hibernation. All rattlesnakes encountered during this period were captured and weighed, measured, sexed, and marked with a PIT tag as described above. Ten male rattlesnakes were selected to receive radio transmitters. Transmitters implanted in 2006 included one 3.8 gram PD-2, two 9 gram SI-2, seven 5 gram SB-2T temperature sensitive transmitters (Holohill Systems Ltd., Ontario, Canada). Surgical procedures were identical to those used in 2005. Each snake was released at or near its capture site after being held overnight to ensure proper recovery from surgery.

I located each snake using a three element Yagi antenna (Wildlife Materials International Inc., Murphysboro, Illinois) and a Telonics TR-2 receiver (Telonics Inc., Mesa Arizona) between 11 May and 6 August 2006. I located each snake about two to three times per week. I intentionally located snakes more frequently (about three times per week) between 14 May and 27 May to obtain more detailed information on their dispersal movements following hibernation. Upon locating each snake, I recorded the date, time, weather conditions, and a description of the snake's habitat and behavior. I also recorded its location using a hand-held GPS (Garmin GPSmap 76CS, Garmin International Inc., Olathe, Kansas). GPS accuracy ranged from 2-10 meters with a mean accuracy of approximately 5 meters. If I was unable to obtain satisfactory satellite reception (accuracy >12 meters), I flagged the snake's location and recorded the location at a later date. I was unable to locate snakes between 20 July and 25 July due a wildfire that burned much of the area north of the TRWFS. Seven of these snakes were also located 12-14 October 2006 to determine if the snakes used the same hibernaculum in consecutive winters.

I also captured each non-telemetered rattlesnake I opportunistically encountered during the summer of 2006 while tracking telemetered snakes. Each non-telemetered snake captured was weighed, measured (SVL and TL), sexed, marked with a PIT tag, and released at its capture location. A blood sample was also taken from the caudal vein of each snake. Previously marked snakes which were encountered in the field were weighed in the field, scanned for the presence of a PIT tag, and released at their capture location. The locations of all rattlesnake observations, captures, and recaptures were recorded using a handheld GPS unit.

To examine rattlesnake habitat selection, I measured several vegetation features at 65 rattlesnake radio telemetry observations (3-6 observations per snake). I collected mesohabitat data within a 10x10 meter square centered on a rattlesnake radio telemetry location with the four sides of the square facing the four cardinal directions. Vegetation cover measurements were taken along two parallel transects in the square, the position and orientation of which were randomly selected to avoid biasing measurements towards the center of the plot. I recorded the following vegetation cover types at every 1-meter point (0-10) along each transect: rock, forb, exotic grass, native grass, wood, and shrub. To standardize the data collection and reduce bias in taking measurements, I fastened wire cross-hairs to each end of a 3x12 centimeter PVC pipe. These crosshairs were lined up over each 1-meter point and I recorded each cover type which intersected these crosshairs. Each cover type was measured independently. I also classified the shrub cover of each plot into one of five categories: 0%, 1-25%, 26-50%, 51-75%, and 76-100% shrub cover. I also counted the number of burned and unburned fallen logs (>7.5 cm in diameter, following Reinert, 1984) and burned and unburned conifer trees (>7.5 cm DBH, following Reinert, 1984) in each square. I collected microhabitat data by recording the percent cover of big rock (≥fist size or about 10x10 cm), little rock (<fist size or about 10x10 cm), forb, exotic grass, native grass, wood, and shrub within a 1x1 meter plot centered on the telemetry observation. The plot's sides were orientated towards the four cardinal directions. I collected data at rattlesnake telemetry observations after the snake had moved from that location or if the snake

was underground. Measurements were not taken if the snake had not moved from a location where I had previously collected vegetation measurements or if the snake had moved <10 meters from a previous location where I had collected vegetation measurements. I also did not collect vegetation measurements for telemetry observations where the snake was actively moving.

I collected these same vegetation data at a corresponding random point (n=65). Random points were located by taking a random compass bearing and random distance <150 meters of a rattlesnake telemetry observation. I selected 150 meters to represent the area available to a snake because it appeared that rattlesnakes would not regularly move over 150 meters during the three to four days between successive telemetry observations. Although some snakes did move >150 meters between successive telemetry observations, most snakes did not. I collected mesohabitat and microhabitat data at these random points as described above.

Data Analysis

I used t-tests to compare the mean mass, SVL, and TL between rattlesnakes captured at each hibernacula complex and between males and females captured during the spring and summer of 2006. I separated radio telemetry observations collected between August 2005 and April 2006 (hereafter referred to as the 2005 observations) from those collected between 11 May and 6 August 2006 (hereafter referred to as the 2006 observations). I used 2006 observations in all subsequent analysis. I measured the straight line distance between each rattlesnake radio telemetry observation collected using Animal Movement Extension (Hooge and Eichenlaub, 1997) in ArcView GIS 3.2 (ESRI, Redlands, CA). I calculated the total distance moved as the sum of all distances between radio telemetry observations collected between 11 May and 6 August 2006. Because the frequency of the 2006 observations varied among snakes, I measured the straight line distance between all observations, observations made on different days, and observations separated by $\geq$1 day. There was no significant difference in the mean total distance moved among the three calculation methods (repeated measures analysis of variance, $F_{2,30}=0.00$, $p=0.9997$). Total movement distances reported were calculated using observations separated by $\geq$1 day and these distances were used in all future analysis to reduce the degree of temporal and spatial dependence between successive observations. I measured the maximum distance moved from each snake's capture/release site or over wintering site (for the two snakes marked in 2005). I calculated the movement rate of each movement segment as the number of meters moved per 24 hours by dividing the length of the movement segment by the number of hours between each observation.

I compared the total distance moved between the two hibernacula complexes using a t-test. I also compared the distance moved, maximum straight lined distance moved from the hibernaculum, and movement rate among months using a repeated measures analysis of variance (ANOVA). If a significant difference was determined, I used a Tukey's post-hoc test to determine which months were significantly different. I used a Spearman's rank correlation to determine if total movement distance and maximum distance moved from the hibernacula were correlated with snake body mass.

I measured the bearing of each movement segment using Hawth's Analysis Tools (Beyer, 2004) in ArcGIS (ESRI, Redlands, CA). I used these bearings to calculate the mean angle of movement (φ), mean angular deviation (s), and the length of the mean vector (r) for each snake's summer movement pattern (Batschelet, 1981; Zar, 1996). The length of the mean vector is a measure of angular concentration and indicates how straight a series of movements are (Batschelet, 1981). To test whether a snake's movements were uniformly distributed (i.e. random) I used a Rao's spacing test (Batschelet, 1981). This test is appropriate for multimodal data and is using the length of the arc between adjacent samples to calculate a test statistic. I also calculated r values for each snake by month (May, June, and July/August) and by season (spring, 11 May-21 June and summer, 22 June-5 August). I then used a repeated measures analysis of variance (ANOVA) to compare the mean r value among months and a t-test to compare the mean r value between seasons. I used a post hoc Tukey's test to determine which months were significantly different from each other. Circular descriptive statistics and Rao's spacing tests were conducted using Oriana software (Version 2.0, Kovach Computing Service, Pentraeth, Wales, UK).

I calculated the home range size for each snake with >15 observations (n=11) using multiple methods. Several methods have been used to calculate home ranges reported in previous studies of rattlesnakes (Reinert and Zappalorti, 1988; Secor, 1994; Reed and Douglas, 2002; Jenkins and Peterson, 2005; Moore and Gillingham, 2005; Marshall et al., 2006). The most common of these are the minimum convex polygon (MCP, Jennrich and Turner, 1969) and the fixed density kernel (FK, Worton, 1989). The MCP is the smallest polygon that contains all observations of that animal (Jennrich and Turner, 1969). FK home ranges are probabilistic estimators of an animal's occurrence in an area and can be calculated for a variety of probabilities (e.g. 50%, 95%, Worton, 1989). The value of the smoothing parameter, h, used to estimate kernel bandwidth can greatly influence the size of FK home ranges. I calculated 50% and 95% FK home ranges using the Animal Movement Extension in ArcView 3.2 (Hooge and Eichenlaub, 1997) using the least-squares cross-validation (LSCVh) smoothing parameter because this method has been used in earlier studies of rattlesnake home range size. However, LSCVh has a tendency to "under-smooth" the data, resulting in excessively small home range estimates (Horne and Garton, 2006). Likelihood cross-validation (CVh) has recently been proposed as an alternative to LSCVh in estimating the smoothing parameter and performs better at sample sizes <50 (Horne and Garton, 2006). For this reason, I also calculated 50% and 95% FK home ranges with the Home Range Tools on ArcGIS (Rodgers et al., 2005) using CVh values calculated using Animal Space Use (Horne, 2006). I used a Spearman's rank correlation to test for a correlation between home range size and body mass.

I used digital elevation models (DEM) with 10x10 meter pixels to measure the elevation of each telemetry observation for rattlesnakes with >15 observations (n=11). I also created slope and aspect layers using Spatial Analyst in ArcGIS and measured the percent slope and aspect of each observation. I plotted the elevation of observation against date to examine how elevation use varied across the summer. I compared the aspect of telemetry observations between rattlesnakes from the Pioneer Creek and The J hibernacula complexes using a Mardia-Watson-Wheeler test (Batschelet, 1981). I also compared the aspect of radio telemetry observations of rattlesnakes from each hibernaculum complex among months using a multi-sample Mardia-Watson-Wheeler test (Batschelet, 1981). I used Oriana software (Version 2.0, Kovach Computing Service, Pentraeth, Wales, UK) to conduct these tests.

I used these GIS layers to examine rattlesnake selection for topographic features at the landscape and home range scale. I defined available habitat at the landscape level by creating a circular buffer with a three kilometer radius around the capture or over-wintering of each telemetered snake with >15 observations using ArcGIS. A three kilometer radius was chosen because it included the maximum straight line distance moved by a snake from its hibernaculum, thereby accounting for the possibility that a snake may continue to move away from its hibernaculum after I ceased monitoring its movement in early August. I then generated random points within this three kilometer buffer and measured the elevation, percent slope, and aspect of these points. I generated three times the number random points (n=855) as there were rattlesnake telemetry observations (n=285). To examine rattlesnake selection for topographic features at the home range scale, I generated a series of random points with the 95% CVh FK home range of each snake with >15 observations. In this analysis, the available habitat for each snake was uniquely defined by its home range. The number of random points generated for each snake was three times the number of telemetry observations. The elevation, percent slope, and aspect were measured for each random point. I converted aspect into two separate variables: 1) the degree departure from north and 2) the degree departure from east. Each of these variables could range from 0 to 180 with smaller values being closer to north or east and larger values being closer to south or west. I used a Spearman's rank correlation to test for colinearity among these four variables. None of the variables were highly correlated with each other ($r \leq 0.1273$).

I used logistic regression (PROC LOGISTIC, SAS 1999) to compare observations and random points. I created logistic regression models of all combinations of all four variables and ranked models using Akiake's Information Criterion (AIC) and calculated the change in AIC (ΔAIC) for each model (Burnham and Anderson, 2002). Models with ΔAIC <2 are considered equally well supported, models with ΔAIC <4 are considered to have some support, and models with ΔAIC >4 are considered to have little support (Burnham and Anderson, 2002). I also calculated AIC weights for each model which represent the probability that a given model is the correct model (Burnham and Anderson, 2002). I used model averaging to calculate the model parameter estimates and odds ratios for all models with ΔAIC <4 to address model uncertainty (Burnham and Anderson, 2002). I also used AIC weights to assess the relative importance of each model term by calculating parameter weights (Burnham and Anderson, 2002). For models at the home range scale, I included snake identification number as a categorical variable to account for the fact that the available habitat is unique to each snake. I included a null model in the landscape level analysis to examine whether adding any variable substantially improved model fit. For the home level analysis, I included a "null model" containing" only the class variable snake identification number to determine if adding additional variables accounted for more variation than simply identifying each individual snake.

I generated a vegetation cover map in ArcGIS using digital orthophotos and multispectral ADAR imagery (Figure 3). I manually digitized polygons representing nine habitat classes: bunchgrass, burned conifer, unburned conifer, rocky outcrop, bare talus, riparian, irrigated pasture, non-irrigated pasture, and water/sandbar (Table 1). This cover map encompassed the 95% CVh FK home ranges of eight snakes with >15 telemetry observations within about one kilometer of the Taylor Ranch Field Station. I then classified each telemetry observation for these eight snakes into one of these nine habitat classes. To determine the available habitat for each snake, I calculated the proportion of each habitat class within the 95% CVh FK home range of each snake using ArcGIS. Compositional analysis was then used to test for selection of habitat classes at the home range scale (Aebischer et al., 1993). Compositional analysis treats each animal as the sampling unit, rather than each telemetry observation, and provides a ranking of habitat classes. The analysis was performed using Resource Selection for Windows (Leban, 1999).

To examine rattlesnake habitat selection at the mesohabitat and microhabitat scales, I used conditional logistic regression (PROC LOGISTIC, SAS 9.1, no intercept mode). This form of logistic regression compares data from each snake observation to data from the corresponding random point, rather than pooling all snake observations and random points (Compton et al., 2002; Moore and Gillingham, 2006). Conditional logistic regression is appropriate because each vegetation plot at a telemetry observation was paired with a corresponding random point. I analyzed data separately at the mesohabitat and microhabitat scales. I used a Spearman's rank correlation to assess colinearity among continuous variables. Colinearity was low for both mesohabitat scale variables ($r \leq 0.3270$) and at the microhabitat scales ($r \leq 0.3359$). For the mesohabitat scale analysis, I created several a priori models which represented the habitat classes used in the home range scale habitat selection analysis (Table 2). Additional models were created to represent secondary habitat classes. Because vegetation measurements at each vegetation plot were taken along two transects, I summed the measurements along each transect to create a single value for each variable. I used all continuous variables and one categorical variable (percent shrub cover classification (shrubC) of each 10x10 m plot) in developing models. For models including a shrub term, I ran two separate models, one using the categorical variable shrubC and the second using the continuous variable for shrub cover collected using the two transects.

