FIVE YEAR STUDY OF FACTORS AFFECTING JUMPING MICE (*Zapus*) ON THE MEDICINE BOW NATIONAL FOREST, WYOMING:

SIX-YEAR PROJECT REPORT, 2009

Prepared by:

Hannah Griscom, Zoologist
Doug Keinath, Senior Zoologist
Alan Redder, Statistician

Wyoming Natural Diversity Database
University of Wyoming
1000 E. University Ave // Department 3381
Laramie, Wyoming 82071

Prepared for:
Alan Williamson
Forest Wildlife Biologist
Medicine Bow-Routt NF's &
Thunder Basin NG
2468 Jackson Street
Laramie, WY 82070

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INTRODUCTION

This report details the results of a small mammal survey performed in 2009 as part of an administrative study aimed at the Preble's meadow jumping mouse (PMJM) (*Zapus hudsonius preblei*) on the Medicine Bow National Forest. The 5-7-year study was initiated in 2004 with the intention to inventory and monitor Preble's populations at fixed points, correlate population trends with general habitat characteristics, and measure population responses to fire and livestock grazing. In addition to a detailed report of trapping results from 2009, a summary of findings for the entire project is presented here.

The 'Preble's' subspecies of the meadow jumping mouse, *Zapus hudsonius preblei*, occurs along the foothill drainages of the front range of Colorado and Wyoming. It was listed by the U.S. Fish and Wildlife Service as Threatened on May 13, 1998 due to habitat degradation and destruction. Finding that the subspecies was sufficiently secure within the Wyoming portion of its range, the USFWS delisted *Zapus hudsonius preblei* within Wyoming on July 10, 2008 (USFWS 2008).

In the Medicine Bow National Forest, the PMJM overlaps in range with the Bear Lodge meadow jumping mouse (*Z. hudsonius campestris*) and the western jumping mouse (*Z. princeps*). They also all use riparian habitats and, in hand, look identical, making species identification impossible in 'catch and release' trapping. For this reason, we refer to individuals of *Zapus* documented on the Medicine Bow National Forest, and elsewhere in the region, as "suspected" Preble's meadow jumping mice or simply *Zapus*.

STUDY AREA

From 2004 to 2008, fixed trapping transects were located on the Laramie Peak Unit of the Douglas Ranger District and on the Pole Mountain Unit of the Laramie Ranger District (Griscom et al. 2008). The transects were selected in 2004 with the help of US Forest Service District

Biologists, Tim Byer and Steve Kozlowski, and Rangeland Management Specialists, Charlie Bradshaw and Darin Jons. At the time, the eight selected transects allowed for the study of impacts from both livestock grazing and prescribed fire. Unfortunately, prescribed fires that were being planned by the USFS on the Laramie Peak Unit did not come to fruition during the period of this project, so it was not possible to assess the influence of fire on *Zapus* abundance. Also, because grazing intensity is not quantitatively monitored on the Laramie Peak Unit, it was difficult to study grazing impacts there. The Pole Mountain Unit, in contrast, has a grazing utilization monitoring program which we capitalized on in order to examine the influence of grazing intensity on *Zapus* density in the same pasture. In order to add some spatial variation into this analysis, the 4 transects located on the Laramie Peak Unit were moved in 2009 to pastures with histories of high and low grazing intensities on the Pole Mountain Unit. This resulted in all 8 riparian trapping transects being located on the Pole Mountain Unit in 2009. Four of those transects were at the same locations used in years passed (MCL, SLC, SFMCC, MCC). The 4 new transects were placed along riparian corridors near unique grazing utilization cages on Middle Crow Creek, South Fork Middle Crow Creek, North Branch Crow Creek, and Middle Lodgepole Creek. Figure 1 shows a map of all 8 transects and Table 1 gives the exact locations with reference to nearby grazing utilization monitoring sites. Appendix B displays aerial photo and topographic map views of all 12 trapping transects used since 2005.

POPULATION MONITORING

Methods

The first year of the study (2004) was primarily an inventory year, designed to confirm presence or absence of *Zapus* in habitats where management impacts could be monitored. Three transect locations were modified in the second year (2005) to capture more jumping mice, but all 8 transects remained the same through 2008 until the changes made in 2009 described above. In all years, trapping methods conformed to the guidelines established by the U.S. Fish and Wildlife Service (USFWS 1999) and the methods described below have been used at all transects in all years.

Each transect consisted of two lines of 100 Sherman live traps (H. B. Sherman Traps, Inc., Tallahassee, Florida), one line on either side of the stream. Traps were placed five meters apart and staggered alternately on the ground adjacent to the creek bank and approximately five meters from the creek bank in a 'zig-zag' fashion. All traps contained dry polyester bedding material, 3-way livestock feed, and were set in the evening and checked early the following morning. Captured animals were identified in the field and released at the capture site. To determine the exact number of jumping mice captured, each *Zapus* was marked individually with semi-permanent paint. The paint colors persisted throughout the week of trapping so recaptured animals could be identified. Photos were taken of each jumping mouse, sex was recorded, and geographic coordinates of the capture location were logged with a GPS unit.

One baited, open trap is equivalent to one raw trap night. Therefore, one evening of trapping effort on each transect is equivalent to 200 raw trap nights (2 lines with 100 traps each). Each transect was surveyed for approximately 800 raw trap nights (over 4 consecutive nights). For analyses, raw effort per transect was corrected for disturbed (i.e., tripped-but-empty) and occupied traps using the technique of Beauvais and Buskirk (1999) and reported as adjusted, or net trap nights. Adjusted trap night figures are based on an assumed probability of trap availability prior to closure. Therefore, the number of closed traps per night (disturbed + captures) is divided in half and subtracted from the total number of traps that remained open during the trapping effort. For the purpose of tracking basic *Zapus* population trends, the number of individual jumping mice captured per transect was also standardized by the linear length of riparian habitat sampled (yielding number of *Zapus* per linear, riparian kilometer). For most analyses this number is used instead of raw *Zapus* numbers in order to standardize between transects by year.

