A Faunal Survey of the Centennial Valley Sandhills, Beaverhead County, Montana

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Prepared by:

Paul Hendricks and Michael Roedel

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State Library Building • P.O. Box 201800 • 1515 East Sixth Avenue • Helena, MT 59620-1800 • 406-444-3009

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Executive Summary

The Montana Natural Heritage Program, in partnership with Red Rock Lakes National Wildlife Refuge and the Bureau of Land Management—Dillon Field Office, has completed a terrestrial faunal survey of the Centennial Valley Sandhills of southeastern Beaverhead County. No previous comprehensive animal survey has been conducted in these Sandhills, the second largest sandhills complex in Montana. This work compliments previous studies of the plants and vegetation dynamics in the Centennial Sandhills by associating a number of animal species to specific physical features and successional stages at this site. Maintaining the current diversity of animals will depend upon the controlled introduction of disturbance processes such as fire and grazing to create a mosaic of vegetation in various stages of succession. Disturbances should be conducted at scales appropriate for the entire Centennial Valley as well as the Sandhills specifically.

The Sandhills support a diverse array of vertebrates and invertebrates with affinities to shrub-steppe habitats more representative of the entire Centennial Valley. Eighteen mammal species, 29 bird species, 3 amphibian and reptile species, 4 tiger beetle species, and 14 butterfly and skipper species were documented in the Sandhills during the 1999 survey.

Three state mammal species of special concern were documented: Preble's Shrew (*Sorex preblei*), Black-tailed Jackrabbit (*Lepus californicus*), and Great Basin Pocket Mouse (*Perognathus parvus*). Preble's Shrew is collectively the twentieth state record and the first for Beaverhead County, Black-tailed Jackrabbit is the fourteenth state record, and Great Basin Pocket Mouse is the first record for the Centennial Valley and the first record for Montana since 1961. The shrew appeared to be widespread at low density, the jackrabbit was observed in stabilized sandflats with scattered sagebrush cover, and the pocket mouse was associated with scattered sagebrush in stabilized low-dune habitat. A fourth species of special concern, Pygmy Rabbit (*Brachylagus idahoensis*) was not seen in 1999 but has been reported recently in the Sandhills in stands of dense big sagebrush.

Three Montana Partners In Flight (PIF) Priority II bird species (Sage Thrasher, Brewer's Sparrow and Grashopper Sparrow) were present daily. The thrasher was associated only with tall and mature big sagebrush, the Brewer's Sparrow also was associated with sagebrush, but in a variety of size classes. Grasshopper Sparrow, a rare transient species in the Centennial Valley, was present in a localized site of grassy habitat with little shrub cover. Defensive behavior by a pair of Long-billed Curlews, and discovery of an old nest of Ferruginous Hawk, both PIF Priority II species, indicated these species bred in the Sandhills.

Two tiger beetle species, *Cicindela formosa* and *C. decemnotata*, were common in sandy blowouts or other early-seral sites, but in different parts of the Sandhills. *C. tranquebarica*, was localized on or near sites where sandy or pebbly soil was somewhat moist. *C. longilabris*, was encountered only twice in sandy sites with moderate shrub and grass cover. The rare Idaho Dunes Tiger Beetle (*C. arenicola*), endemic to Idaho and present 64 km (40 miles) south in the St. Anthony Dunes (Fremont County), was not encountered but may occur.

As opportunities present themselves, additional surveys of selected groups/species with specific habitat or food needs (small mammals, songbirds, ground beetles, butterflies) may be warranted. In addition, surveys of all animal groups should be conducted throughout the Centennial Valley to identify the significance of the sandhill-associated fauna to the entire valley system.

Acknowledgements

We are especially grateful to Jim Roscoe (BLM Dillon Field Office) and Danny Gomez (Red Rock Lakes National Wildlife Refuge) for their interest and support of this project on BLM and USFWS lands. Through their guidance and on-the-spot orientation, field work was more productive than it might otherwise have been. We thank Stan Vlahovich (Montana DNRC) and Bill and Judy Staudenmeyer for permission to visit state and private lands, respectively, under their stewardship. Tim Swanson (TNC) provided useful landowner contacts for the Centennial Valley Sandhills area.

For help with specimen identification we thank Dave Dyer (University of Montana: shrews), Kerry Foresman (University of Montana: shrews), Mike Ivie (Montana State University: tiger beetles), Will Kerling (Missoula: butterflies), and Steve Kohler (Montana DNRC: butterflies). For permission to examine museum collections of tiger beetles we thank Frank Merikel (University of Idaho) and Rich Zack (Washington State University). Ryan Rauscher (Montana FWP) provided records of Pygmy Rabbit in the sandhills area, and Dennis Flath (Montana FWP) shared his knowledge of small mammal records (especially shrews and pocket mice) from the Centennial Valley and elsewhere in Beaverhead County.

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Introduction

Extensive sandhills are rare in Montana. The state's 2 major areas of sandhills lie at extreme opposite corners of the state – the largest in northeastern Montana near the Medicine Lakes in Sheridan County, and the second largest in southwestern Montana in the Centennial Valley of Beaverhead County — both partially within National Wildlife Refuges. While the flora of these areas has been studied recently (Cooper et al. 1999, Lesica and Cooper 1999, Heidel et al. 2000), the fauna has not been as well documented, especially that of the Centennial Sandhills.

Sandhills terrain is a product of wind and sand. Sandhills occur in wind corridors where blowing sand might be funneled, in the windward foothills of mountain ranges, and in areas where wind speeds are no longer sufficient to move sand any farther or where improved growing conditions increase the probability of dune stabilization by plants. Sandhills are characterized by erodible, well-drained soils that are very susceptible to disturbances such as fire, grazing, and burrowing (Knight 1994). Sandhills often occur as isolated patches across a regional landscape, and contribute significantly to local biodiversity by supporting distinctive species and communities. Because disturbance can easily alter these sites, sandhill complexes support vegetation in various stages of succession, often harboring early-succession species and communities that are rare at local, regional or global scales and dependent on disturbance for survival (Lesica and Cooper 1999). For example, the Centennial Sandhills support 4 rare plant species that are restricted to early succession sites (Lesica and Shelly 1991, Lesica and Cooper 1999): Idaho painted milkvetch (*Astragalus ceramicus* var. *apus*), Idaho pale evening-primrose (*Oenothera pallida* var. *idahoensis*), Fendler's cat's-eye (*Cryptantha fendleri*), and sand wildrye (*Elymus flavescens*). Sandhills habitats also support animal species of limited distribution, some of which (usually invertebrates) are sand-obligate species (Rumpp 1967, Knisley 1979, Rust 1986).

The flora and fauna of Beaverhead County, which includes the Centennial Sandhills, have affinities to the Great Basin (Dorn 1978, Lesica et al. 1984, Hoffmann and Pattie 1968, Hoffmann et al. 1969b). These natural similarities distinguish this sandhill complex from the Medicine Lake Sandhills in northeastern Montana. Five mammal species on the state special concern or watch lists are limited to southwestern Montana (Black-tailed Jackrabbit, Pygmy Rabbit, Wyoming Ground Squirrel, Great Basin Pocket Mouse, Western Spotted Skunk), and two other species of concern (Preble's Shrew, Merriam's Shrew) are associated with habitats found in the Centennial Valley, especially sagebrush-steppe (Armstrong and Jones 1971, Cornely et al. 1992).

In addition, the rare Idaho Dunes Tiger Beetle (*Cicindela arenicola*), currently known only from Idaho, occurs in the St. Anthony Dunes of Fremont County (Rumpp 1967, Logan 1995, Pearson et al. 1997) only 64 km (40 miles) south of the Centennial Valley Sandhills. Because the valley is remote and near the edge of several species' distributions, and has not been well surveyed, there is good potential to find this or other species new to Montana, as well as, an opportunity to document significant range extensions of more common species. This is especially true for small mammal and tiger beetle communities, since these groups contain species that are habitat specific and/or are relatively obscure and poorly documented in Montana, particularly in sandhills and shrub-grassland habitats.

Because of the very limited distribution of sandhills habitat in Montana and the distinctive nature of its plants and animals, documenting the fauna is an important first step toward effective management of the biological diversity associated with these habitats. The objectives of this study were to:

1) document the vertebrate species present in the Centennial Sandhills;

2) document selected groups of invertebrates (especially tiger beetles);
3) identify relationships between species distributions, stages of vegetation succession and sandhills physiognomy; and
4) provide information to assist managers in maintaining the faunal diversity of this unique area.

Study Area

Centennial Valley

The Centennial Valley of Beaverhead County, located about 80 km west of Yellowstone National Park, is a relatively undeveloped area of Montana and a biodiversity "hot spot" (Povilitis and Mahr 1998). The valley is about 75% public and 25% private ownership. Public lands include units administered by the U. S. Fish and Wildlife Service, U. S. Bureau of Land Management, U. S. Forest Service, and State of Montana. Livestock grazing and livestock-related agriculture are the principal land uses.

The valley is an east-west trending basin about 60 km in length of 1600 km^2 within the "Southwest Montana Intermontane Basin and Valleys" subsection of the Beaverhead Section (Nesser et al. 1997). The climate is cold and continental, with warm dry summers and cold dry winters, and is characterized by 22-50 cm of precipitation, of which 10% falls as snow. The steep-sloped Centennial Mountains form the valley's southern boundary, with several summits between 2850 and 3087 meters in elevation. The Continental Divide runs along the crest of the Centennial Mountains, which form the north rim of the broad Snake River basin to the south. The less rugged Gravelly and Snowcrest ranges lie to the north of the valley, each with elevations exceeding 3180 m. This broad, flat-bottomed basin was likely formed both by erosion and by downfaulting which has occurred here since the Miocene (Alden 1953). The gradient of the valley floor is very slight, and there is little evidence of downcutting at the outflow of the Red Rock Lakes (Banko 1960).

The valley supports over 700 plant species and at least 20 major vegetation community types, including the rare three-tip sagebrush-Idaho fescue (*Artemisia tripartita-Festuca idahoensis*) type that forms the climax vegetation of the Centennial Sandhills (Lesica and Cooper 1999). Over 261 bird species have been documented for the valley, including the Trumpeter Swan (*Cygnus buccinator*), which Red Rock Lakes National Wildlife Refuge was established to protect. The valley also hosts one of the two remaining native populations of Montana Arctic Grayling (*Thymallus arcticus montanus*), and one of three known native populations of Lake Trout (*Salvelinus namaycush*). In addition, the eastern portion of the valley offers a movement corridor and year-round habitat for larger carnivores such as Lynx (*Felis lynx*), Wolverine (*Gulo gulo*), Gray Wolf (*Canis lupus*), and Grizzly Bear (*Ursus actos horribilis*).

Centennial Sandhills

The Centennial Sandhills, which lie in the northeast corner of the Centennial Valley, are a unique feature of the Greater Yellowstone Ecosystem. They form a band approximately 2-3 km wide and 14 km long (between 44°40'N, 111°42' W and 44°42'N, 111°49'W) and cover about 3200 ha in 18-20 legal sections north of Lower and Upper Red Rock lakes. The sandhills consist of small and generally stabilized dunes created by sands deposited probably during the late Pleistocene. They are in various stages of activity, with the most active and tallest lying north of Lower Red Rock Lake (in T13S R2W) and the lower and most stable dunes present in the eastern portion of the sandhills (in T13S R1W), east of Tepee Creek (see Figure 1). Average elevation of the sandhills is about 2030 m.

The Sandhill vegetation is a mixture of successional types (Lesica and Cooper 1999) dominated by shrubs (big sagebrush, *Artemisia tridentata*;

Figure 1. Centennial Sandhills study area in Beaverhead County. West Hills is area west of Tepee Creek, East Hills is east of Tepee Creek

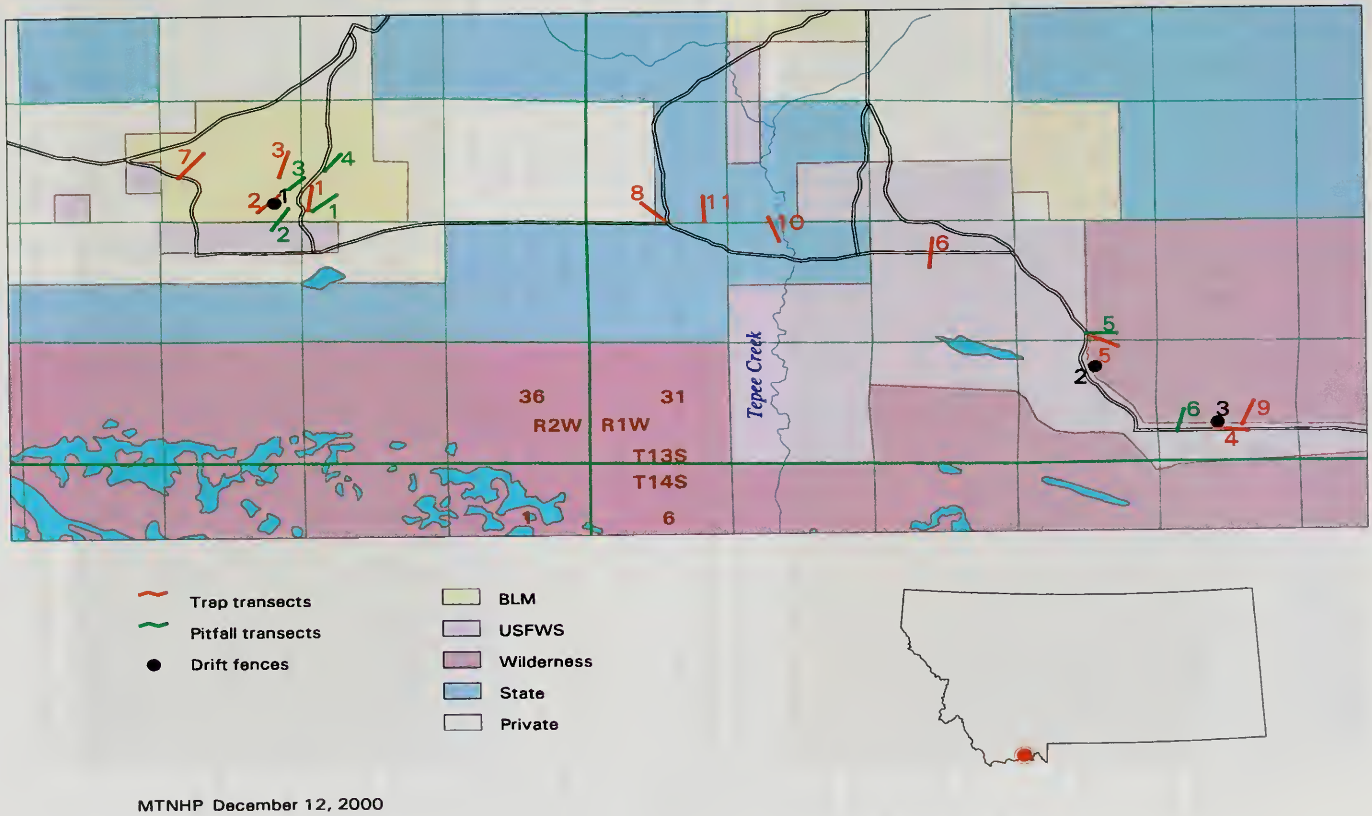


Figure 2: Sparsely vegetated blowout in the West Hills. Individual is netting the tiger beetle *Cicindela formosa*.

