RELATIVE ABUNDANCE OF SMALL MAMMALS IN SAGEBRUSH STEPPE HABITATS IN RELATION TO VEGETATION CHARACTERISTICS

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ABSTRACT

The western border of South Dakota is located along a transition zone between the mixed grass prairie to the east and the sagebrush steppe habitat to the west. Several inhabitants of the sagebrush steppe community, such as the sagebrush vole (*Lemmiscus curtatus*), and Merriam's shrew (*Sorex merriami*) have been only collected from single localities in South Dakota. The purpose of this study was to document the relative abundance of small mammals in the sagebrush steppe region of western South Dakota in relation to vegetation characteristics. Small mammals were sampled on 35 sagebrush steppe sites using live traps, snap traps, and pitfalls. Percent cover of the shrub canopy and herbaceous understory was quantified by the line-intercept method and Daubenmire frames, and horizontal cover was estimated. Abundance of small mammals was then compared to metrics of local vegetation to determine the habitat associations of small mammals in the sagebrush steppe habitats that were sampled.

A total of 264 individual small mammals representing 9 species were captured out of a total of 6930 trap nights. Most notable was the capture of one sagebrush vole and two Merriam's shrews, but the deer mouse (*Peromyscus maniculatus*), and the thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) were the most abundant species captured. In 2001, deer mice were negatively correlated with percent grass cover between shrubs and positively correlated with percent bare ground between shrubs. In 2002, deer mice were positively

associated with average maximum width and height of *A. tridentata wyomingensis* and percent other ground cover between shrubs, and negatively associated with percent sagebrush cover, percent shrub cover, and number of *A. filifoli*a. No significant correlations were found for the thirteen-lined ground squirrel. Although our sample size was insufficient to perform a rigorous statistical analysis, hispid pocket mice were found only in stands of *A. filifolia*. Further research is needed to determine if small mammals are selecting habitat based on the local vegetation or other abiotic factors such as soil or topography.

Keywords

Habitat, sagebrush, Small mammals, *Artemisia*, rodents, steppe, deer mice, sagebrush vole, *Lemmiscus curtatus*, Merriam's shrew, *Sorex merriami*

INTRODUCTION

The western border of South Dakota lies along a transition zone between the sagebrush steppe habitat found mostly further to the west and the mixed grass prairie of western South Dakota. According to Jones et al. (1983), species of the Great Basin Faunal Element, such as Merriam's shrew (*Sorex merriami*), northern pocket gopher (*Thomomys talpoides*), and the sagebrush vole (*Lemmiscus curtatus*), join with members of the mixed-grass prairie community in this transition zone. Burning, bulldozing, grazing, herbicide treatment, and introduction of non-native grasses have significantly reduced the extent of sagebrush steppe habitat in the western United States (Branson 1985; Line 1997). Additionally, about 60% of mixed-grass prairie in South Dakota, North Dakota, and Montana has been converted to tillage agriculture (Higgins et al. 2002).

The small mammal fauna of the sagebrush steppe regions of western South Dakota has been documented by a few researchers, but most studies have focused on Harding County in the extreme northwestern corner of the state. Visher (1914) listed 40 species of mammals in an early survey of the region, but major portions of this area have been subsequently altered by the activity of humans (Higgins et al. 2002). Anderson and Jones (1971) reported 53 species of mammals from Harding County, but were unable to capture the sagebrush vole and Merriam's shrew, two species typically found in sagebrush-grassland habitat, despite intensive trapping in sagebrush flats to the north of Camp Crook.

Relatively little is known of the distribution and habitat associations of small mammals associated with sagebrush steppe. In 1970, a specimen of Merriam's shrew was captured 0.8 km west of the border between Carter County, Montana and Harding County, South Dakota (Lampe et al. 1974), but was not documented in South Dakota until 1993 in Butte County, South Dakota (Mullican 1994). The only record of sagebrush voles in South Dakota previous to this study was by Birney and Lampe (1971) who collected two specimens in northwestern Harding County. Thus, the transition zone between the sagebrush steppe and

the mixed-grass prairie of western South Dakota appears to be near the limit of the zone of tolerance for mammals of the Great Basin Faunal Element.

