FINAL REPORT ON THE GEOGRAPHIC EXTENT OF THE PREBLE'S MEADOW JUMPING MOUSE POPULATION ON THE UNITED STATES AIR FORCE ACADEMY.

TO THE UNITED STATES AIR FORCE ACADEMY
COLORADO SPRINGS, COLORADO

Janelle G. Corn, Christopher A. Pague, Aaron R. Ellingson, Michael Sherman, Tad Zwiejacz, Gwen Kittel, and Chris Fleming

Colorado Natural Heritage Program
110 Natural Resources Building
Colorado State University
Fort Collins, Colorado 80523

October 20, 1995

INTRODUCTION

During an inventory of rare animals and plants by the Colorado Natural Heritage Program (CNHP) on the United States Air Force Academy (USAFA) in 1994, the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) was found along Monument Creek. This globally rare subspecies is a candidate for listing under the Endangered Species Act by the U. S. Fish and Wildlife Service. The Preble's meadow jumping mouse occurs only along the Rocky Mountain Front Range in Colorado and Wyoming. It is known in Colorado from fewer than 50 specimens and 22 locations from Larimer, Weld, Boulder, Jefferson, Denver, Adams, Arapaho, Douglas, and El Paso Counties (Armstrong 1972, CNHP unpublished data), and has been documented from southeastern Wyoming by 7 historical records (Compton and Hugie 1993a), although recent records from Wyoming are unknown (C. Garber, pers. comm.). Judging from its limited ecological and geographic distribution in Colorado, the mouse is probably a Pleistocene relict, perhaps once widespread in tallgrass prairie across the eastern plains, but now restricted to scattered localities on the Colorado Piedmont (Fitzgerald et al. 1994), and apparently only within relatively short distances from riparian vegetation.

The status of extant populations of Preble's meadow jumping mouse is poorly known. In addition to the single capture from the USAFA on Monument Creek found during surveys in 1994, extant populations are known from the Rocky Flats Environmental Site, the City of Boulder Open Space lands (Compton and Hugie 1993b), and East Plum (F. Harrington, pers. comm.; Colorado Natural Heritage Program, unpublished data) and West Plum Creeks in Douglas County. Unsuccessful surveys of historic capture locations (T. Ryan, pers. comm.; C. Meaney, pers. comm.), and extensive urbanization of these locations, suggest that many populations have been extirpated.

Based on the capture of Preble's meadow jumping mouse on the USAFA, a preliminary conservation planning boundary for the Monument Creek Site was recommended by the CNHP. This plan considered the large extent of habitat suitable for jumping mice, the occurrence of other significant elements within the site including globally and regionally rare or imperilled plant species, buffers from potentially detrimental adjacent land uses, and maintenance of the ecological processes thought to be important to jumping mouse populations.

Understanding the local distribution of the Preble's meadow jumping mouse on the USAFA is critical to wise conservation planning. A more accurate recommended conservation planning boundary, along with management and protection recommendations, will provide the USAFA with a proactive planning tool for operations and conservation goals. This work compliments the Academy's outstanding land management programs, and furthers the goals of the Legacy Resource Management Program to improve the management of significant biological, geophysical, cultural, and historical resources on Department of Defense lands. In addition, information gained from this study will contribute to the conservation of the Preble's meadow jumping mouse across its range, by adding to our knowledge of the status and habitat requirements of this globally significant, but poorly known, subspecies.

However, the actual extent of the population on the USAFA cannot be known from a single capture. For this reason, the CNHP proposed to conduct more extensive surveys to determine the geographic extent of occurrence of this population within the bounds of the USAFA.

OBJECTIVES

The objectives of our survey were:
(1) to determine the geographic extent of *Zapus hudsonius preblei* within suitable habitats at the U. S. Air Force Academy using live-trap methods;
(2) to use both positive and negative capture results to formulate a conservation planning area that will adequately protect this population; and
(3) to provide management and protection recommendations regarding this area that allow for proactive, not reactive, conservation decision-making.

METHODS

Methods followed those outlined in the proposal, except as indicated. Potential Preble's jumping mouse habitat on the USAFA was identified from maps, aerial photographs, and field notes from previous surveys. Potential habitat was stratified by 1 square mile sections, and trapping effort was distributed among habitat types in each section in proportion to their relative representation. Our work was extended one week to sample an unnamed tributary of Monument Creek around Reservoir No.2, to provide information on the occurrence of jumping mice in an area proposed for expansion of a golf course over the next few years. This was an approximately 2.5-mile length of tributary. Transect placement was at regular intervals along the length of the tributary in the best potential habitat for jumping mice at each interval.

Live trapping was conducted 19 June-11 August using four 50-trap transects per one-mile section of Monument Creek or its tributaries. Each transect consisted of 2 parallel traplines, with 25 traps set 5 m apart on each trapline, and traplines placed 10 m apart. One trapline was placed within approximately 5 meters of water's edge, and the parallel trapline was placed an additional 10 m from the water.

Because larger numbers of jumping mice were captured than expected and were captured more rapidly (i.e. in the first or second night of trapping on many transects) than expected, trapping effort was modified from the original proposal. Traps on each transect were set for 4 nights (200 total trapnights/transect). If no jumping mice were caught in 4 nights on any transect in a section, the traps were opened for a fifth night (250 total trap nights).

A few captures early in the trapping season occurred on portions of transects that extended into upland habitats adjacent to the riparian areas being sampled. For this reason, and also in order to comply as much as possible with the USFWS' Interim Survey Guidelines (1995) recommended protocol for sampling for this subspecies, we modified placement of transects in each section. Instead of four riparian transects per mile, we placed three transects in riparian habitat and parallel to the stream, and one transect in upland habitat beginning at the edge of the riparian habitat and running perpendicular to the stream. No upland perpendicular transects were set along the tributary around Reservoir No. 2. However, riparian habitats were so limited in width along this reach of stream that traplines most distant from the water's edge typically sampled upland habitats.

Each jumping mouse was photographed, weighed, and measured according to the USFWS recommended protocol, and its age and sex noted. The observed sex ratio was compared to a 50:50 ratio using a *G* test (Sokal and Rohlf 1981).

Beginning 11 July (the fourth week of trapping), we began marking each mouse captured to determine the number of individuals caught on each transect. Each time a jumping mouse was captured, it was marked with a dot at the base of the tail using a permanent marker. Measurements and related information were collected only for the first capture of each individual. Subsequently, the number of dots at the base of the tail were recorded, a new dot was added, and the animal was released. The proportion of all captures that were unique individuals was calculated for each transect from the 4 weeks of marking, and averaged over all transects and weeks of marking. Total captures from the first 3 weeks of trapping without marking were adjusted for recapture using this average proportion. We estimated the number of individuals captured during the entire trapping effort as the sum of the estimated number in the first three weeks and the known number from the last 4 weeks of trapping.

Capture locations were marked with numbered flags on wires and the area around each location was flagged. Each capture site was photographed and the following information recorded: distance to water; cover (sparse, moderate, or dense), average height, and dominant species for each stratum (ground cover, herbaceous, shrub, and tree). Each capture location was mapped on a sketch of the transect, and each transect was mapped on a topographic map.

After trapping was completed, each transect was revisited and the vegetation at each transect and each capture location was classified qualitatively by community type(s). More detailed quantitative sampling was conducted on selected transects. Plant community types most frequently used by *Zapus* and community types where we recorded the occurrence of *Zapus* for the first time were sampled quantitatively. Some communities with captures of *Zapus* have been described in the literature previously, and so were not sampled in detail. Others were monospecific (e.g. *Typha* and *Bromus inermis* monocultures), and warranted no further description.

Quantitative sampling of each plant community was conducted by estimating percent canopy cover for woody plant species and for life form (tree, shrub, graminoid or forb) in representative habitat along traplines using the line-intercept method. Percent canopy cover by life form and for woody plant species was estimated on 50-m transects using line-intercept. Herbaceous species cover and ground cover (litter, gravel, moss) was determined using ocular estimation of percent cover within 20 x 50 cm micro-plots. Twelve to 17 microplots (depending on the extent of the plant community being sampled) were placed at 3 m intervals along the length on the line-intercept transect. From 1 to 4 transects were sampled for each plant community type, depending on the frequency of occurrence of each community type, and the frequency of *Zapus* captures in each community type. Finally, species composition and percent cover of grass and forb species were measured on micro-plots centered on all capture points occurring in communities sampled quantitatively.

Aerial photographs (color, June 23, 1988, Natural Resources Group, USAFA) of Monument Creek and its tributaries were examined to estimate the total aerial extent of *Zapus hudsonius preblei* habitat on the AFA and to draw site boundaries for this subspecies on the AFA.

RESULTS

We trapped June 19 - August 11, 1995, for a total of 9675 trapnights, with 150-250 trapnights per site. Trapping effort was reduced from the average 200 trapnights on some sites due to weather-caused reductions in

trapping effort or establishment of some transects on the second of 4 nights' trapping. Jumping mice were captured on at least one transect in each section sampled. In only one section (upper W. Monument) were there no captures of *Zapus* on any of the 4 transects in 4 nights' trapping (800 trapnights); one jumping mouse was captured on the fifth night on one of those transects.

We caught 0-14 jumping mice per transect (0 - 9.3 jumping mice / 100 trap-nights), and had 100 total captures, for an average of 1.03 captures per 100 trapnights. During the second half of the project, we marked 27 unique individuals among 45 total captures on 10 transects. The average proportion of captures that were unique individuals on transects where marks were applied was 0.74/transect. Extrapolating this ratio to the earlier part of the project when marking was not used, we estimate that 67 unique individuals were captured during the project. Appendix I summarizes trapping results by transect.