Figure 3: Stabilized dunes with shrub and grass cover in the West Hills

three-tip sagebrush, *A. tripartita*; common rabbitbrush, *Chrysothamnus nauseosus*; green rabbitbrush, *C. viscidiflorus*), forbs (silvery lupine, *Lupinus argenteus;* silky lupine, *L. sericeus;* brittle prickly-pear, *Opuntia fragilis;* slender-flowered scurf-pea, *Psoralea tenuiflora*), and grasses (thick-spiked wheatgrass, *Agropyron dasystachyum*; Idaho fescue, *Festuca idahoensis*; prairie junegrass, *Koeleria cristata*; needle-and-thread, *Stipa comata*). Sandhill sites occur in 3 classes based on topography and effects of sand movement: lower-slope erosion blowouts, (Figure 2), upper-slope deposition, and stabilized (both upper and lower slopes), (Figure 3). Lesica and Cooper (1999) identified three successional stages (early-, mid-, and late-seral) from the previous classes.

During our 1999 field work we used the Lesica-Cooper succession classification as a reference for documenting animal detections. We found that four physiognomic types (inter-dune trough, dune crest, low dunes, and sand flats) were also useful for our purposes in categorizing trapline and driftfence locations (see Appendix 3). Inter-dune troughs were elongate depressions between parallel dune ridges of the West Hills. They were equivalent to the stabilized class but often supported denser stands of sagebrush than were found on dune slopes; troughs also covered more extensive and relatively flat terrain. Dune crests were equivalent to either deposition or stabilized classes, but sometimes occurred as lengthy and wide ridge tops that gently sloped along the main dune axis. The low dunes category was generally equivalent to the stabilized class, but contained small sparsely vegetated sandy depressions intermixed among dune swales; this category was most extensive east of Tepee Creek. Sand flats were extensive expanses of low-relief terrain supporting sagebrush and grasslands in various degrees of cover; an area roughly 6 km wide east-to-west bracketing Tepee Creek fit into this physiognomic category.

Survey Methods

We visited the Centennial Sandhills four times during the summer of 1999: 24-28 May, 28 June-3 July, 26-30 July, and 20-23 September. Daily temperature minima and maxima were recorded with a Taylor minimum-maximum thermometer to characterize weather conditions during the periods of daily sampling. We employed a variety of techniques to sample a diverse array of animal groups. In some cases we actively searched for animals or their spoor, while in other cases we used a variety of passive trapping methods. These are described below for each animal group. In many cases we attempted to systematize sampling procedures, but opportunistic sampling was also employed to increase our survey coverage of the Sandhills. We also searched the Heritage databases, published and gray literature, and museum records for documented historical occurrences of target species, especially for mammals, amphibians, reptiles, and tiger beetles. Tiger beetle collections at the University of Idaho and Washington State University were examined for specimens collected in Beaverhead County and adjacent localities in Idaho.

Common and/or scientific names in tables and text throughout follow Jones et al. (1986) for mammals, American Ornithologists' Union (1998) for birds, Stebbins (1985) for amphibians and reptiles, Pearson et al. (1997) for tiger beetles, and Opler (1999) for diurnal butterflies. Statistical analyses, where used, follow standard procedures presented in Sokal and Rohlf (1981). Statistical significance of tests is assumed when $p < 0.05$, although we recognize that statistical significance is not the same thing as biological significance. Throughout the text "West Hills refers to that portion of the sandhills west of Tepee Creek and "East Hills" is that portion of the sandhills east of Tepee Creek (see Figure 1).

Mammals

We documented large and medium-sized mammals (lagomorphs or larger) whenever encountered, but made no attempt to sample them systematically. We inspected dens for evidence of recent or current occupancy and sampled prey remains if available, and we traversed the densest and most extensive stands of big sagebrush (*Artemisia tridentata*) looking for sign (pellets, burrows) of Pygmy Rabbit (*Brachylagus idahoensis*). When traversing areas of moderate to dense cover, two observers followed separate routes to increase the likelihood of flushing cottontails or jackrabbits.

Our intensive small mammal sampling involved systematic trapping and examination of raptor pellets for skulls. We deployed 3 trap types (live traps, snap traps, and pitfall traps) along line transects or drift arrays to sample small mammals. Different species of small mammals are more or less likely to be captured using any single trapping method (Jones et al. 1996, Allen et al. 1997), so we used a variety of trapping techniques to increase the probability of detecting the complete small mammal fauna. Shrews (Soricidae) in particular are most likely to be captured using pitfall traps. We placed trap transects selectively (Appendix 3) to sample a variety of terrain representing different succession classes, rather than distributing them randomly or systematically. Total trapping effort included 2772 live and snap trap nights and 8380 pitfall trap nights (Table 1).

We placed both live traps (folding Sherman traps 7.6 x 8.9 x 22.9 cm, model LFATDG) and snap traps (Museum Special) together on transects of 30 stations, with stations spaced approximately 10 m apart in roughly a straight line. One live trap and 2 snap traps were placed at each station within one meter of the station. Live traps were baited with a commercial seed mixture of millet, cracked corn, and sunflower seed; a small wad of polyester fiber material was placed in the back of traps to provide insulation for potential trapped animals. Snap traps were baited with a mixture of rolled oats and peanut butter. Traps were placed late on one day and left in place for 3 or 4 nights, with daily morning visits to document captures. We closed snap traps during the day to minimize capture of diurnal birds and recaptures of chipmunks (*Eutamias minimus*), live traps remained open. A total of 11 live/snap trap transects were run during summer (Figure 1), 3 during each visit except two in September. During the last 2 sample periods (late July, late September) only snap traps were deployed, as live traps were more time consuming to use and captures in live traps were very low.

We established 6 pitfall transects (Figure 1) on 25 and 26 May. Pitfall traps used were coffee cans (15 x 17 cm) buried with the rim flush to the ground surface. Pitfall transects consisted of 10 cans, one per station, placed in a relatively straight line approximately 30 m apart. We checked pitfall traps daily when we were at the site and left them

TABLE 1. Total trapping effort (trap nights) in the Centennial Sandhills, Beaverhead County, Montana in 1999.

Sampling period	Live trap	Snap trap	Pitfall (transect)	Pitfall (drift array)
Period 1 (late May-Jun)	300	600	2020	384
Period 2 (late Jun-Jul)	270	522	1740	348
Period 3 (late Jul-Sep)		720	3240	648
Period 4 (late Sep)		360		
Total trap nights	570	2202	7000	1380

in place between sample periods until retrieved on 22 September.

We also installed 3 drift fence pitfall arrays (Figure 1) on 27 May. Drift fence arrays increase the area effectively sampled and generally are more productive than lone pitfall traps (Corn 1994, Jones et al. 1996), but they require additional materials and are more time consuming to install. Drift arrays were arranged with three 2.5 m long masonite fins radiating out from a central pitfall can (Figure 4). Masonite fins were held in place with wooden lath. An additional pitfall can was placed at the end of each fin. Thus, 4 pitfall cans were associated with each drift fence array. Drift fence arrays were checked following the protocol for pitfall transects and left in place until retrieved on 22 September.

Captured mammals were identified to species, when necessary using keys in Hoffmann and Pattie (1968) and Clark and Stromberg (1987) as well as more detailed literature. Individuals were weighed and measured, and sexed if possible. Vouchers of some species (especially shrews) were preserved for additional study and determination by Dr. Kerry Foresman, and deposited in the Philip L. Wright Vertebrate Museum at the University of Montana. We also routinely searched for regurgitated raptor pellets below wooden fence posts and other potential perches in the sandhills. Pellets were collected and dissected for small mammal skulls and other vertebrate remains. Small mammals recovered from pellets were identified to species based on skull characteristics.

Birds

We conducted no systematic counts of birds, but maintained daily lists of bird species detected during other work, recording the area where they where detected, and any additional striking behavior or habitat notes (such as singing or association with a particular habitat feature). Although we conducted no nest searches, we documented all nests located, recording stage of nesting, nest contents, and nest position.

Amphibians and Reptiles

We found virtually no wetland areas in the Sandhills during our visits, and so devoted little time to active searches for amphibians. We identified frogs by call and visually as we encountered them. We sought reptiles as we drove roads and traversed the study area during other activities.

Systematic sampling was limited to the earlier-described pitfall transects and drift fence arrays, which are standard sampling techniques for these vertebrate groups (Corn 1994), especially for adult salamanders and lizards that may be overlooked using other techniques. Vouchers were collected and deposited in the herpetological collection at the Idaho Museum of Natural History, Idaho State University.

Insects

We focused our insect sampling on 2 groups, tiger beetles (genus *Cicindela*) and diurnal butterflies (Lepidoptera: Papilionoidea and Hesperioidea). We chose these groups because they are visible and often tied to local habitat conditions. Captured individuals were subdued with ethyl acetate in a killing jar and pinned for later examination, or identified in the field.

We sampled tiger beetles (Figure 5) in two ways: active searching/sweep-netting, and pitfall trapping. As with many other small terrestrial organisms, tiger beetles are readily captured in pitfall traps (Morrill et al. 1990, Clark and Blom 1992, Berghe 1992), and drift fences improve capture success (Knisley and Schultz 1997). Because our primary objective was to document habitat use and species presence, rather than relative abundance, we did not place preservative in the pitfall cans to kill insects. Nevertheless, our pitfall traps were successful in capturing about 200 individual tiger beetles.

During our first 3 visits to the Sandhills, we documented relative abundance at 4 sites by walking 100 m road transects and counting numbers of each species, noting habitat adjacent to the road,

Figure 4: Drift fence array showing radiating fins around a central pitfall can, with an additional pitfall can at the end of each fin.

Figure 5: The tiger beetle *Cicindela formosa*, the common species in West Hills blowouts.

time of day, and air temperature (tiger beetles are very temperature sensitive: Knisley and Schlutz 1997). We also noted mating or nesting behavior, and documented general habitat features and succession class of sites where beetles were encountered.

Tiger beetle specimens were identified under a dissecting microscope using the key developed by Willis (1968) and descriptions in other sources, such as Knisley and Schultz (1997) and Leonard and Bell (1999). Dr. Mike Ivie verified identifications of voucher specimens for all species documented; vouchers were deposited in the Entomology Museum at Montana State University.

We sampled diurnal Lepidoptera (butterflies and skippers) only on 29 and 30 July, during the peak of the summer. Because our survey did not focus on this insect group, the sampling was brief and opportunistic, and the list we generated is only preliminary. No effort was made to estimate relative abundance. Species were netted and identified in the field using Opler (1999). Notes on habits and habitat were made at the time of capture. Vouchers were collected and papered for later examination and determination by state experts Steve Kohler and Will Kerling (Missoula).

Results

Between late May and late September 1999 our surveys documented 18 species of mammals, 29 species of birds, two amphibian and one reptile species, four species of tiger beetles, and 14 species of diurnal butterflies (Appendices 7-9). Most of these were found both east and west of Tepee Creek, but there were some noticeable differences in distribution patterns, discussed below.

Mammals

Bats: We did not sample for bats, since the sandhills offer few sites that would concentrate activity, and there appears to be few suitable sites for roosting or raising young. However, bats probably forage over the Sandhills during summer. Few bat species have been documented from the Centennial Valley; only Little Brown Bat (*Myotis lucifugus*) is on the refuge list. However, Townsend's Big-eared bat (*Plecotus* [=*Corynorhinus*] *townsendii*), a Montana species of special concern, has also been documented on the refuge (Hoffmann et al. 1969a); 2 specimens were collected on 25 August 1965 (UMZ 12776 and 12777; University of Montana Philip L. Wright Vertebrate Museum).

Shrews: We captured shrews only in pitfall traps (Appendices 5 and 6) at the low rates (0.30/100 trap nights) not unusual for shrews (Kirkland et al. 1997). However, success in the drift arrays (0.80/100 trap nights) was 4 times greater than for pitfall transects (0.20/100 trap nights), even though there were only one fifth as many trap nights. This suggests that drift arrays may be the most suitable method for future monitoring of shrew abundance and habitat use in the Sandhills.

We captured 25 individual shrews, including 8 Dusky Shrews (*Sorex monticolus*), 6 Masked Shrews (*S. cinereus*), and 2 Preble's Shrews (*S. preblei*). Nine shrews were not identifiable to species (they were either Masked or Preble's) because skulls were incomplete and did not have enough measurable traits for reliable determination. However, palatal length and interorbital breadth measurements (Table 2) indicate at least some of the unidentified shrews were probably Preble's (Hoffmann et al. 1969b, Hoffmann and Fisher 1978, Tomasi and Hoffmann 1984, Long and Hoffmann 1992).