Results

In 2009, trapping surveys were conducted between July 20 and August 18. The small mammal trapping effort included data collected from roughly 3.2 kilometers of streamside habitat. Table 2 displays the dates trapped, adjusted trap nights, and *Zapus* captures associated with each transect. Problems with trap disturbance and predation (raccoon or other) occurred on the

SFMCC transect during the last 2 night of trapping (despite trapping and relocation efforts). This not only reduced the number of available traps from 800 to 612 but resulted in 9 small mammal captures that were unidentifiable because of predation. Since some of these captures could have been *Zapus,* results for SFMCC should be treated with caution.

A total of 65 individual meadow jumping mice (*Zapus*) were captured in 2009 across all transects with at least one capture at each transect (Table 2). In our 2008 report (Griscom et al. 2008), we stated that *Zapus* abundance had gradually increased across transects since the projects' inception in 2004. This is probably at least in part due to a progressive improvement in drought conditions. Wetter ground conditions would favor *Zapus* production and survival by providing adequate food and cover. Figure 2 displays total captures from permanent transects on Laramie Peak and Pole Mountain since 2005 and the associated drought index class for that year (drought classes were visually interpreted from North American Drought Monitor maps on NOAA's Satellite and Information Service (NOAA 2009)). Drought classes have gone from 'Extreme' in 2004 to 'Normal' in 2008 and 2009.

After 6 years of monitoring, some general conclusions can be made about specific transects (Figure 3). On the Laramie Peak Unit, CWC (along Cottonwood Creek) and FP (Friends' Park) had high numbers of *Zapus*, and populations at FP and HC (Hubbard's Cupboard) may be increasing. On the Pole Mountain Unit MCC (along Middle Crow Creek) and SLC (along South Lodgepole Creek) have consistently high *Zapus* numbers and appear to be increasing, whereas abundance at MLC (along Middle Lodgepole Creek) is gradually declining. Of the 4 new transects established in 2009, *Zapus* abundance was highest at HG7, along Middle Crow Creek (Figure 4).

The composition of small mammals trapped in 2009 (Table 3) was similar to previous years with deer mice, voles, jumping mice, and shrews comprising the majority of captures. Occasionally, least chipmunks, golden-mantled ground squirrels, bushy-tailed wood rats, short-tailed weasels, and long-tailed weasels were also captured in 2009. Deer mice have always been the most abundant small mammal caught at transects, although they were conspicuously absent at LC13, a new transect established in 2009 which has received little grazing over the last 5 years. Meaney

et al. (2002) found a positive relationship between livestock grazing and deer mouse abundance which could explain their absence at this site. Interestingly, LC13 also had more weasel captures than any other transect in any other year (6 total). Appendix A is a list of all 17 documented mammal species captured at transects since 2004. Because detailed morphometric and dental measurements are required for identifying some voles (*Microtus* spp.) and shrews (*Sorex* spp.), laboratory measurements were made on a number of preserved trap mortalities to determine species. Nevertheless, not all captures in these two genera were identified to species, so the list may not fully represent richness in these genera.

HABITAT STUDIES

Although the importance of well-developed riparian vegetation in supporting PMJM populations was understood at the inception of this project (Armstrong et al. 1997), few studies had looked at the specific vegetation characteristics correlated with PMJM density, and no habitat work had been conducted in the Medicine Bow National Forest. In an attempt to quantify the specific vegetation variables which favor *Zapus* abundance on the Medicine Bow National Forest, WYNDD collected detailed vegetation measurements in 2004 along all trapping transects. Methods for measuring vegetation were adapted from the Preble's Meadow Jumping Mouse Habitat Monitoring Protocol (Ruggles et al. 2004). Along transects running perpendicular to the stream, relative and absolute cover classes of forbs, graminoids, litter, trees, shrubs, subshrubs, and bare ground were measured at 0, 15, 25, and 50 meters from the stream bed. In WYNDD's 2004 report, Smith et al. stated that they had low confidence that this method had captured the vertical structure and complexity likely to be most important to *Zapus*. For this reason, the vegetation methods used in 2004 were not repeated in subsequent years. In 2008, Griscom et al. revisited the 2004 vegetation data in light of 5 years of trapping in search of cover variables that might explain differences in *Zapus* densities, but still, none were found to be significant.

Recent studies in Colorado have shed more light on the particular vegetation variables that influence PMJM densities. One key study by Trainor et al. (2007) used radio-tagged mice to delineate high-use and low-use areas within the riparian zone which were then measured for microhabitat variables. Although their general approach to measuring vegetation cover was

similar to ours, cover was measured in absolute percent, instead of percent 'class', and Daubenmire (1959) plots were placed closer together, centered around high-use and low-use areas. After performing a multi-variate analysis, Trainor et al. found that high-use areas had greater cover of shrub, grass, and woody debris than low-use areas. In addition, graminoid cover was 3 times more abundant than forbs and the high-use sites tended to be very close to stream edges.

Their results highlight the PMJM's concentrated use of microhabitat patches (often with many mice sharing the same patch) while ignoring the rest of the landscape. In light of this, it is clear that by measuring vegetation at random locations and working perpendicular to the stream, instead of parallel, WYNDD was not adequately centering in on patches most used by jumping mice in its 2004 study. Trainor et al. (2007) conclude that species conservation efforts should focus on encouraging recruitment and growth of willows (*Salix* spp.), native wetland grasses, sedges (*Carex* spp.), and rushes (*Juncus* spp.) in riparian areas within the species' range.

In the Medicine Bow National Forest, beaver (*Castor canadensis*) clearly play a prominent role in creating and maintaining high-quality PMJM habitat. Three of the 12 transects used in this project were along active beaver dams, and they also represent 3 of the 4 most highly productive transects for *Zapus* (x-bar: SLC; 30/km, HG7; 45/km, FP; 45/km). Beaver management should be considered a tool for creating high-quality PMJM habitat in the future.

FIRE EFFECTS

During the initial site selection and study design period of this project in 2004, Forest Service Biologists hoped to learn more about the potential interactions between fire and PMJM populations. It appeared likely that at least one of the transects established on the Laramie Peak Unit (Hubbard's Cupboard; HC) would undergo a prescribed burn in subsequent years, and WYNDD would be able to measure *Zapus* densities before and after the fire. Unfortunately, since 2004, the NEPA process has proven slow, and no prescribed burns have occurred within the transects. As a result, we have not been able to address this question directly.