All but one *Zapus* capture were adults. Measurements of adults were (ave [range]): **mass**: 18.6 g [14-27]; **total length**: 207.5 mm [187-231]; **tail length**: 126.2 mm [105-137]; **body length**: 81.3 mm [63-98]; **hind foot length**: 29.7 mm [27-36]. Measurements of some animals captured early in the trapping efforts (June) were smaller than average and may have been young of the year, suggesting that this species may produce more than one litter per year on the Academy. Multiple litters occur in Preble's meadow jumping mouse populations elsewhere in Colorado (F. Harrington, pers. comm.) The sex ratio of adults favored females (33 males:37 females); however, this was not significantly different from a 50:50 sex ratio (G_{adj} = 0.2287, $P > 0.50$). Average tail length follows that reported in the USFWS' Interim Survey Guidelines (1995), but body lengths of some individuals were larger than expected for this species (>89 mm). Appendix II reports individual measurements of all captures.

Other species captured during live trapping included deer mouse (*Peromyscus maniculatus*), Northern rock mouse (*Peromyscus nasutus*), meadow vole (*Microtus pennsylvanicus*), dwarf shrew (*Sorex nanus*), Merriam's shrew (*Sorex merriami*), western harvest mouse (*Reithrodontomys megalotus*), Colorado chipmunk (*Tamias quadrivittatus*), and long-tailed weasel (*Mustela frenata*). House mice (*Mus musculus*) were captured on one site.

The average distance to water from the point of capture of Preble's jumping mice on the USAFA was 6.6 m (range <1 m to 30 m, n = 83 capture locations). Although 2 mice were caught in dry, upland habitats types on riparian transects that extended into upland, none were captured on transects set perpendicular to the riparian zone (n = 9 transects). Plant community structure at points of capture was similar to that reported in the literature. Ground cover was fairly dense (73% of capture locations had dense or moderate cover, n = 70) and deep (ave = 5 cm, SE = 0.485, n = 70). Herbaceous cover was very frequently dense (91% of capture locations had dense or moderate cover, n = 78), and shrub cover was often fairly dense (53% of capture locations had dense or moderate cover, n = 78). Structural characteristics of individual capture locations is reported in Appendix III. Herbaceous species at capture locations were predominantly introduced species (Table 1). Two captures occurred in locations dominated by introduced (weedy) forbs, one in a mesic graminoid community and one in a *Salix exigua* community.

Most *Zapus hudsonius preblei* occurred in habitats similar to those recorded in the literature for this subspecies in other part of its range

(Table 2): willow (*S. exigua, S. monticola*) riparian areas along stream margins (40 capture locations on 18 transects); snowberry (*Symphoricarpos occidentalis*) communities near streams (11 capture locations on 5 transects); cottonwood stands (*Populus angustifolius*), both young and mature, in association with *S. exigua* (8 capture locations on 5 transects); and wet graminoid (cattail [*Typha latifolia*], sedge [*Carex nebraskensis*], and rush [*Juncus arcticus*]) communities (7 capture locations on 5 transects).

Several plant communities were used by *Z. h. preblei* on Monument Creek and its tributaries that had not been reported previously for this species. Our greatest number of captures (9.3/100 trap-nights) occurred on a transect in an alder (*Alnus incana*)-willow (*S. exigua*) community along Kettle Creek. We also captured jumping mice in ponderosa pine (*Pinus ponderosa*) dominance types on tributaries of Monument Creek. On West Monument Creek, jumping mice used a Ponderosa pine/alder-dogwood (*Cornus sericea*)-river birch (*Betula fontinalis*) community; one capture on Black Squirrel Creek was located in a Ponderosa pine/little bluestem (*Schizachyrium scoparium*) community. Gambel oak (*Quercus gambelii*) plant associations were used by jumping mice in 2 locations: on West Monument Creek and below Reservoir No.2. Incidental upland communities in which jumping mice were captured were *Bromus inermis* and tallgrass prairie (*Andropogon gerardii*). Finally, a few communities originally identified as mature cottonwood communities from aerial photographs turned out to be mature stands of crack willow *(S. fragilis)*, an introduced species that probably only reproduces by sprouting in Colorado. Jumping mice were captured in 2 of 3 of these communities sampled. Quantitative measures of the characteristics of the plant communities trapped on the AFA are reported in Appendix IV.

CONSERVATION SITE PROFILE

We identified 2 distinct occurrences of Preble's meadow jumping mice from our surveys of Monument Creek and its tributaries on the AFA. An "occurrence" was defined as occupied habitat (capture records) occurring within 3 miles of continuous unsurveyed habitat or within one mile of surveyed habitat. Both occurrences were incorporated into a single **conservation site**, an area in need of special protection and management due to the presence of plant and animals species of concern in Colorado and/or globally. In addition to a large population of Preble's meadow jumping mice, several other rare animals and plants occur on the site.

SITE NAME: Monument Creek

SIZE: Primary Boundary (Zone A)--2600 ac; Secondary Boundary (Zone B)--8,640 ac within the USAFA, and 1,830 ac outside (E of) the USAFA.

BIODIVERSITY RANK: B2

This site is of high global significance because it is one of the best known for this globally imperilled subspecies.

PROTECTION URGENCY RANK: P3

Although immediate threats to this site are unknown, specific threats are imminent unless precautionary measures are taken.

MANAGEMENT URGENCY: M4

Current management of the area provides adequate habitat and ecological integrity for the continued existence of the mouse. In a few areas, it is

likely that negative impacts occur to the jumping mouse population (e.g. from domestic animal predation.) Management within the site boundaries will be required at some future time.

LOCATION: At the U.S. Air Force Academy, approximately 13 miles north of Colorado Springs, this site encompasses the length of Monument Creek through the Academy, all of its tributaries to the east, and Deadman's Creek and West Monument Creek to the west, as well as a buffer zone that ensures protection of the integrity of the Creek and its tributaries.

QUADRANGLE: Pikeview, Monument

GENERAL DESCRIPTION: Monument Creek flows from north to south through the length of the Academy. Substrate is gravel to silt. The floodplain is defined by steep eroding sandstone cliffs on the east banks, and generally gentle terraces on the west. Many active beaver ponds are found along the creek, creating large pools, flooding the riparian vegetation, and eventually filling in with silt. Water sources from some of the tributaries sustaining large populations of jumping mice such as that below the (now defunct) sewage disposal site NE of the Academy and Kettle Creek along the edge of an old landfill at the south end of the Academy, are highly altered flows.

Riparian vegetation along the creek is generally dominated by tall and often dense stands of willow (*Salix* spp.) with scattered stands of narrow-leaf cottonwood (*Populus angustifolia*). Stream banks retain native graminoid vegetation in the form of sedges (*Carex* spp.) and rushes (*Juncus* spp.). Surrounding uplands are generally midgrass prairie that has been variously modified, primarily by the domination of introduced grasses including smooth brome (*Bromus inermis*), and cheatgrass (*Bromus tectorum*). Occasional patches of native vegetation in these grasslands include needlegrass (*Stipa comata*) and big bluestem (*Andropogon gerardii*), and blue grama (*Bouteloua gracilis*) is relatively widespread. Ponderosa pine (*Pinus ponderosa*) occurs in small patches along the eastern edge of the floodplain.

Exotic species of plants and animals occur throughout the site. Uplands throughout the area have been modified by the introduction of smooth brome, which appears to have been extensively seeded over large areas. The herbaceous layer in the riparian zone is also dominated by exotic species, especially Kentucky bluegrass (*Poa pratensis*), smooth brome, and thistle species (*Carduus nutans* and *Cirsium arvense*). Other aggressive weeds such as knapweed (*Centaurea* spp.) are present in lower numbers. The exotic crack willow (*Salix fragilis*) occurs in places, but it likely has little chance of spreading. The house mouse (*Mus musculus*) was trapped on a transect near adjacent buildings; their effects on jumping mice are not known.

Prior to the establishment of the Air Force Academy Reservation, the site was used for logging and ranching operations since settlement in the 1860's (Ripley 1994). Logging has not occurred since 1915 (Ripley 1994). Cattle grazing has not occurred since the purchase of the area by the Air Force Academy in the 1950's (Ripley 1994). This has allowed herbaceous and woody riparian vegetation to remain dense. In the absence of grazing, the streambed integrity is likely greater than a grazed site would be, as well. In any case, a lack of grazing may be related to the present occurrence of Preble's meadow jumping mice over their historic range (F. Harrington, pers. comm.).

NATURAL HERITAGE RESOURCE SIGNIFICANCE:

Element	Common Name	Occur. Rank	Global Rank	State Rank	Federal Status	State Status
Zapus hudsonius preblei	Preble's meadow jumping mouse	A	G5T2	S2	C2	SC
Zapus hudsonius preblei	Preble's meadow jumping mouse	D	G5T2	S2	C2	SC
Potentilla ambigens	Southern Rocky Mountain cinquefoil	B	G3	S1S2		
Woodsia neomexicana			G4?	S2		
Sorex merriami	Merriam's shrew		G5	S3		
*Rana pipiens**	Northern leopard frog*		G5	S3S4		SC
Celastrina sp. 1	Hops vine blue butterfly		G2	S2		
Euphilotes rita coloradensis	Colorado blue butterfly		G4T5?	S2S3		

Our proposal described the criteria we consider when ranking element occurrences (EOs): quality, condition, viability, and defensibility. The large population of jumping mice on Monument Creek in the USAFA, including adults in reproductive condition and juveniles, suggests that this site is of high quality for this species, with a population in good condition and with high viability. Monument Creek represents a large population of jumping mice with evidence of persistence. The population occurs in a large extent of contiguous habitat with ecological processes more-or-less intact. Protection of the area is likely. For these reasons, it is one of the best possible examples of *Z. h. preblei* populations. Indeed, these results suggest this to be the best known jumping mouse site at present. Even though the overall community is modified hydrologically and dominated by exotic plant invaders, it contains those elements--good herbaceous and woody cover, lack of human development in adjacent uplands, protection from grazing-- that appear to be critical for use by jumping mice.