I used AIC adjusted for small sample sizes (AICc) to rank each mesohabitat and microhabitat model (Burnham and Anderson, 2002). I used AICc because the ratio of sample size (n) to model parameters (K) was <40:1 (Burnham and Anderson, 2002). I calculated AIC weights for each model and used these values to assess the relative importance of each model term (Burnham and Anderson, 2002). For the microhabitat scale analysis, I also created several a priori models to represent different cover types which rattlesnakes may show selection for or against (Table 3). I also used AICc to rank these models and calculated AIC weights for each model. AIC weights were also used to assess the relative importance of each model term. To address a relatively high level of model selection uncertainty, I used model averaging to calculate the model parameter estimates and odds ratios for all models with ΔAIC <2 (Burnham and Anderson, 2002).

Results

In August 2005, I captured and marked six prairie rattlesnakes (4 males and 2 non-pregnant female). Two of the male rattlesnakes captured in August 2005 received radio transmitters and were monitored during the fall and winter using radio telemetry to locate their hibernacula. In 2006, I captured and marked (with radio transmitters and/or PIT tags) a total of 35 rattlesnakes (19 males, 14 non-pregnant females, and two gravid females). Nineteen unmarked rattlesnakes were captured and marked in April 2006 (12 males, 6 non-pregnant females, and one gravid female) at the Pioneer Creek hibernaculum (n=10), The Upper J (n=6), and The J (n=3). Of these 19 rattlesnakes, nine males were selected to receive radio transmitters (Pioneer Creek, n=5, The Upper J, n=3, The J, n=1). An additional non-pregnant female was captured at the Pioneer Creek den on 12 May. Between 22 May and 6 August, I captured and marked an additional 15 rattlesnakes within about two kilometers of the TRFWS (seven males, seven non-pregnant females, and one gravid female).

The snakes which received radio transmitters in 2005 were located five to six times, respectively, between August 2005 and February 2006. One snake over-wintered at The J and the second at the Pioneer Creek hibernaculum. Neither snake crossed Big Creek. One male which was captured at The J on 29 April 2006, was captured and marked 23 August 2005 on the south side of Big Creek on the TRWFS and had crossed Big Creek to over-winter in The J. This male received a radio transmitter in April 2006. The non-pregnant female which was captured at The J on 11 May 2006 had also been captured on the TRFWS and marked on 20 August 2005. This snake had also crossed Big Creek to over-winter in The J.

I recaptured two additional marked snakes during the summer of 2006. One was a female captured at the Pioneer Creek hibernaculum on 28 April. She was recaptured near the top of the Pioneer Creek ridge (1512 meters elevation) on 13 June about 173 meters SW of her initial capture point (1415 meters elevation). This snake was preparing to shed when I recaptured it as its eyes were cloudy. The second recapture was a male which was captured on 4 June on the hiking trail along lower Cliff Creek (1182 meters elevation). This snake was recaptured on 28 June about 135 meters SSW of his initial capture location. He was recaptured in an area of open bunchgrass and arrowleaf balsamroot on the north side of Big Creek (1172 meters elevation).

There was no significant difference in mass or SVL between male (n=19) and non-pregnant female rattlesnakes (n=14) PIT tagged during this study (p=0.1123 and p=0.1228, respectively). Males did tend to be larger (mass=277±118 SD and SVL=77.28±11.18 SD) than non-pregnant females (mass=216±85 SD and SVL=71.94±6.73 SD).

I collected 327 total radio telemetry observations between 11 May and 5 August on 12 male prairie rattlesnakes. Of these, 301 observations were separated by $\geq$1 day (Table 4). I located each snake a mean of 25 times (range 15-29) over a mean of 76 days (range 40-83). The battery in one transmitter died in mid June, resulting in 15 observations for that snake over 40 days. Mean total distance moved between 1 May and 5 August for the 11 snakes tracked over the entire summer was 3.95 kilometers (±0.37 km SE) and ranged between 2.32 and 6.03 kilometers. There was no significant difference in mean total distance moved between the two hibernacula complexes (p=0.8944). Mean total distance moved was significantly different among months ($F_{2,20}$=8.60, p=0.0020). A post-hoc Tukey's test revealed that mean total distance moved in July/August was significantly greater than mean total distance moved in May and June (Figure 4). There was a significant positive correlation between snake body mass and total distance moved (r^2=0.6923, p=0.0126, Figure 5). Snakes moved a mean of 1.30 km (±0.242 km SE) away from their capture point or over-wintering location. Three snakes moved over two kilometers from their capture point (Table 4). The mean maximum straight line distance moved was significantly different among months ($F_{2,20}$=7.35, p=0.0040, Figure 6). Rattlesnakes moved increasingly further from their hibernaculum as the summer progressed. A post-hoc Tukey's test revealed that mean maximum distance moved in July/August was significantly greater than mean maximum distance moved in May (Figure 6). There was no significant difference between the mean maximum distance moved in May and June. There was no significant relationship between snake body mass and maximum distance moved (r^2=0.3636, p=0.2453, Figure 5). There was no significant difference in maximum distance moved between the two hibernacula complexes (t=0.87, p=0.4036). Mean movement rates were not significantly different among months ($F_{2,20}$=2.05, p=0.1550) although movement rates did increase slightly over the summer (Figure 7).

The directionality of summer movement patterns was low for most snakes (Table 5). Only two snakes moved in significantly straight lined movements over the course of the summer (*r*'s=0.390-0.549, p<0.05). The other nine snakes tracked over the entire summer displayed very low movement directionality (*r*'s=0.024-0.296, p>0.10). Mean r values were not significantly different between spring and summer (p=0.9952) or among months ($F_{2,20}$=2.19, p=0.1290). However, rattlesnake movements were typically straighter during May (mean r=0.449) than during June (mean r=0.294) and July/August (mean r=0.247).

The home range estimates for each snake varied according to method used to calculate home range size (Table 6). Ninety five percent FK home ranges calculated using Animal Movement Extension in ArcView 3.2 and the LSCVh smoothing factor tended to be larger than either 100% MCP or 95% FK home ranges calculated using Home Range Tools in ArcGIS and the CVh smoothing factor. Ten of the eleven snakes tracked over the entire summer had multiple core activity areas as indicated by multiple 50% FK home ranges using Home Range Tools and the CVh smoothing factor (Figure 8). There was no significant correlation between home range size and mass for any of the three home range estimation methods. There was also considerable overlap in 95% FK home range estimates, particularly among snakes which spent the summer near The J complex or along lower Rush Creek. However, there was very little overlap in 50% FK home ranges.

There was substantial variability in the elevation use patterns over the summer among individual snakes. Among snakes from The J complex, three snakes moved down in elevation and spent the summer at relatively low elevations along Big Creek (Figure 9). Two snakes showed sharp increases in elevation use during the middle of the summer. These increases were associated with traveling up or across ridgelines. The sixth snake initially resided at a similar elevation to the hibernaculum before traveling across a steep ridge line. However, this snake's transmitter battery failed shortly thereafter. Snakes from the Pioneer Creek complex also showed considerable variability in elevation use over the summer. Two snakes appeared to move toward higher elevations as the summer progressed while two snakes appeared to move toward lower elevations over the summer (Figure 10). A fifth snake resided at elevations above the hibernacula until early July and then used slightly lower elevations for the remainder of the summer. The sixth snake used lower elevations during the early and late part of the summer and moved to higher elevations for a short period in late June and early July.

The aspect of rattlesnake radio telemetry observations were significantly different between the two hibernaculum complexes ($W=175.534$, $p<0.0001$). Snakes from The J complex typically used areas with northeasterly aspects while snakes from the Pioneer Creek complex typically used southwesterly aspects (Figure 11). The aspects used by all twelve telemetered snakes were non-uniform (Table 7). The aspects used by snakes from The J complex became more northerly as the summer progressed (Figure 11). The mean aspect of May observations was significantly different than the mean aspect of observations in June and July/August (W=12.548, p=0.002 and W=12.189, p=0.002, respectively). However, the mean aspect of June observations was not significantly different than the mean aspect of July/August observations (W=3.039, p=0.219). There was no clear trend in the change of aspect for snakes from the Pioneer Creek complex, although the mean angle of aspect tended to decrease (i.e. become more southerly) as the summer progressed. The mean aspect of May observations for snakes from the Pioneer Creek complex was significantly different than the mean aspect of June observations (W=12.941, p=0.002). The mean aspect of June observations was also significantly different than the mean aspect of July/August observations (W=10.762, p=0.005). The difference between the mean aspect of May and July/August observations was marginally significant (W5.344, p=0.069). However, aspect use became less concentrated as the summer progressed as indicated by decreasing r values (i.e. decreasing angular concentration) for snakes from both hibernaculum complexes (Table 8).

At the landscape level, rattlesnakes appeared to use lower elevations and less steep slopes than were available (Table 9). Rattlesnakes also appeared to use more southerly and westward aspects than were available (Table 9). The best model for topographical habitat selection at the landscape level was the model containing elevation and percent slope (Table 10). This model had an AIC weight of 0.5089, indicating that this model has about a 50% probability of being the correct model. Two additional models were within two ΔAIC of this model and a third was within four ΔAIC indicating that these models are competitive. All four of these models contained elevation and slope and were substantially better than the null model. The model average parameter estimates and odds ratios were significant for both elevation and slope (Table 11). The cumulative AIC weight for both elevation and slope was 1.00 and 0.9964, indicating a high level of importance for these variables. Parameter estimates for both elevation and slope were negative indicating that, at the landscape level, rattlesnakes selected lower elevations and less steep slopes than were available. North-south and east-west aspect were included in the three competing models. However, neither of these model averaged variables was significant.

There was much less variation in topographic features between rattlesnake telemetry observations and random points at the home range scale than the landscape scale (Table 12). The best model for topographic feature selection at the home range scale was the model containing only elevation (Table 13). However, there was very low support for any single model at the home range scale suggesting low, if any, selection for topographic features. Two additional models had ΔAIC <2 and six additional models had ΔAIC <4. The AIC weight for the top model was 0.2285, indicating relatively low model support. Additionally, the AIC weight for the "null model" containing only the class variable of snake identification was <4. Elevation was included in seven of the nine models with ΔAIC <4. The parameter estimate for elevation was significant ($p<0.05$) in each of the top models it was included. However, no other parameter estimates were significant ($p>0.05$). The model averaged parameter estimate and odds ratio from the top nine models were not significant as the 95% confidence intervals for the parameter estimates and odds ratios overlapped zero and one, respectively (Table 14). Negative parameter estimates for elevation indicate that rattlesnakes tended to use lower elevations than were available.

Most rattlesnake telemetry observations occurred in bunchgrass habitat (35%) followed by riparian and burned conifer, 18% and 17% respectively (Figure 12). Habitat use and availability varied considerably among snakes although snakes appeared to largely use most habitat classes in proportion to their availability (Figure 13). Rattlesnake use of habitat classes at the home range scale was significantly different from random indicating some habitat selection (Wilk's λ=0.0655, X^2=21.6832, df=7, p<0.05). Bunchgrass was ranked highest followed by riparian and non-irrigated pasture (Table 15). Unburned conifer was ranked lowest followed by rocky outcrop. Although rattlesnakes appeared to show selection among all habitat classes, pair-wise comparisons of habitat use were not significantly different (Table 15). The difference in habitat use between bunchgrass and unburned conifer approached significance (t= -2.2027, p=0.0635) which may have contributed to the overall significant result. Bunchgrass, riparian, talus, and non-irrigated pasture were used more than expected from their availability. Burned conifer, outcrop, and irrigated pasture were used less than expected based on availability. However, these differences did not appear to be statistically significant. Unburned conifer was used in proportion to its availability and had very low use.

The mean values of several vegetation characteristics differed between rattlesnake telemetry observations and random points (Table 16). Rattlesnakes appeared to exhibit some selection for vegetation features at the mesohabitat (10x10 m) scale. The top model represented the outcrop habitat class and included rock and the categorical shrub variable (Table 17). The next best model (ΔAICc=1.78) included number of unburned trees, wood, and the categorical shrub variable. The AIC weights for these two models were 0.2558 and 0.1052, respectively. These low values indicate a rather high degree of model uncertainty, suggesting that rattlesnake habitat selection for these variables is weak. Seven models had ΔAICc<4 and the cumulative

AIC weights of these models was 0.70142, also indicating relatively weak habitat selection. However, the categorical shrub variable had a very high parameter weight of 0.9964 and was included in the top seven models. The variable rock had a moderately high parameter weight (0.4679) and was included in three of the top seven models. The parameter estimates in these models were positive and significant to marginally significant (p=0.0410-0.0599) indicating moderate selection of rocky habitats. Although the number of unburned trees appeared in only two top models and had a low parameter weight (0.17684), its parameter value was negative, suggesting avoidance of areas with high numbers of unburned trees. Rattlesnake use was significantly associated with shrub cover (X^2=18.8278, df= 4, p=0.0008). Vegetation plots at rattlesnake observations most frequently had 1-25% shrub cover while vegetation plots at random points most frequently had 0% or 1-25% shrub cover (Figure 14).

Model uncertainty was quite high at the microhabitat scale analysis. Seven models were highly competitive (ΔAICc<2) and an additional eight models were somewhat competitive (ΔAICc<4, Table 18). The top two models contained shrub and forb and shrub and big rock, respectively. AICc weights were also very low, 0.14067 and 0.13809 respectively, also suggesting weak selection for these variables. These seven top models contained seven variables and model averaged parameter estimates of these variables were not significant (Table 19). However, the variable shrub had a fairly high parameter weight of 0.84394 and was included in all of the top seven models. The parameter estimate for this variable was positive. The variables forb and big rock had moderate parameter weights of 0.41887 and 0.34441, respectively. The parameter estimate for forb was negative while the estimate for big rock was positive.

Discussion

It appears that prairie rattlesnakes in the Big Creek drainage do hibernate communally, similar to other western and prairie rattlesnake populations (Nussbaum et al., 1983; Duvall et al., 1985; Cobb, 1994; Parker, 2003). The low number of recaptures of PIT tagged rattlesnakes over the entire course of this study (4 of 41, 9.8%) during this study was somewhat surprising given the large amount of time spent in the field. However, mark-recapture studies of snakes often suffer from low numbers of recaptures due to the secretive nature of many snakes (Fitch, 1987). Bender (1980) reported low recapture rates of prairie rattlesnakes along Big Creek in a previous study.