The purpose of this study was to document the number of small mammals in the sagebrush steppe region of western South Dakota in relation to vegetation characteristics. Selected sites that were part of a study of the influence of local vegetation on avian species (Lewis 2004) were sampled for small mammals using live traps, snap traps, and pitfalls. The line-intercept method (Canfield 1941) and PVC frames (Daubenmire 1959) were used to quantify the percent cover of shrub canopy and herbaceous understory, and horizontal cover was estimated by the staff-ball method of Collins and Becker (2001) on all study sites by Lewis (2004). Abundance of small mammals was then compared to metrics of local vegetation to determine the habitat associations of small mammals in the sagebrush steppe habitats that were sampled.

METHODS

Study Area

This study was conducted in Butte, Fall River, and Harding counties of western South Dakota from approximately 43.23° N to 45.75° N latitude, excluding the Black Hills of South Dakota, and from 103.26° W to 104.03° W longitude. Elevations ranged from 905 m in Butte County to 1190 m in Fall River County. This part of the Missouri Plateau overlies Cretaceous sediments of the Pierre, Fox Hills, and Hell Creek formations frequently interspersed with buttes of Tertiary sediments (Anderson and Jones 1971). Most of the study sites were grazed by cattle or sheep. Of the sites surveyed, 12 were in Butte County, 14 were in Fall River County, and 9 were in Harding County (Appendix A).

Western South Dakota is commonly classified as mixed-grass prairie (Brown 1985, Rotenberry and Wiens 1980) or at least not classified as shrubland (Wiens et al. 1987, Paige and Ritter 1999). However, two South Dakota reports have acknowledged that sagebrush exists in this area (SDOU 1991, Johnson and Larson 1999). Johnson and Larson (1999), characterized the area for this study as Wheatgrass-Big Sagebrush Plains, containing scattered to fairly dense dwarf shrubs, and dominated by western wheatgrass (*Agropyron smithii*), Wyoming big sage (*Artemisia tridentata wyomingensis*), Junegrass (*Koeleria macrantha*), Sandberg's bluegrass (*Poa secunda*), and needle-and-thread grass (*Stipa comata*). The eastern Fall River County study sites were exceptional because the dominant shrub on these sites was sand sagebrush (*A. filifolia*), which is rare or absent in the rest of the Dakotas.

Small Mammal Surveys

Small mammals were trapped during the summers of 2001 and 2002 along three 100 m transects spaced 10 m apart per study site, with the center transect located along the same line used for the vegetation sampling. One folding Sherman live trap ($7^1/_2$ x $7^1/_2$ x 20 cm) and one Museum Special snap trap

were placed at 10-m intervals along the length of each transect. Additionally, one pitfall trap made with a no. 10 tin can was placed at each station along the center transect only. Thus, a total of 33 Sherman live traps, 33 Museum Special snap traps, and 11 pitfall traps were placed on each study site. Live traps were pre-baited and locked open with clothespins one day before traps were set with a mixture of cracked corn, wheat, and millet. Mullican and Keller (1986) found that sagebrush voles (*Lemmiscus curtatus*) were captured much more frequently when using sliced carrots for bait, rather than using grain or peanut butter and grain mixtures typically used for trapping small mammals, so sliced carrots were added to the live traps and pitfall traps in addition to the grain mixture to attract sagebrush voles. Following the pre-baiting period, traps were set between 18:00 and 20:30 hours, and checked every morning for three consecutive days. Museum skins and skulls of representative individuals of each species captured were prepared and deposited in the Sternberg Museum at Fort Hays State University, Hays, Kansas.

Vegetation Sampling

Vegetation surveys were conducted by Lewis (2004) in conjunction with a study of the influence of local vegetation on the abundance of avian species in sagebrush steppe habitats of North and South Dakota. Details of the methods may be found in Lewis (2004). Shrub variables used in this study included: shrub cover (Canfield 1941, Higgins et al. 1994), average maximum height of shrubs (maximum height of individual shrubs averaged for each site), index of shrub size (maximum length by maximum width of individual shrubs averaged for each site), number of live shrubs, number of dead shrubs, and shrub density (shrubs/m^2). Herbaceous vegetation variables included: ground cover between shrubs and ground cover under shrubs (Daubenmire 1959). The ground cover types quantified were percent cover grass, percent cover forbs, percent bare ground, and percent cover of other materials, including rocks, litter, etc. In addition, maximum effective height of herbaceous vegetation within the Daubenmire frames, measured both between and under shrubs. Horizontal cover was quantified using a staff-ball method described by Collins and Becker (2001).