Based on our definition of an element occurrence, a capture site below Reservoir No. 2 and north of the AFA Golf Course constituted an element occurrence separate from the Monument Creek population. The capture of a single jumping mouse below Reservoir No. 2 in 1500 trap-nights suggests a very low estimated population size. The capture location is isolated and of poor quality, dominated by exotic plants (toadflax [*linaria vulgaris*]) in an upland habitat type that Preble's have not been reported to use previously. The nearby riparian area has little surface water in an ephemeral stream, at least at the time of capture (August 1995), and is also dominated by exotic species, especially Kentucky bluegrass, smooth brome, and thistle species (*Carduus nutans* and *Cirsium arvense*). The golf course nearby is heavily used (we found numerous golf balls during trapping). Other portions of this tributary are highly degraded--the streambank is cut down, the floodplain is scoured in areas, and much of the length of the stream did not have surface water at the time of the survey. However, because Preble's is a globally significant species, the capture site must be noted. We have assigned the site a biodiversity rank of general significance, since the site is small, apparently

of marginal and degraded habitat, and generally will be more difficult to maintain. This occurrence was ranked 'D', indicating that relative to other occurrences of this subspecies, this occurrence is of low priority.

CURRENT STATUS: Because the Academy is protected as a military educational institute, its defensibility is good. Monument Creek, its tributaries, and the adjacent uplands have not been impacted by livestock grazing for decades. Lack of heavy use of the riparian area by recreationists likely improves streamside vegetation and reduces stream degradation. Adjacent uplands, although with altered plant composition, are protected from development. This reduces impacts on the hydrologic regime and on the mouse community more directly by reducing access to the riparian area by domestic dogs and cats (C. Meaney, pers. comm.).

The hydrologic integrity of the tributaries of Monument Creek and Monument Creek itself is poor in places. A healthy riparian ecosystem reflects native hydrological regimes, with natural ebbs and flows of water inputs, and good water retention and storage capacity of the soil. Livestock grazing along riparian areas reduces the water-holding capacity of the soil and removes streamside vegetation that could buffer the system from physical alteration during peak flows. Water diversion for irrigation and alteration of natural water flows depletes the water table, allowing the invasion of upland vegetation into the riparian community, and drying out streamside soils. Dry soils are easily erodible; combined with unnatural, large flushes of water, entrenching of the streambed and further lowering the water table occur. Increased urbanization also results in increased peak flows and reduced water retention.

Erosion of banks on tributaries both east and west of Monument Creek, and on portions of Monument Creek itself, suggests that this is weakly functioning riparian system, likely still recovering from the decades of grazing and farming that occurred on this site prior to the establishment of the AFA Reservation. Maintenance of natural flows of water and protection from off-site development will be critical for the continued recovery of this site. For the flow below the non-operational sewage disposal site, our concern is whether water will persist in the future. For all areas, our concern is the periodic, unbuffered influx of water that could cause erosion and degrade the streambed further.

A high EO rank is suggested from trapping results on Monument Creek, but consideration must be made of several factors that would tend to lower the rank of the site from a broader ecological perspective. Considering the quality of the site solely in terms of plant community quality, the riparian area would not be rated highly. The riparian vegetation of the USAFA is highly modified from a pristine condition, with herbaceous plant species composition dominated by exotic species of grasses and forbs throughout the area. Invasion by exotic mammal species was documented, as well, with the capture of house mice on a transect near Ice Lake where jumping mice were also captured.

Adjacent landowner cooperation in managing water issues and protecting the connectivity corridors to the north will likely be required to preserve the areas' value to jumping mice.

BOUNDARY JUSTIFICATION: The boundary presented here (Figure 1) was determined from systematic sampling of Monument Creek and its tributaries, and takes into

account the capture of *Zapus* in upland grassland habitats. It is based on existing land uses in the riparian area and adjacent uplands; if at any time in the future land uses on the Air Force Academy change dramatically, the placement of the boundary must be reconsidered in light of changing land use patterns. The boundary is likely to provide protection for the globally imperilled jumping mouse under certain conditions, which we will state explicitly below. We recognize 2 boundaries: the **primary** boundary (or Zone A) includes the primary floodplain plus a 100 m buffer above the floodplain of the creek and its tributaries. The **secondary** boundary (or Zone B) extends beyond the primary boundary to encompass the grassland or forested uplands outside the riparian zone (approximately 1.5 km).

The primary boundary delineates the area (Zone A) which must be physically protected to assure the persistence of the Preble's meadow jumping mouse population. Here, land use activities have the potential to directly affect the mouse population and its habitat. In Zone A, existing uses should be maintained with little or no additional uses, in order to prevent habitat destruction or fragmentation. This boundary is only valid if current land use practices on the AFA do not change.

The area between the primary and secondary boundaries (Zone B) should be managed to prevent indirect threats to the jumping mouse population and its habitat. Potential threats are wholesale disturbance of upland soils that could increase erosion, significant alteration of the hydrology of Monument Creek, and increased domestic cat predation. Zone B may be used in ways that allow the hydrologic regime of the Monument Creek system to continue the recovery from the historic degradation. At a minimum, it should be maintained in its present condition. Compatible uses are those which result in minimum siltation and which allow vegetation structure to naturally evolve along the creek and its tributaries. Compatible uses are activities such as light livestock grazing or construction of scattered structures for use as classrooms or other campus buildings for academic use.

The secondary boundary encompasses the area within which certain land uses should not occur if jumping mice are to maintain viability on this site. Incompatible land uses include wholesale disturbance of the soil, such as for farming or large-scale construction of concentrations of buildings, or construction of parking lots that alter drainage patterns. Any soil-disturbing activities should maintain strict siltation controls.

Construction of additional housing for human habitation should be considered an incompatible use of land within Zone B to minimize the number of domestic cats. Domestic pets can decimate wild populations of rodents, and may pose a grave threat to the jumping mouse population if they invade the riparian habitat; the only method to control their activity is to prevent access to Monument Creek and its tributaries. Since cats have large home ranges (1 - 1.5 km radius; J. Coleman, Univ. Wisconsin, pers. comm.), and since cats are associated with houses, a large buffer zone is required within which no new housing projects should be constructed. An exception to this recommendation could be one where housing needs are met with strict enforcement of a 'no-cat policy'. This is generally an unattractive policy, but would adequately address the conservation need.

The secondary boundary to the east of Monument Creek extends only as far as the interstate highway, which in some areas provides less than a 1.5 km buffer to the primary boundary. The interstate provides an adequate buffer against invasion by domestic pets from potential housing developments to the

east of the interstate (J. Coleman, pers. comm.). Use of riparian areas adjacent to the interstate by jumping mice suggests that they are undeterred by its presence. However, the buffer we recommend is valid only under certain conditions. First, any additional construction of interchanges on the highway should not destroy existing riparian habitat; thus, future highways should span riparian habitat. Second, any changes to the hydrology of the area should be buffered, and altered runoff should be controlled . Finally, the interstate highway is an effective boundary against invasion by domestic pets only if culverts are fenced.

PROTECTION AND MANAGEMENT CONSIDERATIONS: Maintaining the habitats that support jumping mice and other important elements on this site will require maintenance of ecological processes on the site. Protection and management should incorporate steps to maintain natural hydrologic integrity (hydroperiod, water quality, etc.), control exotic plant species, and reduce predation by domestic pets.

We have established a primary site boundary for this occurrence using a 100-m buffer. However, we do not know the precise role of the buffer nor the size and type of buffer that is sufficient to protect the site. Further information is needed on hydrologic processes in the Monument Creek drainage and on the effects of various kinds of adjacent land uses on populations of jumping mice, in order to be able to provide an adequate buffer for the site. The role of beavers in maintaining and buffering the system, and their status on the site, needs to be determined. Evidence in other western riparian stream systems suggest that beavers played a major role in the evolution of riparian natural communities and stream hydrology (Knight 1994).

One of the most important questions that we must begin to answer is the process(es) responsible for the large year-to-year fluctuations in captures of this species, a pattern observed not only by us, but also by others (B. Wunder, pers. comm.) The USAFA offers a unique opportunity for the log term population studies of the species which are necessary for understanding ecological trends (Pimm 1991).

Preble's jumping mice use areas dominated by a variety of exotic plant and animal species, but we do not know whether they are intolerant of any specific invader or would thrive better with the reduction in one or more invader species. While control of some of the exotic invaders is desirable, and in some cases required by law, the type and timing of control measures should be considered in light of jumping mouse activity and behavior. It is possible that application of general broad-leaf herbicides could cause direct loss of habitat and mice from vehicular traffic during application. Additionally, a general herbicide could reduce the seeds which may be the main food of jumping mice, particularly during prehibernation fattening. Loss of herbaceous cover in areas without a dense woody shrub canopy could increase predation on this species, and/or preclude the mice from using affected areas. The diets and habitat use patterns of this species need to be determined in order to make specific recommendations regarding the best level of control of exotics that should be used, as well as the timing and use of pesticides.

Hydrology is a concern not only in establishing an appropriate buffer, but also in identifying off-site and Zone B alterations to the system that may reduce the integrity of this site. Study of the natural hydrological processes of the area are needed to understand the system. Consideration should be given to reducing erosion into the stream and reducing degradation

of the streambed in other ways, by identifying areas of problem runoffs and controlling them.

