

CONSERVATION AND MANAGEMENT PLAN
FOR
PREBLE'S MEADOW JUMPING MOUSE
ON THE
U.S. AIR FORCE ACADEMY

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EXECUTIVE SUMMARY

Formal conservation agreements are required for all U.S. Air Force installations containing Threatened and Endangered species, in accordance with AFI 32-7064 under authority of the U.S. Endangered Species Act. This Conservation and Management Plan for Preble's meadow jumping mouse (PMJM) provides guidance for U.S. Air Force Academy management decisions over the next five years (2000-2005). It is based upon the most current scientific knowledge available. Research is ongoing, however, and this plan should be modified as new information is collected.

Current Species Status

In May of 1998, the Preble's meadow jumping mouse subspecies (*Zapus hudsonius preblei*) was listed as "threatened" under the Endangered Species Act of 1973 (ESA) by the U.S. Fish and Wildlife Service (USFWS). The restricted range of the subspecies and increasing difficulty of finding substantial populations initially spurred conservation interest PMJM. In 1991, Rocky Flats Environmental Technology Site (RFETS) discovered PMJM during the course of small mammal inventories (Ryon, pers. comm., Bakeman, pers. comm.), but few PMJM-specific surveys were conducted in the early 1990's. Preble's meadow jumping mouse was first captured on the U.S. Air Force Academy (USAFA) by the Colorado Natural Heritage Program (CNHP) in 1994. Annual surveys on the USAFA since 1994 have established that USAFA supports one of the largest and most stable populations of PMJM currently known.

The Preble's meadow jumping mouse currently occurs only in several watersheds along Colorado's Front Range and in southeastern Wyoming. The historic abundance of PMJM is unclear. However, trapping surveys indicate that a number of historic PMJM sites are apparently no longer occupied. These sites have been disturbed and/or isolated as a result of changing land use. Evidence also suggests that the Denver metropolitan area has formed a barrier between the northern and southern extents of the PMJM range. In Colorado, PMJM is currently documented from seven counties (Weld, Larimer, Boulder, Jefferson, Douglas, Elbert, and El Paso). The largest and most stable populations documented across the range of the sub-species occur in East and West Plum Creeks in Douglas County, and in Monument Creek on the USAFA in El Paso County.

Habitat Requirements

Preble's meadow jumping mice are often found in dense, herbaceous riparian vegetation. Known PMJM locations sometimes have an overstory canopy layer, but usually have a well-developed shrub layer and a thick herbaceous layer. Most often the shrub cover consists of willow species (*Salix*), but the species composition seems to be secondary to the overall presence of a mature shrub component. What seems universally true for meadow jumping mouse habitat is that a dense, herbaceous ground cover need be present. Most often, PMJM are found in close association with these dense, riparian habitats. Numbers of PMJM captures appear to decrease the further one moves from this characteristic habitat (Corn et al. 1995, Meaney et al. 1996). Based on a study of kidney structure, it is believed that PMJM are dependent upon open water (Wunder 1998), which may explain their close association to these habitats.

Preliminary estimates of habitat use at USAFA indicate 70% time spent in riparian shrub communities and 30% in upland grasslands, but specific activities in each habitat type are unknown. Upland use has occurred during the day as well as at night. Studies in Douglas County suggest that upland grasslands may serve as feeding “hotspots” (T. Shenk unpublished data), but this has not been specifically observed on USAFA. It is clear, however, that PMJM are regularly and consistently using upland grasslands adjacent to riparian habitat, so we assume that this habitat type must be important for some life history component(s).

Conservation Goals

1. Maintain and enhance AFA populations of PMJM, and associated native plant and animal species, as directed by the U.S. Air Force Academy Integrated Natural Resources Management Plan (INRMP) and Environmental Assessment, 1997.
2. Protect the integrity of the USAFA portion of the main stem of Monument Creek (approximately 6.5 miles).
3. Protect seven (7) miles of USAFA tributaries to Monument Creek that are currently occupied by PMJM, and contain PMJM habitat that is connected to habitat along Monument Creek.

Overall, conservation of the PMJM will not only benefit the recovery of this listed species, but will also benefit the preservation of all native fish and wildlife species that use riparian and associated shrub and grassland habitats. In addition, conservation of PMJM will maintain the integrity of that portion of the Monument Creek watershed on USAFA lands.

In order to fully demonstrate maximum protection of PMJM on the USAFA, specific numeric conservation goals for the PMJM population and for its habitat will need to be set. However, based on the data currently available, we considered the setting of conservation goals to be premature. Analysis of data from the 1999 and 2000 field seasons, in conjunction with the results of the 1998 field season, should allow the USAFA to set conservation goals with a reasonable degree of confidence. Therefore, we recommend that this section of the plan be updated no later than FY2001.

Conservation Objectives

1. Maximize extent, quality, and connectivity of PMJM habitat within the USAFA.
2. Conduct research and monitoring projects to increase understanding of PMJM life history and habitat requirements.
3. Eliminate or minimize threats to PMJM and its habitats within USAFA boundaries.
4. Actively participate in the El Paso County planning effort to encourage maximum protection of PMJM populations and associated habitats on adjacent lands, and to ensure long-term viability of USAFA population.

Research Needed

Further research is needed to better understand PMJM habitat and life history requirements. Specific research needs include, but are not limited to:

- ◆ hibernacula locations and characteristics
- ◆ diet and habitat use
- ◆ survival (overwinter and active season) and mortality factors

- ◆ correlation between vegetation and PMJM abundance (incl. patch size, composition, spatial distribution)
- ◆ fluctuation patterns in population size from year to year
- ◆ system dynamics (e.g., beaver, flood, fire) and response to stochastic disturbance
- ◆ response to human alterations, including cats, weed control, and development density
- ◆ behavior patterns, including seasonal changes in movement patterns and feeding
- ◆ genetics

The Plan is organized into five parts:

1. **Introduction** - a brief overview of the project, the planning process and guiding principles.
2. **Conservation Assessment** - current knowledge on PMJM ecology and habitat requirements, as well as rangewide reasons for decline and conservation issues on the USAFA.
3. **Conservation Goals, Objectives, and Strategies** for protection of PMJM on the USAFA.
4. **Conservation Zones** – specific geographic locations on the USAFA where conservation strategies should be implemented.
5. **Mouse Management Areas** – details on status, issues, and recommendations for action in each USAFA drainage occupied by PMJM.