Our collection of Preble's Shrew is new for the Centennial Valley and Beaverhead County, the nearest previous collection being 40 km to the northeast at Quake Lake in Gallatin County (1968). Preble's Shrew is a species of concern in Montana (Appendix 2). Our collections of Dusky Shrew (*Sorex monticolus*) and Preble's Shrew (*S. preblei*) are new species records for the Refuge.

TABLE 2. Standard skull measurements from shrews (*Sorex*) collected in the Centennial Sandhills, Beaverhead County, Montana in 1999. All measurements (in mm) were made with a microscope fitted with an optical micrometer. Sample size varies where skulls are incomplete.

Species	n	Palatal length	Condylobasal length	Interorbital breadth
S. cinereus	4	6.6, 6.7, 6.6, 6.6	15.84, 16.08	2.7, 2.7, 2.8, 2.6
S. preblei	2	5.9, 6.0	14.16, 14.52	2.45, 2.6
S. species	3	5.8, 5.9, 6.2	no measurements	2.4, 2.6

The majority of shrews — 72% (18 of 25 captured) — were trapped in the East Hills. Equal numbers of shrews were captured on pitfall transects in the West and East Hills (7 individuals each), even though there were twice as many trap nights of effort in the West Hills (4680 vs. 2320). This suggests that shrews are much more abundant in the southern areas of the East Hills. This pattern also holds for the drift array results (Appendix 6). The 2 confirmed Preble's Shrews came from pitfall line 3, and the 3 potential Preble's specimens from drift array 3 in the East Hills and pitfall line 4 in the West Hills. These results suggest that this rare shrew may be widespread at low density in the Sandhills.

There was no clear correlation between pitfall trap captures and habitat types. More shrews were captured on lines with moderately dense shrub cover than where shrub cover was sparse (see Appendix 3). The difference, however, was not statistically significant (binomial probability $P = 0.338$), partly because of small sample size. Complicating the situation were the drift array results: no shrews were captured in array 1 (a blowout with sparse cover) but 6 were captured in array 3 (also a blowout with sparse cover), and 5 in array 2 (low depression with sparse cover).

Five of 6 Masked Shrews (*S. cinereus*) were caught in sparse shrub/grass cover, but total captures were too few to identify with confidence any microhabitat association. The 2 confirmed and 2 of the potential Preble's Shrews were also captured in sparse shrub/grass cover. Dusky Shrew (*S. monticolus*) captures were evenly divided between habitats with moderate and sparse cover. The lack of obvious microhabitat association, especially for Masked Shrew, has been noted at other sandhills and shrub-steppe locations (Wrigley 1974, Kirkland et al. 1997). In other areas, each species has been found in shrub-steppe habitats (Ports and George 1990, Kirkland et al. 1997, Sutter et al. 1999), sometimes occurring together in the same habitats as they do in the Sandhills. However, Dusky and Masked shrews are often considered montane species associated with mesic habitats.

<u>Lagomorphs</u>: We encountered 2 Lagomorph species during our surveys. White-tailed Jackrabbit (*Lepus townsendii*) was seen only once, on 21 September in the West Hills, but fresh remains were also found in the West Hills on 25 May and in the East Hills on 30 July, indicating a widespread distribution but at relatively low density. Jackrabbits are apparently less common now in the Centennial Valley than they were 10-15 years ago (D. Gomez, personal communication). Black-tailed Jackrabbit was seen once, on 27 July west of Tepee Creek in sparse low-stature sagebrush (T13S,R1W,S19SW). This species has not yet been reported on Refuge lands, but could occur in the Sandhills portion of the Refuge. Davis (1937)

first reported the species in Montana, but there have been few additional records (13 total in the Heritage databases, including one in 1969 from an unknown locality in the Centennial Valley).

We failed to detect Pygmy Rabbit in our survey, but there is a recent record (19 August 1997) from the West Hills (T13S,R2W,S14SW) in a stand of dense big sage (Rauscher 1997, personal communication). Both Black-tailed Jackrabbit and Pygmy Rabbit may have entered the state following an increase in sagebrush cover in southwestern Montana since the late nineteenth century (Hoffmann et al. 1969b, Arno and Gruell 1983, Lesica and Cooper 1997), as there are no Montana records for either species prior to 1918. Both are species of special concern in Montana (Appendix 2).

Rodents: We captured 137 individuals of 6 rodent species (Appendices 4-6): 19 Least Chipmunk (*Tamias minimus*), 17 Northern Pocket Gopher (*Thomomys talpoides*), 6 Great Basin Pocket Mouse (*Perognathus parvus*), 57 Deer Mouse (*Peromyscus maniculatus*), 39 Montane Vole (*Microtus montanus*), 1 Meadow Vole (*M. pennsylvanicus*), and 5 unidentifiable *Microtus*. Deer Mouse was the most abundant small mammal captured (1.84 captures/100 trap nights) and occurred throughout the sandhills in most habitats except in relatively dense low-stature sagebrush troughs (trap line 3) and mesic grass/sedge bottom (trap line 4). In these sites Montane Vole was the only small rodent captured. Typically, where one species was captured the other species was caught far less or not at all (Appendix 4); only one trap line (line 7) produced nearly equal numbers. However, voles were more likely to be caught in pitfalls (Appendix 5), and our collective data show that Montane Vole was also widely distributed in all habitats in the Sandhills. Meadow Vole, however, was captured only once, on pitfall line 5 in the East Hills.

Least Chipmunk (*Eutamias minimus*) and Northern Pocket Gopher (*Thomomys talpoides*) were captured in both the East and West Hills. Most captures were from dune crests and dune slopes in erosion and deposition sites where evidence of their burrows was also most evident, consistent with the observations of Lesica and Cooper (1999). Chipmunks were rarely captured (one of 19 individuals) on "flat" terrain (trap lines 4, 6, and 10: see Appendix 3). The same pattern was evident with the pocket gopher; 12 of 13 captured (all juveniles) were on dune slopes, and the one individual that wasn't was less than 20 m from a dune slope.

Great Basin Pocket Mouse (*Perognathus parvus*) was captured 6 times, only in the East Hills (Appendices 5 and 6) and perhaps related to the late successional stage of the East Hills dunes. Pocket mice dig burrows at the base of sagebrush plants (Clark and Stromberg 1985), which are larger and more mature (making burrows more stable) in the East Hills. Lower grazing intensities in the East Hills also make available more forb and grass seeds (Lesica and Cooper 1999), the primary foods of the Great Basin Pocket Mouse (Verts and Kirkland 1988).

Great Basin Pocket Mouse has been reported in Montana fewer than ten times, with the bulk of these records from 1961 (Hoffmann et al. 1969b) and no reports since then until our 1999 collections. Our 1999 collections also represent the first documented occurrence for the Centennial Valley, and a range extension about 60 km east from Sage Creek near Dell. Great Basin Pocket Mouse is a species of concern in Montana (Appendix 2).

We did not trap Wyoming Ground Squirrel (*Spermophilus elegans*) and observed few in the Sandhills, although we found some skulls at Coyote dens and in raptor pellets. Three were observed in the East Hills at a cattle guard along the road in T13S,R1W,S28NE on 1 July, and 2 were seen in the West Hills along the road in T13S,R2W,S22NE. Both sightings were near small stands of big sagebrush. This species was formerly considered a race of Richardson's Ground Squirrel (*S. richardonii*), and is found in

TABLE 3. Individual skulls recovered from raptor pellets collected throughout the Centennial Sandhills, Beaverhead County, in 1999.

Species	n	%
Microtus pennsylvanicus	56	47.1
Microtus montanus	33	27.7
Spermophilus species	11	9.2
Microtus species	5	4.2
Thomomys talpoides	4	3.4
Peromyscus maniculatus	3	2.5
other mammal	4	3.4
bird	3	2.5

Montana in valley bottom and foothill sage plains and grasslands only in the southwestern part of the state (Hoffman et al. 1969b, Zegers 1984).

Raptor pellets contained remains of 119 individuals (Table 3) of which 112 represented 6 mammal "species". Birds and "other mammal" made up the remaining 7 individuals. Proportions of *Microtus*, *Peromyscus*, and *Thomomys* in pellet samples differed significantly from our trapping results ($G = 77.61$, df = 2, $P < 0.001$). Almost half of the trap captures were *Peromyscus*, while this species represented only 3% of the pellet sample. Also striking was the ratio of *Microtus montanus* to *M. pennsylvanicus* in the two samples ($G = 50.362$, df = 1, $P < 0.001$). Nearly all of the 40 identified voles in our traps were *M. montanus*, but this species made up less than 40% of the pellet sample.

Where the 2 microtine species co-occur, *M. pennsylvanicus* prefers moist areas while *M. montanus* is found more often in drier sites (Hodgson 1972); our trap results identify this as the pattern for the Centennial Sandhills, with *M. pennsylvanicus* present only infrequently near the perimeter of the sandhills proper. Raptors (owls, harriers, buteos: Appendix 8) probably hunted most frequently over the extensive wetlands to the south of the sandhills, capturing *M. pennsylvanicus* where it is likely more abundant, and returned to perches in the sandhills to digest their meals and cast pellets. This hypothesis is supported by the presence of three Muskrat (*Ondatra zibethicus*) skulls in the pellet sample. *Peromyscus* tends to avoid wet habitats (Clark and Stomberg 1985), explaining its low representation in raptor pellet samples and providing additional support for the above hypothesis.

Carnivores: We detected 3 carnivore species during our survey. Coyotes (*Canis latrans*) were often heard in both portions of the sandhills, and 2 dens were found (one each in the East and West hills). We noted little sign of Badger (*Taxidea taxus*), but found a skull in the West Hills. Red Fox (*Vulpes vulpes*) was seen once, on 2 July in the East Hills. Coyote and/or Red Fox probably raided some of our trap lines, as there was evidence that a carnivore had disturbed traps on a few occasions. We failed to find any sign of Striped Skunk (*Mephitis mephitis*) in the sandhills, but anticipate that this species is sometimes present, especially along the southern margins adjacent to wetlands.

Ungulates: Our survey documented 3 ungulate species in the Sandhills. A small band of Pronghorn (*Antilocapra americana*) was observed daily in the West Hills (2 fawns on 28 July) and another small band was seen less frequently in the East Hills. We observed a single cow Elk

(*Cervus elaphus*) on 26 May in the big sagebrush flats west of Tepee Creek, apparently heading for the lush vegetation adjacent to the southern edge of the sandhills. A lone doe Mule Deer (*Odocoileus hemionus*) was seen in dense big sage in the East Hills on 1 July.

Birds

We observed 29 bird species in the sandhills (Appendix 8), of which 7 were recorded only as flyovers. Most resident species (those encountered daily in the sandhills) were typical of shrub steppe-grassland habitat elsewhere in Montana (Feist 1968, Best 1972, Bock and Bock 1987), and included two Montana Partners In Flight (PIF) Priority II species, both sagebrush obligates: Sage Thrasher and Brewer's Sparrow (Paige and Ritter 1999). Of particular note were daily observations of at least 3 singing Grasshopper Sparrows in the West Hills (T13S,R2W,S22 and 23) from late May to early July, in extensive patches of grass with little low-shrub cover. This species is listed on the refuge checklist as rare or accidental in the Centennial Valley, but our observations indicate a small breeding population may be established in the Sandhills. Grasshopper Sparrow is a ranked as a Priority II grassland species by Montana PIF, experiencing range-wide declines.

We observed Sage Thrasher only in stands of mature (ca. 100 cm tall or taller) big sage. Although we saw this species daily, it was present only in low densities and we found no nests. Much more abundant was Brewer's Sparrow, which we found widely associated with sagebrush. We found four nests of Brewer's Sparrow (on 28 May a nearly completed nest in a 72 cm tall big sage; on 29 June with 4 eggs in a 45 cm tall three-tip sage; on 30 June with 1 egg [later 3] in a 91 cm tall big sage; on 2 July with 3 eggs in a 42 cm tall three-tip sage).

Two nests of Vesper Sparrow, found on 30 June, contained 4 eggs and 4 young, respectively. Both nests were built on the ground, one at the base of a 24 cm tall rabbitbrush (*Chrysothamnus*) and the other in a small bunch of grass. One Horned Lark nest was found on 25 May, containing 3 eggs; the cup was sunk in the ground next to a thick tuft of grass in an early-seral site with sparse grass and no shrub cover.

Other shrub-steppe grassland species frequently noted included Short-eared Owl, Savannah Sparrow, and Western Meadowlark; we failed to find nests of any of these species. Pairs of Long-billed Curlew also appeared twice; one was very vocal near drift array 2 in the East Hills on 29 June and probably had a chick nearby. Ferruginous Hawks were seen on two occasions, and an old ground nest atop a high dune in the West Hills indicated this species sometimes nests in the sandhills. All five species are on the refuge list as confirmed breeders. Ferruginous Hawk and Long-billed Curlew are Montana PIF Level II Priority grassland species.

Amphibians and Reptiles

We documented 2 amphibian species, Tiger Salamander (*Ambystoma tigrinum*) and Striped Chorus Frog (*Pseudacris triseriata*), and one species of reptile, Western Terrestrial Garter Snake (*Thamnophis elegans*), in the Centennial Sandhills in 1999 (Appendix 7). The Natural Heritage Program database had no previous records of these species for the sandhills (Roedel and Hendricks 1998), but each has been documented previously on refuge lands and elsewhere in the upper Centennial Valley. It seems likely that the chorus frog and garter snake have been encountered previously in the sandhills but not reported. None of these species is of special concern in Montana, as all are widespread in the state.

Tiger Salamanders were captured in pitfall traps in the East Hills. On 28 June, 2 adults were recovered from pitfall line 5 and a single adult from pitfall line 6 (see Figure 1 and Appendix 3 for locations). Another adult salamander was recovered from drift array 3 on 22 September. These animals belong to the group called mole salamanders, named for their use of burrows as adults.

Following breeding in nearby wetlands to the south, Tiger Salamanders probably return to the sandhills in search of underground refugia. The population in the upper Centennial Valley may persist because of the Sandhills' proximity to extensive breeding habitat nearby in the wetlands.