The pattern of movement over the course of the summer varied among snakes. Three snakes traveled along side tributary drainages, two up Pioneer Creek and one up Cliff Creek. Two snakes traveled into the lower Rush Creek drainage. Four snakes appeared to reside in the Big Creek drainage near the Taylor Ranch Field Station. Two snakes, both from The J complex, traveled over a ridge to the east of the hibernacula. One of these snakes proceeded to travel into the Cougar Creek drainage, moving a total of 2.92 kilometers and moving 2.12 kilometers from The J complex. The final snake monitored in this study remained along the top of the Pioneer Creek ridge from 13 May to 4 July. He then crossed Pioneer Creek and spent the remainder of the summer along the side of the Big Creek valley.

The total movement distances and maximum distances moved from the hibernacula observed during this study were greater than I expected based on the rugged topography of the study area. Male western rattlesnakes in southern Idaho moved a mean of 1.49 kilometers away from the hibernacula (Jenkins and Peterson, 2005) which is much more comparable to the mean maximum distance moved observed in my study. However, non-pregnant female western rattlesnakes in southern Idaho moved a mean of 4.48 kilometers from the hibernaculum and these movements could exceed eight kilometers (Cobb, 1994). Male prairie rattlesnakes in southern Wyoming moved between 2.0 and 2.5 kilometers from the hibernacula (King and Duvall, 1990). Only three snakes in this study moved over 2.0 kilometers from their over-wintering site. However, these two studies were conducted in shrub-steppe habitats where the topography is much less rugged than the Big Creek drainage. Male western rattlesnakes in southwest Wyoming traveled a maximum distance of 846 meters during the summer (Ashton, 2003). Parker (2003) observed that the mean total distance moved of male western rattlesnakes in northwest Wyoming was 2.12 kilometers and these snakes moved a mean of 792 meters from their hibernacula. Although prairie rattlesnakes in central Idaho did not move as far as prairie or western rattlesnakes in some populations, the movement distances reported in this study are comparable to some distances reported in previous studies. This suggests that prairie rattlesnakes are capable of undertaking relatively extensive movements in mountainous landscapes.

The extensive movements reported for other populations of prairie and western rattlesnakes appear primarily directed at locating summer foraging habitat (Duvall et al., 1985; Duvall et al., 1990; King and Duvall, 1990; Cobb, 1994; Jenkins and Peterson, 2005). Studies on prairie rattlesnakes in southern Wyoming indicates that males and non-pregnant females move along straight lined paths until encountering a patch of small mammal prey (Duvall et al., 1985, 1990). These snakes then typically ceased their straight lined movements and engaged in shorter, less directional foraging movements for most of the summer. Highly directional movements are very efficient in locating spatially separated or unpredictable resources, such as prey or mates (King and Duvall, 1990; Duvall and Schuett, 1997). Western rattlesnakes in southeastern Idaho typically selected summer foraging habitats with high small mammal abundance (Jenkins and Peterson, 2005).

The overall summer movements of prairie rattlesnakes in this study had very low directionality although some snakes did appear to move in a relatively linear pattern during the course of the entire summer. Although movements during the month of May were more directional than movements later in the summer, these differences were not significant. This pattern is similar to the pattern observed for prairie rattlesnakes in southern Wyoming (Duvall et al. 1985; King and Duvall, 1990) but of much less magnitude. There was considerable variation in movement directionality among snakes during the course of the summer. Some snakes appeared to forage in a relatively discrete area while other snakes moved continually away from the hibernaculum over the course of the summer. This lack of movement directionality may reflect the distribution of small mammal prey. Small mammals, particularly mice (*Peromyscus* spp.) appeared to be widely distributed near the TRWFS when sampled using track tubes (J. Bauder, unpublished data). If small mammal prey is abundant or uniformly distributed, rattlesnakes may not need to undertake efficient search patterns to locate prey or restrict their foraging activities to one area. It does not appear that the movements of prairie rattlesnakes in the Big Creek drainage are as influenced by the distribution of prey as prairie rattlesnakes in southern Wyoming. However, additional information is needed on the distribution of small mammals to determine how this factor influences prairie rattlesnake movement in the Big Creek drainage.

The increase in total distance moved that was observed over the course of the summer was likely due to mate searching activities by these male snakes in the late summer. Male rattlesnakes search for receptive females from mid-July through early September (Ernst, 1992).

Male prairie rattlesnakes in Wyoming have also been observed to continue their movements in the late summer to locate females (Brown, 1990; King and Duvall, 1990). Two telemetered snakes in this study were observed with female rattlesnakes during late July or early August. One telemetered rattlesnake was found tightly coiled with another, smaller rattlesnake, presumably a female, on 2 August. A second telemetered snake was observed within a few meters of an unmarked female on 27 July. At least three additional telemetered snakes continued fairly extensive movements during the late summer which appeared to be directed at locating females. During the course of these movements, these snakes left the area where they had previously resided and made searching type movements for the remainder of the summer.

Jenkins and Peterson (2005) observed that some large (~1 meter long and high body condition) male western rattlesnakes in southeastern Idaho appeared to spend the entire summer searching for mates and did not forage. These snakes also moved greater total distances during the summer than other males and non-gravid females. In this study, total movement distance was positively correlated with body mass but no such correlation was observed between maximum distance moved and body mass. This indicates that larger snakes do not achieve a greater total distance moved by continuing to move away from the hibernaculum. Rather, these snakes appear to move some maximum distance from the hibernaculum and spend the remainder of the summer moving between this area and the hibernaculum. It is possible that the more extensive movements undertaken by larger snakes may be related to mate searching. Mate searching movements may also be responsible for the reduced directionality of movements later in the summer as most mate searching movement patterns observed in this study had low directionality. The lack of movement directionality during mate searching movements may indicate that receptive females are not spatially unpredictable, thereby negating the need to undertake straight line search patterns.

The movement rates reported in this study were lower than those reported for rattlesnakes in southern Idaho or southern Wyoming (King and Duvall, 1990; Jenkins and Peterson, 2005). Male prairie rattlesnakes in southern Wyoming moved a mean 196 meters per movement (King and Duvall, 1990). However, male western rattlesnakes in northern Arizona moved a mean of 28.9 meters per tracking day and male western rattlesnakes in southwest Wyoming moved a mean of 45 meters per movement (Ashton, 2003). The rugged topography of my study area may act to reduce snake movement rates.

Home range size varied widely among snakes in this study. Prairie rattlesnake home range size in south-central Wyoming varied between 1.7 and 9.9 ha and averaged 5.7 ha (Brown, 1990). Male western rattlesnakes in southeast Idaho had a mean core home range size (50% FK) of 5.09 ha (Jenkins and Peterson, 2005). A mean activity home range size of male western rattlesnakes in northern Arizona was 15.8, 16.9, and 1.9 ha using MCP, 95% and 50% FK, respectively (Reed and Douglas, 2002). The variability in rattlesnake activity area size may be due to the use of different methods to calculate the size of the area but may also reflect the distribution of resources. However, the home range sizes observed in this study were considerably larger than those reported by other researchers. This result was unexpected given the rugged topography of the Big Creek drainage.

Rattlesnakes appeared to show selection for lower elevations and less steep slopes at the landscape level. The elevation within my three kilometer study area ranges from 1141 to 2371 meters. Telemetered rattlesnakes were observed between 1153 and 1768 meters. Although some rattlesnakes did move towards higher elevations during the summer, these elevations were still relatively low compared to available elevations across the landscape. Rattlesnakes may avoid high elevations (>2000 meters) because of temperature or habitat constraints. Snow persists for longer periods during the spring at higher elevations and this may restrict the time available for surface activity. Additionally, most of the xeric, open habitats where rattlesnakes were observed, such as bunchgrass slopes or mountain mahogany rock outcrops, occur at lower elevations. Higher elevations are largely dominated by coniferous forest, where rattlesnakes were seldom observed. Higher levels of canopy cover in these higher elevation forests may also lower surface temperatures below the temperatures rattlesnakes prefer for surface activity. Avoidance of higher elevations is unlikely related to food availability. I commonly observed chipmunks (*Tamias* spp.) and ground squirrels (*Spermophilus* spp.) along ridge tops near the TRWFS, suggesting that small mammal prey is readily available in these areas. Avoidance of higher elevations and steep slopes may also be related to energetic costs. It may require high amounts of energy to travel to high elevations and move up steep slopes. These costs may not outweigh the benefits associated with such movements (e.g. prey availability, less intraspecific competition).

Although the aspect of rattlesnake telemetry observations did not significantly differ from the aspect of random points, rattlesnakes tended to use locations with more southerly and westerly aspects at the landscape scale. Despite this overall trend, rattlesnakes from the two hibernacula complexes used significantly different aspects. This is likely a result of the topography of the Big Creek drainage which consists primarily of north and south facing slopes. Rattlesnakes from the south facing J complex primarily used northeast aspects while rattlesnakes from the north facing Pioneer Creek complex primarily used southwest aspects. Southwest aspects provide the greatest opportunity for sunlight exposure throughout the day and may provide a longer time available for basking. This may be particularly important for snakes from the Pioneer Creek complex because the habitat on the south side of the Big Creek drainage is primarily burned conifer forest. This forested habitat may limit the ability of snakes to thermoregulate, thereby making selection for southwest aspects more important. In contrast, open bunchgrass and mountain mahogany rock outcrops are more widespread along the north side of the Big Creek drainage. The terrain surrounding The J complex is much less rugged and more open than the terrain surrounding the Pioneer Creek complex resulting in increase sunlight exposure. As a result, rattlesnakes from The J complex may be better able to meet their thermoregulatory requirements utilizing easterly aspects which would receive the morning sun and may not need to select for southwestern aspects.

The aspect of rattlesnake observations was more concentrated early in the summer (i.e. greater r values and lower angular deviation). As the summer progressed, aspect use became less concentrated. Additionally, the mean aspect of rattlesnake observations tended to shift as the summer progressed. This shift was most pronounced for snakes from The J complex which tended to use more northerly aspects as the summer progressed. Snakes from the Pioneer Creek complex tended to use more southerly aspects as the summer progressed but this trend was much less distinct and significant. The shift towards northerly aspects by snakes from The J complex may be a result of using cooler aspects as the summer progressed. This may be particularly important given the open habitat on the north side of the drainage which may make thermoregulation during the hot mid-summer months more challenging. Thermoregulating during these months may be less of a challenge for snakes on the more northerly aspects of the south side of the drainage. This may explain the lack of a shift in aspect use over the summer by snakes from the Pioneer Creek Complex.

The elevation, slope, and aspect of rattlesnake telemetry observations showed little difference between available locations at the home range scale. None of the models used in the analysis had a high likelihood of being the correct model (i.e. low AIC weights) and model averaged parameter estimates were not significant. This suggests that rattlesnakes do not show selection for elevation, slope, and aspect at the home range scale. The range of these variables was much less at the home range scale which may explain the lack of selection. However, the inclusion elevation in all of the top models and its negative parameter estimate suggest that rattlesnakes may show some minimal preference for lower elevations at this finer scale. Alternatively, rattlesnakes may be generalists in their use of elevation, slope, and aspect at this scale. Four snakes made considerable movements up in elevation during all or a portion of the summer which exceeded the elevation of their hibernacula complexes. An additional snake spent the first half of the summer on the Pioneer Creek ridge above the elevation of the Pioneer Creek complex. This indicates that rattlesnakes are capable of using a wide range of elevation. However, the majority of the snakes monitored in this study resided at elevations lower than their hibernacula complexes suggesting that most prairie rattlesnakes in this area do not select for high elevations.

It appears that topography does not act as a substantial barrier to rattlesnake movement, topography. This observation is supported by the movements of snakes towards higher elevations, across ridge lines, and up steep slopes, as well as the relatively high movement distances observed. However, topography probably does influence rattlesnake movement to some extent. I hypothesized that topography would act as a barrier to rattlesnake movement and act to funnel snakes towards the lower elevation riparian areas. It appeared that only five of the twelve snakes followed this pattern and three of snakes moved up and down the sides of Big

Creek valley on multiple occasions. Although three snakes did reside in the tributary drainages of Pioneer or Cliff Creek, these snakes were often observed over 100 meters away from the creeks along the sides of the creek valleys. Two snakes actually crossed the high ridge top east of The J, showing that rattlesnakes will cross high ridges. During the course of this study, three rattlesnakes crossed Big Creek once and one snake crossed Big Creek twice, once in 2005 and again in 2006. An additional snake crossed Pioneer Creek. This indicates that rivers and creeks do not act as barriers to rattlesnake movement.

However, the rattlesnakes in this study did not exhibit the long-distance, straight lined movements shown by rattlesnakes in southern Idaho and southern Wyoming (Duvall et al., 1995; King and Duvall, 1990; Cobb, 1994). Although this observation may be more indicative of the distribution of important resources, such as prey or mates, it is possible that prairie rattlesnakes in the Big Creek drainage do not undertake long distance movements because such movements may be too energetically costly in mountainous landscapes. Topography may also act to influence rattlesnake movement patterns by channeling snake movements along riparian valleys. The long distance movements observed by the two rattlesnakes traveling up the Pioneer Creek drainage may be an example of this type of influence. Additionally, rattlesnakes may follow topographic features such as ridge lines. Three rattlesnakes from the Pioneer Creek complex dispersed from the hibernaculum by following a ridge line until they reached the area near the confluence of Rush Creek and Big Creek. Although topography may act to guide rattlesnake movements, the results of this study indicate that rattlesnakes are capable of traveling across topographic features such as hillsides and ridges and that such features do not act as absolute barriers to movement.

Prairie rattlesnakes in the Big Creek drainage appear to act largely as habitat generalists. No strong selection for habitat classes was observed at the home range scale. However, rattlesnakes primarily used bunchgrass, riparian habitats, and rocky outcrop habitats. Use of pasture habitats and unburned conifer was low. These results are consistent with previous studies that have shown that rattlesnakes are associated with open, xeric habitats in the western US (Diller and Johnson, 1982; Storm et al., 1995). Prairie and western rattlesnakes are not typically found in forested habitats. The high use of riparian habitat is noteworthy because this habitat class made up only 10% of the available habitat and accounted for 18% of all rattlesnake observations. During the summer, rattlesnakes are typically seen along hiking trails in and near riparian habitats (J. & H. Akenson, pers. comm.), yet it is unknown if rattlesnakes prefer riparian habitats or if such observations are the due to higher human traffic along the trails. The use of radio telemetry in this study supports the observation that rattlesnakes frequent riparian habitats. A selection for riparian habitats by rattlesnakes has been observed in Arizona (Reed and Douglas, 2002).