PART 1: INTRODUCTION

This Conservation and Management Plan for Preble's meadow jumping mouse (PMJM) provides guidance for U.S. Air Force Academy management decisions over the next five years (2000-2005). It is based upon the most current scientific knowledge available. Research is ongoing, however, and this plan may be modified as new information is collected.

The Plan and It's Purpose

Formal conservation agreements are required for all U.S. Air Force installations containing Threatened and Endangered species, in accordance with AFI 32-7064 under authority of the U.S. Endangered Species Act. As stated in the attached Preble's Meadow Jumping Mouse (PMJM) Conservation Agreement (Agreement), implementation of specific conservation actions detailed in this Conservation and Management Plan (Plan) will reduce the threats that warranted listing of the PMJM under the Endangered Species Act to an acceptable level. The primary purpose of this document is to describe the specific objectives and strategies required to secure the long-term conservation of PMJM within the U.S. Air Force Academy (USAFA). A second purpose is to present information on how PMJM may be conserved outside of the USAFA.

Project Overview and the Planning Process

In May of 1998, the Preble's meadow jumping mouse subspecies (*Zapus hudsonius preblei*) was listed as "threatened" under the Endangered Species Act of 1973 (ESA) by the U.S. Fish and Wildlife Service (USFWS). The restricted range of the subspecies and increasing difficulty of finding substantial populations initially spurred conservation interest PMJM. In 1991, Rocky Flats Environmental Technology Site (RFETS) discovered PMJM during the course of small mammal inventories (Ryon, pers. comm., Bakeman, pers. comm.), but few PMJM-specific surveys were conducted in the early 1990's. Preble's meadow jumping mouse was first captured on the U.S. Air Force Academy (USAFA) by the Colorado Natural Heritage Program (CNHP) in 1994. Annual surveys on the USAFA since 1994 have established that USAFA supports one of the largest and most stable populations of PMJM currently known.

In 1995, the USAFA entered into a cooperative agreement with the Colorado Natural Heritage Program to conduct field surveys for PMJM. In 1997 the agreement was expanded to include production of a site conservation plan for PMJM protection. When the PMJM was listed as Threatened under the U.S. Endangered Species Act in 1998, the USAFA and CNHP rolled their process into a larger collaborative planning project led by the Colorado Department of Natural Resources (DNR).

DNR's collaborative planning project encompassed all known occupied PMJM habitat in Colorado. Occupied habitat was organized into five "subareas" based on the counties in which PMJM was known to occur (Larimer/Weld, Boulder, Jefferson, Douglas/Elbert, and El Paso). The Monument Creek population of PMJM, including mice on the USAFA, was included in the El Paso County subarea. The planning process consisted of two components: 1) stakeholder development of a Habitat Conservation Plan in each subarea, and 2) independent accumulation of pertinent scientific information on PMJM and evaluation of conservation issues by a PMJM Science Advisory Team (Science Team).

The structure of the science team's discussions was adapted from the planning method developed by The Nature Conservancy called "Site Conservation Planning". Site Conservation Planning is, in essence, a five-step method designed to identify strategies that will eliminate or mitigate threats to targeted species, as follows:

1. **Conservation targets and goals** – species targeted for conservation action and goals against which conservation success will be measured.
2. **Ecological systems** - the life history and habitat requirements of targeted species, and the ecological processes that are necessary to sustain the species and its habitat.
3. **Situation analysis** – stresses on the species or its habitat (direct or indirect deleterious impacts from natural or anthropogenic processes or events), and sources (usually anthropogenic) of each stress.
4. **Strategies** – actions that can be taken to eliminate or mitigate stresses.
5. **Conservation Zones** - specific locations on the landscape where strategies need to be implemented to achieve conservation goals.

Much of the information in this plan is a result of the deliberations of the PMJM Science Advisory Team. However, conservation strategies presented herein were developed jointly by USAFA and CNHP, and do not necessarily represent consensus of the Science Team. Where specific recommendations by the Science Team have been incorporated, details are presented in applicable appendices.

Guiding Principles

The guiding principles listed below were developed by the Science Team to guide development of conservation strategies. They are synthesized from scientific data or theory pertinent to conservation planning. These principles are derived from consensus among the conservation biology community, and as such, contribute to the confidence with which conservation strategies are developed. The strategies in this plan are based on these principles:

1. Larger reaches of habitat containing larger populations are better than the same or smaller reaches with smaller populations.
2. Populations are influenced by adjacent land uses and landscape context. Conservation activities that consider only riparian habitat are inadequate.
3. At a local scale, interconnected or adjacent reaches of habitat are preferable to isolated reaches.
4. Populations geographically well distributed across their native range are less susceptible to extinction than species confined to small portions of the range.
5. Populations representing the range of ecological variability (e.g., elevation, climate, stream order, soils, hydrology, etc.) at local, regional, and rangewide scales are less susceptible to extinction.
6. Populations that are stable or increasing over time are better than populations declining over time.
7. Conservative estimates of population sizes, habitat parameters, and conservation targets preserve options for adaptive management. Decisions based on fewer data warrant more conservative approaches.

PART 2: CONSERVATION ASSESSMENT

Species Description

The Preble's meadow jumping mouse is a small, brown rodent with a conspicuous dark dorsal band. For its body size, it has large hind legs and hindfeet and an extremely long tail. Adults average approximately 187-255 mm (7-10 inches) long and 17-22 grams in weight.

Distribution

Although the meadow jumping mouse (*Z. hudsonius*) is common and widespread across North America, the Preble's meadow jumping mouse subspecies (*Z. h. preblei*) currently occurs only in a few watersheds along Colorado's Front Range and in southeastern Wyoming. The historic abundance of PMJM is unclear. However, trapping surveys indicate that a number of historic PMJM sites are apparently no longer occupied. These sites have been disturbed and/or isolated as a result of changing land use (Ryon 1996). Evidence also suggests that the Denver metropolitan area has formed a barrier between the northern and southern extents of the PMJM range (Shenk 1998). In Colorado, PMJM is currently documented from seven counties (Weld, Larimer, Boulder, Jefferson, Douglas, Elbert, and El Paso). The largest and most stable populations documented across the range of the sub-species occur in East and West Plum Creeks in Douglas County, and in Monument Creek on the USAFA in El Paso County.