Striped Chorus Frog was heard calling in many wetland locations in and near the sandhills in May and June, especially along Tepee Creek and from the wetlands immediately south of the West Hills. Two dispersing adults were recovered from drift array 2 on 22 September; another two were recovered at drift array 3 on the same date. These individuals may have been seeking burrows (Koch and Peterson 1995), as they are often found far from permanent water elsewhere in Montana (personal observation) and sometimes breed in temporary ponds in road tracks.

Most observations of Western Terrestrial Garter Snake, in June and July, were in sandy roads in both the East and West Hills. This species was also observed off-road in the West Hills (T13S,R2W,S23SW) on 1 July. This widespread species is often associated with wetland and aquatic habitats in the Greater Yellowstone Ecosystem (Koch and Peterson 1995).

Insects

Tiger Beetles: We documented 4 tiger beetle species in the Centennial Sandhills in 1999: *Cicindela decemnotata*, *C. formosa*, *C. longilabris*, and *C. tranquebarica* (Appendix 9). We had hoped to find the globally rare Idaho Dunes Tiger Beetle (*C. arenicola*), but did not. The Centennial Mountains are a formidable barrier between the Centennial Sandhills and the nearest population of this Idaho endemic, in the St. Anthony Dunes of Fremont County (Rumpp 1967, Logan 1995). Nevertheless, further searching would be worthwhile, and might also yield other species of tiger beetle new to the Centennial Sandhills fauna.

Transect counts (Table 4) and pitfall data show that *Cicindela formosa* was the most abundant tiger beetle in the West Hills, and *C. decemnotata* was the most abundant species in the East Hills. Both species were especially prevalent in sandy sites with sparse vegetation cover (early-seral vegetation in erosion and deposition sites). Our data support the observation of Lesica and Cooper (1999) that *C. formosa* is mostly confined to this kind of habitat. It was captured in pit fall traps on pitfall lines 1, 2, and 3, and at drift array 1, all in the West Hills. *C. decemnotata* was captured in on pitfall line 5 and at drift array 3, both in the East Hills. However, both species occurred outside their areas of concentration. We counted a few *C. formosa* on road transects in the East Hills (Table 4) but never saw or captured them there off of the road. During a 25 May traverse of the West Hills (T13S,R2W,S22 and S23) we noted 2 *C. decemnotata* among about 160 *C. formosa* in 14 blowouts and deposition sites.

Cicindela tranquebarica, was seen almost exclusively on the road near Tepee Creek (Table 4), where the water table was probably near the ground surface and the sand sometimes slightly damp. This was the only tiger beetle known to occur with the Idaho Dunes Tiger Beetle at some sites (Rumpp 1967, Logan 1995) and tends to be a habitat generalist (Pearson et al. 1997, Leonard and Bell 1999). *C. longilabris* was seen only in the East Hills (T13S,R1W,S35SWSW), twice on 27 May in the presence of *C. decemnotata* on a sandy game trail in mid-seral habitat. *C. longilabris* is less associated with sandy habitats and more often found in forested or alpine sites (Pearson et al. 1997, Leonard and Bell 1999).

We saw all tiger beetle species, with the exception of *Cicindela longilabris*, throughout the summer from late May to late September, though all were more abundant between late May and early July. All species, again with the exception of *Cicindela longilabris*, were observed copulating between 27 May and 1 July.

The presence of *C. formosa* in the Centennial Sandhills is noteworthy. This location is well

TABLE 4. Counts of tiger beetles (*Cicindela*) on road transects in the Centennial Sandhills in 1999. All transects were 100 m in paced length. Roads at all sites were sandy.

Location (TRS)	Area	Date	Time	Adjacent habitat	Temp (F)	Species (No. individuals)
T13SR1WS29NW	Tepee Creek	27 May	12:00-12:10	sedge-grass sand flat	70	*C. tranquebarica* (23)
"	"	1 Jul	14:33-14:41	"	65	*C. tranquebarica* (6)
T13SR1WS27SW	East Hills	27 May	12:30-12:40	low shrub-grass dunes	70	*C. decemnotata* (7), *C. formosa* (3)
"	"	1 Jul	13:50-14:00	"	65	*C. decemnotata* (1)
T13SR1WS34NE	East Hills	28 May	11:10-11:20	low shrub-grass dunes	70	*C. decemnotata* (7), *C. formosa* (4)
T13SR2WS22SE	West Hills	27 May	10:45-10:50	tall shrub-grass dunes	70	*C. formosa* (19)
"	"	28 Jul	10:50-10:56	"	75	*C. formosa* (14)
"	"	29 Jul	12:15-12:20	"	80	*C. formosa* (8)

beyond the range limit east of the mountains that is depicted in the latest distribution map (Pearson et al. 1997). This species has not yet been reported for Idaho (Shook 1984).

Diurnal butterflies: Butterflies and skippers were collected only on 29 and 30 July in an effort to begin a list of species associated with the sandhills (Appendix 9). The list is nowhere near complete, and the collecting conducted was not sufficient to identify specific microhabitat associations in the sandhills, if in fact they occur. Most of the species collected associate primarily or exclusively with open grasslands or shrub-steppe habitats (Opler 1999); grasses, lupines, stonecrops, and asters are the larval food plants for several species. In the latest published state list (Kohler 1980) Beaverhead County is not listed as a location for four of the species (*Satyrium fuliginosum*, *Icaricia lupini*, *Oarisma garita*, and *Hesperia juba*). Considerable collecting has been undertaken throughout the state since then, and there now are county records for each (W. Kerling and S. Kohler personal communication). However, only limited collecting has been conducted in the Centennial Sandhills, and these may be new records for this specific locality.

Discussion

We found a variety of vertebrate and invertebrate species using the Centennial Sandhills during our 1999 inventory. It is likely that a few additional vertebrate species will be discovered in the sandhills when more surveys are undertaken.

The list of invertebrates is in its infancy; we expect sand obligate species (Rust 1986) to be identified when additional invertebrate groups are studied. For now, the species of tiger beetles identified represent the only invertebrate group that is probably nearly complete. For all vertebrate and invertebrate species identified, several stand apart as having restricted distributions tied to physical features or vegetation within the Centennial Sandhills.

Several mammal species in the Centennial Sandhills have specific habitat requirements, although their microhabitat relationships are not clear. Perhaps of greatest interest are the four mammal species of special concern that are now known to occur in the sandhills. Both Pygmy Rabbit and Black-tailed Jackrabbit are associated with moderate or dense stands of sagebrush (MacCracken and Hansen 1982, Katzner and Parker 1997), which provide food for the former species and shelter for both; Black-tailed Jackrabbit is more abundant in ungrazed habitat where grass cover is greater. Currently both species are present in very low number in the sandhills, and this probably is related to the limited availability of preferred sagebrush habitat. However, low jackrabbit density throughout the Centennial Valley is reflected in their low frequency of occurrence in raptor (*Buteo*) diets (Restani 1991), and other factors may be limiting their abundance. In the sandhills, Great Basin Pocket Mouse appears to be restricted to stabilized low dunes, as they were captured only in the East Hills, despite intensive trapping in the West Hills. This pattern might be explained by a greater availability of grass and forb seed (Lesica and Cooper 1999) and better burrow stability afforded by more mature sagebrush. Preble's Shrew, unlike the pocket mouse, appears to be more widespread at low density (assuming the unidentified shrews indicated in Table 2 were this species) and not tied to any particular succession stage or physionomic class, so long as sagebrush cover is present. For both species, additional systematic trapping to define distributions and microhabitat associations is desirable.

Of the other small mammals, Least Chipmunk and Northern Pocket Gopher are found where there is significant topographical relief in the sandhills, associated with dune slopes and crests regardless of the succession stage (early to late seral). However, pocket gopher activity is most evident in early seral sites, as noted by Lesica and Cooper (1999). Both species are virtually absent in sand flats or broad inter-dune troughs. Meadow Vole is restricted to the edges and small depressions of the sandhills where more mesic habitat is available or nearby. Masked Shrew, Dusky Shrew, Montane Vole, and Deer Mouse are widespread, although the latter species apparently is uncommon in expansive sandflats and broad inter-dune troughs.

Five bird species noted in the sandhills are state PIF Priority II species. For one of these, Ferruginous Hawk, there is no evidence of current breeding, but the species was observed hunting in the area and an old ground nest was found in the West Hills. Presence of this hawk in the sandhills is probably determined by prey availability and landscape structure (nest sites), although habitat availability could affect its presence indirectly through influences on its favored prey (Bechard and Schmutz 1995), which in the Centennial Valley are voles, ground squirrels, and pocket gophers (Restani 1991). Our observations on the other 4 PIF Priority species (Long-billed Curlew, Sage Thrasher, Brewer's Sparrow, Grasshopper Sparrow) indicate confirmed or likely breeding in the sandhills. Long-billed Curlews seek breeding sites with short dense grass usually < 25 cm in height (Allen 1980, Pampush and Anthony 1993, Paige and Ritter 1999). This species is currently uncommon in the sandhills, but behavior of one pair indicated the presence of young. Sage Thrasher and Brewer's Sparrow are sagebrush obligates, closely associated with sagebrush of different structure and negatively associated with grass cover (Paige and Ritter 1999, Reynolds et al. 1999, Rotenberry et al. 1999). Populations of these species drop where sagebrush cover is below 10% over large areas. Sage Thrasher is most closely associated with tall dense sage, while Brewer's Sparrow occurs in sage < 1.5 m tall and in less dense stands. Brewer's Sparrow is widespread and relatively abundant in the Centennial Sandhills wherever sagebrush is present; Sage Thrasher is restricted to small patches of taller big sage and dense stands of the same. Grasshopper Sparrow occurs in the Centennial Sandhills in a small and possibly isolated breeding population (at least 3 singing males) in relatively dense grass with low sagebrush cover, so far known only from the West Hills. Grasshopper Sparrow settles in sites with taller grasses and generally avoids grasslands with extensive shrub cover, although some shrub cover is favored (Vickery 1996); in sagebrush-grassland in southcentral Montana, this species was significantly less abundant on plots that experienced fire eradicating all sagebrush cover (Bock and Bock 1987).

We found no sign of Greater Sage-Grouse (*Centrocercus urophasianus*) in the sandhills during our survey. Absence could be due in part to a lack of adequate density and height of sagebrush favored as summer habitat (J. Roscoe personal communication).

Only three amphibian and reptile species were observed in the sandhills. None appear closely associated with any habitat other than the various adjacent wetlands. However, the population of tiger salamander that exists in the upper Centennial Valley may persist largely because of the close proximity of the sandhills to extensive wetlands, providing it ideal habitat in which to find refuge in burrows during non-breeding periods.

Our survey of diurnal butterflies was so brief that we could not identify patterns of landscape use. Nevertheless, we can predict areas where some species are likely to occur, based on their larval food plant preferences (Opler 1999). Larvae of the 3 skipper species feed on grasses and sedges, so we would expect them to occur widely in the Sandhills. Riding's Saytr feeds on grasses, especially blue grama (*Bouteloua gracilis*), and will probably be most prevalent in the East Hills where it was commonly seen in 1999. Both Boisduval's Blue and Sooty Hairstreak specialize on lupines (*Lupinus* spp.), so we expect these butterfly species to occur throughout the sandhills in all successional stages, but more commonly in stabilized late-seral areas of the East Hills where lupines are most abundant (Lesica and Cooper 1999). Rocky Mountain Parnassian specializes on stonecrop (*Sedum*) and will likely be found where this plant is most abundant, probably the East Hills. For butterfly species requiring specific larval food plants, such as some of the above, additional survey work might reveal correlations between the predicted distributions and various successional stages of Sandhills vegetation.

Tiger beetles provide the best examples of Sandhills animal species that are closely associated with early-seral vegetation and unstable sites, like the 4 rare plant species studied by Lesica and Cooper (1999). Indeed, tiger beetles were one of the first animal groups in which different species were found to favor specific successional stages (Shelford 1907). In our surveys, two of the Centennial Sandhills species, *Cicindela formosa* and *C. decemnotata*, were most common in early-seral erosional or depositional sites with sandy soil and low vegetation cover. These habitats closely match those described for *C. formosa* at other locations (Shelford 1907, Wallis 1961, Knisley 1979).

C. decemnotata, however, is not considered a sand dunes and blowouts specialist like *C. formosa*, but is found throughout its range in upland grassland, arid shrubland, and clay banks habitats (Pearson et al. 1997). For example, the species is listed as an uncommon species of the Idaho National Engineering Laboratory northwest of Idaho Falls (Stafford et al. 1986), where it is found on sandy loams and loess (Aridisols) in sagebrush-grasslands. In western Canada it has been collected on dry, gravelly clay soils (Wallis 1961, Hooper 1969). Its broader range of habitat associations might explain why *C. decemnotata* was the prevalent tiger beetle in the East Hills, where the dunes are more stabilized with increased vegetative cover (Lesica and Cooper 1999). Overall, however, this species too was more strongly associated with low-cover sandy sites in the Sandhills.

Competition may offer further explanation for the distribution patterns we found of these respective tiger beetle species in the Centennial Sandhills. Because the local distribution of tiger beetles is determined by preferred oviposition substrates (Shelford 1907), *Cicindela formosa* and *C. decemnotata* may be competing for similar egg-laying habitat in the Sandhills. *C. formosa*, being the larger of the two species, may be dominant at breeding sites in the West Hills and exclude *C. decemnotata* from the more extensive early-seral habitat that is available there. Further study might clarify whether such competitive interaction accounts for their respective distribution patterns in the Sandhills.

Recommendations and Conclusions

Most habitats support plant and animal species that are generalists-those found across a wide array of habitats, and specialists-those with restricted distributions and specific habitat requirements (Cody 1974). This complicates multi-species management because habitat manipulations for the benefit of one species will likely be at the expense of others. The challenge, then, is to design management strategies that are effective in maintaining and/or restoring the full range of plant and animal species native to an area. Perhaps the best management approach for the Centennial Sandhills fauna is to focus on disturbance processes under which these species evolved, and which maintain a diverse array of cover conditions and stages of plant succession (Lesica and Cooper 1999) at specific spatial and temporal scales. In pursuing this approach, it should be kept in mind that the Sandhills themselves are but one site, albeit unique, in the larger Centennial Valley system. Adaptive management should include larger-scale disturbances, since small-scale disturbances alone probably do not replicate former patch dynamics across the entire Centennial Valley.