Riparian habitat may contain higher densities of small mammal prey relative to the surrounding habitat, thereby causing rattlesnakes to select for riparian habitats. However, small mammal (primarily mice (*Peromyscus* spp.)) abundance sampled using tracking tubes indicated that small mammal abundance did not differ among habitats (J. Bauder, unpublished data). In particular, small mammal abundance was typically high in upland bunchgrass, burned conifer, talus, and rocky outcrop habitats and was low to high in riparian habitats. As a result, it appears that any preference for riparian habitat is not related to prey availability. However, additional work must be conducted on small mammal abundance among habitats to support this conclusion. Riparian habitats also provide abundant cover in the form of shrubs and forbs and immediate access to water. Abundant cover could provide suitable thermal environments during the hot summer months and cover from predators. Rattlesnakes near Taylor Ranch moved into the shade and were found closer to water as the summer progressed and temperatures increased (Bender, 1980).

Rattlesnakes also appeared to act as habitat generalists at the mesohabitat and microhabitat scales as evidenced by a relatively high level of model uncertainty. However, rattlesnakes did appear to show selection for some vegetation characteristics. Models at the mesohabitat scale performed better (i.e. lower AIC values and less model uncertainty) than models at the microhabitat scales, indicating that rattlesnakes respond to selection at a relatively broad scale. The best models at both scales contained terms which measured shrub cover. Ten by ten meter plots around rattlesnake observations most frequently had 1-25% shrub cover. Very few 10x10 meter plots at rattlesnake observations had 0% shrub cover. This suggests that rattlesnakes may prefer low to moderate levels of shrub cover instead of high levels of shrub cover. At the mesohabitat scale, rattlesnakes showed selection for high rock cover and, to a lesser extent, low exotic grass cover, fewer unburned trees, and high woody debris cover. At the microhabitat scale, rattlesnakes showed some selection for high shrub cover, low forb cover, and high big rock cover. However, these trends were not significant, further indicating that rattlesnakes do not show strong selection for fine scale vegetation characteristics.

Use of sites with high shrub cover may provide rattlesnakes with ideal prey ambush locations and shelter from heat and predators. This selection for shrub cover may reflect the high use of riparian habitat at the home range scale. Selection for shrub and rock cover may also indicate that, while rattlesnakes most often use bunchgrass habitats, they may select for patches of shrub and rock within those habitats. Although rattlesnakes appeared to be negatively associated with exotic grass (i.e. cheat grass) this association was not significant. The negative association with the number of unburned trees may reflect the low use of unburned conifer habitats. The potential biological reasons behind the negative association with high forb cover are unclear. Forbs may be most abundant in cool, mesic locations such as north facing forests or wet habitats. These locations are rarely used by rattlesnakes which may reflect the negative association with high forb cover.

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Figure 1
Location of the Frank Church River of No Return Wilderness in central Idaho

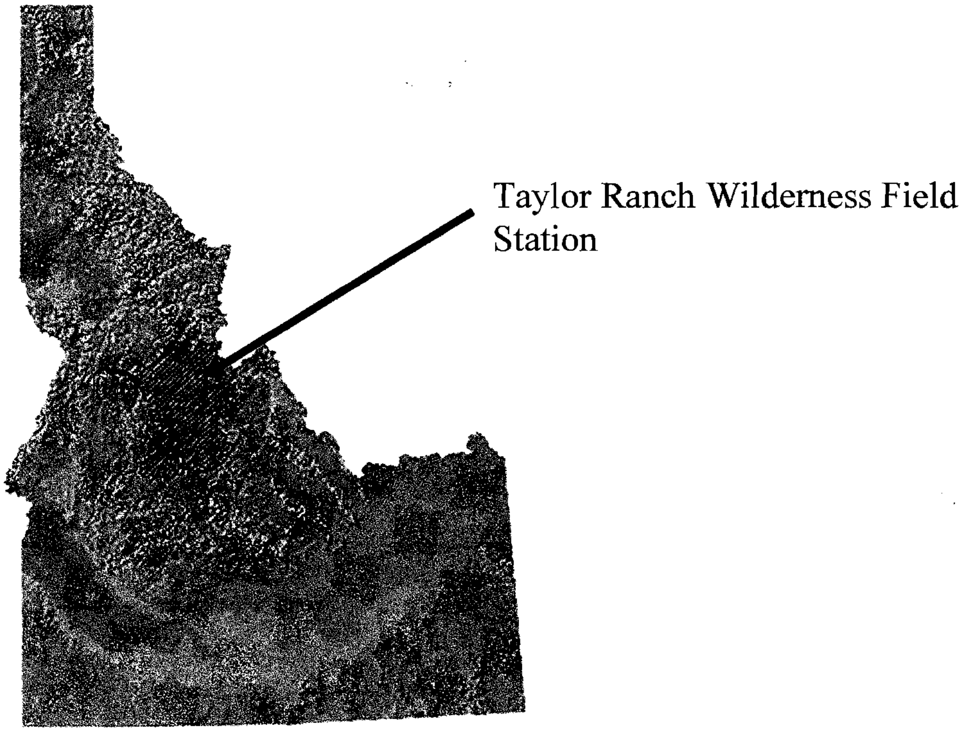


Figure 2

Map of Taylor Ranch Wilderness Research Station and surrounding study area including the two rattlesnake hibernacula used in this study

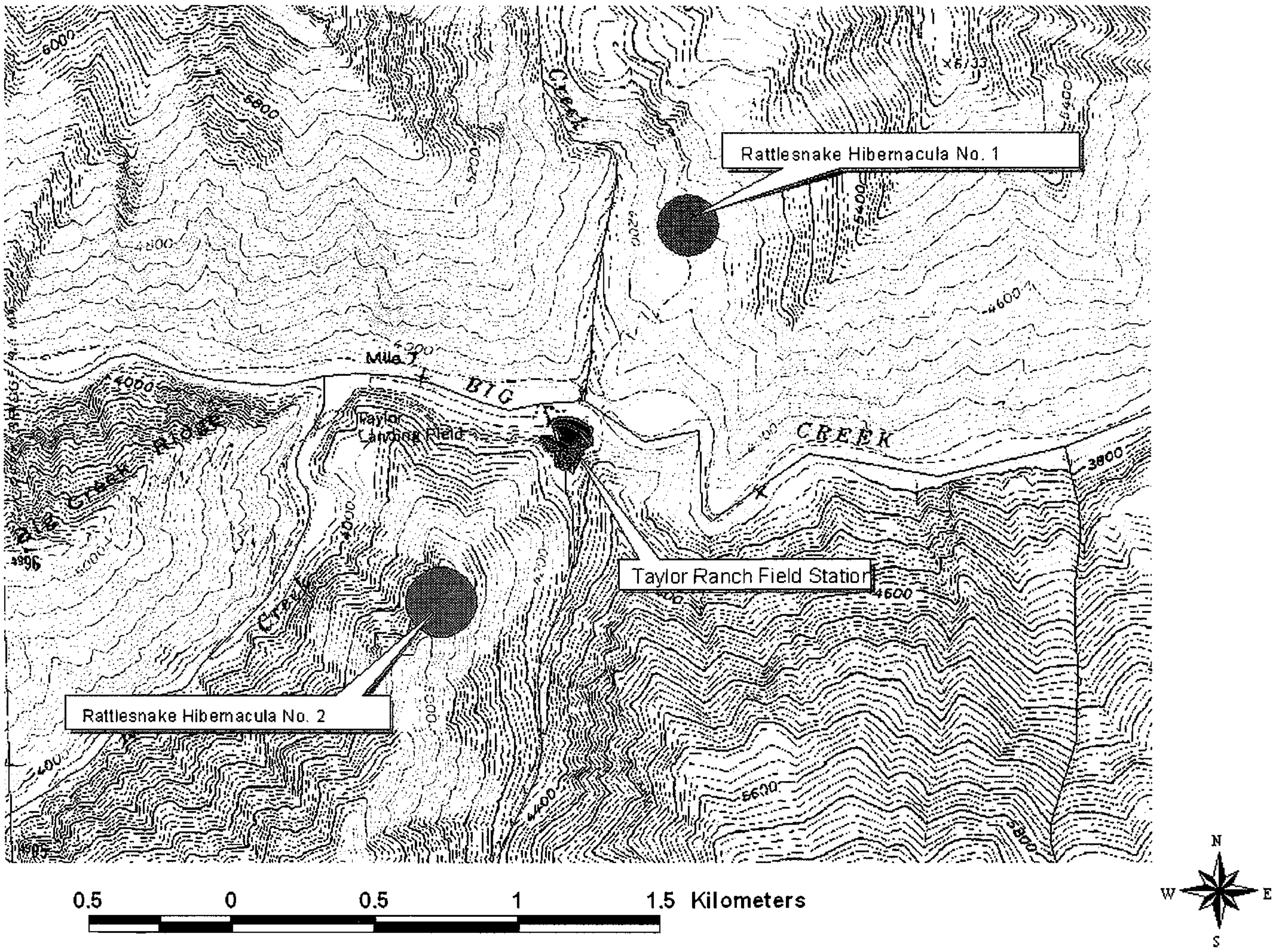


Figure 3

Habitat cover map of area around the Taylor Ranch Wilderness Field Station

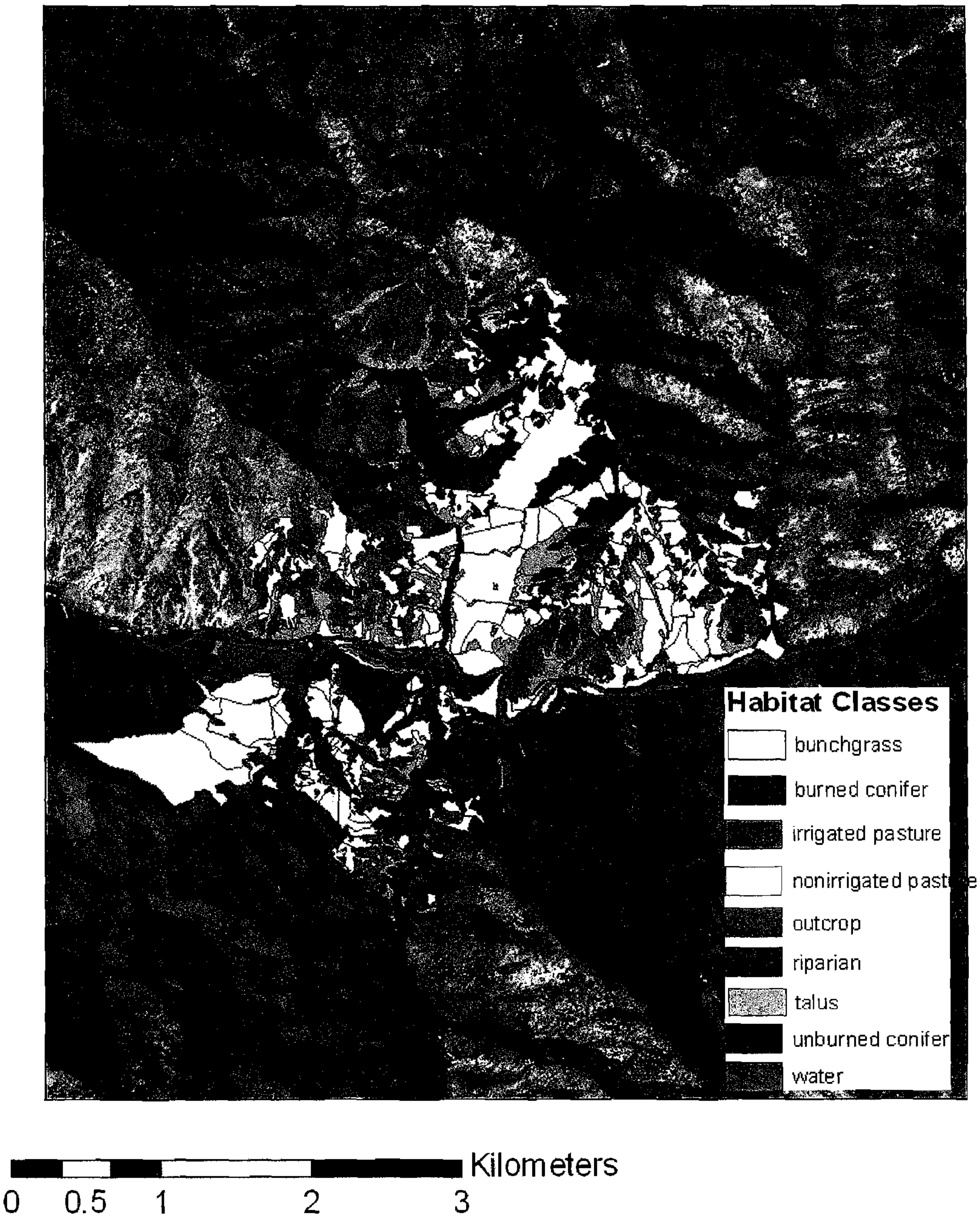
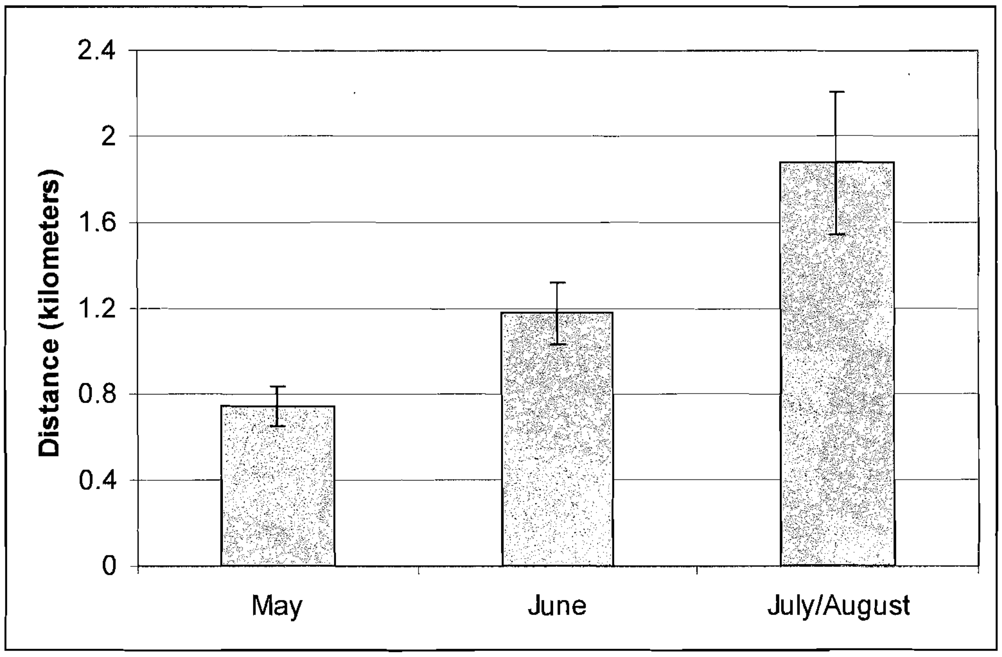