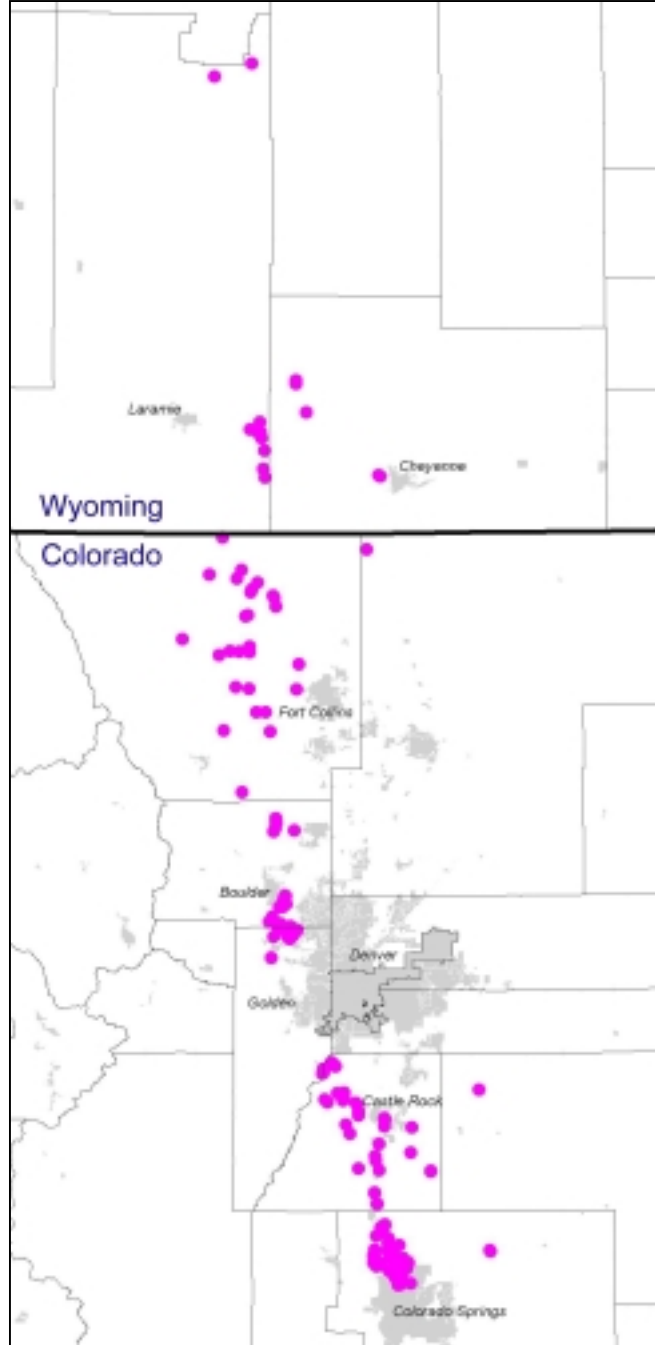


Zapus hudsonius preblei
photograph by Robert Schorr

Habitat Requirements

Preble's meadow jumping mice are often found in dense, herbaceous riparian vegetation. Known PMJM locations sometimes have an overstory canopy layer, but usually have a well-developed shrub layer and a thick herbaceous layer. Most often the shrub cover consists of willow species (*Salix*), but the species composition seems to be secondary to the overall presence of a mature shrub component. Exotic, invasive plant species do not appear to conflict with PMJM habitat needs (Armstrong et al. 1997). Non-native plants such as Canada thistle (*Cirsium arvense*), toadflax (*Linaria* spp.), and smooth brome (*Bromus inermis*), do not prohibit PMJM occupying an area. What seems universally true for meadow jumping mouse habitat is that a dense, herbaceous ground cover need be present. Most often, PMJM are found in close association with these dense, riparian habitats. Numbers of PMJM captures appear to decrease the further one moves from this characteristic habitat (Corn et al. 1995, Meaney et al. 1996). Based on a study of kidney structure, it is believed that PMJM are dependent upon open water (Wunder 1998), which may explain their close association to these habitats.

Figure 1: Range and Distribution of Preble's meadow jumping mouse (*Zapus hudsonius preblei*)



Right: Typical Preble's meadow jumping mouse habitat near Husted, along Monument Creek on the U.S. Air Force Academy. Note especially the density of the vegetation. Weedy species, such as the yellow toadflax shown here, do not preclude occupation by PMJM.

Below: PMJM habitat along Monument Creek. PMJM is usually found in riparian vegetation close to open water. Upland benches with grass/forb and shrub cover are also regularly used.



Preliminary estimates of habitat use at USAFA indicate 70% time spent in riparian shrub communities and 30% in upland grasslands, but specific activities in each habitat type are unknown. Upland use has occurred during the day as well as at night. Studies in Douglas County suggest that upland grasslands may serve as feeding “hotspots” (T. Shenk unpublished data), but this has not been specifically observed on USAFA. It is clear, however, that PMJM are regularly and consistently using upland grasslands adjacent to riparian habitat, so we assume that this habitat type must be important for some life history component(s).

Life History

The following discussion outlines what we currently know about the life history and habitat use of PMJM in Colorado. Those characteristics of the PMJM life cycle considered most critical to the formation of conservation strategies are highlighted below. For additional details, including information on taxonomy, genetics, and small mammal assemblages, refer to Shenk 1998 and Armstrong et al. 1997.

As noted in Shenk 1998, where specific data on the ecology of the PMJM subspecies is lacking, information has been extrapolated from studies of *Z. hudsonius* conducted in the eastern and mid-western U.S. Although some evidence indicates similarities in natural history and ecological requirements between PMJM and other *Z. hudsonius* subspecies, care should be taken in interpreting biological and ecological data extrapolated over the range of the species.

Reproduction and Mortality

Zapus hudsonius may produce up to three litters per season (Whitaker 1963), with an average of 5-6 young per litter (Quimby 1951). Peaks occur in early to mid-June, August, and possibly September (Whitaker 1963). Age at first reproduction is poorly known for PMJM, but *Z. hudsonius* females have been known to give birth at three months of age (Quimby 1951).

Not much is known about PMJM longevity, but some recaptured individuals have survived at least three years. Estimates of survival rates based on mark-recapture studies of 69 individuals at the USAFA indicate that approximately 52% of the individuals from July survive until September (R. Schorr 1999 unpublished data). In a Douglas County study from 1998, over summer survival (June 1 – October 5) was estimated at approximately 36% (T. Shenk unpublished data). Studies in Boulder County indicate approximately 60% survival over summer (June to August) (Meaney et al. 1999).