The secondary boundary is recommended to protect the riparian area from use by domestic cats. Cats will not cross roadways, but can readily avoid the them by going under them through culverts (J. Coleman, pers. comm.) Chain-link fencing is known to be an effective barrier to their passage and some type of culvert fencing should be implemented if the secondary boundary as now recommended is to be effective. Managing cats already present in Zone B may be possible by educating residents about the effects of cats on wildlife, and encouraging them to control the reproductive output of their pets (Coleman and Temple 1993).

We do not know where the single jumping mouse captured below Reservoir No. 2 came from or whether a larger population occurs near the point of capture in areas other than those surveyed thus far. Because this portion of the site is of limited quality as far as we now know, no management steps are warranted at this time. The most prudent action would be a more complete trapping survey of the area to determine the true conservation significance. The riparian habitats around Reservoir No. 2 should be examined as well as natural or man-made (from golf course runoff, for example) seeps in the area of the capture to attempt to identify a source population. We repeat that, given our existing state of knowledge, the single capture of a jumping mouse at the site is atypical.

If further surveys do not result in any more captures of jumping mice in potential habitat adjacent to this site, and if surveys occur over a sufficient period of time to demonstrate that lack of captures is not solely due to a possible 'low point' in the population fluctuations that are known to occur for this species, then this site could be considered non-essential to the protection of the jumping mouse population. Even if more jumping mice are found on or near this site, if their occurrence can be demonstrated to be due to or enhanced by the existence of the present golf course (possibly due to regular watering of greens), then development of the site could potentially occur to the benefit of this population of jumping mice. In any case, we believe that it is a worthy challenge to the golf course designers to attempt a design which permits coexistence of small mammals and this highly sought recreational activity.

Current activities do not threaten Monument Creek Site immediately. However, the globally significant nature of the site, and the possibility of development both on and off the USAFA which may threaten this site in the future, suggest a need for the site to be protected more formally in some manner. Given the continuing development of land on the USAFA, we recommend that this site be given special conservation recognition. Special area designation such as Research Natural Area or Special Interest Area can be conferred by the Department of Defense to ensure the protection of this unique site into the future. Such a designation could refer only to Zone A, or it could include the entire area. In either case, a management plan should be developed to address the needs for site viability and integrity as described herein.

OFFSITE CONSIDERATIONS:

The primary offsite concerns are the maintenance of the integrity of the hydrologic regime of the Monument Creek watershed, and ensuring the connectivity of this occurrence of *Zapus hudsonius preblei* with more northern

occurrences (known and predicted). The importance of the hydrologic system to the site has been discussed above. The maintenance of the integrity of watershed flows will require cooperation of adjacent landowners, particularly those north and east of the Academy.

Connectivity of all extant occurrences of Preble's meadow jumping mouse should be promoted to maximize the likelihood of subspecies persistence (Hudson 1991). The occurrence of Preble's meadow jumping mouse on the Academy is at or near the southern margin of the distribution of this subspecies. More northern populations in good condition occupy the central portion of this subspecies' historic range. Since the USAFA is near the southern extent of this subspecies' range and habitat to the south has been heavily urbanized, it is important to maintain connections to northern populations. Maintaining suitable habitat northward along Monument Creek and other suitable habitats will require the cooperation of public and private landowners to ensure the persistence of jumping mice on the Academy and in the state of Colorado.

LITERATURE CITED

Armstrong, D.A. 1972. Distribution of mammals in Colorado. Monograph of the Museum of Natural History, University of Kansas. No. 3. 415 pp.

Coleman, J. Department of Wildlife Ecology, University of Wisconsin, Madison, WI. 1995. Personal communication to J. Corn.

Coleman, J.A., and S.A. Temple. 1993. Rural residents' free-ranging domestic cats: A survey. Wildl. Soc. Bull. 21:381-390.

Compton, S.A., and R.R. Hugie. 1993a. Status report on *Zapus hudsonius preblei*, a candidate endangered subspecies. Status report prepared by Pioneer Environmental Consulting Services Inc., Logan, UT. Under contract to the U. S. Fish and Wildlife Service. 31 pp.

Compton, S.A., and R.R. Hugie. 1993b. Addendum to the status report on *Zapus hudsonius preblei*, a candidate endangered subspecies. Status report prepared by Pioneer Environmental Consulting Services Inc., Logan, UT. Under contract to the U. S. Fish and Wildlife Service. 8 pp.

Fitzgerald, J.P., C.A. Meaney, and D.A. Armstrong. 1994. Mammals of Colorado. Colorado Associated University Press, Boulder, CO. 467 pp.

Garber, C. Wyoming Natural Heritage Program Zoologist. 1995. Personal communication to C. Pague.

Harrington, F. private consultant. 1995. Personal communication to J. Corn.

Hudson, W. E. (ed). 1991. Landscape Linkages and Biodiversity. Defenders of Wildlife and Island Press. 196 pp.

Knight, D. H. 1994. Mountains and Plains: The Ecology of Wyoming Landscapes. Yale Univ. Press. 338 pp.

Meaney, C. private consultant. 1995. Personal communication to C. Pague.

Pimm, S. L. 1991. The Balance of Nature. Univ. Chicago Press. 434 pp.

Ripley, J.D. 1994. Vegetation of the United States Air Force Academy and the adjacent regions of the Pike National Forest, El Paso County, Colorado. Department of Biology, U.S. Air Force Academy, Colorado Springs, CO. 423 pp.

Ryan, T. Rocky Flats Ecology Group. 1995. Personal communication to J. Corn.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry, 2nd Ed. W.H. Freeman and Co., San Francisco.. 859 pp.

U. S. Fish and Wildlife Service. 1995. Interim survey guidelines for Preble's meadow jumping mouse. Ecological Services, Colorado Field Office, Golden, CO. 14 pp.

Wunder, B.A. Department of Biology, Colorado State University, Fort Collins, CO. 1995. Personal communication to J. Corn.

Table 1. Vegetation at points of capture of *Zapus hudsonius preblei* on the U.S. Air Force Academy in 1995.

	Transect 1A			Transect 3C "Reservoir No. 1"						
				Salix exigua-Salix monticola						
Capture Points	**16**	**17**	**AVG**	**39**	**38**	**30**	**40**	**28**	**42**	**AVG**
Total graminoid cover	**95**	**95**	**95**	**5**	**3**	**40**	**15**	**25**	**75**	**27**
Agropyron dasystachum	10	10	10	5	3	40	10	25	40	20
Bromus inermis	0	0	0	0	0	0	20	0	25	8
Carex spp.	20	0	10	0	0	0	0	0	0	0
Elymus canadensis	0	0	0	0	0	0	0	0	5	1
Juncus arcticus	10	10	10	0	0	0	0	0	0	0
Poa pratensis	45	5	25	0	0	0	0	0	63	10
Total forb cover	**13**	**0**	**6**	**95**	**35**	**75**	**30**	**60**	**1**	**49**
Ambrosia dumosa	0	0	0	20	0	20	0	0	0	7
Artimesia frigida	0	0	0	10	0	0	0	0	0	2
Centaurea maculosa	0	0	0	60	25	30	0	0	0	19
Conyza canadensis	3	0	2	5	0	20	20	10	0	9
Linaria vulgaris	0	0	0	0	10	0	0	0	0	2
Sisymbrium austriacum	0	0	0	5	0	0	0	0	0	1
Solidago speciosus	0	0	0	0	0	10	10	3	1	4
Taraxacum officinale	0	0	0	20	0	30	0	10	0	10
Thermopsis divaricarpa	10	0	5	0	0	0	0	0	0	0
Verbascum thapsus	0	0	0	0	0	0	0	50	0	8
Ground Cover										
Bare soil	0	0	0	0	0	0	0	0	10	2
Gravel (<76 mm)	0	0	0	100	80	100	100	100	80	93
Litter	80	90	85	0	20	0	0	1	10	5
Wood	20	10	15	0	0	0	0	0	0	0

Table 1. Continued.

	Transect 6C		
	Populus angustifolia	*Salix exigua*	
Capture Points	**48**	**45**	**AVG**
Total graminoid cover	**1**	**75**	**38**
Bromus inermis	0	10	5
Carex aquatilis	1	0	0.5
Poa pratensis	0	75	38
Total forb cover	**10**	**1**	**6**
Linaria vulgaris	10	0	5
Solidago speciosus	0	1	0.5
Ground Cover			
Gravel (<76 mm)	2	0	1
Litter	95	90	92
Wood	3	0	2
Moss	0	10	5

	Transect 8B				
	Symphorocarpos occidentalis				
Capture Points	**70**	**72**	**57**	**64**	**AVG**
Total graminoid cover	**42**	**56**	**0**	**10**	**27**
Bromus inermis	0	0	0	10	2
Poa pratensis	42	56	0	0	24

Total forb cover	**0**	**5**	**51**	**8**	**16**
Ambrosia dumosa	0	0	10	0	2
Unknown forb	0	5	40	5	12
Verbascum thapsus	0	0	1	0	0.25
Ground Cover					
Bare soil	0	10	0	40	12
Litter	100	90	100	60	88

Table 1. Continued.

	Transect 8D									
	Alnus incana / mesic graminoid									
Capture Points	**58**	**59**	**75**	**60**	**71**	**61**	**66**	**62**	**65**	**AVG**
Total graminoid cover	**75**	**85**	**45**	**65**	**60**	**40**	**75**	**80**	**60**	**65**
Agrostis stolonifera	0	50	0	0	35	40	0	70	20	24
Bromus inermis	0	5	25	0	15	0	75	20	50	21
Calamagrostis canadensis	1	0	0	0	10	0	0	0	0	1
Carex aquatilis	0	0	20	10	0	0	0	0	0	3
Carex lanuginosa	35	0	10	0	0	0	0	0	0	5
Elymus canadensis	0	0	0	0	0	0	0	1	0	0.1
Equisetum arvense	0	0	0	0	10	0	10	0	0	2
Equisetum laevigata	0	0	0	0	1	0	0	0	0	0.1
Juncus arcticus	0	30	0	0	0	0	0	0	0	3
Poa pratensis	0	30	30	0	45	25	0	20	10	18
Total forb cover	**3**	**1**	**30**	**60**	**3**	**0**	**0**	**0**	**0**	**11**
Cirsium spp.	0	0	0	40	0	0	0	0	0	4
Solidago speciosus	0	1	30	30	3	0	0	0	0	7
Taraxacum officinale	3	0	0	0	0	0	0	0	0	0.3
Ground Cover										
Bare soil	60	0	60	0	40	90	50	60	40	44
Litter	40	100	40	100	60	10	50	40	60	56

Table 1. Continued.