Figure 4

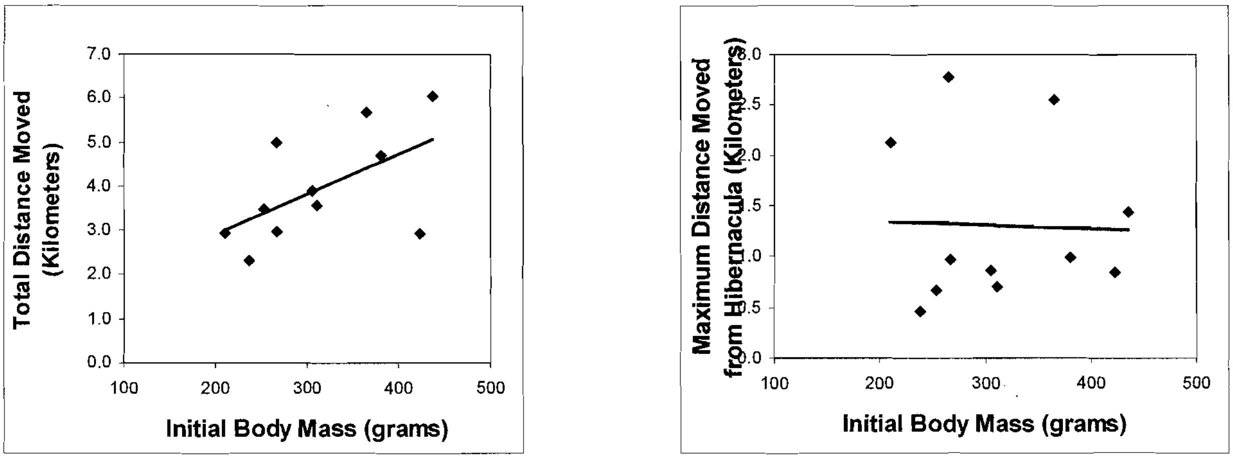
Mean total distance moved by month for eleven male prairie rattlesnakes in the Big Creek drainage of the Frank Church Wilderness in Idaho during the summer of 2006



Repeated measures ANOVA, $F_{2,20}$=8.60, p=0.0020

Figure 5

Correlation plots of total distance and maximum distance moved against body mass at the beginning of the summer for eleven prairie rattlesnakes in the Big Creek drainage in central Idaho during the summer of 2006

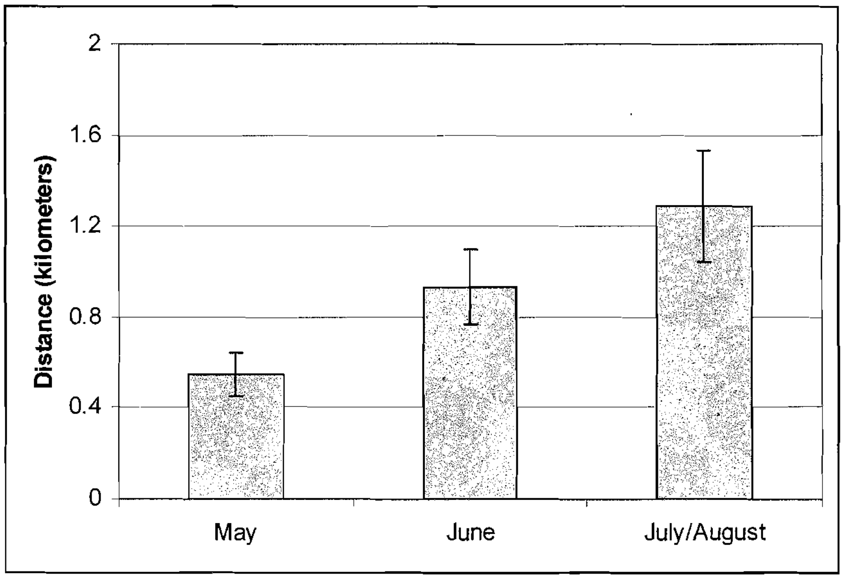


r^2=0.6923, p=0.0126

r^2=0.3636, p=0.2453

Figure 6

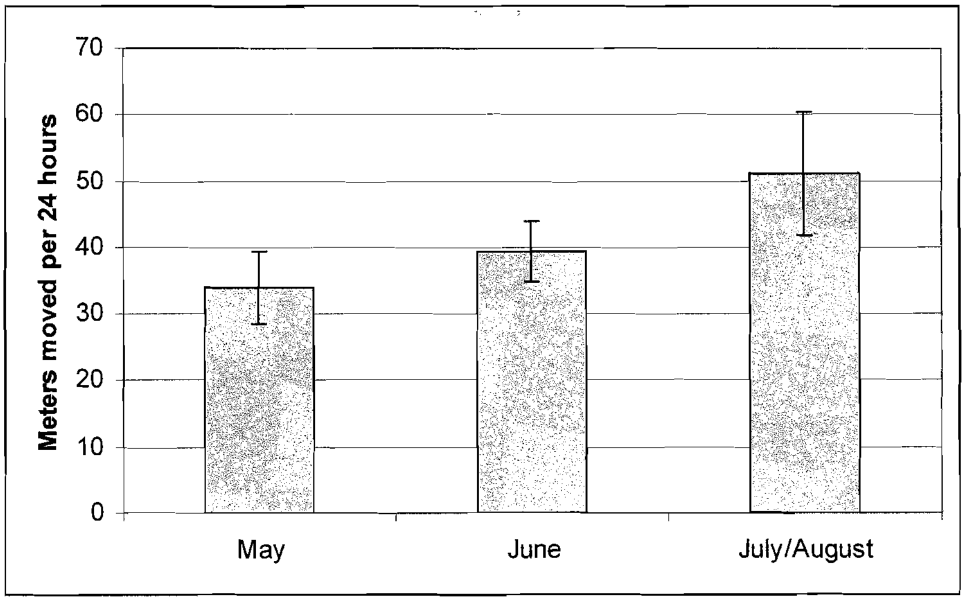
Mean maximum straight line distance moved from the hibernaculum by month for eleven prairie rattlesnakes in the Big Creek drainage in central Idaho during the summer of 2006



Repeated measures ANOVA, $F_{2,20}$=7.35, p=0.0040

Figure 7

Mean movement rate (meters per 24 hours) by month for eleven male prairie rattlesnakes in the Big Creek drainage in central Idaho during the summer of 2006



Repeated measures ANOVA, $F_{2,20}=2.05$, $p=0.1550$

Figure 8

50% CVh fixed kernel, 95% CVh fixed kernel,
and 100% minimum convex polygon
home ranges for five prairie rattlesnakes
in the Big Creek drainage in central Idaho
during the summer of 2006

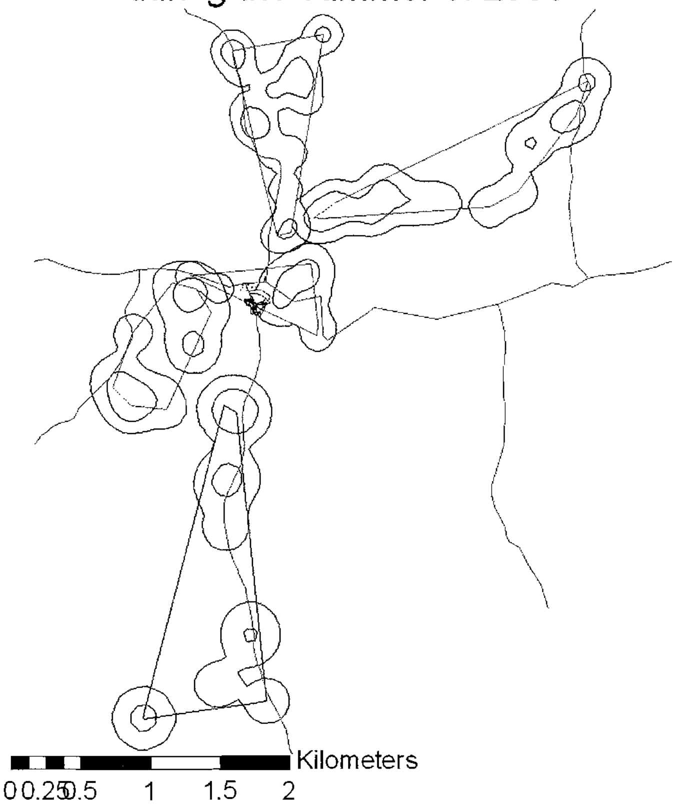


Figure 9

Change in elevation of radio telemetry observations over the summer by prairie rattlesnakes from The J Hibernaculum Complex in the Big Creek drainage in central Idaho during the summer of 2006

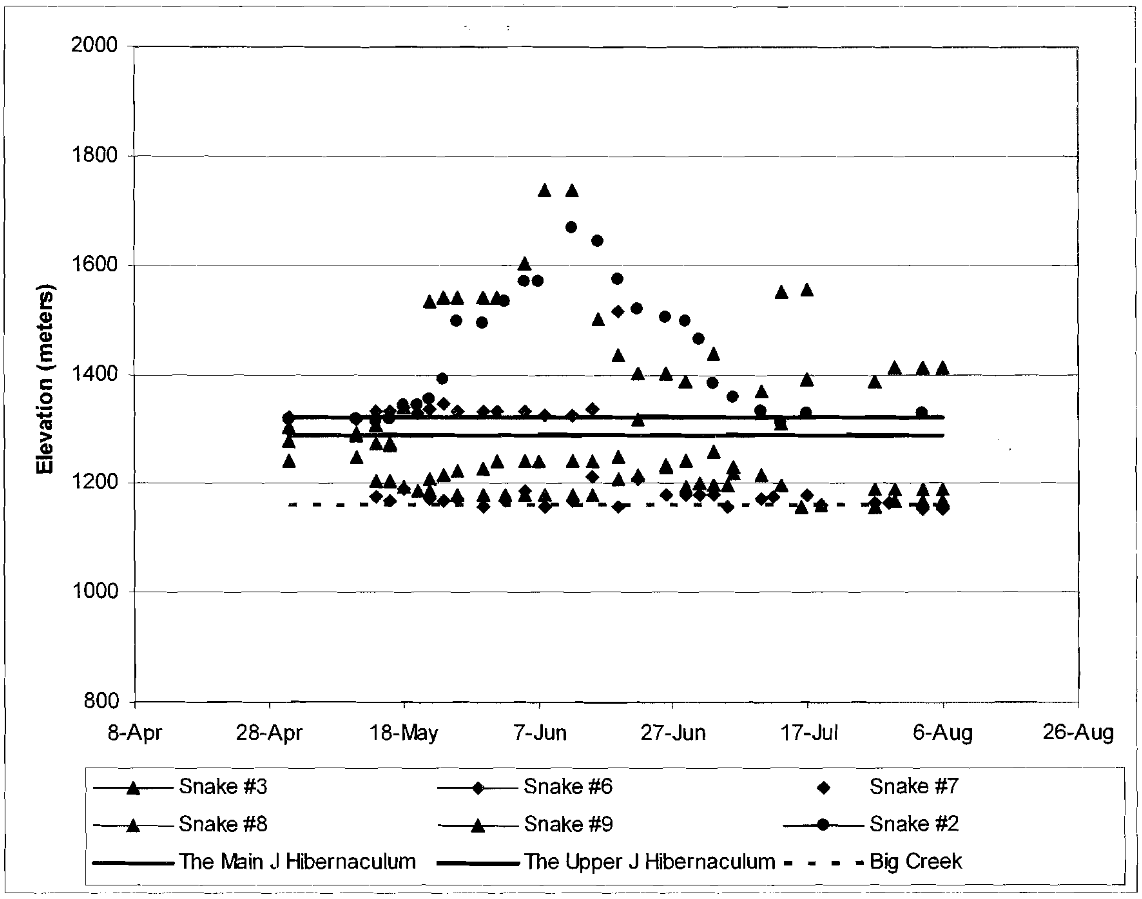


Figure 10

Change in elevation of radio telemetry observations over the summer by prairie rattlesnakes from The Pioneer Creek Hibernaculum Complex in the Big Creek drainage in central Idaho during the summer of 2006

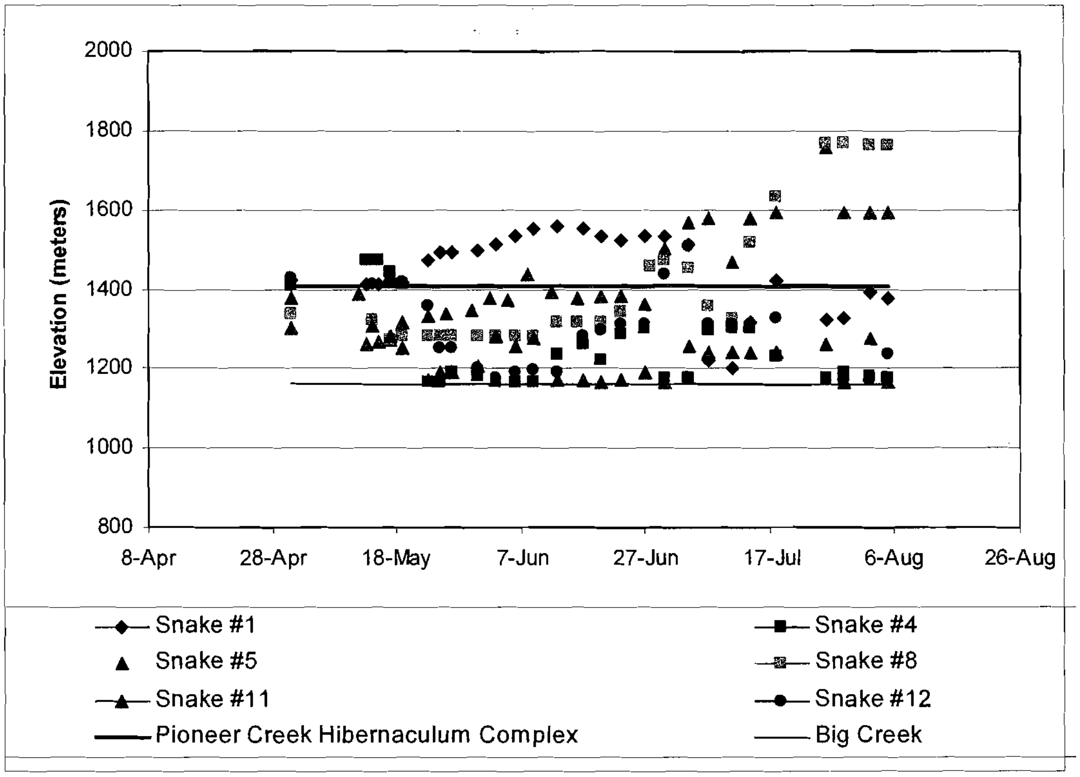
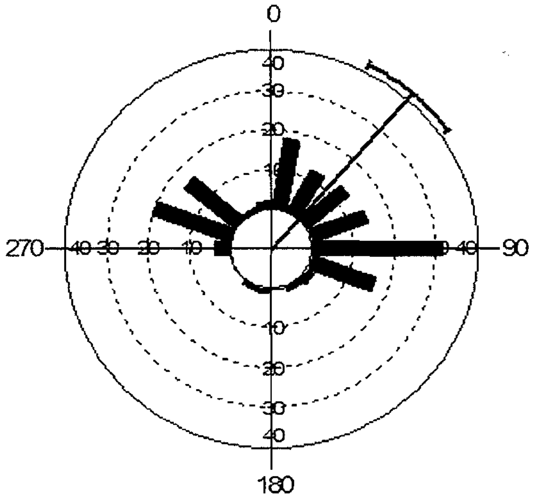