We do not have much information on over-winter survival. Meaney et al. (1999) calculated a winter survival rate of approximately 22% in Boulder County. Over-winter loss of 67% was observed in a *Z. hudsonius* population in New York, presumably from insufficient fat stores (Whitaker 1963). Other observed sources of mortality of *Z. hudsonius* include cannibalism (Sheldon 1934), and accidental drowning, roadkill, and predation by house cats, garter snakes, rattlesnakes, and fox (T. Shenk, unpublished data). Additional presumed causes of PMJM mortality include starvation, exposure, and disease (Whitaker 1972).

Hibernation

Meadow jumping mice spend at least 7 months per year in hibernation, in underground burrows that they create themselves. The only confirmed PMJM hibernaculum documented in Colorado (at RFETS) was a leaf litter nest approximately 30 cm below ground, 9 meters above a creek bed

under thick shrub cover of chokecherry (*Prunus virginiana*), poison ivy (*Toxicodendron rydbergii*) and snowberry (*Symphoricarpos* spp.) (Wunder pers. comm., Bakeman pers. comm.). Note that this location is upland of the habitat used during the major active period (Armstrong et al. 1997).

Seven possible hibernacula have been documented at the U.S. Air Force Academy. Distances from the creek ranged from 7 meters to 31 meters; there was no consistency in aspect among these sites. Four sites were within the riparian willow shrub zone, and three were outside, but all seven sites were under some shrubby vegetation (snowberry, willow, or oak) (R. Schorr unpublished data). Only 2 were outside the 100-year floodplain. Based on limited data from presumed hibernacula on the USAFA, it would appear that PMJM do not move an appreciable linear distance along the waterway to hibernate (in contrast to some observations of Douglas County PMJM). PMJM will move away from the waterway to hibernate, but rarely relocate to another section of stream that was not previously used during their activity period (R. Schorr unpublished data).

Eight other possible hibernacula have been documented in Douglas County. Detailed descriptions of these sites are not available, but distance data indicate that five of the eight mice using these possible hibernacula traveled greater than or equal to 90 meters from “the center of their typical September night time locations.” One mouse moved 750 meters to a possible hibernaculum. The greatest distance from the center of a main drainage was 341 meters, or 78 meters if tributaries were considered (T. Shenk, unpublished data). These results contrast with observations from the USAFA.

Male *Zapus* emerge from hibernation prior to females (late April-early May and early to late May, respectively). In Colorado, adult PMJM have been captured as early as May 5 for males and May 21 for females, and as late as October 10. Juveniles have been captured as late as October 26 (male) and 27 (female). At USAFA the earliest capture was May 19, the first day of trapping – individuals may have been active earlier. Based on telemetry activity, latest activity observed at USAFA was mid-October (R. Schorr unpublished data). Based on these dates, the active period for PMJM is roughly May 1 through October 31 (Armstrong et al. 1997).

Behavior and Movement

PMJM are active primarily during twilight or at night. However, they can also be observed during the day. Individuals have been seen sitting motionless during the day under shrub cover, in nests composed of grass, leaves, and woody material (R. Schorr, M. Bakeman, T. Ryon, T. Shenk pers. comm.).

Radio telemetry studies at RFETS indicate movement both up and down stream channels, as well as perpendicular to the drainage. Mice stayed in riparian/wetland areas, and did not travel over cobbles. Mice also moved along contours into adjacent drainages, again staying in riparian areas. Adult mice were observed to move 1.6 kilometers (approximately a mile) in a 24-hour period (T. Ryon unpublished data)

Movement information summarized from research conducted in Douglas County during 1998 indicate the following (T. Shenk unpublished data):

- ◆ Maximum movement is greater than 1 mile.
- ◆ Greater use of upland habitats than was previously assumed was observed.
- ◆ PMJM exhibit fidelity to day nest and night sites presumably used for feeding.

- ◆ There are seasonal shifts in movement patterns. (Movement shifts match dietary shifts, but a cause/effect relationship is unclear.)
- ◆ PMJM use both perennial and intermittent tributaries adjacent to capture drainages. Lateral movement from the stream is less on high order streams and increases on low order streams and meanders/floodplains.
- ◆ Long distance movement (>90 m) to new locations was observed prior to hibernation in September.

Compared to other Colorado locations, USAFA mice do not appear to be as mobile. Average distance traveled over the life of a radio collar (approximately 3 weeks) is 180 meters, with minimum and maximum distances of 90 and 280 meters, respectively. Home range size calculated for eight individuals at the USAFA averaged 0.61 hectares, with minimum and maximum estimates of 0.066 ha. and 1.5 ha respectively. Jumping mice have not been observed to move through upland habitat from one drainage to another at the USAFA (R. Schorr unpublished data).

Food Preferences

Armstrong et al. (1997) summarized available information on food preferences of meadow jumping mice as follows:

Studies of food habits in central and eastern United States indicate that they are governed by availability more than preference (Whitaker 1963). Grass seeds of several species are probably the most important component of the diet, and mice will shift to those species that have available seed. Invertebrates and fungi are also readily eaten. Mice feed on both adult and larval invertebrates, especially *Coleoptera* (beetles). Invertebrate feeding is very important in the spring as mice emerge from hibernation, and may consist of half of the diet at that time. Mice also feed on various species of fungi, which are often encountered during burrowing activity. As the growing season progresses, graminoid seeds dominate the diet.

Research in Douglas County indicates that PMJM are consuming more fungi and arthropods than researchers expected. This study also indicates that shifts in diet content match movement shifts, but a cause/effect relationship is unclear (T. Shenk unpublished data).

Shenk has also observed that PMJM from different stretches of streams studied in Douglas County regularly congregate at the same feeding “hotspots”. Additional research is needed to determine what mice are eating, as well as whether or not these nightly congregations have behavioral or social significance.

PMJM are not known to store food. Therefore, they must consume food prior to hibernation. Because sufficient energy to survive over winter must be provided by fat stores accumulated prior to hibernation, the availability of adequate food resources during this time of year is a critical factor for these mice. It seems reasonable to assume that graminoid seeds are especially important during this period due to the proportionally high fat content of this food source (T. Ryon pers. comm.).

Abundance and Density

Preliminary estimates of abundance from mark-recapture studies conducted on USAFA from 1998 indicate approximately 2521 individuals on the USAFA (R. Schorr unpublished data).