Very little has been published about fire and its impacts on *Zapus* populations in the western United States. One recent study (Frey and Malaney 2009) mentioned fire, along with drought, and livestock grazing, as a contributing factor in the reduction of *Zapus hudsonius luteus*'s habitat in New Mexico over the last 50 years, however the relationship was not specifically examined in their study. One would expect that a fire hot enough to burn through a montane riparian area would at least result in a short-term reduction of gramanoid and willow cover. Given the PMJM's dependence on these cover types, a short-term reduction in abundance would probably follow in the wake of a large riparian fire. If invasive exotic species were to take hold after such a fire, this would probably have a more negative long-term impact on PMJM than the fire itself.

GRAZING EFFECTS

One of the primary objectives of this project is to measure the impacts of livestock grazing on PMJM populations. PMJM's association with high grass, shrub, and woody debris can primarily be explained by their diet and need for protection from predators (primarily snakes) (Trainor et al. 2007). They are insectivores and granivores, and rely more on graminoid seeds than forb seeds (Trainor et al. 2007). Willow and woody debris create microclimates that favor grass and arthropod production, as well as provide cover from predators (Trainor et al 2007). Because livestock tend to congregate in riparian areas and feed on mesic grasses and willows, they can significantly alter plant composition and structure. In a study conducted along Sheep Creek on the Roosevelt National Forest in northern Colorado, grazing exclosures had significantly more graminoid and litter cover, and willow cover was 8.5 times greater than in nearby pastures where livestock utilization was approximately 65% every summer (Schulz and Leininger 1991).

A recent search of peer-reviewed journal articles addressing *Zapus* abundance in relation to livestock grazing yielded 4 articles, 3 of which found a negative relationship. In the Sheep Creek study mentioned above, western jumping mice (*Zapus princeps*) were very abundant in grazing exclosures, and almost absent from grazed pastures (Schulz and Leininger 1991). Similarly, meadow jumping mice in southwest Pennsylvania (*Zapus hudsonius Zimmermann*) were more

abundant in grazing exclosures than in grazed areas (Giuliano and Homyack 2004). Working with meadow jumping mice in New Mexico (*Zapus hudsonius leteus*), Frey and Malaney (2009) found that the species no longer occupied historic sites that had undergone continuous grazing over the last 20 years. The study that found no relationship was near Boulder, Colorado. Meaney et al. (2002) did *not* find a difference between PMJM abundance on grazed and ungrazed sites there while conducting small mammal studies.

Methods

Forest Service lessees generally graze cattle on Medicine Bow National Forest allotments every year from approximately June through September, and rotate cattle from one pasture to another once designated levels of utilization have been met. On Pole Mountain allotments, the guideline is to leave 3-6 inch stubble height of sedges depending on the season, and 45% utilization of upland grasslands. Pasture utilization data are collected by USFS range specialists in late summer by quantitatively comparing standing biomass inside and outside small exclosures and calculating the percent of biomass (mostly grass) consumed by cattle and wild ungulates in each fenced pasture (data made available by John Lamman, Rangeland Management Specialist, Laramie Ranger District). Each of the 8 Pole Mountain Unit transects surveyed by WYNDD in 2009 had at least one exclosure cage within the same pasture where percent utilization was measured. In the cases when more than one utilization cage was proximate to a *Zapus* transect (i.e., MCC, SFMCC, MLC), average percent utilization of the cages was used. We would have liked to have studied the impact of *season* of grazing ('early summer' versus 'late summer') in addition to grazing intensity, but our current understanding is that the USFS does not track this information for every pasture. Table 1 shows the grazing monitoring sites associated with each transect and the average percent utilization recorded at those sites from 2006-2009.

In order to assess the relationship between grazing intensity and *Zapus* density, we started by plotting *Zapus* density as a function of percent utilization in the same pasture and year. Although this gives us a general picture of the relationship, the points in the regression cannot be considered independent because many are from the same transect (in different years). The problem of pseudoreplication can be overcome by blocking the data by transect and by year in a

linear mixed effects model. The ANOVA test performed on the blocked data measures whether or not the slope is equal to zero (which would indicate no relationship between grazing utilization and *Zapus* density).

Results

Figure 5 displays density of *Zapus* as a function of percent utilization for all transects and all years. A general negative trend emerges, with two of the new transects (LG19 and LC13) serving as clear outliers with low levels of grazing and *Zapus* density, and the other two (HG7 and HB4) falling within the trend seen at permanent transects. There seems to be an especially strong effect on *Zapus* at utilization levels above 40%. Figure 6 displays *Zapus* density and grazing utilization by year in each of the four established transects. In SFMCC and MCC, one can see a clear inverse relationship where *Zapus* density drops or rises in any particular year in response to grazing intensity.

When the data are parsed out by transect, the 4 new transects established in 2009 fall out of the analysis because only one year of data was available for each (Figure 7). The combined least-squares linear regression slopes for the 4 established transects are significantly less than zero (Figure 7; slope = -0.504, df = 18, p = 0.0002). The p-value of 0.0002 indicates that the relationship is strongly negative. Interestingly, the transect that appears to have the most neutral relationship is SLC. Of the four, this is also the transect with the most extensive wetland network created by beaver dams. It seems likely that PMJM at this site are somewhat buffered by heavy grazing because of the many 'micropatches' of thick willow and grasses that are inaccessible to cattle.

Figure 8 shows the data parsed by year (2004-2009) and includes the 4 new transects established in 2009. The combined least-squares linear regression slopes for all years is less than zero (slope = -0.39, df = 20, p = 0.0078). As in the analysis above, the p-value of 0.0078 indicates a strong negative relationship. We conclude, based on these tests, that grazing intensity has a clear inverse relationship to *Zapus* density.

Two of the four new transects (HG7, HB4) fall into the pattern seen at permanent transects, but the other two are outliers (LG13, LG19). Given differences in willow and graminoid cover between transects, one can assume that habitat quality or carrying capacity of PMJM also varies between sites. The fact that the negative relationship between grazing and *Zapus* is still is evident in the face of these differences in habitat, soils, and hydrology between transects only serves to underline the relationship.