Lesica and Cooper (1999) recommended a number of measures for returning natural disturbance cycles to the Sandhills at appropriate time intervals (their recommendations do not address the question of spatial scale and patchiness of disturbance that are optimal for the Sandhills). We discuss these recommendations below, emphasizing their implications for the Sandhills' animal species. Additional guidelines appropriate to the Centennial Sandhills are presented in Peterson (1995), Saab et al. (1995), and Paige and Ritter (1999).

Sagebrush manipulation

Sagebrush encroachment has contributed to the stabilization of the Sandhills. Sagebrush removal has complex impacts on the plants and animals associated with it (Peterson 1995), but there is good evidence of the immediate and short-term effects on several animal species. Extensive clearing of sagebrush (especially mature big sage) will have negative impacts on Pygmy Rabbit, Black-tailed Jackrabbit, Sage Thrasher, Brewer's Sparrow, and possibly Great Basin Pocket Mouse and Preble's Shrew (Best 1972, Bock and Bock 1987, Verts and Kirkland 1988, Cornely et al. 1992, Rauscher 1997, Paige and Ritter 1999, Reynolds et al. 1999). However, conversion of sagebrush to grassland benefits Long-billed Curlew, and Grasshopper Sparrow as long as scattered shrubs are left at low density (Bock and Bock 1987, Vickery 1996).

Sagebrush manipulation, if conducted, should be limited and dispersed to maintain large expanses of sagebrush cover (over 10%) in various ages and size classes. Stands of dense mature sagebrush should probably be left undisturbed, as they are especially important sites for Pygmy Rabbit and Sage Thrasher (Rauscher 1997, Paige and Ritter 1999) and are uncommon in the Sandhills.

Fire

Fire is a natural process of the Sandhills landscape. Fire suppression leads to a decline in diversity of successional habitats through vegetation encroachment; in the eastern U.S., loss of some tiger beetle species requiring open habitat has been linked to fire suppression (Knisley and Schultz 1997). The effects of fire will probably be similar to mechanical/chemical removal of sagebrush, producing a decrease in overall shrub cover for several years. However, because fire burns unevenly it creates a mosaic of successional habitats leaving some shrub cover if properly managed. Sage Thrasher and Brewer's Sparrow persist following prescribed fire, if the burn pattern leaves a patchwork of structural and cover conditions (Rotenberry et al. 1999). Absence of Greater Sage-Grouse in the Sandhills and elsewhere in the Centennial Valley may relate to fire, in that spring-cool burns enhance the abundance of three-tip sage. Threetip sage tends to be avoided in summer by sage-grouse because it offers less cover of the appropriate height and density (J. Roscoe personal communication).

Fire could benefit species like the Grasshopper Sparrow by stimulating increased growth in grasses, thereby providing more nesting cover. Some increased availability of grasses is also beneficial to Black-tailed Jackrabbit and Great Basin Pocket Mouse, providing increased cover and food for each. Controlled fire may also be used to reactivate dune dynamics by removing bunchgrasses that stabilize the Sandhills (Lesica and Cooper 1999). However, as Lesica and Cooper (1999) pointed out, effectiveness of fire in creating early and mid-seral conditions will vary depending on a large variety of conditions, including dune topography and current cover conditions. Invasion of exotic grasses (especially cheatgrass) could affect intensity and frequency of natural fires and damage native species habitat, through indefinite loss of sagebrush cover (Paige and Ritter 1999). Close monitoring for invasion of exotic grasses should be a priority.

Livestock grazing

Livestock grazing can have many direct impacts on the Sandhills fauna (Saab et al 1995, Lesica and Cooper 1999); these include trampling, competition for food, and mechanical alteration or removal of cover. Cattle compete for food with native herbivores such as Black-tailed Jackrabbit and Great Basin Pocket Mouse, which tend to be more abundant on ungrazed sites (MacCracken and Hansen 1982, Verts and Kirkland 1988). Moderate to heavy livestock grazing reduces habitat quality for Grasshopper Sparrow (Saab et al. 1995, Vickery 1999) by removing nesting cover. On the other hand, this type of grazing may benefit Long-billed Curlew and more common species like Horned Lark by reducing vegetation height and cover if grazing occurs before the onset of nesting (Paige and Ritter 1999). In the Sandhills area, nesting commences for many bird species before cattle are introduced (personal observation).

Heavy grazing should benefit tiger beetle species associated with early-seral disturbance by creating more early and mid-seral habitat. Lesica and Cooper (1999) suggested that heavy grazing will also help maintain early-seral vegetation on slopes where trampling in significant. However, livestock can destroy tiger beetle larvae by trampling their burrows (Knisley and Sdchultz 1997), especially if livestock are concentrated in small areas or are grazed at high densities.

As with fire, grazing is most beneficial and useful as a management tool when it creates a mosaic of cover types and disturbance regimes. The most reasonable grazing system for the Sandhills is probably some form of rest or deferred rotation grazing (Saab et al. 1995), where portions of the Sandhills are left undisturbed while others are grazed. These grazing systems distribute the disturbance across the landscape in an uneven pattern. Currently, early-seral habitat is most abundant in the West Hills where grazing and disturbance is also greatest. There is an obvious correlation here between grazing and the presence of early-seral vegetation in the Sandhills.

Concluding remarks

Lesica and Cooper (1999) recommended that prescribed fire be used every 20-30 years to remove bunchgrasses and sagebrush in patches of some unspecified patch size. Controlled fire followed by intense livestock grazing for 1-2 years could significantly reduce vegetation cover, reinitiating blowout development in the East Hills and maintaining successional dynamics in the West Hills. Through use of natural and controlled fire and grazing, early-seral conditions to which the rarest species are linked should increase in the Sandhills. This approach appears most appropriate for sandhills invertebrates and small mammals, such as tiger beetles, shrews, and pocket mice, with specific small patch requirements. However, as Lesica and Cooper (1999) prudently pointed out, their recommendations should first be tested by means of replicated demonstration areas spread through the Sandhills. Demonstration areas would be used to determine the relationships between scale, frequency, and intensity of disturbances that will maintain the mosaic of early- to late-seral vegetation "capable of supporting the full spectrum of native species (Lesica and Cooper 1999, p. 300)."

We concur with the suggestions of Lesica and Cooper (1999), with an additional comment. The most effective management program will also involve coordinating the activities of all owners (Fish and Wildlife Service, Bureau of Land Management, State, and Private) with lands in the Sandhills, as the entire site should be managed as an integrated unit with a unified goal. Extending this reasoning one additional step, the Sandhills should also be managed as but one unit, albeit unique, within the larger sagebrush-grassland system of the entire Centennial Valley.

Future work

It remains to be determined how unusual the Sandhills fauna is for the entire Centennial Valley, especially the distributions and associations of invertebrates, small mammals, and songbirds, as few concentrated surveys have been conducted elsewhere in the valley. We therefor recommend additional surveys for sagebrush obligate and grassland associated vertebrates (e.g., Sage Thrasher, Brewer's Sparrow, Grasshopper Sparrow, Preble's Shrew, Great Basin Pocket Mouse, Pygmy Rabbit) and invertebrates (e.g., tiger beetles, grasshoppers, butterflies) throughout the entire Centennial Valley. This survey work would help place the significance of the Sandhills-associated fauna in the larger landscape context. In conjunction with habitat modeling, valley-wide surveys could further inform management regarding patch size requirements and distribution across the landscape. Because the Centennial Valley is an integrated system, management of special concern species should be conducted across the entire valley rather than at specific sites within the valley. Species such as early-succession sandhills obligate plants and invertebrates, restricted to unique sites and requiring special management attention, are the exceptions.

Finally, we also recommend additional survey work be conducted in the Sandhills themselves for two reasons. First, Sandhills distribution and status for vertebrate species of special concern or high conservation interest including Preble's Shrew, Pygmy Rabbit, Black-tailed Jackrabbit, Great Basin Pocket Mouse, Sage Thrasher, and Grasshopper Sparrow are still uncertain, and microhabitat relationships remain largely unknown. To understand how these species will respond to prescribed disturbance in the Sandhills requires better information about their habitat requirements and distributions. Second, there are groups of invertebrates that were not thoroughly surveyed but which are known to contain sandhills-obligate species (spiders, ground beetles, grasshoppers) closely tied to early stages of succession (Rust 1986), or species with specific food plant requirements (butterflies) that serve as indicators of the spectrum of sandhills habitats. These groups probably are the best animal indicators of the overall health of the Centennial Sandhills because their requirements are quite specific.

Literature Cited

Alden, W. C. 1953. Physiography and glacial geology of western Montana and adjacent areas. U. S. Geological Survey Professional Paper 231. 200p.

Allen, J. N. 1980. The ecology and behavior of the Long-billed Curlew in southeastern Washington. Wildlife Monographs No. 73:1-67.

Allen, K. L., D. Flath, and T. Weaver. 1997. Small mammal capture efficiencies among three trap types. Intermountain Journal of Sciences 3:1-6.

American Ornithologists' Union. 1998. Checklist of North American birds, seventh edition. American Ornithologists' Union, Washington, D.C. 829 p.

Armstrong, D. M., and J. K. Jones, Jr. 1971. *Sorex merriami*. Mammalian Species No. 2:1-2.

Arno, S. F., and G. E. Gruell. 1983. Fire history at the forest-grassland ecotone in southwestern Montana. Journal of Range Management 36:332-336.

Banko, W. E. 1960. The Trumpeter Swan: its history, habits, and population in the United States. North American Fauna Number 63. 214 p.

Bechard, M. J., and J. K. Schmutz. 1995. Ferruginous Hawk (*Buteo regalis*). *In* The Birds of North America, No. 172 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C. 20 p.

Bergh, E. V. D. 1992. On pitfall trapping invertebrates. Entomological News 103:149-156.

Best, L. B. 1972. First-year effects of sagebrush control on two sparrows. Journal of Wildlife Management 36:534-544.

Bock, C. E., and J. H. Bock. 1987. Avian habitat occupancy following fire in a Montana shrubsteppe. Prairie Naturalist 19:153-158.

Clark, T. W., and M. R. Stromberg. 1987. Mammals in Wyoming. University of Kansas Museum of Natural History, Public Education Series No. 10. 314 p.

Clark, W. H., and P. E. Blom. 1992. An efficient and inexpensive pitfall trap system. Entomological News 103:55-59.

Cody, M. L. 1974. Competition and the structure of bird communities. Monographs in Population Biology No. 7. Princeton University Press, Princeton, NJ. 318 p.

Cooper, S. V., C. Jean, and B. L. Heidel. 1999. Plant associations and related botanical inventory of the Beaverhead Mountains Section, Montana. Unpublished report to the Bureau of Land Management. Montana Natural Heritage Program, Helena. 235 pp.

Corn, P. S. 1994. Straight-line drift fences and pitfall traps. Pp. 109-117, *In* Measuring and monitoring biological diversity. Standard methods for amphibians (W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, D.C. 364 p.

Cornely, J. E., L. N. Carraway, and B. J. Verts. 1992. *Sorex preblei*. Mammalian Species No. 416:1-3.

Davis, W. B. 1937. Some mammals from western Montana and eastern Idaho. Murrelet 18:22-27.

Dorn, R. D. 1978. Great Basin vegetation in Carbon County, Montana. Madrono 25:105-106.

Feist, F. G. 1968. Breeding-bird populations on sagebrush-grassland habitat in central Montana. Audubon Field Notes 22:691-695.

Green, J. S., and J. T. Flinders. 1980. *Brachylagus idahoensis*. Mammalian Species No. 125:1-4.

Heidel, B., S. V. Cooper, and C. Jean. 2000. Plant species of special concern and plant associations of Sheridan County, Montana. Report to the U. S. Fish and Wildlife Service. Montana Natural Heritage Program, Helena. 22pp. plus appendices.

Hodgson, J. R. 1972. Local distribution of *Microtus montanus* and *M. pennsylvanicus* in southwestern Montana. Journal of Mammalogy 53:487-499.

Hoffmann, R. S., and R. D. Fisher. 1978. Additional distributional records of Preble's shrew (*Sorex preblei*). Journal of Mammalogy 59:883-884.

Hoffmann, R. S., and D. L. Pattie. 1968. A guide to Montana mammals: identification, habitat, distribution and abundance. Missoula: Associated Students of University of Montana Store. 133 p.

Hoffmann, R. S., D. L. Pattie, and J. F. Bell. 1969a. The distribution of some mammals in Montana. II. Bats. Journal of Mammalogy 50:737-741.

Hoffmann, R. S., P. L. Wright, and F. E. Newby. 1969b. The distribution of some mammals in Montana. I. Mammals other than bats. Journal of Mammalogy 50:579-604.

Hooper, R. R. 1969. A review of Saskatchewan tiger beetles. Cicindela 1(4):1-5.

Jones, C., W. J. McShea, M. J. Conroy, and T. H. Kunz. 1996. Capturing mammals. Pp. 115-155, *In* Measuring and monitoring biological diversity. Standard methods for mammals (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, D.C. 409 p.

Jones, J. K., Jr., D. C. Carter, H. H. Genoways, R. S. Hoffmann, D. W. Rice, and C. Jones. 1986. Revised checklist of North American mammals north of Mexico, 1986. Occasional Papers of The Museum Texas Tech University Number 107:1-22.

Katzner, T. E., and K. L. Parker. 1997. Vegetative characteristics and size of home ranges used by Pygmy Rabbits (*Brachylagus idahoensis*) during winter. Journal of Mammalogy 78:1063-1072.

Kirkland, G. L., Jr., R. R. Parmenter, and R. E. Skoog. 1997. A five-species assemblage of shrews from the sagebrush-steppe of Wyoming. Journal of Mammalogy 78:83-89.

Knight, D. H. 1994. Mountains and plains: the ecology of Wyoming landscapes. Yale University Press, New Haven, CT. 338 p.