Density estimates from the same study are 26 individuals/ha in June and 82 individuals/ha in late summer. These numbers should be interpreted with great caution, however, for several reasons. First and foremost, these estimates are based on data from only one field season. Additional data from at least two more field seasons will be necessary to increase the confidence with which this number can be used. (In fact, based on preliminary results from 1999 surveys, we suspect that this year's abundance estimate will be lower than 2521.) Second, the density estimates used to calculate abundance were based on the distance traveled by only one mouse. Third, populations of meadow jumping mice are known to fluctuate considerably from year to year (Blair 1940, Whitaker 1972, Adler et al. 1984, Boonstra and Hoyle 1986), and may vary by as much as 75% annually (Muchlinski 1988).

Rate of PMJM capture from trapping efforts at U.S. Air Force Academy, Rocky Flats Environmental Technology Site (RFETS) and Boulder County all support the theory that PMJM populations, like other populations of meadow jumping mice, undergo fluctuations in abundance from year to year (T. Ryon, M. Bakeman, C. Meaney, R. Schorr pers. comm.).

Although preliminary abundance and density estimates for USAFA are useful in beginning to formulate conservation goals, additional research will be necessary to confidently document persistence, abundance, and density of PMJM over time.

Characteristics of Riparian Systems Occupied by PMJM

The survival of PMJM is closely linked to the persistence of the habitats upon which the mice depend. The riparian and upland systems where PMJM occur are, therefore, appropriate targets for conservation action in and of themselves. In fact, most of the strategies presented in Part 3 of this plan are based on the need for maintenance or rehabilitation of riparian and associated upland habitat. In general, attributes necessary to sustain properly functioning riparian systems are:

- ◆ Unconstricted river channel movement
- ◆ Natural succession of riparian communities through early and late seral stages
- ◆ Occasional non-catastrophic disturbance during mid- and late-seral stages of riparian community development, including flooding at 3-75 year return intervals, fire, or periodic grazing of short duration (winter only, or short season with 3-5 year rest)
- ◆ Occasional catastrophic disturbance (100-500+ year flood events)
- ◆ Long time spans (approximately 10-20 years) between disturbance events with no disturbance other than normal stream flow events

The relationship between streamflow and maintenance of riparian vegetation has not been quantified for the Front Range systems occupied by PMJM. Clearly, however, some threshold for in-stream flow and/or groundwater is necessary in order to prevent loss of function or succession to a dryland system. Fortunately, although human modification of the local hydrology has obviously taken place, Monument Creek and its tributaries seem to have retained enough natural function to support healthy riparian vegetation. One question that remains unanswered is the degree of future change this system can sustain.

Characteristics of Upland Habitats Used by PMJM

The upland areas used by PMJM can be characterized as a mosaic of grasslands, oak scrub, and ponderosa pine woodlands. Periodic fire and grazing by native ungulates were major ecological processes that influenced the vegetation. The patchy nature of fire and grazing resulted in a shifting mosaic of vegetation types on the ground over time.

Historic fire return intervals for the Front Range ponderosa pine forests range between 8 and 45 years (Laven et al. 1980, Mehl 1992). Shortgrass to mixed grass prairie on level topography burned approximately every 5-10 years, and approximately 20-30 years on dissected topography (Wright and Bailey 1980).

Restoration of historic vegetation patterns on a landscape scale may not be possible due to conflicting land uses. On a local scale, use of management tools such as prescribed fire should emphasize maintenance of a mosaic of vegetation types over time.

Reasons for Rangewide PMJM Decline

The USFWS final rule to list the PMJM as a Threatened Species discussed threats to this subspecies based on the five listing factors set forth in section 4 of the Act (Federal Register 1998). These factors are:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Overutilization for commercial, recreational, scientific, or educational purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms;
5. Other natural or manmade factors affecting its continued existence.

Based on our reading of the rule, the primary justifications for listing appear to be factor 1 (modification of habitat and range) and factor 4 (inadequacy of existing regulatory mechanisms). The USFWS summarized its decision to list in the following statement:

“...the Preble’s meadow jumping mouse, historically a rare mammal, has declined...Riparian habitats required to support Preble’s have been severely modified or destroyed by human activities in many areas...With current human population increases, the loss and modification of riparian habitat continues. Existing regulations have proven inadequate to protect Preble’s, as witnessed by its apparent decline and the continued destruction and modification of its habitats.”

Human activities discussed in relation to the alteration, degradation, loss, and fragmentation of PMJM habitat across its range include:

- ◆ residential, commercial, and recreational development
- ◆ highway construction
- ◆ stream alteration in physical structure and hydrology
- ◆ grazing and conversion of grasslands to farms
- ◆ water development and flood control practices
- ◆ mining
- ◆ threats from hazardous material

Other issues noted as needing additional research into potential effects on PMJM were all related to human development and land use. These issues were: weeds, increased predation associated with human developments (both wildlife and domestic cats), pesticides and herbicides, and other effects of intensive human development such as noise, air pollution, and water pollution.

Conservation Issues on the USAFA

Based on the Science Team's analysis of conservation issues in Colorado, rangewide declines of PMJM can be attributed to complex interactions among many human activities and landscape conditions, as described in Appendix A. On the USAFA, the primary issues that should be addressed in order to achieve long-term conservation of PMJM are **isolation of populations, habitat destruction, habitat degradation, and potential for catastrophic events.**

Isolation of Populations

Population isolation results from the introduction of barriers into previously connected landscapes such that mice are not able to leave one population and join another. Common causes of PMJM population isolation include human developments, roads and other infrastructure, and hydrologic alteration that leads to drying up of streams. Isolation may result in loss of genetic variability or increased vulnerability to catastrophic events.

Overall, the Monument Creek drainage contains one of the largest and healthiest PMJM populations documented within the range of the subspecies (Corn et al. 1995, R. Schorr unpublished data). This is due, in large part, to the extent and integrity of the riparian communities and adjacent uplands that exist along the main stem of the USAFA stretch of Monument Creek. However, surrounding land use changes, especially the increase in urbanized area, have isolated the Monument Creek population from other populations to the north of the Palmer Divide. Notes from the Long Expedition of 1820 record the observation that Palmer Lake, when full, drained both north to the Platte River and south to the Arkansas River (Goodman and Lawson 1995). This strongly suggests connection across the Palmer Divide. Because of this isolation, rates of immigration/emigration may be lower than the historical norm. A primary concern associated with altered rates of immigration/ emigration is long-term reduction in genetic variability. Whether or not the Monument Creek population is large enough to avoid this problem is unclear.