RESULTS

Two hundred sixty-four individual small mammals representing 9 species were captured on 35 study sites out of a total of 6930 trap nights in western South Dakota. No animals were captured in pitfall traps during either 2001 or 2002, so calculations of trap nights do not include pitfalls. The mean number of animals captured per 100 traps nights for live traps was 4.6 and was significantly higher, ($T=3.71$, $P=0.001$, d.f.=31) than the mean of 2.3 animals/100 trap nights for snap traps when tested with a paired sample t-test. Capture rates of small mammals were very low in 2001 with a mean of 3.0 animals per 100 trap nights, which was very highly significantly different ($T=-7.31$, $P<0.0001$, d.f.=24) from the mean of 13.7 animals per 100 trap nights for 2002.

The deer mouse (*Peromyscus maniculatus*) (total of 206 captures) and the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) (total of 34 captures) were the most frequently captured species, and were the only ones captured across enough of the study sites to warrant regression against vegetation metrics. Notable among the other species captured were two rare species for which there have only been one record each for South Dakota (Birney and Lampe, 1972; Mullican, 1994), the sagebrush vole (*Lemmiscus curtatus*) and Merriam's shrew (*Sorex merriami*) with one and two captures respectively. Other species captured, in decreasing order of their relative abundance, include the hispid pocket mouse (*Perognathus hispidus*), olive-backed mouse (*Perognathus fasciatus*), western harvest mouse (*Reithrodontomys megalotis*), grasshopper mouse (*Onychomys leucogaster*), and the house mouse (*Mus musculus*).

Species richness was low ranging from 0 to 4 over the 35 study sites sampled, with a mean ± 1 S.D. of 1.74 ± 1.22. The mean Shannon-Weaver diversity index ± 1 S.D. on those sites where at least one species was captured (N=27) was 0.631 ± 0.58. Diversity indices ranged from 0 to 1.96 over all sites sampled, and were greater in 2002 than in 2001.

Small Mammal Diversity versus Local Vegetation Variables

Simple linear regression of the Shannon-Weaver diversity index versus vegetation metrics revealed three variables which were statistically significant. Horizontal cover at 25 cm was significantly correlated with species diversity (ρ=0.415, p=0.032, d.f.=25). Maximum effective height of the herbaceous vegetation between shrubs (the tallest part of any herbaceous plant as measured in the large Daubenmire frames) also varied significantly with species diversity (ρ=0.431, p=0.025, d.f.=25), as well as the number of sand sage bushes (ρ=0.553, p=0.003, d.f.=25). A fourth variable, horizontal cover at 10 cm was almost significantly correlated with species diversity (ρ=0.378, p=0.052, d.f.=25). A multiple regression against diversity indices was performed using those variables whose coefficients were significantly different from zero, but was no better at explaining the variation in diversity than univariate analyses.

Deer Mouse Relative Abundance versus Local Vegetation Variables

F-tests for equality of variances of the relative abundance of deer mice between 2001 and 2002 and between early and late summer were performed to determine if data could be pooled over the time period of the study. Between 2001 and 2002, variances of the relative abundance of deer mice were significantly different (F=0.21, p=0.001, d.f.=21, 13). Between early summer and late summer, no significant differences were found in the variances of the relative abundance of deer mice (F=2.33, p=.102, d.f.=19, 15). Thus, data from both early and late summer were pooled in the following regression analyses of deer mouse relative abundance versus vegetation metrics.

During the summer of 2001, deer mice were negatively correlated with percent grass cover between shrubs (ρ=-0.525, p=0.014, d.f.=19), and positively correlated with percent bare ground cover between shrubs (ρ=0.616, p=0.003,

d.f.=19). In 2002, deer mice were negatively correlated with percent sagebrush cover (ρ=-0.695, p=0.018, d.f.=9), percent shrub cover (ρ=-0.672, p=0.024, d.f.=9), and the number of *A. filifolia* (ρ=-0.626, p=0.039, d.f.=9). Variables positively correlated with deer mice abundance in 2002 included average maximum width of Wyoming big sage (ρ=0.692, p=0.018, d.f.=9), average maximum height of Wyoming big sage (ρ=0.843, d.f.=9) and percent cover of other plants between shrubs (ρ=0.673, p=0.023, d.f.=9).