Knisley, C. B. 1979. Distribution, abundance, and seasonality of tiger beetles (Cicindelidae) in the Indiana Dunes region. Proceedings of the Indiana Academy of Science 88:209-217.

Knisley, C. B., and T. D. Schultz. 1997. The biology of tiger beetles and a guide to the species of the South Atlantic States. Virginia Museum of Natural History Special Publication Number 5. 210 p.

Koch, E. D., and C. R. Peterson. 1995. Amphibians & reptiles of Yellowstone and Grand Teton national parks. University of Utah Press, Salt Lake City, UT. 188 p.

Kohler, S. 1980. Checklist of Montana butterflies (Rhopalocera). Journal of the Lepidopterists' Society 34:1-19.

Leonard, J. G., and R. T. Bell. 1999. Northeastern tiger beetles: a field guide to tiger beetles of New England and eastern Canada. CRC Press, Boca Raton, FL. 176 p.

Lesica, P., and S. V. Cooper. 1997. Presettlement vegetation of southern Beaverhead County, Montana. Montana Natural Heritage Program, Helena, MT. 35 p.

Lesica, P., and S. V. Cooper. 1999. Succession and disturbance in sandhills vegetation: constructing models for managing biological diversity. Conservation Biology 13:293-302.

Lesica, P., G. Moore, K. M. Peterson, and J. H. Rumley. 1984. Vascular plants of limited distribution in Montana. Montana Academy of Sciences Monograph No. 2. 61 p.

Logan, D. R. 1995. Idaho Dunes Tiger Beetle survey 1995: *Cicindela arenicola* Rumpp. Idaho Bureau of Land management Technical Bulletin No. 95-17. 18 p. + appendices.

Long, C. A., and R. S. Hoffmann. 1992. *Sorex preblei* from the Black Canyon, first record for Colorado. Southwestern Naturalist 37:318-319.

MacCracken, J. G., and R. M. Hansen. 1982. Herbaceous vegetation of habitat used by Blacktail Jackrabbits and Nuttall Cottontails in southeastern Idaho. American Midland Naturalist 107:180-184.

Morrill, W. L., D. G. Lester, and A. E. Wrona. 1990. Factors affecting efficiency of pitfall traps for beetles (Coleoptera: Carabidae and Tenebrionidae). Journal of Entomological Science 25:284-293.

Nesser, J. A., G. L. Ford, C. L. Maynard, and D. S. Page-Dunroese. 1997. Ecological units of the Northern Region: subsections. General Technical Report INT-GTR-369. Ogdon, UT: US Department of Agriculture, Forest Service, Intermountain Research Station. 88 p.

North, G. J., and R. E. Marsh. 1999. Black-tailed Jackrabbit, *Lepus californicus*. Pp, 699-701, In The Smithsonian Book of North American Mammals (D. E. Wilson and S. Ruff, eds.). Smithsonian Institution Press, Washington, DC.

Opler, P. A. 1999. A field guide to Western Butterflies, second edition. Houghton Mifflin Company, New York, NY. 540 p.

Paige, C., and S. A. Ritter. 1999. Birds in a sagebrush sea: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID. 47 p.

Pampush, G. J., and R. G. Anthony. 1993. Nest success, habitat utilization and nest-site selection of Long-billed Curlews in the Columbia Basin, Oregon. Condor 95:957-967.

Pearson, D. L., T. G. Barraclough, and A. P. Vogler. 1997. Distributional maps for North American species of tiger beetles (Coleoptera: Cicindelidae). Cicindela 29:33-84.

Peterson, J. G 1995. Ecological implications of sagebrush manipulation: a literature review. Montana Fish, Wildlife & Parks, Helena, MT. 49 p.

Ports, M. A., and S. B. George. 1990. *Sorex preblei* in the northern Great Basin. Great Basin Naturalist 50:93-95.

Povilitis, T., and M. H. Mahr. 1998. Montana's Centennial Valley: natural diversity hot spot and wildland corridor. Natural Areas Journal 18:116-123.

Rauscher, R. L. 1997. Status and distribution of the Pygmy Rabbit in Montana. Montana Fish, Wildlife & Parks Nongame Program, Bozeman, MT. 19 p. + appendices.

Restani, M. 1991. Resource partitioning among three *Buteo* species in the Centennial Valley, Montana. Condor 93:1007-1010.

Reynolds, T. D., T. D. Rich, and D. A. Stephens. 1999. Sage Thrasher (*Oreoscoptes montanus*). *In* The Birds of North America, No. 463 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. 24 p.

Roedel, M. D., and P. Hendricks. 1998. Amphibian and reptile inventory on the Headwaters and Dillon Resource Areas in conjunction with Red Rock Lakes National Wildlife Refuge: 1996-1998. Montana Natural Heritage Program. Helena, MT. 68 p.

Rotenberry, J. T., M. A. Patten, and K. L. Preston. 1999. Brewer's Sparrow (*Spizella breweri*). *In* The Birds of North America, No. 390 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. 24 p.

Rumpp, N. L. 1967. A new species of *Cicindela* from Idaho (Coleoptera: Cicindelidae). Proceedings of the California Academy of Sciences 35:129-140.

Rust, R. W. 1986. Seasonal distribution, trophic structure and origin of sand obligate insect communities in the Great Basin. Pan-Pacific Entomologist 62:44-52.

Saab, V. A., C. E. Bock, T. D. Rich, and D. S. Dobkin. 1995. Livestock grazing effects in western North America. Pp. 311-353, In Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues (T. E. Martin and D. M. Finch, eds.). Oxford University Press, New York, NY.

Shelford, V. E. 1907. Preliminary note on the distribution of the tiger beetles (*Cicindela*) and its relation to plant succession. Biological Bulletin 14:9-14.

Shook, G. A. 1984. Checklist of tiger beetles from Idaho (Coleoptera: Cicindelidae). Great Basin Naturalist 44:159-160.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry, second edition. W. H. Freeman and Company, San Francisco, CA. 859 p.

Stafford, M. P., W. F. Barr, and J. B. Johnson. 1986. Coleoptera of the Idaho National Engineering laboratory: and annotated checklist. Great Basin naturalist 46:287-293.

Stebbins, R. C. 1985. A field guide to western reptiles and amphibians, second edition revised. Houghton Mifflin Company, Boston, MA. 336 p.

Sutter, J., J. C. Munger, and D. A. Hengel. 1999. *Sorex monticolus* in shrub steppe habitat in the northern Great Basin. Great Basin Naturalist 59:102-104.

Tomasi, T. E., and R. S. Hoffmann. 1984. *Sorex preblei* in Utah and Wyoming. Journal of Mammalogy 65:708.

Verts, B. J., G. L. Kirkland, Jr.. 1988. *Perognathus parvus*. Mammalian Species No. 318:1-8.

Vickery, P. D. 1996. Grasshopper Sparrow (*Ammodramus savannarum*). *In* The Birds of North America, No. 239 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C. 24 p.

Wallis, J. B. 1961. The Cicindelidae of Canada. University of Toronto Press, Toronto, Ontario. 74 p.

Willis, H. L. 1968. Artificial key to the species of *Cicindela* of North America north of Mexico (Coleoptera: Cicindelidae). Journal of the Kansas Entomological Society 41:303-317.

Wrigley, R. E. 1974. Mammals of the sandhills of southwestern Manitoba. Canadian Field-Naturalist 88:21-39.

Zegers, D. A. 1984. *Spermophilus elegans*. Mammalian Species No. 214:1-7.

APPENDIX 1. Global and State Rank Guidelines

For state ranks, substitute S for G in these definitions

G1 = Critically imperiled globally because of extreme rarity (typically five or fewer occurrences or very few remaining acres) or because of some factor(s) making it extremely vulnerable to exptirpation.

G2 = Imperiled globally because of extreme rarity (typically six to 20 occurrences or few remaining acres) or because of some factor(s) making it very vulnerable to extirpation.

G3 = Vulnerable; either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g. a single Great Plains state, a single physiographic or ecoregional unit) or because of other factors making it vulnerable to extirpation throughout it's range.

G4 = Apparently Secure; Uncommon, but not rare (although it may be quite rare in parts of its range, especially at the periphery). Apparently not vulnerable in most of its range.

G5 = Secure; Common, widespread, and abundant (though it may be quite rare in parts of its range, especially at the periphery). Not vulnerable in most of its range.

GU = Unrankable; Status cannot be determined at this time.

G? = Unranked; Status has not yet been assessed.

<u>**Modifiers and Rank Ranges**</u>

? A question mark added to a rank expresses an uncertainty about the rank in the range of 1 either way on the 1-5 scale.

G#G# Greater uncertainty about a rank is expressed by indicating the full range of ranks which may be appropriate.

Q A "Q" added to a rank denotes questionable taxonomy. It modifies the degree of imperilment and is only used in cases where the type would have a less imperiled rank if it were not recognized as a valid name (i.e. if it were combined with a more common type).

CRITERIA USED FOR RANKING

The criteria for ranking are based on a set of quantitative and qualitative factors. These factors are listed below in order of their general importance:

a. Number of Element Occurrences (EOs):
   the estimated number of EOs throughout the Element's global range;

b. Abundance:
   the estimated global abundance of the Element (measured by number of individuals, or area, or stream length covered);

c. Size of Range:
   the estimated size of the Element's global range;

d. Distribution trend:

the trend in the Element's distribu tion over it's global range;

e. Number of protected EOs:

the estimated number of adequately protected EOs throughout the Element's global range;

f. Degree of threat:

the degree to which the Element is threatened globally;

g. Fragility:

the fragility or susceptibility of the Element to intrusion;

h. Other global considerations:

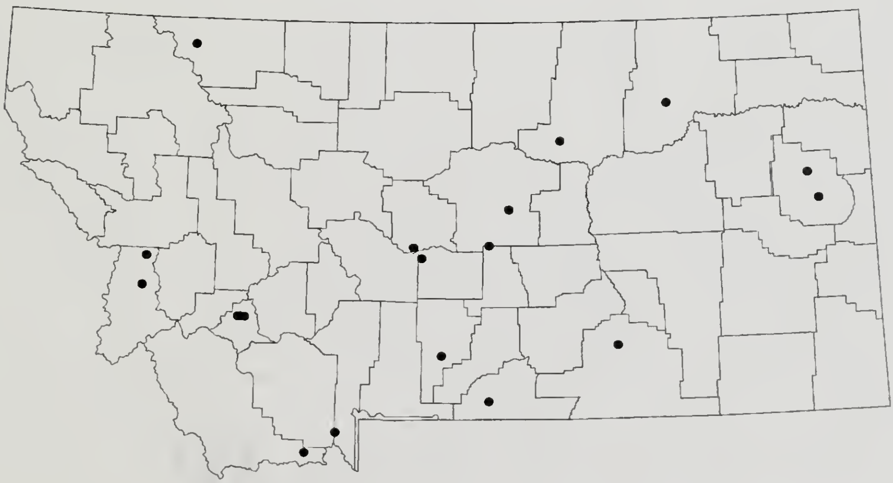
for example, the quality or condition of EOs that affect or may affect endangerment status; unexplained population fluctuations; reproductive strategies that are dependent on specific habitat; etc.

APPENDIX 2. Small mammal species of special concern from the Centennial Sandhills.

Sorex preblei **(Jackson,1922)**
Preble's Shrew
Insectivora: Soricidae
Global Rank: G4; State Rank: S3

DESCRIPTION: Preble's Shrew resembles other long-tailed shrews in Montana, although it is quite small (2.1-4.1 grams). The tail is bi-colored: dark above and pale below. Dorsal fur is grayish to brownish, with silvery pelage on the belly. Sexes are similar in appearance. This species is virtually impossible to identify using external criteria, however. One must examine the teeth and skull to properly distinguish this shrew from other species. There are medial tines on the first upper incisors well within the pigmented portion of the teeth, and the third unicuspid is larger than, or about equal in size to, the fourth unicuspid, placing this shrew in the *cinereus* group. A series of skull measurements is necessary to differentiate *S. preblei* from *S. cinereus* and *S. haydeni* where the species overlap. Condylobasal length is usually < 14.8 mm, cranial breadth is usually < 7.5 mm.

DISTRIBUTION: Preble's Shrew ranges from northeastern California, northern Nevada, northern Utah, and southwestern Wyoming through eastern Oregon, southeastern Washington, central Idaho and across Montana, appearing as several disjunct populations, partly a result of unequal sampling across the geographical range. In Montana Preble's Shrew has previously been confirmed in Big Horn, Dawson, Fergus, Gallatin, Glacier, Judith Basin, Ravalli, Silver Bow, and Sweet Grass counties (14 total locations), and reported from Carbon, Phillips, Valley, and Wheatland counties. The 1999 records (this study) are the first for the Centennial Valley and Beaverhead County.



HABITAT: Recorded habitats of Preble's Shrew include arid and semi-arid shrub-grass associations, openings in montane coniferous forests dominated by sagebrush (Washington), willow-fringed creeks, marshes (Oregon), bunchgrass associations, sagebrush-aspen associations (California), sagebrush-grass associations (Nevada), and alkaline shrubland (Utah). In Montana, most sites where this species has been recorded are arid or semi-arid foothill sagebrush (*Artemisia*)-grassland associations; a few collection localities have been from similar vegetation associations within montane coniferous forest clearings.

COMMENTS: Status and habitat affinities of Preble's Shrew need further attention and review. This species is difficult to distinguish from sympatric Masked (*S. cinereus*) and Hayden's (*S. haydeni*) shrews, and generally requires extensive pitfall trapping over many days to detect. At most localities where this species has been captured it is apparently rare.