Isolation is problematic not only in that the Monument Creek population is separated from other PMJM populations to the north, but also in that sub-populations along tributaries have been separated from the population along the main stem of Monument Creek. On USAFA, this situation is especially pronounced along Deadmans Creek and Lehman Run. In addition, present and future connectivity of populations along eastern tributaries is questionable due to continued development on neighboring private lands.

Preliminary abundance estimates for the USAFA indicate that this population is probably not vulnerable to inbreeding depression. However, connectivity between isolated patches of habitat along tributaries and the main stem of Monument Creek will be required to maximize the long-term viability of these sites.

Habitat Destruction

Habitat destruction refers to the conversion of natural riparian and upland vegetation to other uses. Conversion may be permanent and essentially irreversible (as in the case of residential development, parking lots and recreation facilities, flood control structures, and roads), or it may be at least partially reversible (as in the case of construction of utility lines and trails). The greatest cause for concern in PMJM protection rangewide is permanent, irreversible land conversion.

On USAFA, habitat conversion for recreational development has severed upstream tributary populations from the larger population found along the main stem of Monument Creek. The lawn by the athletic field along Deadmans Creek, and the Eisenhower Golf Course along Lehman Run, have replaced a significant amount of habitat and probably limits movement between upstream and downstream mice. Urban development, including residential, commercial/ industrial, and recreational, continues to increase on surrounding private lands.

Habitat Degradation

Habitat degradation refers to changes in habitat composition, structure, or function that individually, or in combination, hamper the ability of PMJM to feed, reproduce, hibernate, or disperse. On USAFA, the most common source of habitat degradation is alteration of hydrological function related to development on surrounding private lands, as well as on the installation itself. Increased peak flows are the primary concern. Increased storm water runoff from expansion of hard surfaces (such as buildings, parking lots, and roads) on the USAFA have resulted in increased erosion and sedimentation, and have hampered the regeneration of riparian vegetation. This is especially true along Lehman Run. Flood control and water retention measures also have the potential to alter the local hydrology. Note that changes to water quality have not been shown to adversely impact PMJM or its habitat.

Activities that interfere with the function of ecological processes may ultimately result in succession of vegetation to different systems. Long-term alteration of the local hydrology may cause riparian systems to succeed to dryland systems that are unable to support PMJM. Similarly, upland shrub systems may succeed to unsuitable forested environments in the absence of periodic fire. Succession of either riparian or upland vegetation could negatively impact PMJM through reduced availability of food resources and cover habitat.

The presence of some weedy species in PMJM habitat does not appear to preclude occupation by the mouse. However, invasion by non-native species does alter the plant communities that make up PMJM habitat, both in the riparian zone and in the upland grasslands. Additional information is needed on potential long-term impacts of weeds, weed control, and plant species composition on PMJM populations.

Other conditions on the USAFA that may potentially result in degradation of PMJM habitat, and should be evaluated further, include: the trail system, especially the Santa Fe trail; overflows from the sewage treatment plant; and base housing communities in Douglass Valley and Pine Valley. [The Santa Fe Trail is a heavily used, paved recreational trail that runs through the USAFA parallel to Monument Creek.] In addition, continued development of infrastructure on both the USAFA and surrounding private lands, with the resulting increases in storm water runoff and erosion, introduction or spread of exotics, and the heavily utilized transportation corridors

(especially interstate highway and railroad) that parallel Monument Creek through the USAFA, are all potentially threatening.

Catastrophic Events

Catastrophic events are chance occurrences of sudden environmental change that result in destruction of a large percentage of a PMJM population. Possible events on USAFA include catastrophic fire, accidental spills of hazardous materials from roads or railroad, and floods. Because these catastrophes are unpredictable, and therefore impossible to manage for, PMJM conservation efforts must provide for protection of multiple populations, as well as for additional habitat to serve as refugia against such events.

Offsite Considerations

The USAFA basically represents the southern extent of known PMJM range. The future stability of the PMJM population on USAFA, and the ability of USAFA to sustain or improve habitat quality, are closely tied to the hydrologic integrity of the Monument Creek watershed. It should be stressed that this subspecies is directly dependent upon maintenance of a healthy and functioning riparian system and associated uplands. Alterations to the hydrologic regime of the Monument Creek watershed that take place outside USAFA boundaries do have the potential to severely impact the quality and condition of habitat within the boundaries. Management of all lands within the Monument Creek watershed should be conducted in a manner consistent with maintenance of existing flows, hydroperiod, and geomorphology. As urban development on surrounding lands further degrades or destroys PMJM habitat along Monument Creek to the north and the tributaries to the east, the PMJM population on the Academy will become increasingly critical to the persistence of the subspecies within its range of variability. Also, as the hydrologic function is altered and adjacent habitat degrades, the risk to the USAFA PMJM increases, with reduced flexibility in management options for the USAFA.

The quality of potential PMJM habitat along Monument Creek north of the Academy boundary is much narrower and patchier, especially in terms of shrub vegetation. PMJM has been documented by Mark Bakeman (unpublished data) approximately four miles north of the USAFA, in the Town of Monument. The degree of connectivity between these populations is uncertain, but should be investigated. Habitat restoration is warranted to enhance the linkage between the Academy's southern boundary and mice captured along Monument Creek near Woodmen Road. The existing USAFA practice of requiring offsite developments to detain flows across USAFA to historic levels should be continued.

PART 3: CONSERVATION GOALS, OBJECTIVES, AND STRATEGIES

Goals:

1. Maintain and enhance AFA populations of PMJM, and associated native plant and animal species, as directed by the U.S. Air Force Academy Integrated Natural Resources Management Plan (INRMP) and Environmental Assessment, 1997.
2. Protect the integrity of the USAFA portion of the main stem of Monument Creek (approximately 6.5 miles).
3. Protect seven (7) miles of USAFA tributaries to Monument Creek that are currently occupied by PMJM, and contain PMJM habitat that is connected to habitat along Monument Creek.

Overall, conservation of the PMJM will not only benefit the recovery of this listed species, but will also benefit the preservation of all native fish and wildlife species that use riparian and associated shrub and grassland habitats. In addition, conservation of PMJM will maintain the integrity of that portion of the Monument Creek watershed on USAFA lands.