Thirteen-lined Ground Squirrel Relative Abundance versus Vegetation Variables

Between 2001 and 2002, variances of the relative density of thirteen-lined ground squirrels were not significantly different (F=0.509, P=0.182, d.f.=19, 12). Between early summer and late summer trapping periods, variances of the relative density of thirteen-lined ground squirrels were significantly different (F=0.365, P=0.049, d.f.=18, 13). Thus, for all regression analyses, data from 2001 and 2002 for *S. tridecemlineatus* were pooled, whereas regressions of relative abundance of *S. tridecemlineatus* were performed separately on data from the late summer trapping period. Too few animals were captured to perform regression analyses for relative abundance of thirteen-lined ground squirrels versus vegetation variables for early summer trapping periods.

There were no statistically significant associations of thirteen-lined ground squirrels with vegetation variables in 2002. Mean values of vegetation characteristics appeared to be similar on areas where thirteen-lined ground squirrels were captured versus those areas where none were captured. *A. cana* was present on three of the areas where thirteen-lined ground squirrels were captured, but was not found on areas where they were not captured. Likewise, *A. filifolia* was found on five of the areas where thirteen-lined ground squirrels were captured, but was not found where they were not captured. Overall, the relative density of thirteen-lined ground squirrels was low, with a mean of 0.5 individuals/100 trap nights.

Local Vegetation Associated with the Hispid Pocket Mouse

The hispid pocket mouse (*Perognathus hispidus*) was captured on only two study sites in Fall River County. Thus, the small sample size precluded rigorous statistical analysis. There was a qualitative difference in the local vegetation on the sites where *P. hispidus* was captured compared to those areas where they were not found. *P. hispidus* was only captured on those areas where *A. filifolia* was present and *A. tridentata wyomingensis* was absent (Fig. 1). *A. filifolia* was also found on another study site where *P. hispidus* was absent, but only a small number of plants were recorded and *A. tridentata wyomingensis* was the dominant shrub.

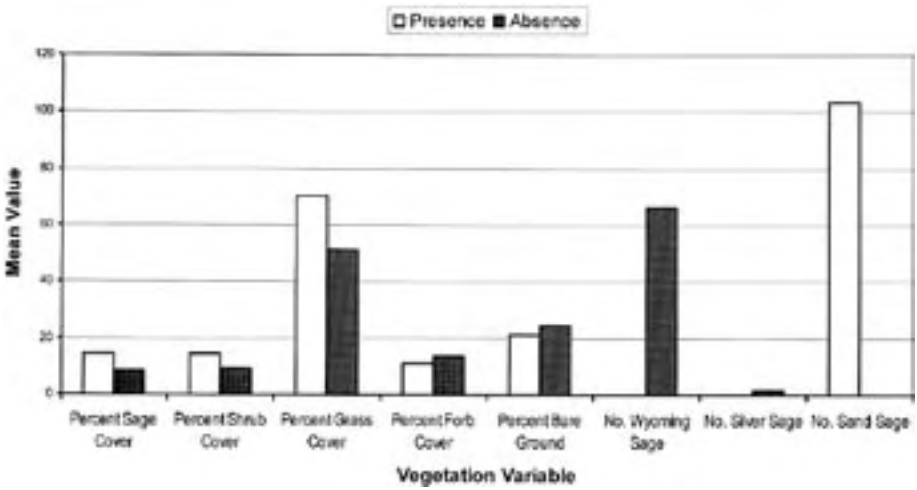

Figure 1. Comparison of mean vegetation variables on sites where* P. hispidus *was captured (N=2) versus mean values on sites where it was absent (N=31). Percent cover estimates for grass, forbs, and bare ground were measured between shrubs.

Local Vegetation Associated with the Presence of the Olive-backed Mouse

The olive-backed mouse (*Perognathus fasciatus*) was found in widely scattered areas, but appeared to prefer areas where sand sage was abundant (fig. 2) in Fall River County. The number of *A. tridentata wyomingensis* was lower and percent grass cover between shrubs was higher on study sites where this species was present. However, the small sample size precluded any rigorous statistical testing of hypotheses concerning the vegetation associations of the olive-backed pocket mouse.

Local Vegetation Associated with the Presence of the Western Harvest Mouse

The western harvest mouse (*Reithrodontomys megalotis*) was only captured on three sites located in Fall River County. A comparison of mean vegetation variables on two of the areas where the western harvest mouse was present with the mean values where it was not captured is shown in fig. 3. *R. megalotis* was captured in typical stands of Wyoming big sage that did not appear to be any different from those stands where it was absent (fig. 3).