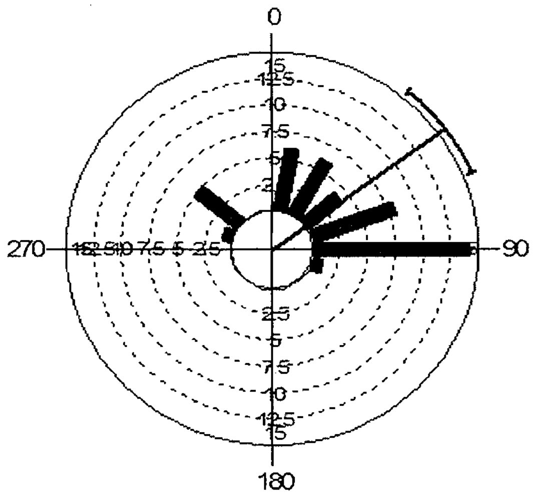
Figure 11a

Aspects of prairie rattlesnake radio telemetry observations by hibernaculum complex and month in the Big Creek drainage in central Idaho during the summer of 2006

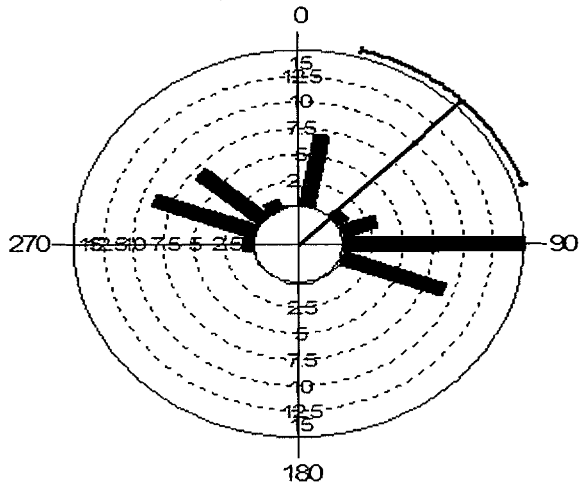
The J Complex – All observations



The J Complex – May



The J Complex – June



Pioneer Creek Complex – July/August

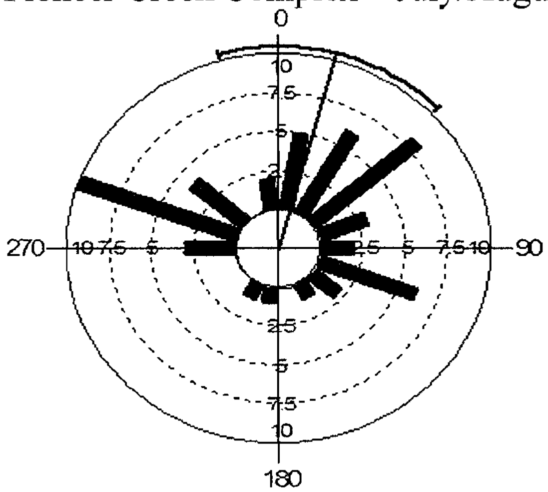
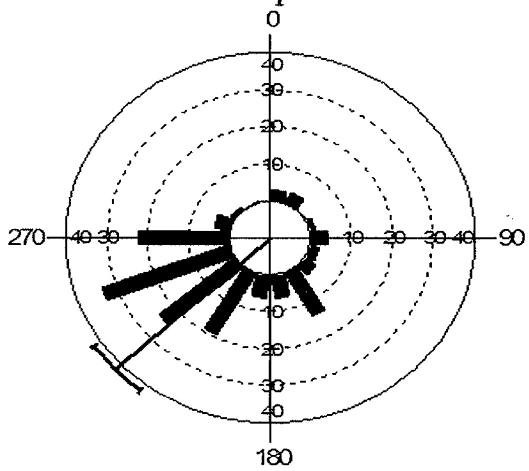
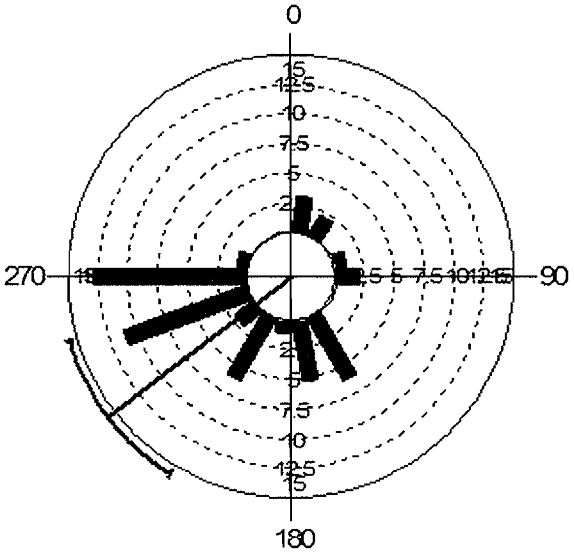


Figure 11b

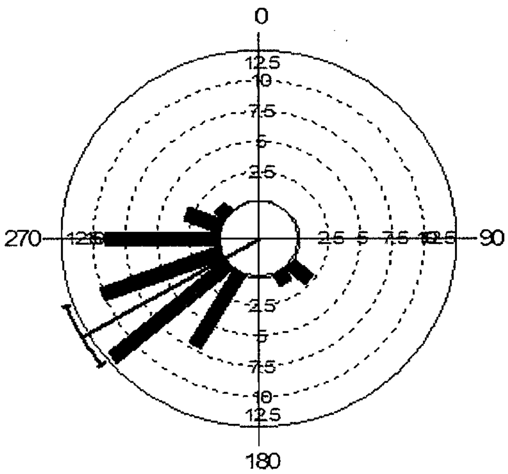
Pioneer Creek Complex – All observations



Pioneer Creek Complex – May



Pioneer Creek Complex – June



Pioneer Creek Complex – July/August

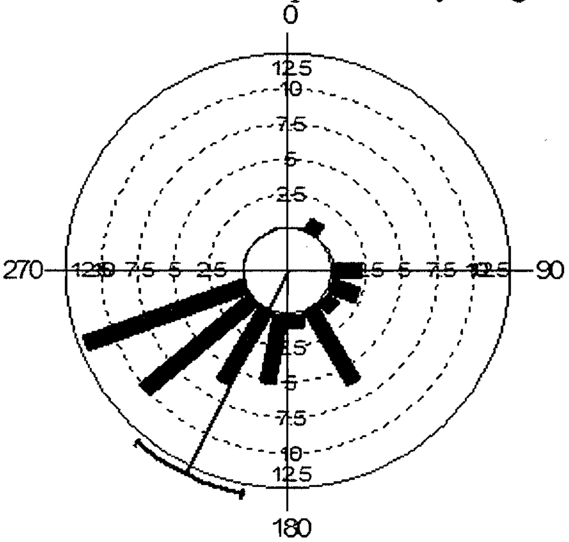


Figure 12

Habitat class availability and use by eight prairie rattlesnakes in the Big Creek drainage in central Idaho during the summer of 2006

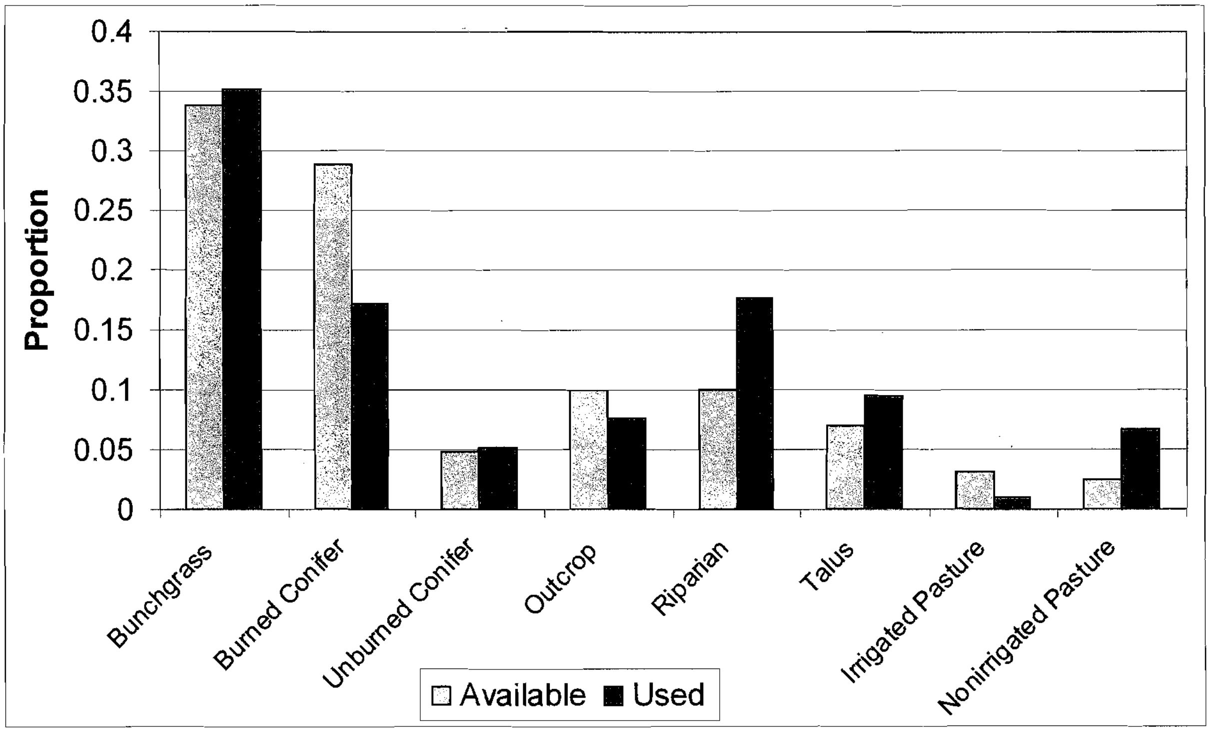
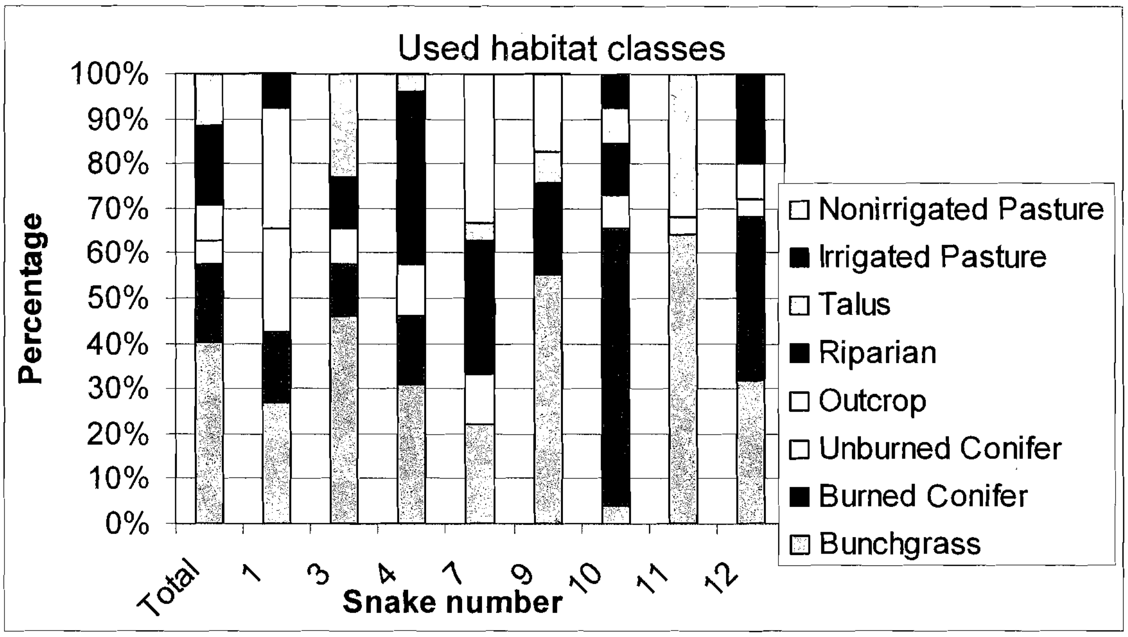


Figure 13

Individual use and availability of habitat classes by eight prairie rattlesnakes in the Big Creek drainage in central Idaho during the summer of 2006