CONCLUSIONS

Population monitoring of *Zapus* on fixed live-trapping transects on the Medicine Bow National Forest since 2005 have shown a stable or slightly increasing trend. This may, in part, be due to a lessening of drought conditions over the 5-year period. Seventeen species of small mammals were documented across transects with deer mice, voles, jumping mice, and shrews constituting the majority of captures.

Because PMJM are granivores and insectivores, they rely on well-developed riparian vegetation for food and cover. WYNDD's attempt to characterize *Zapus* habitat was unsuccessful in 2004, however subsequent research has highlighted the importance of high cover of native grasses, sedges, rushes, willows, and woody debris in riparian areas. Although we have not been able to study the influence of fire directly, we believe that riparian burns would result in a short-term loss of habitat for the PMJM. Re-establishment of riparian structure would probably result in re-colonization by PMJM in the long-term, however exotic plant invasion following fire could keep densities low.

An analysis of grazing intensity on the Pole Mountain Unit, blocked by transect (across years), and year (across transects) shows that as percent utilization increases, nearby jumping mouse density decreases. There appears to be a particularly strong relationship in SFMCC and MCC. A view of all transects and years suggests that grazing levels above 40-50% are considerably more influential in reducing *Zapus* density than lower grazing intensities. If managers choose to enhance or expand PMJM habitat on the Medicine Bow National Forest, they will want to consider increasing the extent and cover of willows, woody debris, and mesic graminoids. Two

potential tools in this effort are monitoring and limiting grazing intensity and improving bank water storage and riparian vegetation by promoting the colonization and expansion of beavers.

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TABLES

Table 1. 2009 Transect Location Information, Pole Mountain Unit, Medicine Bow National Forest. Trap Line Endpoint Coordinates (Universal Transverse Mercator projection, Zone 13, North American Datum of 1983). Where: START = Trap line start point; END = Trap line end point; UTME = Easting coordinate in meters; UTMN = Northing coordinate in meters.

Transect Name	Year Transect Established	Creek Location	Nearby USFS Grazing Monitoring Site Name	Mean %utilization in pasture 2006-2009	START UTME	START UTMN	END UTME	END UTMN
SLC	2005	South Lodgepole	C3	33%	0471210	4568079	0471439	4568049
MLC	2004	Middle Lodgepole	N5 & N8	49%	0473778	4569563	0474043	4569692
SFMCC	2004	S. Fork Middle Crow	G15 & G18	41%	0474317	4555784	0474419	4555761
MCC	2004	Middle Crow	G9 & G10	32%	0475341	4558354	0475518	4558355
LG19	2009	S. Fork Middle Crow	G19	28%	0471412	4556071	0471715	4556099
HG7	2009	Middle Crow	G7	42%	0472912	4558436	0472604	4558453
LC13	2009	N. Branch Middle Crow	C13	11%	0471033	4564549	0470693	4564626
HB4	2009	Middle Lodgepole	B4	48%	0469640	4569062	0469935	4569054

Table 2. Summary of Zapus captured during small mammal trapping efforts on the Medicine Bow National Forest in the summer of 2009.

Transect Results - 2009 (sampling dates)	**Trap Nights**		**Zapus Captured**		**Meters Trapped (+- 50 m)**	**Unique Zapus per km**
	Raw	***Adjusted***	***Total***	***Unique***		
SLC (July 20-24)	800	752	18	15	470	32
MLC (July 20-24)	800	722	1	1	510	2
SFMCC* (July 28-Aug 1)	800	612	2*	1*	400	3*
MCC (July 28-Aug 1)	800	709	31	20	370	54
LG19 (Aug 3-7)	800	770	3	3	340	9
HG7 (Aug 3-7)	800	730	24	17	380	45
LC13 (Aug 13-18)	800	774	8	4	370	11
HB4 (Aug 13-18)	800	778	4	4	330	12

* Trap disturbance from a predator at SFMCC caused mortalities of 9 unidentifiable small mammals. Results should be interpreted with caution.

Table 3. All captures by species and transect, during summer 2009 surveys for jumping mice (Zapus) on the Medicine Bow National Forest.

	Laramie Ranger District - Pole Mountain Unit							
Species	**LG19**	**HG7**	**LC13**	**HB4**	**MCC**	**MLC**	**SFMCC***	**SLC**
Deer mouse (*Peromyscus maniculatus*)	3	33	-	6	81	118	-	38
Unidentified microtus vole (*Microtus* sp.)	39	30	9	8	44	9	25	5
Suspected Preble's meadow jumping mouse (*Zapus hudsonius preblei*)	3	24	8	4	31	1	2	18
Unidentified shrew (*Sorex* sp.)	11	8	19	18	12	3	2	11
Water shrew (*Sorex palustris*)	-	-	2	-	-	-	1	-
Least chipmunk (*Tamias minimus*)	-	-	-	-	-	1	-	1
Golden-mantled ground squirrel (*Spermophilus lateralis*)	-	-	-	-	-	-	-	2
Bushy-tailed wood rat (*Neotoma cinerea*)	-	-	-	-	-	2	-	-
Short-tailed weasel (*Mustela* erminea)	-	-	-	1	-	-	-	-
Long-tailed weasel (*Mustela frenata*)	-	-	1	-	-	-	-	-
Unidentified Weasel (*Mustela sp.*)	-	-	5	-	-	-	-	-
Total Trap Nights (Adjusted)	770	730	774	778	709	722	612	752
Captures per 100 trap nights	7	13	6	5	24	19	5	10

* Continued trap disturbance from a predator during trapping effort at SFMCC caused mortalities of a number of small mammals. Results should be interpreted with caution.

FIGURES

Figure 1. Study Area in the Pole Mountain Unit of the Medicine Bow National Forest showing locations of the 8 survey transects trapped in 2009.