	Transect 9D								
	Salix exigua - Salix monticola								
Capture Points	**88**	**89**	**80**	**87**	**82**	**90**	**77**	**79**	**AVG**
Total graminoid cover	**85**	**45**	**70**	**50**	**75**	**75**	**35**	**80**	**64**
Agropyron dasystachum	35	45	10	30	20	30	0	0	21
Bromus inermis	20	0	20	0	0	45	0	65	19
Elymus canadensis	20	0	10	0	0	0	0	20	6
Juncus arcticus	0	0	0	0	70	0	0	0	9
Total forb cover	**25**	**50**	**60**	**60**	**30**	**0**	**60**	**2**	**36**
Ambrosia dumosa	5	0	3	0	0	0	0	0	1
Artimesia frigida	1	0	0	0	0	0	0	0	0.1
Cirsium spp.	0	40	0	0	0	0	0	0	5
Conyza canadensis	0	10	0	20	0	0	0	0	4
Linaria vulgaris	25	0	25	10	20	0	20	2	13
Mentha arvense	0	0	0	0	0	0	0	0	0
Nepeta cataria	0	0	0	40	0	0	0	0	5
Solidago speciosus	0	0	0	0	0	0	40	0	5
Taraxacum officinale	10	0	40	0	0	0	0	0	6
Unknown forb	0	0	0	0	10	0	0	0	1
Ground Cover									
Bare soil	20	0	20	0	60	10	10	50	21

Gravel (<76 mm)	10	0	0	0	0	0	0	0	1
Litter	60	90	80	100	40	90	90	50	75
Rock	0	10	0	0	0	0	0	0	1

	Transect 9D		
	Symphorocarpos occidentalis		
Capture Points	**84**	**86**	**AVG**
Total graminoid cover	**50**	**10**	**30**
Agropyron dasystachum	50	10	30
Total forb cover	**0**	**60**	**30**
Cirsium spp.	0	10	5
Linaria vulgaris	20	10	15
Mentha arvense	10	0	5
Rudbeckia laciniata	0	30	15
Taraxacum officinale	15	10	12
Ground Cover			
Litter	100	100	100

Table 1. Continued.

	Transect 11A	
	Alnus incana-Cornus sericea	***Salix exigua***
Capture Points	**92**	**95**

Total graminoid cover	**50**	**100**
Bromus inermis	10	60
Equisetum arvense	10	0
Poa pratensis	30	30
Total forb cover	**10**	**35**
Linaria vulgaris	0	30
Maianthemum stellatum	0	5
Taraxacum officinale	10	0
Ground Cover		
Litter	100	100

	Transect 11B		
	Salix exigua		
Capture Points	**86**	**94**	**AVG**
Total graminoid cover	**98**	**0**	**49**
Agrostis stolonifera	25	0	12
Bromus inermis	10	0	5
Poa pratensis	80	0	40
Total forb cover	**10**	**1**	**6**
Fragaria virginiana	5	0	2
Mentha arvense	0	1	0.5
Rubus idaeus	1	0	0.5
Solidago speciosus	1	0	0.5
Vicia americana	5	0	2

Ground Cover			
Litter	100	100	100

Transect 12C	
Pinus ponderosa / Quercus gambelii	
Capture Point	**100**
Total graminoid cover	**80**
Agropyron dasystachum	80
Total forb cover	**30**
Linaria vulgaris	30
Ground Cover	
Litter	100

Table 2. Plant communities sampled during trapping efforts for *Zapus hudsonius preblei* on the U.S. Air Force Academy in1995.

Transect	Dominance Type or Plant Association	Captures
1A	*Salix exigua-Salix monticola*/mesic graminoid	1
	Salix exigua-Salix monticola-Symphoricarpos	4
1B	*Typha latifolia*	0
	Carex nebrascensis	0
	Juncus arcticus (weedy)	0
	Weedy	0
1D	*Typha latifolia*	0
	Carex nebrascensis	1
	Juncus arcticus (weedy)	3
	Weedy	1

2A	*Populus angustifolia* (young)/*Salix exigua*	0
	Bromus inermis	1
2B	*Typha latifolia*	2
	Symphoricarpos occidentalis	0
	Juncus arcticus (weedy)	1
	Weedy	0
2C	*Salix fragilis/Bromus inermis*	0
	Tallgrass prairie (*Andropogon gerardii*)	1
2D	*Salix exigua-Salix monticola*/mesic graminoid	2
	Populus angustifolia (young)/*Salix exigua*	0
3A	(*Salix fragilis)/Alnus incana-Symphoricarpos*	3
3B	*Salix exigua*/mesic graminoid	1
	Alnus incana-Salex exigua-Salix monticola	0
3C	*Salix exigua-Salix monticola*/mesic graminoid	8
3D	*Stipa comata*	0
4B	*Salix exigua-Salix monticola*/mesic graminoid	4
4C	*Pinus ponderosa/Quercus gambelii*	0
4D	*Salix exigua*/mesic graminoid	2
5A	*Typha latifolia*	0
	Symphoricarpos occidentalis	0
	Juncus arcticus (weedy)	0
	Salix exigua/mesic graminoid	0
5B	*Salix fragilis/Bromus inermis*	0
5C	*Bouteloua gracilis* (weedy)	0
5D	*Salix exigua-Salix monticola*/mesic graminoid	2
6A	*Populus angustifolia-Salix amygdaloides/Alnus*	1
6B	*Bromus inermis*	0
6C	*Populus angustifolia-Salix amygdaloides/Alnus*	3
6D	*Populus angustifolia*/*Salix exigua-Alnus incana*	4

7A	*Populus angustifolia*	0
7B	*Populus angustifolia*	0
7C	*Quercus gambelii*	1
7D	*Pinus ponderosa/Quercus gambelii*	0
8A	*Populus angustifolia/Salix exigua*	1
8B	*Symphoricarpos occidentalis*	6
	Salix exigua/mesic graminoid	1
8C	*Bromus inermis-Bromus tectorum*	0
8D	*Alnus incana*/mesic graminoid	13
9A	*Salix exigua*/mesic graminoid	0
	Symphoricarpos occidentalis	0

9B	*Salix exigua-Salix monticola-Symphoricarpos*	1
	Symphoricarpos occidentalis	1
9C	*Pinus ponderosa/Quercus gambelii*	0
9D	*Salex exigua-Salix monticola*/mesic graminoid	10
	Symphoricarpos occidentalis	1
	Weedy	1
10A	*Salex exigua*/mesic graminoid	0
10B	*Salex exigua*/mesic graminoid	0
10C	*Pinus ponderosa/Carex nebrascensis*	0
10D	*Salex exigua*/mesic graminoid	0
	Typha latifolia	0
10E	*Pinus ponderosa/Schizachyrium scoparium*	1
	Juncus arcticus	1
11A	*Salex exigua*/mesic graminoid	1
	Alnus incana-Cornus sericea	1
11B	*Salex exigua*/mesic graminoid	2
11C	*Pinus ponderosa/Quercus gambelii*	0
11D	*Salex exigua-Symphoricarpos occidentalis*	2
12A	*Salix exigua* /mesic graminoid (weedy)	0
12B	Weedy	0
12C	*Pinus ponderosa/Quercus gambelii*	1
12D	*Agropyron* (weedy)	0
12E	*Agropyron* (weedy)	0
12F	Dry wash	0
12G	Dry wash	0
12H	Dry wash	0

Appendix I. Summary of trapping results by transect.

SITE	TN	CAPS	CAPS/100TN	MAX/DAY	MARKS	MARKS/CAPS	CF	INDS (M/R)	AD	JUV	M	F	
	0		1				0.74		1	1			
1A		200	5	2.5	4		0.74		4	5			
1B		200	0	0			0.74		0				
1D		200	6	3	3		0.74		4	7		2	2
2A		200	1	0.5	1		0.74		1	1			1
2B		200	10	5	4		0.74		7	10		4	4
2C		200	1	0.5	1		0.74		1	1			1
2D		200	2	1	1		0.74		1	2		1	
3A		200	3	1.5	2		0.74		2	3		1	1
3B		200	1	0.5	1		0.74		1	1			1
3C		200	8	4	5		0.74		6	8		4	3
3D		200	0	0			0.74		0				
4B		200	4	2	2		0.74		3	4		3	
4C		200	0	0			0.74		0				
4D		200	2	1	1		0.74		1	2			2
5A		200	0	0			0.74		0				
5B		200	0	0			0.74		0				
5C		150	0	0			0.74		0				
5D		150	2	1.3	1		0.74		1	2			2
6A		150	1	0.7	1		0.74		1	1		1	
6B		150	0	0			0.74		0				
6C		150	3	2	1		0.74		2	3			3
6D		150	4	2.7	2		0.74		3	4		2	2
7A		250	0	0			0.74		0				
7B		250	0	0			0.74		0				
7C		250	1	0.4	1		0.74		1	1			1

7D	250	0	0				0.74	0				
8A	200	1	0.5	1	1	1		1	1		1	
8B	200	7	3.5	3.0	2.0	0.3		2	2			2
8C	200	0	0.0									
8D	150	14	9.3	5.0	8.0	0.6		8	8		2	6
9A	150	0	0.0									
9B	200	2	1.0	1.0	1.0	0.5		1	1			1
9C	200	0	0.0									
9D	200	12	6.0	5.0	7.0	0.6		7	7		6	1
10A	200	0	0.0									
10B	200	0	0.0									
10C	200	0	0.0									
10D	150	0	0.0									
10E	150	2	1.3	1.0	2.0	1.0		2	2		2	
11A	200	2	1.0	1.0	2.0	1.0		2	2		1	1
11B	175	2	1.1	1.0	2.0	1.0		2	1	1		2
11C	150	0	0.0									
11D	150	2	1.3	1.0	1.0	0.5		1		1		1
12A	200	0	0.0									
12B	200	0	0.0									
12C	200	1	0.5	1.0	1.0	1.0		1	1			1
12D	200	0	0.0									
12E	200	0	0.0									
12F	200	0	0.0									
12G	150	0	0.0									
12H	150	0	0.0									

Appendix II. Characteristics of individual *Zapus hudsonius preblei* captures.