REFERENCE:

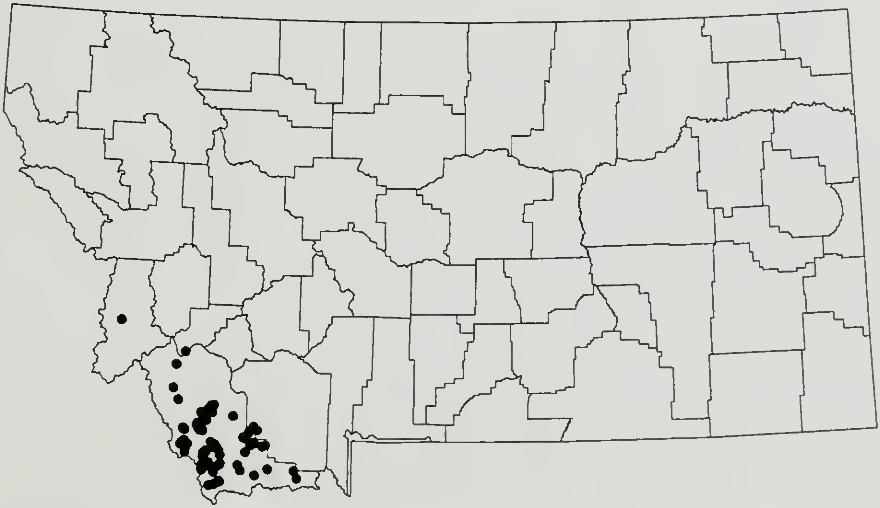
Cornely, J. E., L. N. Carraway, and B. J. Verts. 1992. Sorex preblei. Mammalian Species No. 416:1-3.

Hoffmann, R. S., P. L. Wright, and F. E. Newby. 1969. The distribution of some mammals in Montana. I. Mammals other than bats. Journal of Mammalogy 50:579-604.

***Brachylagus idahoensis* (Merriam, 1891)**
Pygmy Rabbit
Lagomorpha: Leporidae
Global Rank: G4; State Rank: S2S3

DESCRIPTION: The Pygmy Rabbit is smaller than any other North American leporid (averaging about 400-450 grams), with very short hind legs and short rounded ears. The tail is small and inconspicuous with a buff-colored underside, rather than white as in cottontails (*Sylvilagus*). The upper parts are gray, with cinnamon buff on the nape and anterior surfaces of the legs. The skull is small, with a relatively large brain-case and auditory bullae. Supraorbital processes are long compared with those of members in the genus *Sylvilagus*. Postorbital extensions of the supraorbitals are broadest distally, instead of tapering to a blunt end as in *Sylvilagus*. Molariform teeth are relatively small. The anterior surface of the first upper molari-form tooth possesses but a single re-entrant angle while those of *Sylvilagus* have two or three re-entrant angles. The two pair of unpigmented incisors distinguish lagomorph skulls from all rodents.

DISTRIBUTION: The geographic range of the Pygmy Rabbit includes most of the Great Basin in eastern California and Oregon, northern Nevada, western Utah, southern Idaho, isolated populations in southeast-ern Washington and southwestern Wyoming, and extends into southwestern Montana. In Montana the Pygmy Rabbit occurs throughout Beaverhead (many locations), extreme southern Deer Lodge (1 location), and extreme southwestern Madison (2 locations) counties, with a questionable 1937 record from Ravalli County. There are only three records from the Centennial Valley, one of which (in 1997) was from the sandhills area.



HABITAT: The Pygmy Rabbit is closely associated with aggregations of sagebrush (*Artemisia*) throughout their range, especially preferring tall dense clumps of big sage (*A. tridentata*) growing in loose soils; sagebrush is the major component of the diet. In Idaho it also occupies areas supporting greasewood (*Sarcobatus*). In southwestern Wyoming, the pygmy rabbit selectively uses dense and structurally diverse stands of sagebrush that accumulate a relatively large amount of snow; the subnivean environment provides access to a relatively constant supply of food while providing protection from predators and extreme cold weather. The Pygmy Rabbit makes extensive use of burrows largely of their own construction, with entrances usually located at the base of sagebrush plants; burrows may have three or more entrances.

COMMENTS: The Pygmy Rabbit may be locally abundant but unevenly distributed. It may have moved into Montana as sagebrush habitat increased in Beaverhead County following fire suppression during the late nineteenth century. The known distribution in Montana apparently has not changed much during the last 100 years.

REFERENCES:

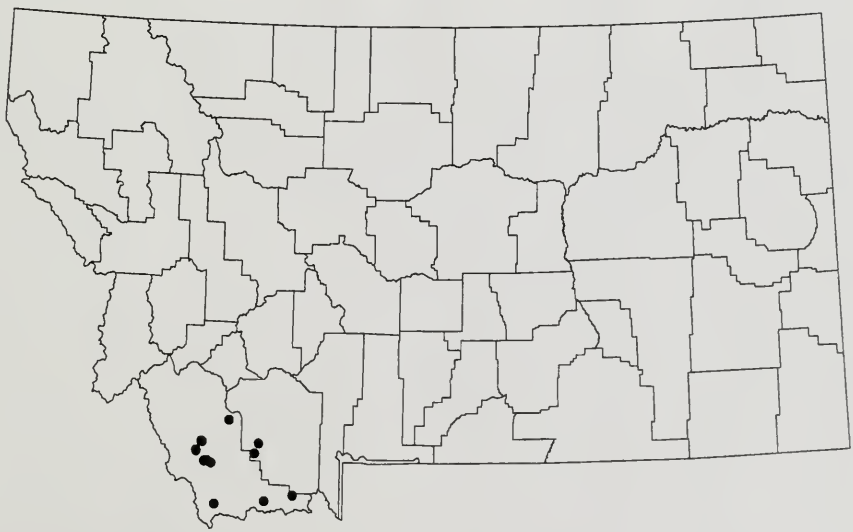
Green, J. S., and J. T. Flinders. 1980. Brachylagus idahoensis. Mammalian Species No. 125:1-4.

Rauscher, R. L. 1997. Status and distribution of the Pygmy Rabbit in Montana. Montana Fish, Wildlife & Parks Nongame Program, Bozeman, MT. 19 pp. + appendices.

***Lepus californicus* (Gray, 1837)**
Black-tailed Jackrabbit
Lagomorpha: Leporidae
Global Rank: G5; State Rank: S2S3

DESCRIPTION: The Black-tailed Jackrabbit is a large (1,300-3,300 grams), slender hare with long legs and ears. The tail has a black dorsal surface that may continue as a line onto the lower back, distinguishing it from the larger White-tailed Jackrabbit (*L. townsendii*) which has a white tail. The upper parts may range from brown to dark gray; the belly and underside of tail are usually a pale gray. The ears are edged and sometimes tipped with black. Unlike the Snowshoe Hare and White-tailed Jackrabbit, Black-tailed Jackrabbits molt only once annually and do not take on a white winter coat. The interparietal bone is fused with the parietals, distinguishing the skulls of hares from the cottontails (*Sylvilagus*) and Pygmy Rabbit (*Brachylagus idahoensis*). Presence of an anterior projection of the supraorbital process differentiates the skull of the two jackrabbit species from the congeneric Snowshoe Hare (*L. americanus*). The first upper incisors have a bi- or trifurcate groove resulting in a complex fold on the anterior surface; *L. townsendii* has a simple groove on the anterior surface of the first upper incisors.

DISTRIBUTION: The Black-tailed Jackrabbit is widespread in the western and central United States, from western Missouri and Arkansas west to the Pacific Coast, and from Washington and Idaho south to Hidalgo and Queretaro in central Mexico. In Montana the Black-tailed Jackrabbit has been documented only in Beaverhead (11 locations) and extreme western Madison (2 locations) counties, with only two reports from the Centennial Valley (one from 1999 during this study).



HABITAT: The Black-tailed Jackrabbit inhabits open plains, fields and deserts, and open country with scattered thickets or patches of shrubs; ideal habitat includes short grasses and herbs for food and ease of locomotion, with scattered brush for cover. This species often becomes abundant on overgrazed land because grazing encourages this type of vegetation. In the Great Basin, the Black-tailed Jackrabbit often inhabits sagebrush (*Artemisia*) desert and semi-desert.

COMMENTS: Black-tailed Jackrabbits may have entered Montana after 1900, following a widespread increase in sagebrush following fire suppression in Beaverhead County. This species is probably more abundant than the relatively few records indicate, although populations undergo dramatic fluctuations; the earliest record was published in 1937.

REFERENCES:

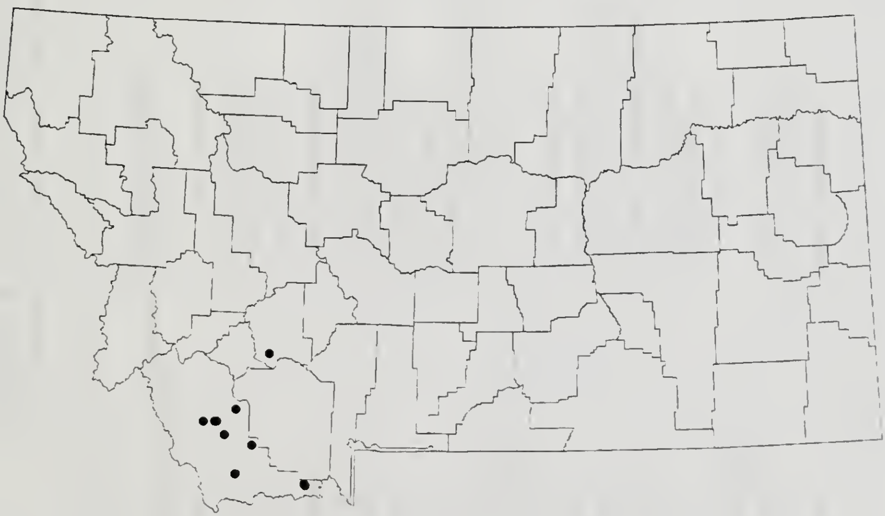
Hoffmann, R. S., P. L. Wright, and F. E. Newby. 1969. The distribution of some mammals in Montana. I. Mammals other than bats. Journal of Mammalogy 50:579-604.

North, G. J., and R. E. Marsh. 1999. Black-tailed jackrabbit, *Lepus californicus*. Pp. 699-701 *In* The Smithsonian Book of North American Mammals (D. E. Wilson and S. Ruff, eds.). Smithsonian Institution Press, Washington, D.C.

Perognathus parvus **(Peale, 1848)**
Great Basin Pocket Mouse
Rodentia: Heteromyidae
Global Rank: G5; State Rank: S2S4

DESCRIPTION: Pocket mice are distinguished by their soft pelage, absence of spines or bristles, somewhat hairy soles on the hind feet, greatly developed mastoids that extend beyond the occipital plane, auditory bullae meeting or nearly so anteriorly, and breadth of the interparietal less than the breadth of the interorbital. The skull has a perforated nasal septum. Grooved upper incisors and external fur-lined cheek pouches are shared by other members of the genus. Diagnostic characteristics of the Great Basin Pocket Mouse include a lobed antitragus, length of the hind foot > 20 mm, occipitonasal length > 24 mm, ears not clothed with white hairs, tail dark above and neither crested nor conspicuously tufted, and the presence of an olivaceous lateral line on the body. The Great Basin Pocket Mouse is the largest member of the genus (16.5-31.0 grams); tail length is 110-120% of the length of the head and body.

DISTRIBUTION: Great Basin Pocket Mice occupy almost the entire Great Basin Region of North America, from south-central British Columbia southward through central and eastern Washington and Oregon, southern Idaho, southwestern Wyoming, most of Nevada and Utah, to northern Arizona and northeast and east-central California. In Montana, Great Basin Pocket Mice are documented only from Beaverhead (8 locations) and Jefferson counties (1 location); the 1999 records (this study) are the first from the Centennial Valley.



HABITAT: The Great Basin Pocket Mouse inhabits arid and semi-arid sandy shrub-steppe covered with short grasses, sagebrush (especially *Artemisia tridentata*), bitterbrush (*Purshia tridentata*), and rabbit brush (*Chrysothamnus*), and also is found in pinyon-juniper woodlands. Usually this species is found in habitats with light-textured loose and deep soils where it can burrow, but it also is sometimes present among rocks. The diet includes a variety of grass and forb seeds; this species may be diminished in areas with heavy livestock grazing because of reduced food availability. Loss of sagebrush cover also diminishes abundance.

COMMENTS: The 1999 records from the Centennial Sandhills are the first in Montana since 1961. The status of the Great Basin Pocket Mouse needs further attention and review. Intensive trapping using pitfall arrays could reveal many additional populations and define in finer detail the distribution, status, and habitat associations of the species in the state.

REFERENCES:

Hoffmann, R. S., P. L. Wright and F. E. Newby. 1969. Distribution of some mammals in Montana. I. Mammals other than bats. Journal of Mammalogy 50:579-604.

Verts, B. J. and G. L. Kirkland, Jr. 1988. Perognathus parvus. Mammalian Species No. 318:1-8.

APPENDIX 3. Descriptions of trapping locations (see Figure 1) for live trap/snap trap lines, pitfall trap lines, and drift fence arrays in the Centennial Sandhills, Beaverhead County, Montana in 1999.

	Legal description	Habitat
Live trap/snap trap lines		
line 1	T13S R2W S23SWSW	dune crest; grassland; mostly erosional
line 2	T13S R2W S22SESE	dune crest/trough; low stature sagebrush/grassland; erosional/depositional
line 3	T13S R2W S22NESE	trough; moderately dense low stature sagebrush; stabilized
line 4	T13S R1W S35SESW	sand flat; grassland/sedge bottom; stabilized
line 5	T13S R1W S34NWNE	low dunes; big sagebrush/grassland; stabilized
line 6	T13S R1W S28NENW/SENW	sand flat; low stature sagebrush/grassland; stabilized
line 7	T13S R2W S22NWSW/NESW	low dunes; sparse low stature sagebrush/grassland; erosional/depositional
line 8	T13S R1W S19SESW	low dunes; sparse big sagebrush/grassland; erosional/depositional
line 9	T13S R1W S35NWSE	low dunes; sparse big sagebrush/grassland; erosional/depositional
line 10	T13S R1W S29NENW/S20SESW	sand flat; sparse low stature sagebrush/grassland along creek; stabilized
line 11	T13S R1W S19SESE	low dunes; moderately dense sagebrush/grassland; erosional/depositional
Pitfall trap lines		
line 1	T13S R2W S23SWSW	trough; moderately dense low stature sagebrush/grassland; stabilized
line 2	T13S R2W S22SESE/S27NENE	dune crest; sparse low stature sagebrush/grassland; erosional/depositional
line 3	T13S R2W S22NESE/S23NWSW	dune crest; sparse low stature sagebrush/grassland; erosional/depositional
line 4	T13S R2W S23NWSW/SWNW	trough; moderately dense low stature sagebrush/grassland; stabilized
line 5	T13S R1W S27SWSE	low dune crest; moderately dense big sagebrush/grassland; stabilized
line 6	T13S R1W S35NWSW	low dunes; sparse big sagebrush/grassland; mostly stabilized
Drift fence arrays		
array 1	T13S R2W S22SESE	dune blowout; sparse grassland; erosional
array 2	T13S R1W S34NWNE	low dune trough; sparse low stature sagebrush/grassland; mostly stabilized
array 3	T13S R1W S35NESW	low dune blowout; sparse grassland; erosional

APPENDIX 4. Small mammals captured on live trap/snap trap lines, Centennial Sandhills, Beaverhead County, Montana in 1999. PEMA: *Peromyscus maniculatus* (Deer Mouse); MIMO: *Microtus montanus* (Montane Vole) MISP: Microtus species (unidentified vole); TAMI: *Tamias minimus* (Least Chipmunk).