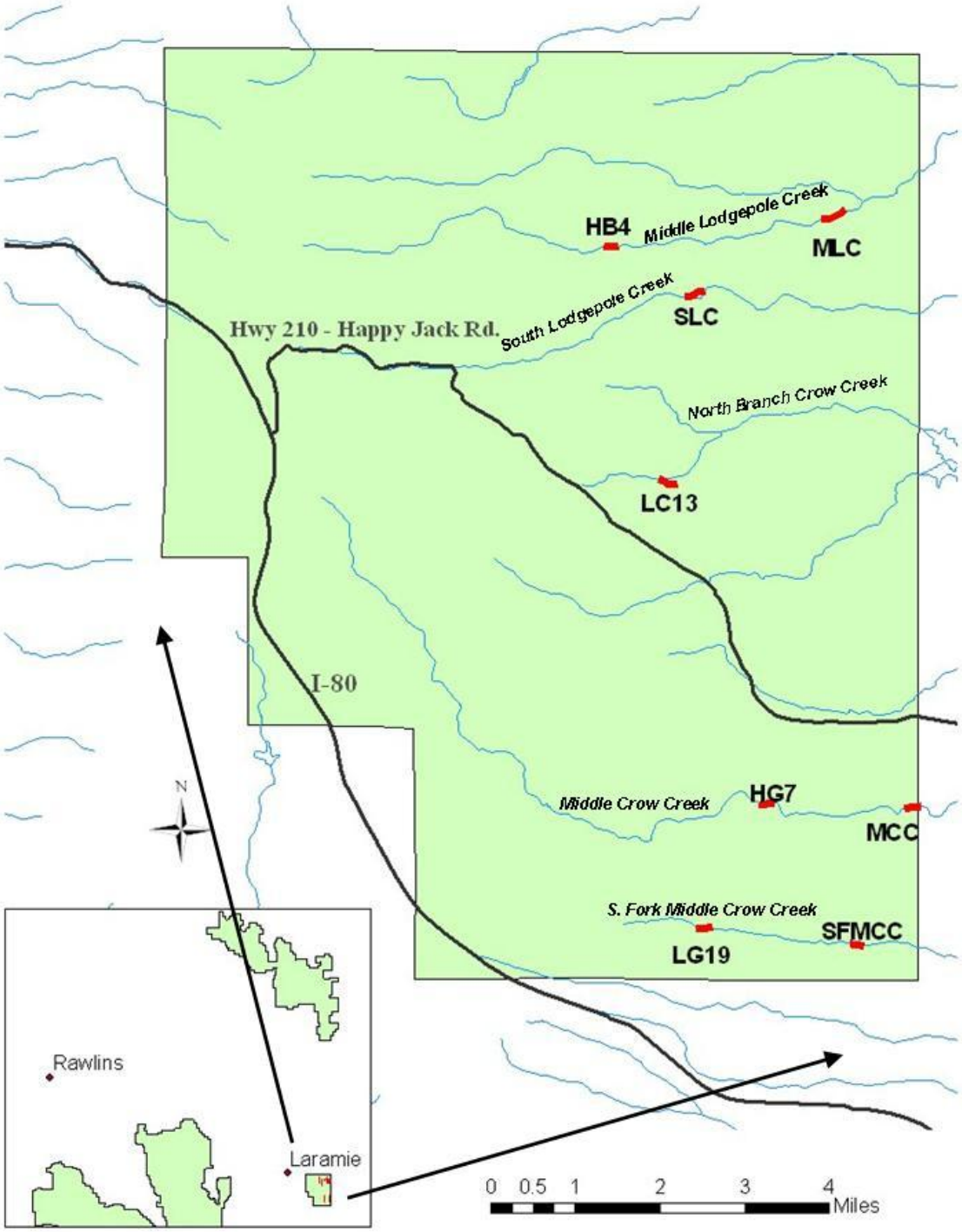


Figure 2. Abundance of Zapus on permanent transects from 2005-2009.

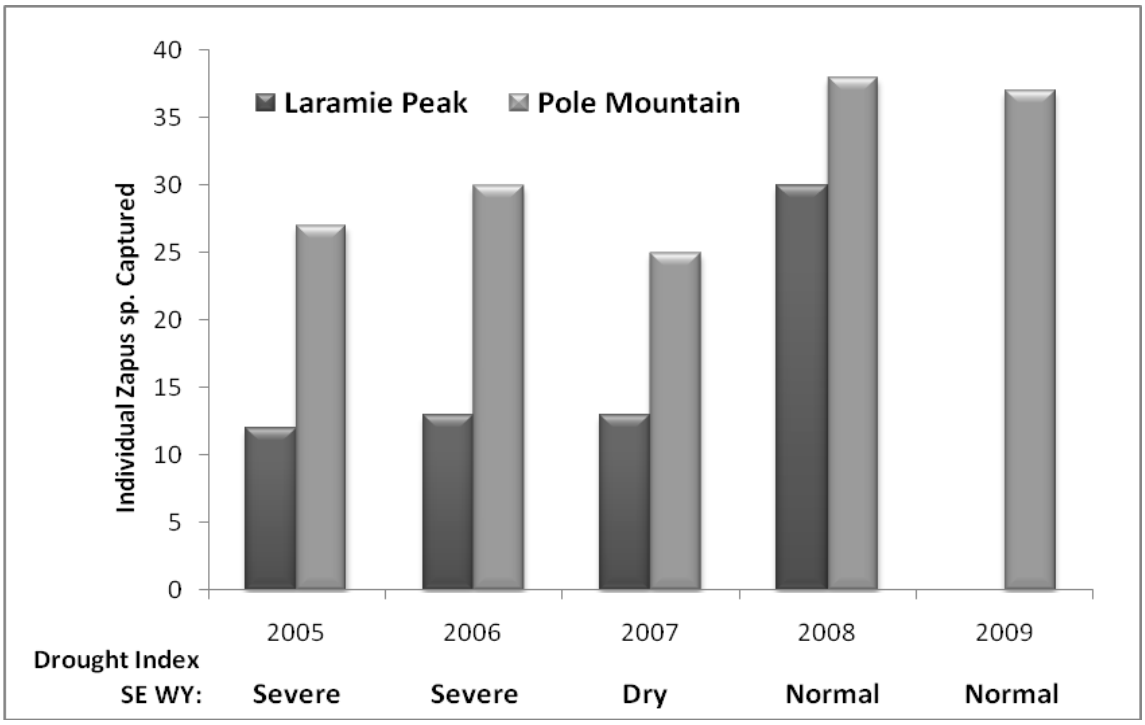


Figure 3. Number of Zapus captured at permanent small mammal transects on the Laramie Peak and Pole Mountain Unit from 2005 to 2009.