Local Vegetation Associated With the Presence of Merriam's Shrew

Merriam's shrew (*Sorex merriami*) was only captured on two sites in Butte County (T11N, R2E, Sec. 23, NW 1/2 and T11N, R2E, Sec. 3, NE 1/2). Both of these areas were within 22 km of the site where the first specimen of *S. mer-*

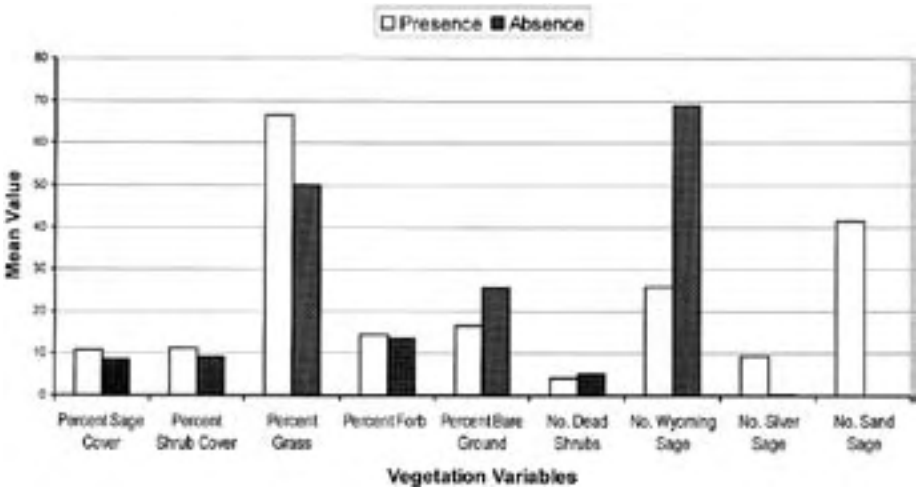

Figure 2. Comparison of mean vegetation variables on sites where* P. fasciatus *was present (N=3) versus mean values on sites where it was absent (N=30). Percent cover estimates for grass, forbs and bare ground were measured between shrubs.

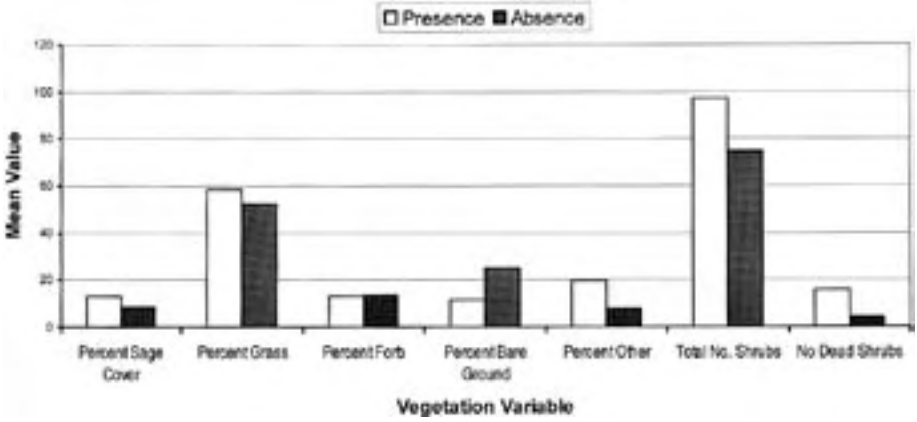

Figure 3. Comparison of mean vegetation variables on sites where* R. megalotis *was present (N=2) versus mean values on sites where it was absent (N=31). Percent cover estimates for grass, forbs and bare ground were measured between shrubs.

riami was recorded for South Dakota (Mullican, 1994). The percent grass cover between shrubs was higher and the total number of shrubs was lower on those areas where *S. merriami* was captured compared to those areas where it was absent (fig. 4); however, the small sample size precluded any statistical comparison of vegetation data. One of the areas where *S. merriami* was captured was located next to a dry wash, which was also the case for the first area where this species was recorded (Mullican, 1994).