In order to fully demonstrate maximum protection of PMJM on the USAFA, specific numeric goals for the PMJM population and for its habitat will need to be set. However, based on the data currently available, we considered the setting of population goals to be premature. Analysis of data from the 1999 and 2000 field seasons, in conjunction with the results of the 1998 field season, should allow the USAFA to set conservation goals with a reasonable degree of confidence. Therefore, we recommend that this section of the plan be updated no later than FY2001.

Objectives:

1. Maximize extent, quality, and connectivity of PMJM habitat within the USAFA.
2. Conduct research and monitoring projects to increase understanding of PMJM life history and habitat requirements.
3. Eliminate or minimize threats to PMJM and its habitats within USAFA boundaries.
4. Actively participate in the El Paso County planning effort to encourage maximum protection of PMJM populations and associated habitats on adjacent lands, and to ensure long-term viability of USAFA population.

Objective 1. Maximize extent, quality, and connectivity of PMJM habitat within the USAFA.

Strategy 1A. Maintain and enhance existing habitat.

Task 1.1:

Ensure availability of adequate habitat, including riparian vegetation as well as upland shrub and grassland habitat, to provide sufficient food resources and cover habitat, and to meet other life history requirements.

Task 1.2

Enhance or restore degraded habitat patches in suitable size, density, and configuration to increase the overall USAFA habitat area, and to facilitate movement between upstream and downstream mice on the main stem of Monument Creek and on tributaries.

- 1.2.1 Monument Creek. Restore riparian habitat 1 km north of Northgate Bridge.
- 1.2.2 Smith Creek. Enhance habitat from Monument Creek to I-25.
- 1.2.3 Smith Creek. Restore habitat from I-25 to USAFA east boundary.
- 1.2.4 Deadmans Creek. Remove athletic equipment and restore/enhance riparian habitat from Parade Loop to Academy Drive.
- 1.2.5 Lower Lehman Run. Investigate connecting riparian habitat from Non-Potable Reservoir #1 to Monument Creek.
- 1.2.6 Lehman Run. Explore possibility of enhancing riparian habitat through Eisenhower Golf Course.
- 1.2.7 West Monument Creek. Return stream flow to original channel below junction with Stanley Creek.

Task 1.3

Maintain, restore, or emulate natural hydrologic regime (i.e., flow quantity, timing, and duration) to support riparian vegetation in suitable density and pattern, and to maintain appropriate channel and floodplain features. Carefully monitor and mitigate any unavoidable hydrological alteration. Control sedimentation and altered runoff.

- 1.3.1 Un-named creek at Aardvark Emergency Airstrip. Construct erosion control dams to regulate flows and extend habitat between Santa Fe trail and USAFA east boundary.
- 1.3.2 Jacks Valley. Stabilize road bank upstream of railroad bridge.

Task 1.4:

Identify and control noxious weeds. Use direct application rather than broadcast control measures where possible. If broadcast measures must be used, monitor PMJM habitat and mitigate unintentional adverse impacts. Avoid weed control activities from August through October to minimize potential loss of available seed crop during the critical pre-hibernation period. Special attention should be paid to any occurrence of Russian olive as this species has the potential to completely replace critical PMJM habitat components.

- 1.4.1 Control Russian olive along Monument Creek 1 km north and south of Northgate overpass. Remove/control knapweed and other noxious weeds along Monument Creek at NP1.
- 1.4.2 Remove/control noxious weeds along Monument Creek at Aardvark Emergency Airstrip.

Objective 2. Conduct research and monitoring projects to increase understanding of PMJM life history and habitat requirements.

Strategy 2A. Collect baseline data on PMJM populations, distribution, life history, and habitat use on USAFA. (See Appendix C for FY00-02 statement of work.)

Task 2.1:

Inventory all potentially suitable habitat for new PMJM populations and confirm status of known populations. Presence/absence surveys should follow the most current USFWS interim trapping guidelines.

- 2.1.1 Monument Branch. Conduct walk-through habitat assessment from confluence to east boundary. Trap for presence if habitat is suitable.
- 2.1.2 Un-named tributary north of Black Squirrel Creek. Last surveyed in 1995 with negative results. Conduct walk-through habitat assessment, and re-trap for presence if habitat is suitable.

- 2.1.3 Black Squirrel Creek from Santa Fe Trail to USAFA boundary. Conduct walk-through habitat assessment and trap for presence if habitat is suitable.
- 2.1.4 Douglass Road. Conduct walk-through habitat assessment from Douglass Road to Monument Creek main stem. Trap for presence if habitat is suitable.

Task 2.2:

Research and document PMJM habitat and life history requirements.

- 2.2.1 hibernacula locations and characteristics
- 2.2.2 diet and habitat use
- 2.2.3 survival (overwinter and active season) and mortality factors
- 2.2.4 correlation between vegetation and PMJM abundance, including patch size, composition, and spatial distribution
- 2.2.5 fluctuation patterns in population size from year to year
- 2.2.6 system dynamics (e.g., beaver, floods, fire) and response to stochastic disturbance
- 2.2.7 response to human alterations (e.g., including cats, weed control, and development)
- 2.2.8 behavior patterns, including seasonal changes in movement patterns and feeding
- 2.2.9 genetics

Task 2.3:

Investigate relationship between hydrological alteration and maintenance of riparian vegetation.

Strategy 2B. Monitor PMJM populations and habitat. (See Appendix C for FY00-02 statement of work.)

Task 2.4:

Develop and implement PMJM population and habitat monitoring protocol to determine status of populations, program effectiveness, and long-term trends. Qualitative habitat monitoring should be done annually. Presence/absence surveys should be conducted annually at selected sites across the range of key habitat types. Quantitative monitoring of selected sites should occur annually. Modify management strategies if necessary based on results of monitoring.

- 2.4.1 Kettle Creek. Conduct long-term monitoring over the life of scheduled projects (i.e., replacing dams 1, 2, and 3 with primary spillways).

Objective 3. Eliminate or minimize threats to PMJM and its habitat within USAFA boundaries.

Strategy 3A. Develop mitigation protocol for future planned habitat alterations and emergencies.

Task 3.1:

Develop programmatic Biological Assessment to define potential impacts and mitigation techniques for foreseeable USAFA management activities, including natural resource management actions as prescribed in the INRMP:

- ◆ regular, recurring maintenance of existing infrastructure, including roads and utilities
- ◆ stormwater management
- ◆ training grounds and other facilities necessary for achieving military mission

Task 3.2:

Limit cumulative disturbance impact to no more than 2% of the USAFA PMJM population per year (approximately 12 acres – see Appendix B for rationale). Do not create barriers to upstream and downstream movement in currently connected habitat. Ensure no net loss of habitat.