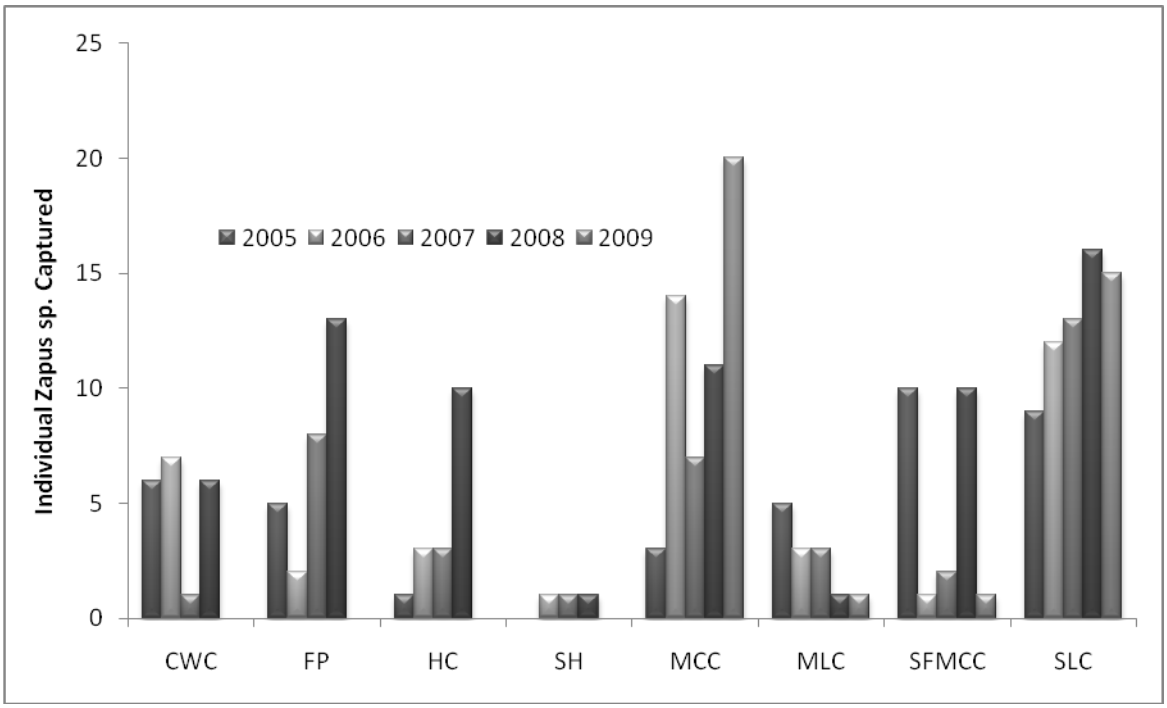


Figure 4. The number of individual Zapus captured on all transects in 2009.

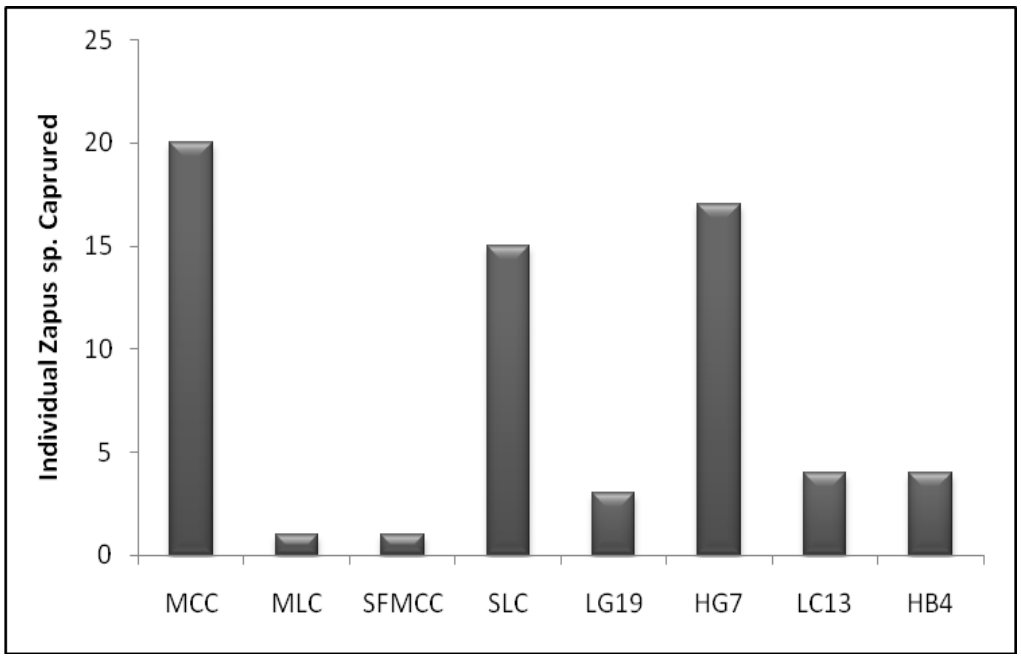


Figure 5. Density of Zapus as a function of grazing intensity in the same pasture, all data. Data are from the Pole Mountain Unit transects from 2004-2009 on the Medicine Bow National Forest.