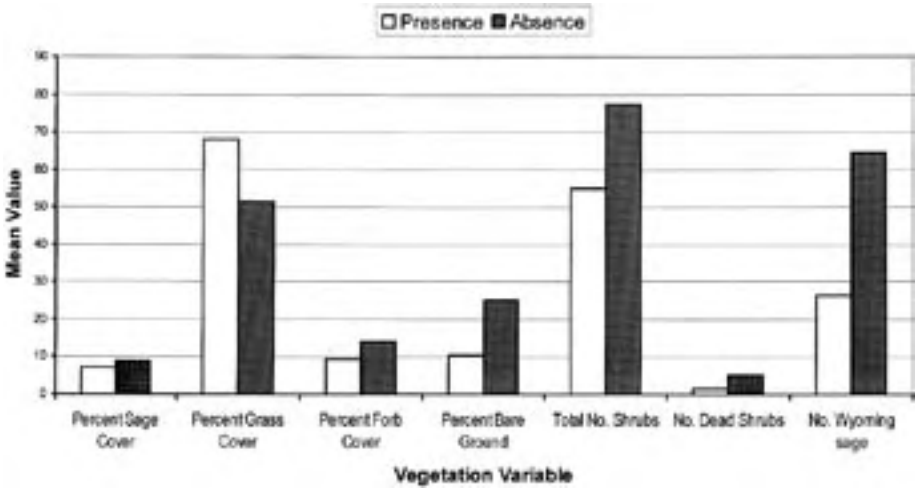

Figure 4. Comparison of mean vegetation variables for sites on which* S. merriami *was present (N=2) versus those where it was absent (N=31). Percent cover estimates for grass, forbs and bare ground were measured between shrubs.

Local Vegetation Associated with the Presence of the Northern Grasshopper Mouse

Only two northern grasshopper mice (*Onychomys leucogaster*) were captured in this study; one in Butte County and one in Harding County. Mean sagebrush, total number of shrubs, and percent grass cover between shrubs were slightly lower on those areas where *O. leucogaster* was present compared to those areas where it was absent (fig. 5). Horizontal cover at 25 and 50 cm was also lower on those areas where this species was present. However, these observations must be considered to be anecdotal due to the small sample size.

Local Vegetation Associated With the Presence of the Sagebrush Vole

One sagebrush vole (*Lemmiscus curtatus*) was captured in Butte County (T14N, R5E, Sec. 19, SE 1/4) about 3 km N of the South Fork of the Moreau River in an area that appeared to be heavily grazed by domestic sheep. The percent grass cover between shrubs and number of live shrubs was lower on this area than on those areas where this species was absent (fig. 6). Additionally, the percent bare ground between shrubs and number of dead shrubs was higher on this area than those areas where it was absent (fig. 6).

Local Vegetation Associated with the House Mouse

One specimen of the house mouse (*Mus musculus*) was captured in a dense stand of *A. tridentata wyomingensis* located near the edge of the town of Edgemont in Fall River County. The presence of this species on this site was most likely related to the proximity to human habitations rather than the local vegetation however.

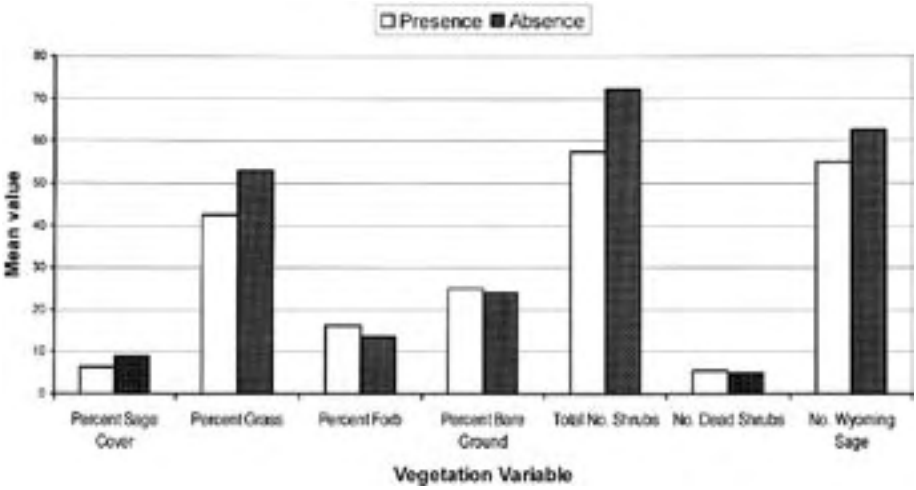

Figure 5. Comparison of mean vegetation variables on those sites where* O. leucogaster *was present (N=2) versus those where it was absent (N=31). Percent cover estimates for grass, forbs and bare ground were measured between shrubs.