NO.	SITE	DATE	AGE	SEX	R	MASS	TOTL	TAIL	BODY	HFL	NOTE
1		06/18/95	A								Seasoning mort
71	A	06/21/95	A	M	S		219	128	91	31	Hair
171	A	06/22/95	A					130		28	Hair;escaped
261	A	06/22/95	A								Daytime cap; released 8pm
161	A	06/22/95	A	M	S		195	115	80	29	Hair;same loc as cap7
181	A	06/22/95	A	M	S		222	130	92	30	Hair
21	D	06/20/95	A								Escaped
91	D	06/21/95	A								Escaped
101	D	06/21/95	A	F	N		222	132	90	32	Hair
81	D	06/21/95	A	M	N		207	128	79	30	Hair
191	D	06/22/95	A	F	N		218	134	84	32	Hair
251	D	06/23/95	A	M	S		209	128	81	30	Hair
202	A	06/22/95	A	F	N		195	123	72	30	Hair
32	B	06/21/95	A				205	130	75	32	Hair
42	B	06/21/95	A	F	N		217	132	85	28	Hair
52	B	06/21/95	A	M	N		200	122	78	27	Hair
122	B	06/22/95	A				208	127	81	30	Hypothermic;recovered
112	B	06/22/95	A	F	N		216	131	85	31	Hair
132	B	06/22/95	A	M	N		215	125	90	28	Hair; same loc as cap 3
142	B	06/22/95	A	M	S		205	125	80	28	Hair; recap
212	B	06/23/95	A	F	N		205	123	82	32	Hair
232	B	06/23/95	A	F	N		216	131	85	29	Hair
222	B	06/23/95	A	M	S		195	120	75	33	Hair
62	C	06/21/95	A	F	P		217	123	94	31	Hair
152	D	06/22/95	A					133		28	Escaped;hair
242	D	06/23/95	A	M	N		215	134	81	29	Hair
343	A	06/29/95	A			24					Escaped
433	A	06/30/95	A	F	N	17	211	127	84	30	Hair
443	A	06/30/95	A	M	S	23	187	105	82	30	Hair
353	B	06/29/95	A	F	N	19	215	133	82	30	Hair
283	C	06/28/95	A								Escaped
313	C	06/29/95	A	F	L	20	207	124	83	27	Hair
303	C	06/29/95	A	M	S	20	198	122	76	29	Hair
383	C	06/30/95	A	F	N	18	202	117	85	29	Hair
403	C	06/30/95	A	F	L	20	196	123	73	28	Hair
423	C	06/30/95	A	M	S	20	196	121	75	30	Hair

413C	06/30/95A	M	S	17	199	128	71	30Hair
393C	06/30/95A	M	S	16	199	124	75	27Hair
324B	06/29/95A	M	S	18		103		27Hair; part of tail missing
334B	06/29/95A	M	S	20	219	133	86	36Hair
364B	06/30/95A							Escaped
374B	06/30/95A	M	S	17	216	135	81	31Hair
274D	06/27/95A	F	N		222	127	95	28Hair
294D	06/29/95A	F	N	21	212	123	89	30Hair
515D	07/06/95A	F	L	19	204	128	76	28Hair
545D	07/07/95A	F	N	16	207	131	76	30Hair
536A	07/07/95A	M	S	17	204	131	73	30Hair
456C	07/05/95A	F	L	22	225	131	94	31Hair
486C	07/06/95A	F	L	19	212	130	82	29Hair
526C	07/07/95A	F	N	16	217	129	88	30Voucher (trap mort)
476D	07/05/95A	F	P	26	203	123	80	31.5Hair
466D	07/05/95A	M	S	17	199	117	82	29Hair
506D	07/06/95A	F	P	27	197	123	74	29Hair
496D	07/06/95A	M	S	15	197	117	80	29Hair
857C	07/20/95A	F	N	19.3	197	120	77	29Hair; voucher specimen
558A	07/11/95A	F	L	19.5	205	125	80	29Hair
578B	07/12/95							Recap(from 8a)
568B	07/12/95A	F	L	17.5	205	131	74	30Hair
638B	07/13/95							2ND Recap
648B	07/13/95A	F	L	18	207	132	75	32Hair
728B	07/14/95							Recap
718B	07/14/95							Escaped
708B	07/14/95							Recap
598D	07/12/95A	F	L	18.5	216	123	93	30Hair
588D	07/12/95A	F	N	18	217	132	85	30Hair; hypothermic
628D	07/12/95A	F	L	19.5	214	132	82	29
618D	07/12/95A	F	P	21	216	132	84	30Hair
608D	07/12/95A	F	L	17.5	216	125	91	30Hair
658D	07/13/95							Recap
668D	07/13/95							Recap; not marked w/2nd dot
698D	07/13/95							Recap
688D	07/13/95A	F	N	20	231	137	94	31Hair
678D	07/13/95A	M	N	18	210	125	85	31Hair
738D	07/14/95							Escaped
758D	07/14/95							Recap

768D	07/14/95							Recap
748D	07/14/95A	M	S	17	203	124	79	31Hair
819B	07/19/95A	F	L	17.5		117		28Hair
919B	07/21/95							Recap
779D	07/18/95A	M	N	18	208	128	80	30Hair;not marked w/ dot
789D	07/18/95A	M	N	16.5	201	123	78	28Hair
809D	07/19/95							Recap
799D	07/19/95A	M	N	19	208	128	80	30Hair; Probably recap#77
839D	07/20/95							Recap
849D	07/20/95A	F	N	16.5	193	125	68	29Hair; hypothermic
829D	07/20/95A	M	S	16	198	117	81	27Hair
899D	07/21/95							2nd recap
869D	07/21/95							Recap
879D	07/21/95A	M	S	19	210	130	80	29Hair
889D	07/21/95A	M	S	21	209	132	77	32Hair
909D	07/21/95A	M	S	14	195	123	72	27Hair
9310E	07/26/95A	M	N	14	204	124	80	29Hair
9810E	07/28/95A	M	N	19	207	127	80	30Hair
9211A	07/25/95A	M	N	20.5	202	124	78	30Hair
9511A	07/27/95A	F	N	19	207	130	77	28Hair
9411B	07/26/95J	F	N	10	177	114	63	30Hair
9611B	07/27/95A	F	N	18	201	25	176	29Hair
9711D	07/27/95							Recap from 11B
9911D	07/28/95							2nd recap
10012C	08/10/95A	F	L		228	130	98	32Hair

Appendix III. Habitat structural characteristics at *Zapus hudsonius preblei* capture locations.

CAPNO	SITE	DISTH2O	GCOV	GSPP	GHGT(CM)	HCOV	HSPP	HHGT	SCOV	SSPP	SHGT	TCOV	TSPP	THGT(M)
	1					D	POA		S	SALIX		NONE		
4=23	2B	5	D	CATTAIL	10	D	CATTAIL	150	NONE			NONE		
	112	B	10			D	EQUISETUM	20	NONE			NONE		
3=13	2B	6		SALIX CWD	30		CAREX	20	S	SALIX	1	NONE		
5=12	2B	1	D	CATTAIL	10	M	CATTAIL	150	NONE			NONE		
	142	B	10			D	EQUISETUM	20	NONE			NONE		
	212	B	6			M	GRASS	20	D	SYMPHORICARPOS	1.25	NONE		
	222	B	10			D	GRASS	20	NONE			NONE		
	62	C	30	M GRASS	5	M	GRASS	10	NONE			NONE		
	152	D	2	SALIX CWD			SOLIDAGO	30	D	SALIX	2	NONE		
	242	D	1			M	GRASS	10	D	SALIX	2	NONE		
	202	A	25	D GRASS	3	M	GRASS	20	NONE			NONE		
	101	D	15	D RUSHES		D	JUNCUS	30	NONE			NONE		
	191	D	15	D SYMOCC CWD	20	D	JUNCUS	25	M	SYMPHORICARPOS	0.4	NONE		
	21	D	25			S	JUNCUS	30	S	SYMPHORICARPOS		NONE		
9=25	1D		3			D	JUNCUS	30	NONE			NONE		
	81	D	10	CAREX	10		CAREX							
7=16	1A		20											
	181	A	2											
	261	A	25											
	171	A	20											
	274	D	1	S DEAD WOOD	5	S	SOLIDAGO	10	S	SALIX EXIGUA	1	NONE		
28/31/41	3C		2	D DEAD GRASS	4	M	GRASS	20	D	SALIX EXIGUA	1.5	NONE		
	294	D	4	S SALIX STICKS	5	M	FORBS	20	M	SALIX EXIGUA	2	NONE		
	303	C	2	M GRASS	4	M	FORBS	15	M	SALIX EXIGUA	1.5	NONE		
32=37	4B		3	D HERB	4	D	GRASS							
	334	B	1	S DEAD HERB	0	S	CLUB MOSS	5	S	SALIX EXIGUA	1	NONE		
	343	A	15	D DEAD GRASS	4	D	B. INERMIS	25	S	SYMPHORICARPOS	0.2	NONE		
	353	B	4	D DEAD JUNCUS	6	D	JUNCUS	25	S	SALIX MONTICOLA	0.5	NONE		
	364	B	1.5	D DEAD GRASS	5	D	SENECIO?	50	S	SALIX EXIGUA	1.5	NONE		
	383	C	6	S SALIX BRANCHES	4	S	COMPOSITAE	20	M	SALIX EXIGUA	1	NONE		
	393	C	5	M DEAD FORBS	3	D	P. PRATENSIS	10	M	SALIX EXIGUA	1	NONE		
	403	C	2	M DEAD GRASS	3	D	B. INERMIS	30	S	SALIX MONTICOLA	0.5	NONE		
	423	C	1	M DEAD GRASS	4	M	P. PRATENSIS	10	M	SALIX EXIGUA	0.75	NONE		