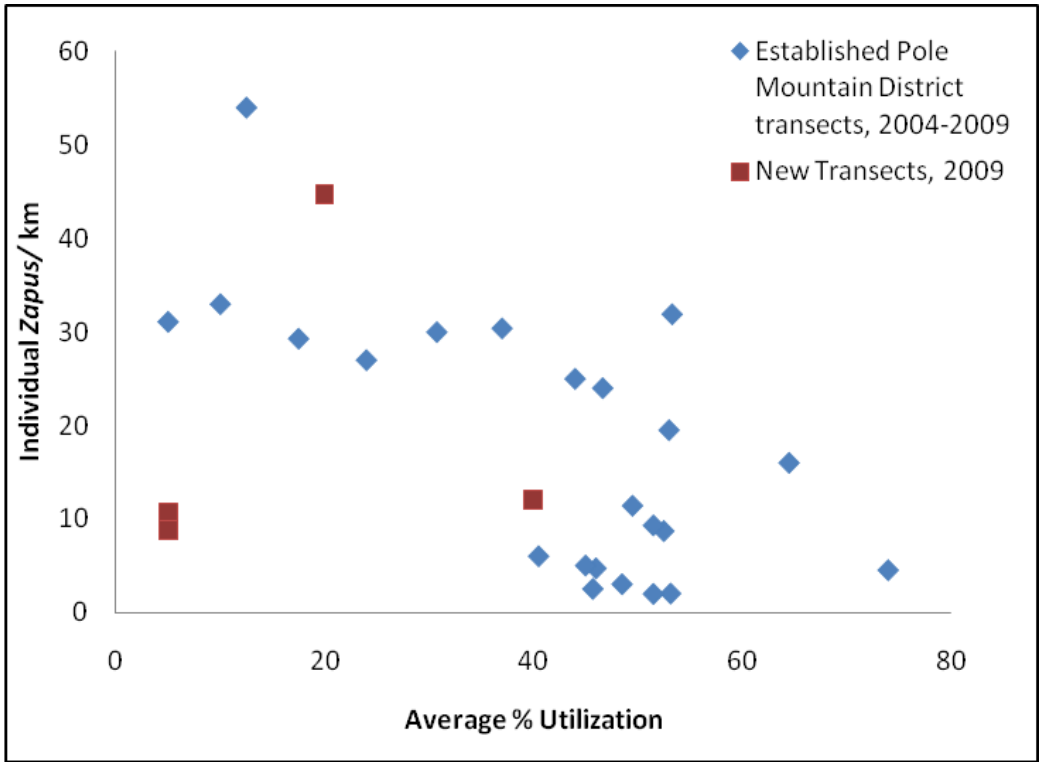


Figure 6. Density of Zapus as a function of nearby grazing intensity. Red triangles represent Zapus density and blue circles represent % utilization. Each graph shows multiple years of data collected along the same transect (2004-2009).

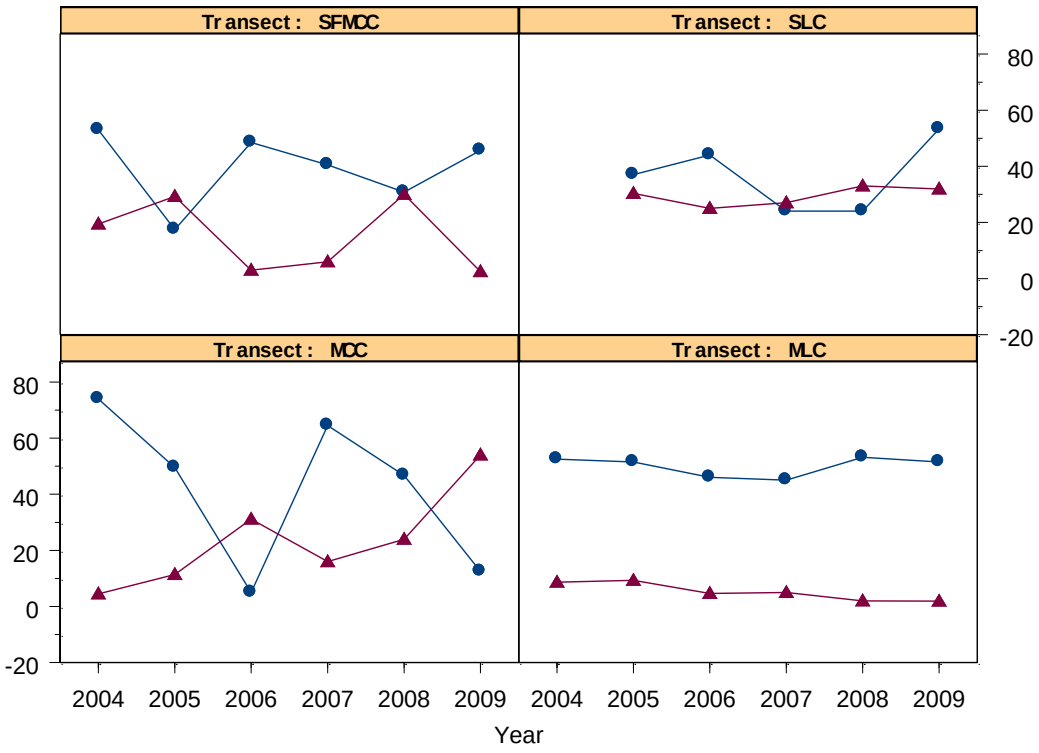


Figure 7. Density of Zapus as a function of nearby grazing intensity, by transect. Each graph represents multiple years of data collected along the same transect (2004-2009).