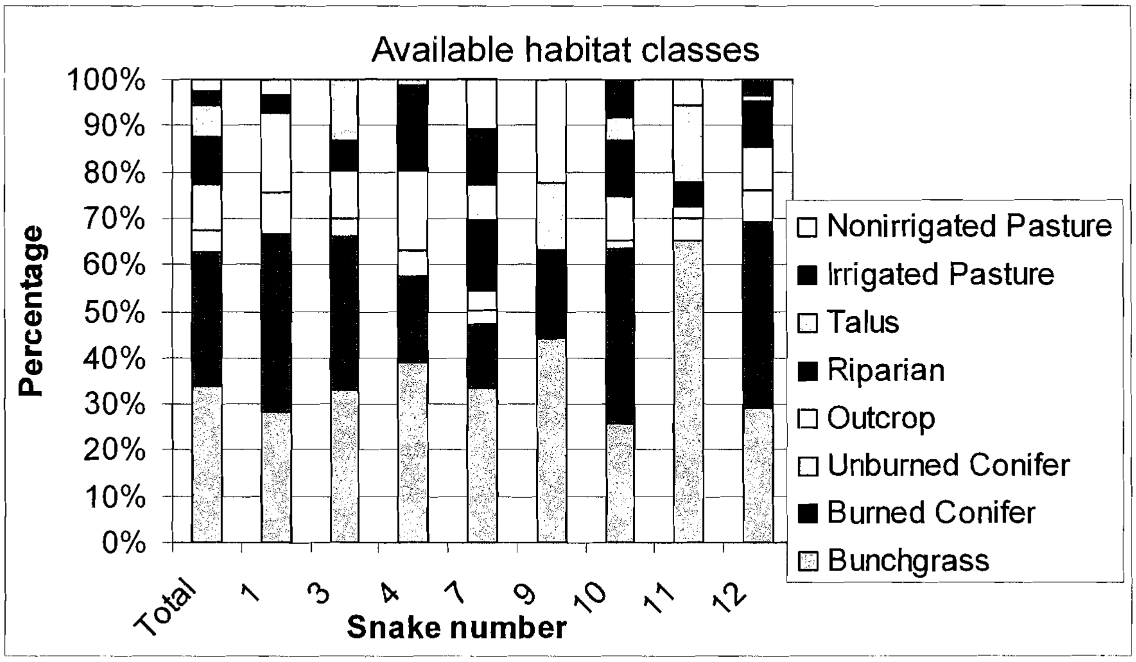
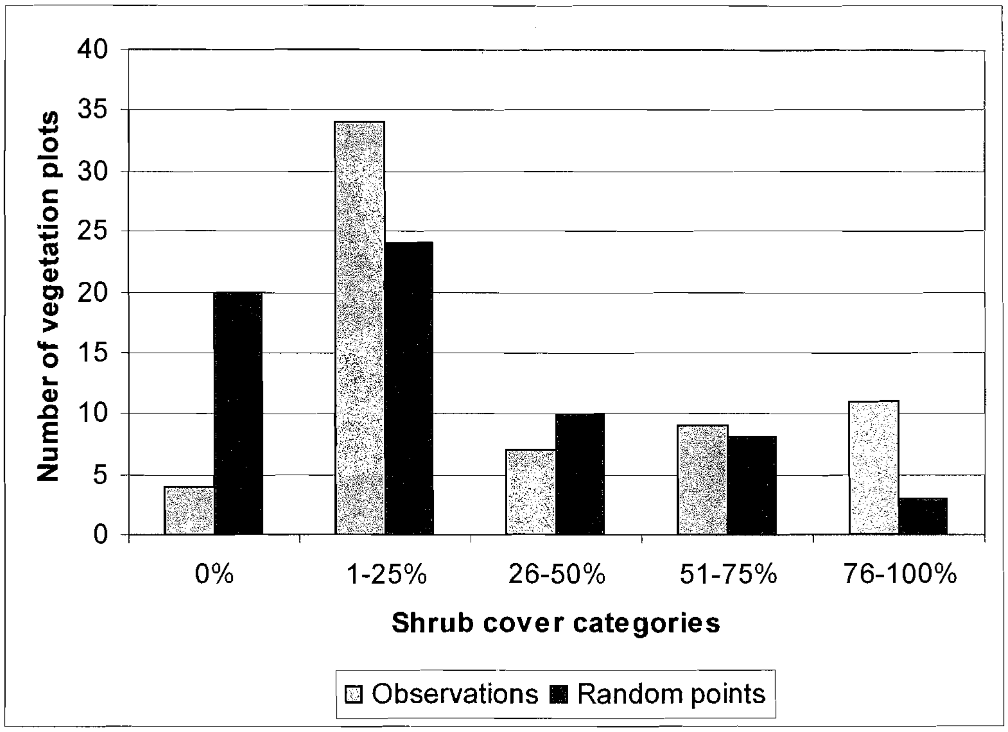


Figure 14

Shrub cover categories of random points and prairie rattlesnake radio telemetry observations in the Big Creek drainage in central Idaho during the summer of 2006



Likelihood ratio chi-square: X^2=18.8278, df=4, p=0.0008

Table 1

Description of habitat classes in the Big Creek drainage in central Idaho used in analyzing prairie rattlesnake habitat selection at the home range scale

Habitat Class	Description
Bunchgrass	Open slopes of grasses, primarily composed of bluebunch wheatgrass, Idaho fescue, and smaller amounts of cheatgrass. May contain scattered patches of talus or small rock outcrops
Burned conifer	Primarily Douglas fir forests with >50% burned timber. Burned in summer 2000. Now consists of standing burned timber, patches of live Douglas fir, mallow ninebark, pinegrass, and cheatgrass. May contian scattered patches of talus or small rock outcrops
Unburned conifer	Primarily Douglas fir and ponderosa pine forests with <50% burned timber. Mallow ninebark and pinegrass present on cooler, northerly aspects while various native grasses are present on drier, southerly aspects.
Riparian	Vegetation within at least 10 meters of a perrenial stream. Consists of a variety of small trees and shrubs including black cottonwood, Rocky Mountain maple, alder, chokecherry, raspberry, thimble berry, and rose.
Rocky outcrops	Large outcrops of rock often containing mountain mahaogany and interspersed with small talus and grass patches
Bare talus	Talus slopes with little or now vegetation
Irrigated pasture	Taylor Ranch Field station airstrip and main pastures which receive irrigation and are harvested for hay. Also grazed by field station stock.
Non-irrigated pasture	An old pasture which no longer recieves irrigation and is not grown for hay but is periodically grazed by field station stock
Water/sandbar	Open water of Big Creek and Rush Creek and associated open, bare sandbars.

Table 2a

A priori models used to determine prairie rattlesnake habitat selection at the mesohabitat scale (10x10m) in the Big Creek drainage in central Idaho during the summer of 2006

	Habitat	Model Description
Primary Habitat Classes	Bunchgrass	exotic grass
	Bunchgrass	native grass+exotic grass
	Bunchgrass	native grass
	Burned Conifer	exotic grass+shrubC[a]
	Burned Conifer	exoitc grass+shrubC+burned log
	Burned Conifer	burned tree+shrubC
	Burned Conifer	burned tree+exotic grass+shrubC+burned log
	Burned Conifer	exotic grass+shrubC+wood
	Burned Conifer	exotic grass+shrubC+forb
	Burned Conifer	burned tree+exotic grass+shrubC
	Burned Conifer	exoitc grass+shrubC+forb+burned log
	Burned Conifer	burned tree+exotic grass+shrubC+wood
	Burned Conifer	exotic grass+shrub
	Burned Conifer	exotic grass+shrub+wood
	Burned Conifer	exoitc grass+shrub+burned log
	Burned Conifer	exoitc grass+shrub+forb+burned log
	Burned Conifer	exotic grass+shrub+forb
	Burned Conifer	burned tree+shrub
	Burned Conifer	burned tree+exotic grass+shrub+burned log
	Burned Conifer	burned tree+exotic grass+shrub
	Burned Conifer	burned tree+exotic grass+shrub+wood
	Burned Conifer	burned tree+exotic grass
	Outcrop	big rock+shrubC
	Outcrop	big rock+shrub
	Riparian	shrubC+wood
	Riparian	shrubC+forb
	Riparian	shrubC+forb+wood
	Talus	big rock
	Unburned Conifer	unburned tree+shrubC+wood
	Unburned Conifer	unburned tree+shrubC+forb
	Unburned Conifer	unburned tree+shrubC+forb+unburned log
	Unburned Conifer	unburned tree+shrub+wood
	Unburned Conifer	unburned tree+shrub+forb+unburned log
	Unburned Conifer	unburned tree+shrub+forb
	Unburned Conifer	unburned tree
	Unburned Conifer	unburned tree+unburned log

Table 2b

A priori models used to determine prairie rattlesnake habitat selection at the mesohabitat scale (10x10m) in the Big Creek drainage in central Idaho during the summer of 2006

	Habitat	Model Description
Secondary Habitat Classes	Grassy Outcrop	big rock+shrubC+native grass
	Grassy Outcrop	big rock+shrubC+exotic grass
	Grassy Outcrop	big rock+shrubC+native grass+exotic grass
	Grassy Outcrop	big rock+shrub+native grass
	Grassy Outcrop	big rock+shrub+exotic grass
	Grassy Outcrop	big rock+shrub+native grass+exotic grass
	Grassy Outcrop	big rock+exoitc grass
	Rocky Bunchgrass	native grass+big rock
	Rocky Bunchgrass	native grass+exotic grass+big rock
	Upland Shrub	shrubC
	Upland Shrub	shrubC+native grass
	Upland Shrub	shrubC+native grass+exotic grass
	Upland Shrub	shrub
	Upland Shrub	shrub+native grass
	Upland Shrub	shrub+native grass+exotic grass

[a]ShrubC is a categorical variable representing percent of shrub cover

Table 3

A priori models used to determine prairie rattlesnake habitat selection at the microhabitat scale (1x1m) in the Big Creek drainage in central Idaho during the summer of 2006

Model description
big rock
big rock+little rock
big rock+shrub+exotic grass
big rock+shrub+native grass
exoitc grass+shrub+wood
exotic grass
exotic grass+big rock
exotic grass+shrub
forb
forb+big rock
forb+exotic grass
forb+little rock
forb+native grass
forb+shrub
forb+shrub+exotic grass
forb+shrub+native grass
forb+wood
little rock
little rock+exotic grass
little rock+native grass
little rock+shrub+exotic grass
little rock+shrub+native grass
native grass
native grass+big rock
native grass+exotic grass
native grass+shrub
shrub
shrub+big rock
shrub+big rock+little rock
shrub+forb+wood
shrub+little rock
shrub+native grass+exotic grass
shrub+wood
wood
wood+exotic grass
wood+native grass

Table 4

Number of radio telemetry observations and movement distances of prairie rattlesnakes in the Big Creek drainage of central Idaho, 11 May through 5 August 2006

Snake ID	Number of Observations[a]	Number of Days Tracked	Total Distance Moved (meters)	Maximum Distance Moved from Capture Point/Overwintering Location (meters)
1	26	80	2936	849
2	25	71	2921	2120
3	26	83	6033	1430
4	26	80	3878	854
5	25	80	5002	2775
6*	15	40	957*	610*
7	27	80	4700	992
8	25	79	5666	2546
9	25	83	3489	674
10	29	83	2319	456
11	26	81	2962	972
12	25	79	3551	710
Mean	25.00	76.58	3950.64	1307.09

[a]These observations only include those seperated by at least one day

*These values are not included in the mean distances and rates reported on this table

Table 5

Directionality statistics for the summer movements of 12 prairie rattlesnakes in the Big Creek drainage of central Idaho, 11 May through 5 August 2006

Snake ID	φ (mean angle of movement)	*s* (angular deviation)	*r* (length of mean vector)	Rao's Spacing Test U	p-value
1	198.587°	121.276°	0.106	144.183	>0.10
2	59.607°	56.301°	0.617	200.088	<0.01
3	334.052°	88.754°	0.301	169.05	<0.05
4	349.729°	122.953°	0.1	145.617	>0.10
5	195.493°	76.554°	0.41	159.647	>0.05
6	96.776°	112.379°	0.146	128.323	>0.10
7	185.829°	122.163°	0.103	119.748	>0.50
8	246.075°	106.351°	0.179	109.18	>0.50
9	78.627°	120.376°	0.11	95.157	>0.50
10	18.261°	123.567°	0.098	113.547	>0.50
11	320.717°	154.814°	0.026	123.307	>0.50
12	158.651°	129.651°	0.077	144.57	>0.10

[a]These observations only include those seperated by at least one day

Table 6

Home range sizes for 11 male prairie rattlesnakes radio tracked between 11 May 2006 and 6 August 2006 in the Big Creek drainage of central Idaho

Snake	AME LSCVh 95% FK	AME LSCVh 50% FK	HRT CVh 95% FK	HRT CVh 50% FK	100% MCP	numer of observations
1	51.61	8.47	43.49	8.71	30.05	26
2	208.28	38.79	89.98	20.93	67.27	25
3	105.03	15.43	67.76	14.81	47.18	26
4	35.61	7.94	32.11	9.59	18.59	26
5	191.29	23.26	142.64	31.01	53.84	25
7	23.29	4.52	39.32	6.81	17.93	27
8	268.91	36.14	99.50	15.33	106.48	25
9	20.85	1.96	23.56	3.80	17.39	25
10	11.28	1.10	13.44	2.59	8.40	29
11	23.32	2.65	49.99	9.68	20.02	26
12	62.90	7.22	69.37	15.90	36.85	25
Mean	91.12	13.41	61.01	12.65	38.54	
SD	90.28	13.54	38.08	8.22	28.89	

Table 7

Summary statistics for the aspect of prairie rattlesnake radio telemetry observations in the Big Creek drainage in central Idaho during the summer of 2006

Snake ID	Hibernaculum Complex	Number of Observations[a]	φ (mean aspect angle)	*s* (angular deviation)	*r* (length of mean vector)	Rao's Spacing Test (U)	p-value
1	Pioneer Creek	26	70.077°	46.005°	0.724	227.264	< 0.01
2	The J	25	215.817°	89.614°	0.294	192.097	< 0.01
3	The J	26	226.842°	31.509°	0.86	240.023	< 0.01
4	Pioneer Creek	26	302.45°	41.431°	0.77	255.869	< 0.01
5	Pioneer Creek	25	89.499°	29.728°	0.874	239.819	< 0.01
6	The J	15	263.918°	39.679°	0.787	231.444	< 0.01
7	The J	27	180.698°	77.607°	0.871	201.579	< 0.01
8	Pioneer Creek	25	91.153°	31.774°	0.857	272.025	< 0.01
9	The J	25	227.519°	40.706°	0.777	251.264	< 0.01
10	The J	29	230.081°	26.564°	0.898	256.259	< 0.01
11	Pioneer Creek	26	12.556°	42.578°	0.759	216.963	< 0.01
12	Pioneer Creek	25	339.043°	56.178°	0.618	229.568	< 0.01
Mean							