433A	15D	DEAD GRASS	3D	P. PRATENSIS	30S	SYMPHORICARPOS	30NONE		
443A	6D	DEAD GRASS	3D	B. INERMIS	S	SYMPHORICARPOS	30D	SALIX FRAGILIS	20
456C	15D	DEAD OAK LEAVES	4M	B. INERMIS	30S	SALIX EXIGUA	2.5S	P. DELTOIDES	20
466D	6M	DEAD SALIX	10D	S. NETTLES	30D	SALIX EXIGUA	3NONE		
476D	2D	GRASS	6D	B. INERMIS	20M	SALIX EXIGUA	1.5NONE		
486C	6S	DEAD SALIX	4M	UNK FORB	50S	SALIX EXIGUA	2NONE		
496D	2D	DEAD GRASS	4M	P. PRATENSIS	30M	SALIX MONTICOLA?	2NONE		
506D	2D	SALIX STEMS	7M	P. PRATENSIS	30S	SALIX MONTICOLA	0.7S	ALNUS INCANA	5
515D	15M	DEAD WOOD	3D	THISTLE	40D	SALIX MONTICOLA	1NONE		
526C	2S-M	SALIX TWIGS	3D	THISTLE	30D	SALIX EXIGUA	1.5NONE		
536A	3M	SALIX TWIGS	4M	CAREX	40S	SALIX EXIGUA	1NONE		
545D	15D	DEAD GRASS	6D	B. INERMIS	30D	SALIX EXIGUA	1		
558A	8S	SALIX TWIGS	4M	P. PRATENSIS	20S	SALIX EXIGUA	0.7NONE		
56/63/70	8B	5S-M	WOODY DEBRIS	3M	P. PRATENSIS	10D	SYMPHORICARPOS	0.8NONE	
57=71	8B	15M	SYMPH BRANCHES	3M	MINT?	10D	RIBES	0.6NONE	
58/68/73	8D	2S		3M	P. PRATENSIS	20M	ALNUS INCANA	2NONE	
598D	3S	STICKS	4D	JUNCUS	40M	RUSSIAN OLIVE	2NONE		
608D	3M	POP BRANCHES	6D	P. PRATENSIS	60S	SYMPHORICARPOS	0.6D	POPANG	15
618D	4S	DEAD WOOD	4M	CLUBMOSS	80S	SALIX EXIGUA	NONE		
62=76	8D	3S	WOODY DEBRIS	7M	P. PRATENSIS	50S	ROSA	0.75D	POPANG	8
648B	7M	SALIX STEMS	5M	B. INERMIS	40M	SALIX EXIGUA	1NONE		
658D	2M	DEAD WOOD	5M	GRASS	50D	SALIX MONTICOLA	2.5D	POPDEL	10
668D	4D	DEAD GRASS	6D	B. INERMIS	40D	ALNUS INCANA	5D	POPANG	12
67=74	8D	4S	WOODY DEBRIS	3M	P. PRATENSIS	50M	SALIX EXIGUA	1.2NONE	
698D	S	DEAD GRASS	2M	P. PRATENSIS	40S	SALIX EXIGUA	1.2NONE		
728B	5D	SYMOCC TWIGS	4D	UNK FORB	10D	SYMPHORICARPOS	0.6NONE		
758D	1M	DEAD GRASS	5D	SOLIDAGO	M	SALIX EXIGUA	3NONE		
779D	2D	DEAD GRASS	4D	B. INERMIS	70M	SALIX EXIGUA	1.5D	P. PONDEROSA	8
789D	1S	DEAD FORBS	4S	MINT	40D	SALIX EXIGUA	2NONE		
799D	1.5M	DEAD GRASS	3D	B. TECTORUM	30D	SALIX MONTICOLA	2.5NONE		
809D	4M	DEAD HERBACIOUS	6M	B. INERMIS	30S	SALIX EXIGUA	1NONE		
819B	2D	SYMOCC STEMS	4D	FORBS	70S	SALIX EXIGUA	1.5NONE		
829D	2M	DEAD GRASS	2D	JUNCUS	30M	SYMPHORICARPOS	0.4NONE		
839D	10S	DEAD FORBS	3M	THISTLE					
849D	5M	DEAD HERBACIOUS	4D	THISTLE	40S	SALIX EXIGUA	0.8NONE		
857C	10D	OAK LEAVES	3D	B. INERMIS	30M	QUERCUS GAMBELII	1.5NONE		
869D	1M	DEAD FORBS	M	TOADFLAX	30D	SYMPHOICARPOS	0.8NONE		

879D	2M	SALIX STEMS	3D	B. INERMIS	40NONE		NONE		
889D	1.5D	DEAD GRASS	2M	B. TECTORUM	30D	SALIX EXIGUA	2NONE		
899D	10D	WOODY TWIGS	4D	B. TECTORUM	20D	SALIX EXIGUA	1.5NONE		
909D	3D	DEAD GRASS	4M	P. PRATENSIS	40M-D	SALIX EXIGUA	1.5NONE		
919B	4S	DEAD GRASS	1M	B. INERMIS	30S	SYMPHORICARPOS	0.5NONE		
9211A	2M	TREE BRANCHES	6M	P. PRATENSIS	30D	ROSA	0.7NONE		
9310E	2M	DEAD JUNCUS	3M	JUNCUS	30S	SALIX SP.	0.7NONE		
9411B	2.5S	WOODY	8S	THISTLE	40D	SALIX EXIGUA	1.5NONE		
9511A	3.5D	DEAD GRASS	4D	B. INERMIS	M	SALIX EXIGUA	2.5NONE		
9611B	3M	DEAD GRASS	6D	UNK GRASS	100S	SALIX MONTICOLA	1NONE		
9711D	4M	DEAD GRASS	5D	UNK GRASSES	40M	SALIX EXIGUA	1.5NONE		
9810E	10S	DEAD GRASS	5S	RUBUS	30S	SALIX MONTICOLA	0.5M	P.PODEROSA	1.5
9911D	2M	DEAD GRASS	4D	SOLIDAGO	40D	SYMPHORICARPOS	1NONE		
10012C	18D	OAK LEAVES	2D	TOADFLAX	40M	PRUNUS	1D	P.PONDEROSA	22
AVE	6.6	AVE	5	AVE	34.9	AVE	2.2	AVE	12.2
MAX	30	MAX	30	MAX	150	MAX	30	MAX	22
MIN	1	MIN	0	MIN	5	MIN	0.2	MIN	1.5
N	83	N	70	N	76	N	70	N	10

Appendix IV. Characteristics of plant communities in riparian habitats where traplines were set for *Zapus hudsonius preblei* on the Air Force Academy.

1. *Salix exigua-Salix monticola* plant association (*n* = 9 transects)

Species	Percent cover on transect:				
	3A	**1A**	**9D**	**3C**	**AVE**
Total Shrub Cover	46	58	95	84	71
Alnus incana ssp. tenuifolia	21	-	-	-	5
Robinia neomexicana	-	-	-	2	0
Rosa woodsii	-	2	-	-	0
Salix exigua	17	51	83	48	50
Salix lucida ssp. caudata	-	-	-	20	5
Salix lutea	-	-	-	3	1
Salix monticola	16	7	13	13	12
Symphoricarpos occidentalis	-	16	-	-	4
Total Graminoid Cover	57	78	78	7	55
Agropyron dasystachum	-	3	35	5	11
Agrostis stolonifera	4	-	-	-	1
Bromus inermis	-	-	30	5	9
Carex lanuginosa	31	12	-	-	11
Carex morcroptera	3	-	-	-	1
Carex spp.	-	17	-	-	4
Eleocharis palustris	5	-	-	-	1
Elymus canadensis	-	-	3	-	1
Equisetum arvense	14	-	-	-	4
Eragrostis spp.	4	-	-	-	1
Juncus arcticus	2	30	-	-	8
Phleum pratensis	0	-	-	-	0
Poa pratensis	-	20	16	1	9
Scirpus microcarpus	1	-	-	-	0
Stipa lettermanii	-	2	-	-	1
Total Forb Cover	12	12	18	61	26
Achillia millifolium	-	0	-	3	1
Ambrosia dumosa	-	0	-	2	1
Ambrosia psilostyla	2	-	-	-	0
Artemesia filifolia	-	1	-	5	1
Centaura diffusa	-	-	-	6	2
Centaura maculosa	-	-	-	12	3
Cicuta douglasii	0	-	-	-	0
Conzya canadensis	-	1	-	7	2
Fragaria virginana	-	-	-	0	0

Glycyrrhiza leptodota	-	2	-	-	1
Linaria vulgaris	-	0	15	14	7
Menthe arvense	2	-	2	1	1
Sisymbrium austriacum	-	-	-	11	3
Solidago speciosa	5	0	-	1	1
Taraxacum officinale	-	-	2	2	1
Thermopsis montana	-	3	-	-	1
Verbascum thalpsus	-	2	-	1	1
Verbena spp.	1	-	-	-	0
unk forb	2	-	1	3	1
Ground Cover					
Bare soil	75	1	6	8	23
Gravel (<76 mm)	-	-	-	7	2
Litter	24	95	91	88	74
Wood	1	3	3	4	3
Moss	1	2	-	3	1

2. *Populus angustifolia-Salix amygdaloides*/*Alnus incana* plant association (*n* = 2 transects).