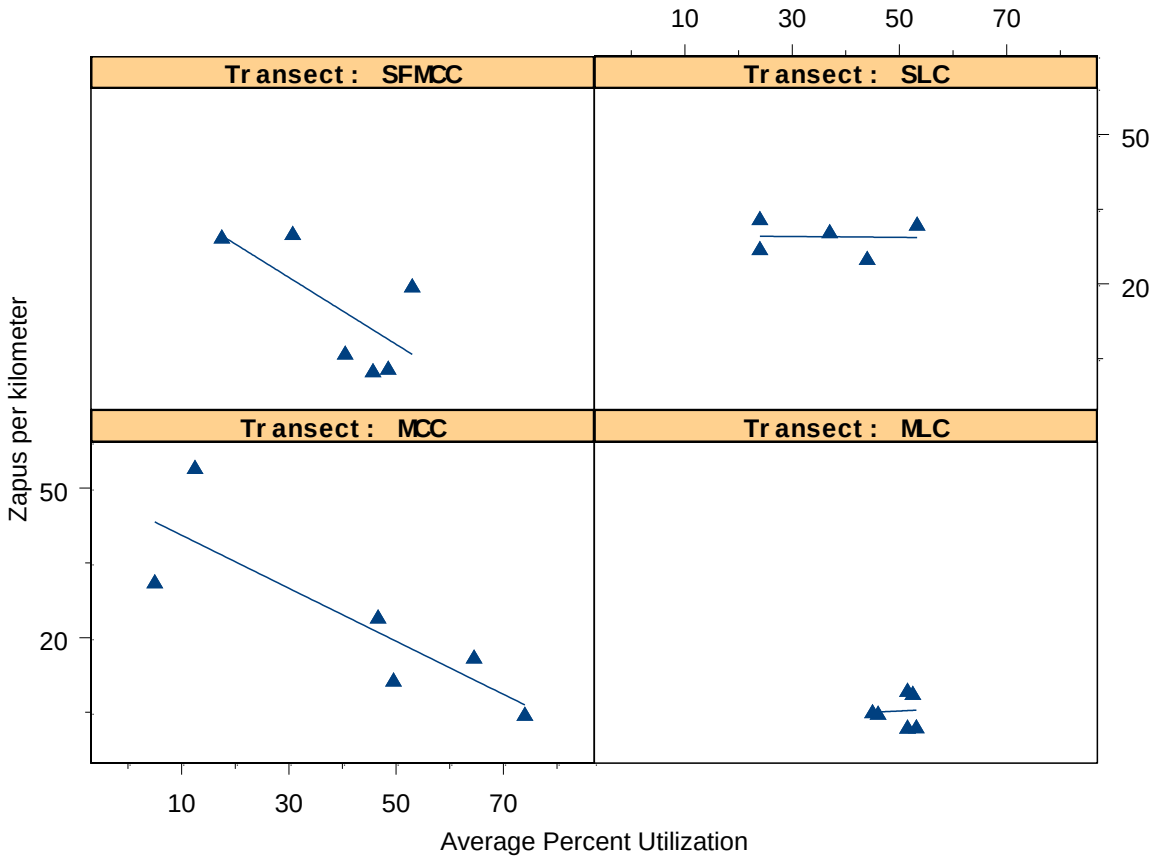
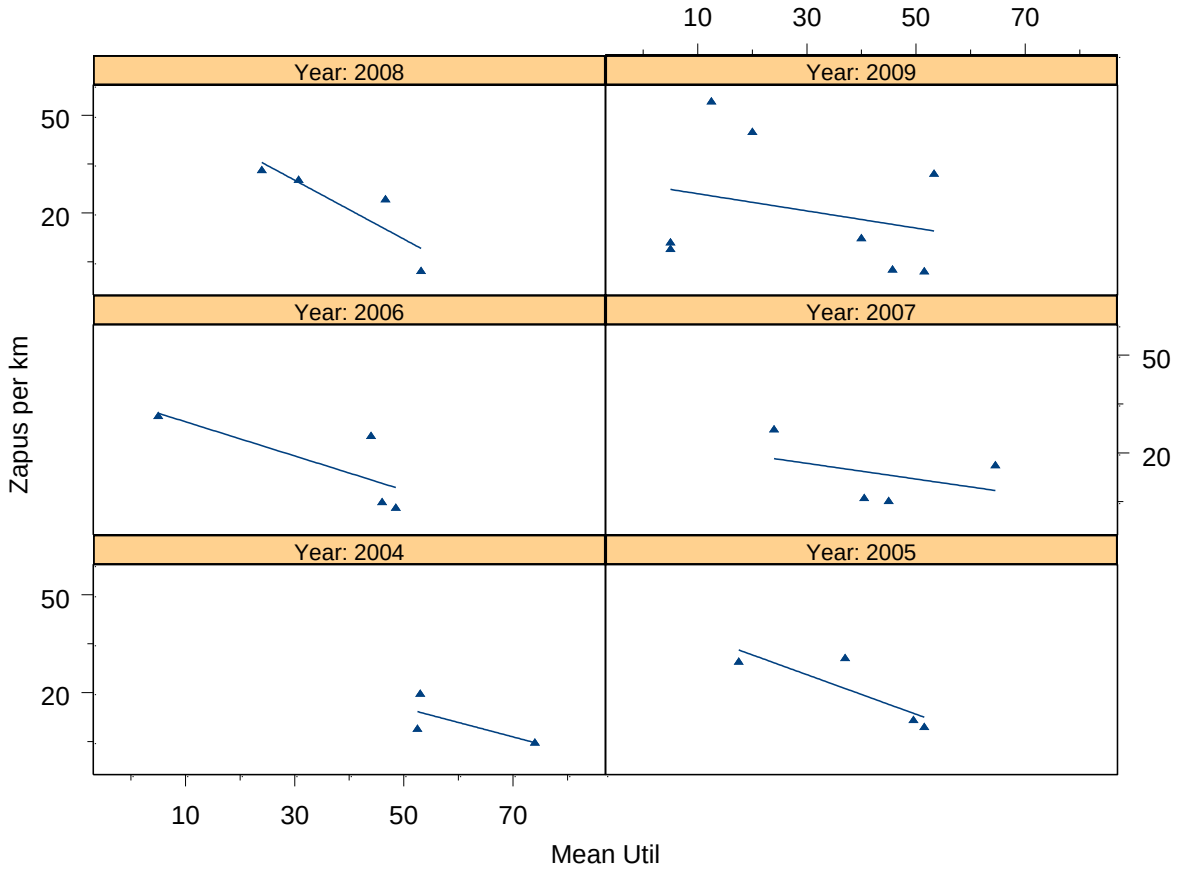


Figure 8. Density of Zapus as a function of nearby grazing intensity, by year. Each graph displays the transects surveyed that year (2004-2009).



APPENDIX A: Mammal and amphibian species documented a small mammal trapping transects in the Medicine Bow National Forest, 2004-2009.

Common Name	**Species Name**
Preble's meadow jumping Mouse	*Zapus hudsonius preblei* (USFWS, genetics)
Western jumping mouse	*Zapus princeps*
Southern red-backed vole	*Clethrionomys gapperi*
Long-tailed vole	*Microtus longicaudus*
Montane vole	*Microtus montanus*
Prairie vole	*Microtus ochrogaster*
Dusky shrew	*Sorex monticolus*
Water shrew	*Sorex palustris*
Deer mouse	*Peromyscus maniculatus*
Bushy-tailed wood rat	*Neotoma cinerea*
Least chipmunk	*Tamias minimus*
Red squirrel	*Tamiasciurus hudsonicus*
Northern pocket gopher	*Thomomys talpoides*
Golden-mantled ground squirrel	*Spermophilus lateralis*
Desert cottontail	*Sylvilagus audubonii*
Short-tailed weasel	*Mustela erminea*
Long-tailed weasel	*Mustela frenata*
Leopard frog	*Rana pipiens*
Crayfish	unknown

APPENDIX B: Maps of Transects