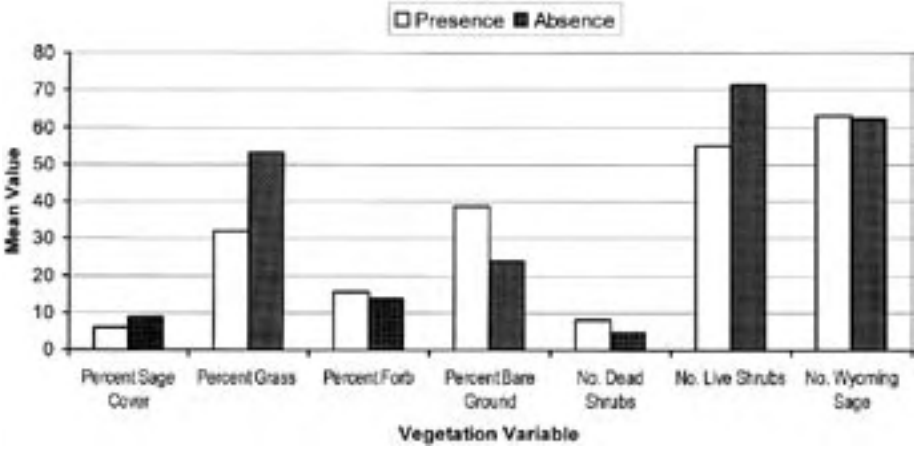

Figure 6. Comparison of mean vegetation variables on sites where* L. curtatus *was captured (N=1) versus mean values on sites where it was absent (N=32). Percent cover estimates for grass, forbs and bare ground were measured between shrubs.

DISCUSSION

Deer Mice

The deer mouse is one of the most ubiquitous small mammals of North America, occupying nearly every conceivable habitat including open grasslands, brushy country, badlands, cliffs, coniferous woodlands, shelterbelts, pastures, and croplands (Jones et al. 1983). The only habitats not typically inhabited by deer mice are dense woodlands and riparian areas occupied by the white-footed

mouse. In this study, deer mouse abundance did not appear to vary with sagebrush cover in 2001, but was negatively associated in 2002. Deer mice are omnivorous and feed opportunistically on a variety of plant and arthropod material (Jones et al. 1983), which may fluctuate annually with climate. According to the National Agricultural Statistics Service (http://www.nass.usda.gov/sd/bulletin/Ab02013.pdf), precipitation during the 2000 growing season (1 April 2000– 30 September 2000) was below average in northwestern South Dakota, but was above average in 2001. Thus, the differences in habitat associations between 2001 and 2002 may have been due to differences in local food availability as a result of differential plant growth from the previous growing season.

Thirteen-lined Ground Squirrels

According to Higgins et al. (2000), thirteen-lined ground squirrels are found mostly in short and mid-length grasslands, prairie dog towns, and disturbed areas such as roadsides. They are very widespread in the northern Great Plains, but avoid tall grass which may obscure their view of predators (Jones et al. 1983). MacCracken et al. (1985) found that thirteen-lined ground squirrel densities were 2-4 times higher in grassland areas than sagebrush-grassland areas of southeastern Montana, and were significantly correlated with grass, prickly pear, and bare ground cover. The lack of any statistically significant associations in this study may have been due to the small sample size and that sagebrush steppe is not the preferred habitat for thirteen-lined ground squirrels.

Hispid Pocket Mice

Hispid pocket mice exhibit a preference for loamy soils (Jones et al. 1983; Higgins et al. 2000). According to Jones et al. (2000) hispid pocket mice prefer areas with considerable bare ground. The amount of bare ground did not appear to be any different on the areas where this species was captured compared to those areas where it was absent. The soil on the sites where *P. hispidus* was captured was of the Dailey-Ascalon Association, which consists of sandy and loamy soil (Lewis, 2004). These areas were unique among the study sites in that the dominant shrub on these sites was sand sage (*A. filifolia*). Thus, in southwestern South Dakota, hispid pocket mice would be expected to be found in stands of sand sage located in sandy, loamy soil. This species is a seed eater and may be able to coexist with the olive-backed pocket mouse by occupying different microhabitats or by partitioning food based on size within these stands of sand sage. Further studies are needed to determine the amount of competition and microhabitat preferences of the hispid pocket mouse and the olive-backed pocket mouse in southwestern South Dakota.