[a]These observations only include those seperated by at least one day

Table 8

Summary statistics for the aspect of prairie rattlesnake radio telemetry observations by month and by hibernaculum complex in the Big Creek drainage in central Idaho during the summer of 2006

Hibernaculum Complex	Month	φ (mean aspect angle)	*s* (angular deviation)	*r* (length of mean vector)	Rao's Spacing Test (U)	p-value
Pioneer Creek	May	240.213°	33.77°	0.841	255.464	< 0.01
	June	232.885°	69.565°	0.479	205.887	< 0.01
	July/August	206.228°	50.849°	0.674	221.47	< 0.01
The J	May	53.589°	49.039°	0.693	234.931	< 0.01
	June	44.191°	80.922°	0.369	235.593	< 0.01
	July/August	15.122°	84.298°	0.339	201.04	< 0.01
Total:						
Pioneer Creek		40.916°	73.72°	0.437	207.497	< 0.01
The J		227.153°	54.854°	0.632	218.955	< 0.01

Table 9

Topographic characteristics of prairie rattlesnake radio telemetry observations and random points at the landscape scale in the Big Creek drainage of central Idaho during the summer of 2006

Elevation (meters)	n	Mean	SD	SE	Lower Range	Upper Range
Observations	285	1322.76	147.58	8.74	1153	1768
Random	855	1611.36	273.91	9.37	1141	2371

Slope (Percent)	n	Mean	SD	SE	Lower Range	Upper Range
Observations	285	53.44	23.69	1.40	0	109.62
Random	855	64.31	22.00	0.75	0	172.5

Degrees from north	n	Mean	SD	SE	Lower Range	Upper Range
Observations	281	92.09	44.02	2.63	0	180
Random	853	84.50	51.95	1.78	0	180

Degrees from east	n	Mean	SD	SE	Lower Range	Upper Range
Observations	281	92.17	59.73	3.56	0	180
Random	853	89.17	52.15	1.79	0	180

Table 10

Logistic regression models examining rattlesnake selection for elevation, slope, and aspect at the landscape scale in the Big Creek drainage during the summer of 2006

model	parameters	-2ln(log-likelihood)	AIC	ΔAIC	AIC weight	cummulative AIC weight
elevation+slope	3	969.164	975.164	0.00	0.50889	0.50889
elevation+slope+aspect(NS)	4	968.928	976.928	1.76	0.21066	0.71955
elevation+slope+aspect(EW)	4	969.074	977.074	1.91	0.19583	0.91538
elevation+slope+aspect(EW)+aspect(NS)	5	968.838	978.838	3.67	0.08106	0.99644
elevation	2	982.588	986.588	11.42	0.00168	0.99813
elevation+aspect(NS)	3	981.822	987.822	12.66	0.00091	0.99903
elevation+aspect(EW)	3	982.561	988.561	13.40	0.00063	0.99966
elevation+aspect(EW)+aspect(NS)	4	981.795	989.795	14.63	0.00034	1.00000
slope+aspect(NS)	3	1230.649	1236.649	261.49	0.00000	1.00000
slope	2	1233.358	1237.358	262.19	0.00000	1.00000
slope+aspect(EW)+aspect(NS)	4	1230.469	1238.469	263.31	0.00000	1.00000
slope+aspect(EW)	3	1233.177	1239.177	264.01	0.00000	1.00000
aspect(NS)	2	1277.839	1281.839	306.68	0.00000	1.00000
aspect(EW)+aspect(NS)	3	1277.255	1283.255	308.09	0.00000	1.00000
null	1	1282.124	1284.124	308.96	0.00000	1.00000
aspect(EW)	2	1281.544	1285.544	310.38	0.00000	1.00000

Table 11

Model averaged parameter estimates and odds ratios examining prairie rattlesnake selection for elevation, slope, and aspect at the landscape scale in the Big Creek drainage during the summer of 2006

Model averaged parameters	Estimate	SE	lower 95% CI	upper 95% CI	odds ratio	lower 95% CI	upper 95% CI
elevation	**-0.0057**	**0.0014**	**-0.0085**	**-0.0030**	**0.9943**	**0.9915**	0.9971
slope	**-0.0123**	**0.0034**	**-0.0191**	**-0.0056**	**0.9877**	**0.9811**	0.9944
aspect(EW)	-0.0001	0.0005	-0.0010	0.0008	0.9999	0.9990	1.0008
aspect(NS)	0.0002	0.0005	-0.0008	0.0012	1.0002	0.9992	1.0012

Bold terms indicate significant parameter estimates

Table 12

Topographic characteristics of prairie rattlesnake radio telemetry observations and random points at the home range scale in the Big Creek drainage of central Idaho during the summer of 2006

Elevation (meters)	n	mean	SD	SE	Lower Range	Upper Range
Observations	285	1322.76	147.59	8.74	1153	1768
Random	855	1339.67	161.96	5.54	1153	1856

Slope (Percent)	n	mean	SD	SE	Lower Range	Upper Range
Observations	285	53.45	23.69	1.40	0	109.62
Random	855	54.36	26.52	0.91	0	126

Degrees from north	n	mean	SD	SE	Lower Range	Upper Range
Observations	281	92.09	44.02	2.63	0	180
Random	853	90.97	48.01	1.67	0	180

Degrees from east	n	mean	SD	SE	Lower Range	Upper Range
Observations	281	92.17	59.73	3.56	0	180
Random	853	97.28	56.83	1.97	0	180

Table 13

Logistic regression models examining rattlesnake selection for elevation, slope, and aspect at the home range scale in the Big Creek drainage during the summer of 2006

model	parameters	-2ln(log-likelihood)	AIC	ΔAIC	AIC weight	cummulative AIC weight
elevation	12	1276.772	1300.772	0.00	0.22850	0.22850
elevation+aspect(EW)	13	1274.913	1300.913	0.14	0.21295	0.44145
elevation+slope	13	1276.728	1302.728	1.96	0.08593	0.52738
elevation+aspect(NS)	13	1276.768	1302.768	2.00	0.08423	0.61161
elevation+slope+aspect(EW)	14	1274.822	1302.822	2.05	0.08199	0.69359
elevation+aspect(EW)+aspect(NS)	14	1274.906	1302.906	2.13	0.07861	0.77220
null (snake identification only)	11	1282.124	1304.124	3.35	0.04276	0.81496
aspect(EW)	12	1280.148	1304.148	3.38	0.04225	0.85721
elevation+slope+aspect(NS)	14	1276.719	1304.719	3.95	0.03175	0.88896
elevation+slope+aspect(EW)+aspect(NS)	15	1274.821	1304.821	4.05	0.03018	0.91914
slope	12	1281.787	1305.787	5.02	0.01862	0.93775
slope+aspect(EW)	13	1279.912	1305.912	5.14	0.01749	0.95524
aspect(NS)	12	1282.102	1306.102	5.33	0.01590	0.97115
aspect(EW)+aspect(NS)	13	1280.148	1306.148	5.38	0.01554	0.98669
slope+aspect(NS)	13	1281.783	1307.783	7.01	0.00686	0.99355
slope+aspect(EW)+aspect(NS)	14	1279.907	1307.907	7.13	0.00645	1.00000

Table 14

Model averaged parameter estimates and odds ratios examining prairie rattlesnake selection for elevation, slope, and aspect at the home range scale in the Big Creek drainage during the summer of 2006

Model averaged parameters	Estimate	SE	lower 95% CI	upper 95% CI	odds ratio	lower 95% CI	upper 95% CI
elevation	-0.0011	0.0011	-0.0032	0.0011	0.9989	0.9968	1.0011
slope	0.0002	0.0006	-0.0011	0.0014	1.0002	0.9989	1.0014
aspect(EW)	-0.0008	0.0010	-0.0027	0.0012	0.9992	0.9973	1.0012
aspect(NS)	0.0000	0.0761	-0.1491	0.1491	1.0000	0.8615	1.1608

Table 15

Matrix of habitat rankings comparing habitat use and habitat availability for prairie rattlesnakes in the Big Creek drainage in central Idaho during the summer of 2006

A higher rank indicates higher disproportionate use

A negetive sign indicates lower disproportionate use of the habitat class in that row reletive to the habitat class in the corresponding column

	Habitat Type								
Habitat Type	Bunchgrass	Riparian	Non-irrigated pasture	Bare talus	Burned conifer	Irrigated pasture	Rocky outcrop	Unburned conifer	Rank
Bunchgrass		1	1	1	1	1	1	1	7
Riparian	-1*		1	1	1	1	1	1	6
Non-irrigated pasture	-1	-1		1	1	1	1	1	5
Bare talus	-1	-1	-1		1	1	1	1	4
Burned conifer	-1	-1	-1	-1		1	1	1	3
Irrigated pasture	-1	-1	-1	-1	-1		1	1	2
Rocky outcrop	-1	-1	-1	-1	-1	-1		1	1
Unburned conifer	-1**	-1	-1	-1	-1	-1	-1		0

Wilk's Lambda = 0.0665, df=7, X^2 = 21.6832, $p<0.05$

*A 3 or -3 would indicate a signficant difference in disproportionate use between two habitats. A 1 or -1 indicates that difference is not signficant ($p<0.05$)

**The difference in disproportionate use was marginally signficant ($p=0.0635$)

Table 16

Vegetation measurements at prairie rattlesnake radio telemetry observations and corresponding random points in the Big Creek drainage in central Idaho during the summer of 2006

Habitat Variable	Telemetry observations (n=65) Mean	SE	Random points (n=65) Mean	SE
Mesohabitat Scale (10x10 meters)				
No. unburned logs (≥7.5 cm wide)	0.62	0.25	0.37	0.13
No. burned logs (≥7.5 cm wide)	0.08	0.03	0.22	0.09
No. unburned trees (≥7.5 cm DBH)	0.05	0.03	0.18	0.14
No. burned trees (>7.5 cm DBH)	0.32	0.10	0.31	0.11
Rock[a]	48.78	4.27	35.97	4.57
Forb	4.52	1.32	6.83	1.50
Exotic grass	29.86	4.38	38.03	4.96
Native grass	12.66	2.88	15.57	3.23
Wood	3.63	1.50	1.38	0.45
Shrub	27.14	4.47	13.94	3.16
Microhabitat Scale (1x1 meters)				
Percent cover of big rock (≥fist sized)	5.46	0.53	4.65	0.60
Percent cover of little rock (<fist sized)	3.68	0.51	4.40	0.65
Percent cover of forb	1.66	0.22	2.29	0.30
Percent cover of exotic grass	8.43	0.88	8.45	0.86
Percent cover of native grass	3.60	0.56	3.60	0.51
Percent cover of wood	0.55	0.16	0.37	0.13
Percent cover of shrub	4.69	0.71	3.28	0.52

[a]See text for definitions of each variable

Table 17

Logistic regression models examining habitat selection by prairie rattlesnakes at the mesohabitat scale (10x10 meters) in the Big Creek drainage during the summer of 2006
Only models with ΔAICc <4 are displayed

Habitat Class	Model	Parameters	-2ln(log-likelihood)	AIC_c	ΔAIC_c	AIC_c weight	cummulative AIC_c weights
Outcrop	rock+shrubC	5	58.556	69.04	0.00	0.25582	0.25582
Unburned Conifer	tree+shrubC+wood	6	58.134	70.82	1.78	0.10521	0.36102
Grassy Outcrop	rock+shrubC+native grass	6	58.407	71.09	2.05	0.09178	0.45280
Grassy Outcrop	rock+shrubC+exotic grass	6	58.528	71.21	2.17	0.08639	0.53920
Upland Shrub	shrubC	4	63.139	71.55	2.51	0.07289	0.61208
Unburned Conifer	tree+shrubC+forb	6	59.522	72.20	3.17	0.05256	0.66464
Burned Conifer	exotic grass+shrubC	5	62.435	72.92	3.88	0.03678	0.70142

Parameter weights	
shrubC	0.99643
rock	0.46790
exotic grass	0.24601
wood	0.17819
tree	0.17684
native grass	0.16134
forb	0.13193

Table 18

Logistic regression models examining habitat selection by prairie rattlesnakes at the microhabitat scale (1x1 meters) in the Big Creek drainage during the summer of 2006

Only models with ΔAICc <2 are displayed

Model	Parameters	-2ln(log-likelihood)	AIC_c	ΔAIC_c	AIC_c weight	cummulative AIC_c weights
forb+shrub	2	81.178	85.27	0.00	0.14067	0.14067
shrub+big rock	2	81.215	85.31	0.04	0.13809	0.27876
shrub+forb+wood	3	80.163	86.35	1.08	0.08194	0.36070
big rock+shrub+native grass	3	80.593	86.78	1.51	0.06608	0.42678
shrub	1	84.987	87.02	1.75	0.05876	0.48555
big rock+shrub+exotic grass	3	80.99	87.18	1.91	0.05419	0.53973
shrub+big rock+little rock	3	81.057	87.25	1.97	0.05240	0.59213

Table 19

Model averaged parameter estimates and odds ratios examining prairie rattlesnake habitat selection at the microhabitat scale (1x1 meters) in the Big Creek drainage during the summer of 2006

Parameter	Parameter weight	Model Averaged Estimate	Model averaged standard error	Lower 95% CI	Upper 95% CI	Model averaged odds ratio	Lower 95% CI	Upper 95% CI
shrub	0.84394	0.06785	0.08983	-0.10822	0.24392	1.07020	0.89743	1.27624
forb	0.41877	-0.03499	0.03445	-0.10251	0.03253	0.96561	0.90257	1.03306
big rock	0.34441	0.02586	0.03736	-0.04736	0.09908	1.02620	0.95374	1.10416
exotic grass	0.18460	0.00083	0.00295	-0.00496	0.00662	1.00083	0.99506	1.00664
native grass	0.16782	0.00252	0.00548	-0.00823	0.01327	1.00252	0.99181	1.01336
wood	0.14749	0.01169	0.01879	-0.02514	0.04851	1.01176	0.97517	1.04971
little rock	0.14226	-0.00092	0.00239	-0.00559	0.00376	0.99908	0.99442	1.00376