Species	Percent cover on transect:		
	6A	**6C**	**AVE**
Total Tree Cover	59	59	58.8
Salix amygdaloides	38	-	19.0
Populus angustifolia (seedlings)	3	-	1.5
Populus angustifolia (saplings)	-	11	5.5
Populus angustifolia (mature trees)	21	31	26.2
Populus X acuminata (saplings)	-	2	1.1
Populus X acuminata (mature trees)	-	8	4.0
Total Shrub Cover	46	14	30.0
Alnus incana ssp. tenuifolia	17	-	8.5
Amorpha fructosa var. angustifolia	2	-	1.0
Prunus virginana	-	1	0.5
Robinia neomexicana	-	-	0.0
Rosa woodsii	15	-	7.5
Salix exigua	2	12	7.2
Salix monticola	4	-	2.0
Symphoricarpos occidentalis	14	1	7.3
Vitis riparia	1	-	0.5
Total Graminoid Cover	38	38	38.1
Agropyron dasystachum	18	8	12.8
Bromus inermis	1	19	10.4
Calamagrostis canadensis	-	1	0.3
Carex lanuginosa	4	5	4.4
Equisetum arvense	1	-	0.4
Juncus arcticus	0	-	0.0
Poa pratensis	17	7	12.0
Total Forb Cover	25	20	22.5
Achillia millifolium	0	-	0.0
Artemesia campestris	-	0	0.1
Artemesia filifolia	0	-	0.0
Artemesia frigida	1	2	1.4
Cirsium canadense	0	-	0.1
Epilobium spp.	-	0	0.0
Heterotheca villosa	-	0	0.1
Linaria vulgaris	-	14	7.1
Maianthemum stellatum	2	-	1.1
Menthe arvense	0	-	0.0
Phsalis hederifolia var. comata	1	-	0.7
Solidago serotinoides	7	2	4.1

unknown forb	2	1	1.7
Ground Cover			
Bare soil	3	7	5
Gravel (<76 mm)	-	-	-
Litter	68	89	79
Wood	4	4	4
Moss	16	1	8

3. *Alnus incana* ssp. *tenuifolia*/mesic graminoid plant association (*n* = 1 transect).

Species	**Percent cover on transect**:		
	8D	**8D**	**AVE**
Total Tree Cover	14.4	47.2	31
Salix fragilis	14	20	17
Populus deltoides ssp. monolifera	-	22	11
Fraxinus pensylvanica	-	5	3
Total Shrub Cover	85	88	87
Alnus incana ssp. tenuifolia	85	84	85
Salix monticola	1	7	4
Salix exigua	6	-	3
Salix lutea	4	-	2
Symphoricarpos occidentalis	12	1	7
Rosa woodsii	3	2	2
Ribes aureum	2.6	-	1
Total Graminoid Cover	38.5	68.2	53
Agropyron dasystachum	3.5	-	2
Agrostis stolonifera	15.6	25	20
Bromus inermis	2.2	22.6	12
Calamagrostis canadensis	-	5	3
Carex aquatilis	4.3	3.6	4
Elymus canadensis	-	7	4
Equisetum arvense	0.2	-	0
Juncus arcticus	4.2	-	2
Poa pratensis	15.8	17	16
Total Forb Cover	17.8	0.12	9
Ambrosia dumosa	0.6	-	0
Aster laevis	0.6	-	0
Bidens frondosa	0.1	-	0
Cirsium canadense	6.5	-	3
Epilobium spp.	0.1	-	0
Geum macrophylum	0.8	0.1	0
Maianthemum stellatum	0.3	-	0
Nepeta cataria	0.3	-	0
Solidago serotinoides	8.8	-	4
Taraxacum officinale	0.1	0.06	0
Ground Cover			
Bare soil	23	45.6	34
Gravel (<76 mm)	67.5	-	34
Litter	9.6	47.5	29
Wood	-	7	4

Moss	-	-	0

4. *Symphoricarpos occidentalis* plant association (*n* = 6 transects).

Species	Percent cover on transect:		
	9D	**8B**	**Ave**
Total Tree Cover	13.8	-	7
Pinus ponderosa	13.8	-	7
Total Shrub Cover	63.4	90	77
Humulus lupulus ssp americanus	0.6	-	0
Quercus gambelli	4	-	2
Rhus trilobata	-	0.1	0
Ribes aureum	3	0.1	2
Rosa woodsii	1.2	2.5	2
Salix exigua	6.6	-	3
Salix monticola	0.1	-	0
Symphoricarpos occidentalis	49.8	90	70
Total Graminoid Cover	52.4	27.1	40
Agropyron smithii	3.2	0.6	2
Agrostis stolonifera	-	2.5	1
Bouteloua gracilis	0.1	3	2
Bromus inermis	4.4	-	2
Elymus canadensis	1.4	1.6	2
Juncus arcticus	-	13.3	7
Poa pratensis	28.8	7.5	18
Total Forb Cover	28.2	6.9	18
Ambrosia dumosa	-	0.1	0
Artemesia frigida	1.5	-	1
Cirsium canadense	10.3	0.4	5
Epilobium spp.	-	0.1	0
Geum macrophylum	1.2	-	1
Glycyrrhiza leptodota	-	0.1	0
Linaria vulgaris	10	-	5
Nepeta cataria	0.4	-	0
Solidago serotinoides	0.2	-	0
Taraxacum officinale	3	-	2
Urtica dioicia	1.2	-	1
Verbascum thalpsus	-	0.2	0
unk Forb	3	5.1	4
Ground Cover			
Bare soil	-	-	0
Gravel (<76 mm)	16.2	-	8
Litter	83.8	92.8	88
Wood	-	2.6	1

5. *Salix exigua*/mesic graminoid plant association (*n* = 11 transeects).

Species	Percent cover on transect 11B
Total Shrub Cover	86.0
Rosa woodsii	1.2
Salix exigua	86.0
Total Graminoid Cover	32.2
Agrostis stolonifera	1.8
Bromis inermis	4.1
Calamagrostis canadensis	6.1
Carex lanuginosa	6.0
Elymus canadensis	0.3
Glyceria grandis	0.1
Poa pratensis	15.7
Scirpus macrocarpa	1.3
Total Forb Cover	12.3
Aster spp.	0.2
Cirsium spp.	3.2
Epilobium spp.	0.6
Fragaria virginiana	0.2
Geum macrophyllum	0.2
Heracleum lanatum	0.6
Mentha arvense	4.6
Plantago major	1.8
Rudbeckia lancinata	0.3
Trifolium repens	0.1
Unknown Forb	0.3
Ground Cover	
Bare soil	5.0
Gravel (<76 mm)	6.0
Litter	86.5
Wood	2.6
Moss	0.0

6. *Alnus incana-Cornus sericea* plant association (*n* = 1 transect).

Species	Percent cover on transect 11A
Total Tree Cover	0.1
Eleagnus angustifolia	0.1
Alnus incana ssp. tenuifolia	34.2
Betula occidentalis	7.5
Cornus sericea	33.1
Physocarpus monogynus	0.8
Ribes inerme	2.0
Rosa woodsii	2.0
Rubus delicious	0.4
Salix bebbiana	8.2
Symphoricarpos occidentalis	4.7
Total Graminoid Cover	58.0
Agrostis stolonifera	8.2
Bromus inermis	10.0
Elymus canadensis	2.6
Equisetum arvense	1.8
Poa pratensis	45.0
Total Forb Cover	22.2
Apocynum androrosaemifolium	4.4
Cirsium spp.	2.4
Convolvulus arvensis	0.1
Geranium richardsonii	0.5
Geum macrophyllum	3.5
Humulus lupulus	1.2
Maianthemum stellatum	0.6
Prunella vulgarius	0.2
Rubus ideaus	8.8
Solidago serotinoides	2.7
Taraxacum officinale	1.2
Ground Cover	
Bare soil	18.8
Gravel (<76 mm)	1.5
Litter	78.0
Wood	-
Moss	1.2
Rock	0.6

7. *Pinus ponderosa*/*Quercus gembelii* plant association (*n* = 2 transects).

Species	Percent cover on transect 12C
Total Tree Cover	72.2
Pinus ponderosa	72.2
Prunus virginiana	1.4
Quercus gambelli	19.6
Ribes cereum	1.6
Total Graminoid Cover	74.0
Agropyron dasystachum	10.8
Bromus inermis	52.5
Bromus tectorum	1.6
Carex spp.	5.0
Elymus canadensis	0.8
Poa pratensis	1.6
Stipa lettermannii	3.6
Total Forb Cover	10.8
Artemesia filifolia	0.8
Convolvulus arvensis	1.1
Linaria vulgaris	9.2
Nepeta cataria	0.8
Unknown forbs	0.3
Ground Cover	
Bare soil	2.0
Gravel (<76 mm)	0.0
Litter	95.0
Wood	3.0
Moss	0.0
Rock	0.0