Other Species

Other species of small mammals were captured in insufficient numbers to make generalizations concerning their habitat preferences. Two rare species, however, were captured that are noteworthy. The sagebrush vole and Merriam's

shrew have only been reported once in South Dakota previous to this study (Birney and Lampe 1972; Mullican 1994). These species are both considered to be sagebrush obligate species, and are rarely found in other habitats. It may be that the lack of bunchgrasses, which are typically dominant further to the west, or competition from the prairie vole (*Microtus ochrogaster*) which is known to inhabit western South Dakota (Mullican, unpublished data), may limit the number of sagebrush voles. Nonetheless, the apparent scarcity of these two species and their absence across large areas of seemingly suitable habitat suggests that their populations should be closely monitored to assure that they remain a part of the fauna of South Dakota.

It is important to note that the vegetation associations found in this study do not necessarily imply causal relationships. Small mammals in western South Dakota may select habitats based on soil or topography, which may in turn affect plant cover. Plant cover does affect food availability and potential nesting sites however. Local vegetation is also an easily identifiable landscape feature used by researchers involved in Gap Analysis programs (Crist 1995) that compare the potential habitat of animals with their actual distribution in order to make educated decisions regarding land management practices in protected areas. The apparent lack of sagebrush obligate species such as Merriam's shrew and the sagebrush vole on the majority of the sites in this study suggests that these species should be carefully examined by those involved with the South Dakota Gap Analysis Program and the South Dakota Natural Heritage Program.

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LITERATURE CITED

Birney, E.C., and R.P. Lampe. 1972. Sagebrush vole (*Lagurus curtatus*) in South Dakota. American Midland Naturalist. 88:466.

Branson, F.A. 1985. Vegetation changes on western rangelands. Range Monograph 2. Society for Range Management, Denver, CO.

Canfield, R.H. 1941. Application of the line intercept method of sampling range vegetation. J. Forestry. 39:388-394.

Collins, W.B., and E.F. Becker. 2001. Estimation of horizontal cover. J. of Range Management. 54:67-70.

Crist, P. 1995. Gap Analysis: A federal initiative for cooperative data development, analysis, and planning. Environmental Planning. 12:3-5.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science. 33:43-64.

Higgins, K.F., E. Dowd-Stukel, J.M. Goulet, and D.C. Backlund. 2000. Wild mammals of South Dakota. South Dakota Department of Game, Fish, and Parks, Pierre, SD.

Higgins, K.F., J.L. Oldemeyer, K.J. Jenkins, G.K. Clambey, and R.F. Harlow. 1994. Vegetation Sampling and Measurement p. 567-591 in Research and management techniques for wildlife habitats (T.A. Bookhout, ed.). The Wildlife Society, Bethesda., MD.

Higgins, K.F., D.E. Naugle, and K.J. Forman. 2002. A case study of changing land use practices in the northern Great Plains, U.S.A.: an uncertain future for waterbird conservation. Waterbirds. 25:42-50.

Jones, J.K, Jr, D.M. Armstrong, R.S. Hoffman, and C. Jones. 1983. Mammals of the northern Great Plains. University of Nebraska Press. 379 pp.

Lampe, R.P., J.K. Jones, Jr., R.S. Hoffman, and E.C. Birney. 1974. The mammals of Carter County, southeastern Montana. Occasional Papers of the Museum of Natural History, the University of Kansas. No. 25: 1-39.

Lewis, A.R. 2004. Sagebrush steppe habitats and their associated bird species in South Dakota, North Dakota, and Wyoming: life on the edge of the sagebrush ecosystem. Dissertation, Dept. of Fisheries and Wildlife Sciences, South Dakota State University, Brookings, SD.

Line, L. 1997. Twilight of America's grasslands. National Wildlife 35:20-29.

MacCracken, J. G., D. W. Uresk, and R. M. Hansen. 1985. Rodent-vegetation relationships in southeastern Montana. Northwest Science. 59:272-278.

Mullican, T.R. 1994. First record of Merriam's Shrew from South Dakota. Prairie Naturalist. 26: 173.

Mullican, T.R. and B.L. Keller. 1986. Ecology of the sagebrush vole (*Lemmiscus curtatus*) in southeastern Idaho. Canandian J. of Zoology 64:1218-1223.

Visher, S.S. 1914. Report on the biology of Harding County, northwestern South Dakota. Bulletin South Dakota Geological Survey. 6:1-103.