Sampling period	**Numbers captured (numbers/100 trap-nights)**			
	PEMA	**MIMO**	**MISP**	**TAMI**
Period 1 (25 May-28 May)				
line 1 (360 trap nights)	10 (2.78)	2 (0.56)	0 (0.00)	6 (1.67)
line 2 (270 trap nights)	10 (3.70)	0 (0.00)	1 (0.37)	1 (0.37)
line 3 (270 trap nights)	0 (0.00)	4 (1.48)	0 (0.00)	0 (0.00)
Period 2 (1 Jul-3 Jul)				
line 4 (270 trap nights)	0 (0.00)	6 (2.22)	0 (0.00)	0 (0.00)
line 5 (252 trap nights)	5 (1.98)	0 (0.00)	0 (0.00)	0 (0.00)
line 6 (270 trap nights)	3 (1.11)	0 (0.00)	0 (0.00)	0 (0.00)
Period 3 (26 Jul-29 Jul)				
line 7 (240 trap nights)	3 (1.25)	4 (1.67)	0 (0.00)	6 (2.50)
line 8 (240 trap nights)	9 (3.75)	2 (0.83)	0 (0.00)	1 (0.42)
line 9 (240 trap nights)	6 (2.50)	1 (0.42)	0 (0.00)	3 (1.25)
Period 4 (21 Sep-23 Sep)				
line 10 (180 trap nights)	3 (1.67)	0 (0.00)	0 (0.00)	1 (0.56)
line 11 (180 trap nights)	2 (1.11)	0 (0.00)	4 (2.22)	1 (0.56)
Total (2772 trap nights)	51 (1.84)	19 (0.69)	5 (0.18)	19 (0.69)

APPENDIX 5. Small mammals captured on pitfall trap lines, Centennial Sandhills, Beaverhead County, Montana in 1999. SOMO: *Sorex monticolus* (Dusky Shrew); SOCI: *Sorex cinereus* (Masked Shrew); SOPR: *Sorex preblei* (Preble's Shrew); SOSP: *Sorex* species (unidentified shrew); PEMA: *Peromyscus maniculatus* (Deer Mouse); MIMO: *Microtus montanus* (Montane Vole); MIPE: *Microtus pennsylvanicus* (Meadow Vole); PEPA: *Perognathus parvus* (Great Basin Pocket Mouse); THTA: *Thomomys talpoides* (Northern Pocket Gopher).

Sampling period	Numbers captured (numbers/100 trap-nights)								
	SOMO	SOCI	SPPR	SOSP	PEMA	MIMO	MIPE	PEPA	THTA
Period 1 (26 May-28 Jun)									
line 1 (340 trap nights)	1 (0.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	5 (1.47)	0 (0.00)	0 (0.00)	0 (0.00)
line 2 (340 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
line 3 (340 trap nights)	0 (0.00)	0 (0.00)	1 (0.29)	0 (0.00)	1 (0.29)	2 (0.59)	0 (0.00)	0 (0.00)	1 (0.29)
line 4 (340 trap nights)	0 (0.00)	1 (0.29)	0 (0.00)	0 (0.00)	0 (0.00)	6 (1.76)	0 (0.00)	0 (0.00)	0 (0.00)
line 5 (330 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.30)	0 (0.00)	1 (0.30)	3 (0.91)	1 (0.30)
line 6 (330 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.30)	0 (0.00)	0 (0.00)	1 (0.30)
Period 2 (29 Jun-28 Jul)									
line 1 (290 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.34)
line 2 (290 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	4 (1.38)
line 3 (290 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.34)	0 (0.00)	0 (0.00)	0 (0.00)
line 4 (290 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
line 5 (290 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
line 6 (290 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.34)	0 (0.00)	0 (0.00)	0 (0.00)
Period 3 (29 Jul-22 Sep)									
line 1 (540 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
line 2 (540 trap nights)	1 (0.19)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.19)	1 (0.19)	0 (0.00)	0 (0.00)	0 (0.00)
line 3 (540 trap nights)	0 (0.00)	0 (0.00)	1 (0.19)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.19)
line 4 (540 trap nights)	1 (0.19)	0 (0.00)	0 (0.00)	1 (0.19)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
line 5 (540 trap nights)	3 (0.56)	0 (0.00)	0 (0.00)	2 (0.37)	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.37)	0 (0.00)
line 6 (540 trap nights)	0 (0.00)	1 (0.19)	0 (0.00)	1 (0.19)	0 (0.00)	1 (0.19)	0 (0.00)	0 (0.00)	0 (0.00)
Total (7000 trap nights)	6 (0.09)	2 (0.03)	2 (0.03)	4 (0.06)	3 (0.04)	18 (0.26)	1 (0.01)	5 (0.07)	9 (0.13)

APPENDIX 6. Small mammals captured at drift fence arrays, Centennial Sandhills, Beaverhead County, Montan SOMO: *Sorex monticolus* (Dusky Shrew); SOCI: *Sorex cinereus* (Masked Shrew); SOSP: *Sorex* species (unid shrew); MIMO: *Microtus montanus* (Montane; Vole); PEPA: *Perognathus parvus* (Great Basin Pocket Mouse); *Thomomys talpoides* (Northern Pocket Gopher).

Sampling period	Numbers captured (numbers/100 trap-nights)					
	SOMO	**SOCI**	**SOSP**	**MIMO**	**PEPA**	**THTA**
Period 1 (27 May-28 Jun)						
drift array 1 (128 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.78)	0 (0.00)	1 (0.78)
drift array 2 (128 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.78)	0 (0.00)	0 (0.00)
drift array 3 (128 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.78)	0 (0.00)
Period 2 (29 Jun-28 Jul)						
drift array 1 (116 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
drift array 2 (116 trap nights)	0 (0.00)	1 (0.86)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.86)
drift array 3 (116 trap nights)	0 (0.00)	2 (1.72)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Period 3 (29 Jul-22 Sep)						
drift array 1 (216 trap nights)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
drift array 2 (216 trap nights)	1 (0.46)	0 (0.00)	3 (1.39)	0 (0.00)	0 (0.00)	1 (0.46)
drift array 3 (216 trap nights)	1 (0.46)	1 (0.46)	2 (0.93)	0 (0.00)	0 (0.00)	1 (0.46)
Total (1380 trap nights)	2 (0.14)	4 (0.29)	5 (0.36)	2 (0.14)	1 (0.07)	4 (0.29)

APPENDIX 7. Mammal, amphibian, and reptile species documented in the Centennial Sandhills, Beaverhead County, Montana during May-September 1999. West Hills is that portion west of Tepee Creek, East Hills that portion east of Tepee Creek.

Common Name	Scientific Name	West Hills	East Hills
MAMMALS			
Masked Shrew	*Sorex cinereus*	X	X
Dusky Shrew	*Sorex monticolus*	X	X
Preble's Shrew	*Sorex preblei*	X	
Black-tailed Jackrabbit	*Lepus califomicus*	X	
White-tailed Jackrabbit	*Lepus townsendii*	X	X
Least Chipmunk	*Tamias minimus*	X	X
Wyoming Ground Squirrel	*Spermophilus elegans*	X	X
Northern Pocket Gopher	*Thomomys talpoides*	X	X
Great Basin Pocket Mouse	*Perognathus parvus*		X
Deer Mouse	*Peromyscus maniculatus*	X	X
Montane Vole	*Microtus montanus*	X	X
Meadow Vole	*Microtus pennsylvanicus*		X
Coyote	*Canis latrans*	X	X
Red Fox	*Vulpes vulpes*		X
Badger	*Taxidea taxus*	X	
Elk or Wapiti	*Cervus elaphus*	X	
Mule Deer	*Odocoileus hemionus*		X
Pronghorn	*Antilocapra americana*	X	X
AMPHIBIANS			
Tiger Salamander	*Ambystoma tigrinum*		X
Striped Chorus Frog	*Pseudacris triseriata*	X	X
REPTILES			
Western Terrestrial Garter Snake	*Thamnophis elegans*	X	X

APPENDIX 8. Bird species documented in the Centennial Sandhills, Beaverhead County, Montana in summer 1999. Sequence and names follow the American Ornithologists' Union Checklist, seventh edition (1998). West Hills is that portion of the sandhills west of Tepee Creek, East Hills is that portion east of Tepee Creek.

Common Name	Scientific Name	West Hills	East Hills
Great Blue Heron	*Ardea herodias*	29 Jun; 2, 28 Jul (all flyovers)	
Canada Goose	*Branta canadensis*	25 May (flyover)	
Mallard	*Anas platyrhynchos*	27 May (flyover)	
Northern Harrier	*Circus cyaneus*	24 May; 28, 29 Jun; 28, 29 Jul; 20 Sep	30 Jun; 1 Jul; 22 Sep
Swainson's Hawk	*Buteo swainsoni*	28 Jun	28, 30 Jun
Red-tailed Hawk	*Buteo jamaicensis*	26 May; 28 Jun	27, 28 May
Ferruginous Hawk	*Buteo regalis*	30 Jun; 29 Jul	
American Kestrel	*Falco sparverius*	29 Jun; 20 Sep	28, 30 Jun; 1 Jul
Prairie Falcon	*Falco mexicanus*	28, 30 Jul	
Sandhill Crane	*Grus canadensis*	24, 27, 28 May	20 Jun
Willet	*Catoptrophorus semipalmatus*	25, 26, 27, 28 May (all flyovers)	
Long-billed Curlew	*Numenius americanus*	25 May; 29 Jun	
Franklin's Gull	*Larus pipixcan*	25 May (flyover)	
Mourning Dove	*Zenaida macroura*	28 Jun	
Short-eared Owl	*Asio flammeus*	24, 26, 27 May; 1 Jun; 28 Jul; 20 Sep	30 Jun; 1 Jul
Common Raven	*Corvus corax*	May; Jun; Jul; Sep daily	May; Jun (nest on windmill); Jul; Sep daily
Horned Lark	*Eremophila alpestris*	May (nest); Jun; Jul daily	1 Jul
Tree Swallow	*Tachycineta bicolor*	28 Jun; 28, 29 Jul (all flyovers)	27 May; 28 Jun
Cliff Swallow	*Petrochelidon pyrrhonota*	29 Jun (flyover)	
Barn Swallow	*Hirundo rustica*	2 Jul (flyover)	28 Jun (nest in culvert), 28 Jul
Mountain Bluebird	*Sialia currucoides*		27 May (nest in box); Jun (daily); 28 Jul (2nd nest in box)
Sage Thrasher	*Oreoscoptes montanus*	May; Jun; Jul daily	Jun daily
Brewer's Sparrow	*Spizella breweri*	May; Jun (2 nests); Jul (nest) daily	May (nest); Jun; Jul daily
Vesper Sparrow	*Pooecetes gramineus*	May; Jun (nest); Jul; Sep daily	May; Jun (nest); Jul; Sep daily
Savannah Sparrow	*Passerculus sandwichensis*	May; Jun; Jul daily	May; Jun daily
Grasshopper Sparrow	*Ammodramus savannarum*	25, 26, 27, 28 May; 29, 30 Jun; 1, 2 Jul	
Red-winged Blackbird	*Agelaius phoeniceus*	26 May	
Western Meadowlark	*Sturnella neglecta*	May; Jun; Jul; Sep daily	May; Jun; Jul; Sep daily
American Goldfinch	*Carduelis tristis*	27 May (flyover)	

APPENDIX 9. List of tiger beetles (Coleoptera: Carabidae) and diurnal butterflies (Lepidoptera: Papilionoidea and Hesperioidea) documented in the Centennial Sandhills, Beaverhead County, Montana in 1999 (buttlerflies late July only). West Hills is that portion west of Tepee Creek, East Hills is that portion east of Tepee Creek.

TIGER BEETLES			
Species	**Habitat**	**West Hills**	**East Hills**
Cicindela decemnotata	blowout, sandy road	X	X
Cicindela formosa	blowout, sandy road	X	X
Cicindela longilabris	grassy stabilized dune		X
Cicindela tranquebarica	moist sandy/pebbly road		X

BUTTERFLIES			
Common Name	**Scientific Name**	**West Hills**	**East Hills**
Rocky Mountain Parnassian	*Parnassius smintheus*	X	X
Blue Copper	*Lycaena heteronea*	X	X
Dorcas Copper	*Lycaena dorcas*		X
Sooty Hairstreak	*Satyrium fuliginosum*	X	X
Melissa Blue	*Lycaeides melissa*	X	X
Boisduval's Blue	*Icaricia icariodes*	X	
Lupine Blue	*Icaricia lupini*	X	
Zerene Fritillary	*Speyeria zerene*	X	X
Northern Crescent	*Phyciodes cocyta*		X
Small Wood-Nymph	*Cercyonis oetus*	X	X
Riding's Satyr	*Neominois ridingsii*	X	X
Garita Skipperling	*Oarisma garita*		X
Juba Skipper	*Hesperia juba*	X	
Common Branded Skipper	*Hesperia comma*	X	X