Task 3.3:

Ensure that emergency actions follow established protocol described in the Endangered Species Act.

- 3.3.1 Immediately initiate consultation with USFWS and keep the agency informed throughout emergency actions.
- 3.3.2 Implement best management strategy as described in the INRMP.
- 3.3.3 Take the following steps to minimize short- and long-term impacts to PMJM habitat:
 - i) Designate a single route through the habitat. The route should be of minimal width (i.e., one narrow lane).
 - ii) Stage heavy equipment outside of the habitat (preferably > 150 feet) whenever possible.
 - iii) Excavate, fill, or clear only those areas absolutely necessary.
 - iv) Remove excess fill from site or to an area at least 150 feet from PMJM habitat.
 - v) Direct dewatering activities away from habitat and into an area that will not drain directly into PMJM habitat.
 - vi) Minimize local and downstream erosion by placing erosion barrier fences around excavated materials, if they are to remain for more than one day.
 - vii) Revegetate disturbed areas as soon as equipment is moved and the response action is completed. Whenever possible, seed mixtures or planting stock should match the vegetation existing at the site prior to disturbance. As a temporary measure, stems from removed shrubby vegetation can be used to cover freshly reseeded ground, providing some cover for PMJM and protecting seedlings. If willows are removed, willow stems should be planted for efficient revegetation.
 - viii) Any residue of chemicals should be cleaned and/or removed from the site to a safe disposal area.
 - ix) To the extent possible, leave no structures, residues, trash, tracks, holes, or other fill materials that will impair the natural hydrologic flow of the streams, wetlands, or ground water.

Task 3.4:

Comply with all post-construction monitoring and mitigation protocols required by the U.S. Fish and Wildlife Service.

Objective 4. Encourage maximum protection of PMJM populations and associated habitats on adjacent lands.

Strategy 4A. Actively participate in the El Paso County comprehensive planning effort to assist in development of complementary conservation strategies for adjacent lands.

Task 4.1:

Promote solutions that offer sufficient opportunity for gene flow and refugia between the USAFA population and populations outside installation boundaries, including upstream Monument Creek, eastern tributaries, and south near Woodmen Road.

Task 4.2:

Encourage the El Paso County planning team to implement conservation strategies that will minimize alteration of the hydrology of Monument Creek, and degradation of USAFA habitat due to impacts from offsite activities.

PART 4: CONSERVATION ZONES

In order to achieve the conservation goals and objectives of this plan, management strategies will need to be implemented in specific locations on the landscape. The Science Team identified possible locations by delineating “conservation zones”. Conservation zones as used herein depict geographic areas where habitat maintenance, habitat restoration, and research activities should be focused. Management strategies are related to each conservation zone, or to specific areas within a zone, as appropriate. The conservation zones appearing on USAFA lands are listed below. Note that zone 4 should ultimately become either Zone 1 or Zone 2 when management objectives are achieved.

Zone 1: Mouse Management Area (MMA)

Zone 2: Connectors/linkages

Zone 4: Potential restoration

The conservation zones presented in this plan are a refinement of the zone concept originally presented in Corn et al. 1995. The PMJM Science Advisory Team has conducted an extensive evaluation of the minimum parameters necessary for effective land conservation targeting this subspecies. The zones depicted here are believed adequate to address direct and indirect impacts to the area utilized by 95% of the mice at a given site. It should be stressed, however, that this subspecies is directly dependent upon maintenance of a healthy and functioning riparian system and associated uplands. Alterations to the hydrologic regime of the Monument Creek watershed that take place outside these boundaries do have the potential to severely impact the quality and condition of habitat within the boundaries. Thus, even though much of the upslope habitats are not included within conservation boundaries, management of these areas should be conducted in a manner consistent with maintenance of existing flows, hydroperiod, and geomorphology throughout the Academy. One further note: the Corn et al. report of 1995 emphasized the issue of domestic cat predation in justifying the Zone B boundary. Current thinking by the Science Advisory Team is that this issue is likely to be a severe threat only under certain conditions that may be rare on the USAFA: high densities of house cats near dense human habitations. Given the magnitude of potential increase in surrounding residential development, however, we believe that this issue, in particular, warrants caution and further investigation.

Zone 1: Mouse Management Area (MMA)

Zone 1 represents areas in which PMJM is known to occur, as well as adjacent habitat patches that are likely to be occupied. Mouse management in this zone should be as inclusive as possible. In most cases, the boundaries of this zone should be measured approximately 100 meters from the best estimation of the 100 year floodplain. Based on the most current information available on mouse movement and habitat use, we believe this area will provide enough undisturbed habitat to accommodate PMJM life history requirements. However, this estimate may change if future research indicates greater use of upland habitats or different movement patterns than is currently documented.

There are currently seven separate MMAs on the Academy, based on stream reaches where PMJM have been found. Status, issues, objectives, and recommendations are listed separately for each. **USAFA Mouse Management Areas are presented in Part 5.**

Conservation Focus: Manage riparian and upland systems to maximize the number of mice and the quality of their habitat.

Recommendations:

1. Limit activities to existing use only. Additional permanent structures should not be erected within this zone.
2. Plan and execute maintenance of existing buildings and infrastructure, weed control, and other management activities to minimize damage or destruction of riparian and upland vegetation.
3. Avoid additional changes to local hydrology. Any unavoidable hydrological alteration should be carefully monitored, and adverse impacts mitigated. Control erosion and altered run-off.
4. Restore local pockets of poor quality habitat, and monitor mice annually to ensure their presence.

Zone 2: Connectors / Linkages

Zone 2 identifies connectors or linkages between populations that once occurred as a single unit, but are now isolated into two or more units. The assumption is that a linkage is practical and that mice will survive there. There are two kinds of links: genetic links and population links. The former would serve to protect or enhance the genetic diversity of each sub-population. The latter would increase the overall population size, creating a more stable single population. The structure of the linkage would differ in each case. A genetic linkage would simply provide adequate structure for a few mice to “make it to the other side” each generation (2-3 years or less).

Potential may exist for re-establishment of a genetic linkage between the Monument Creek watershed and PMJM populations north of the Palmer Divide. The USAFA should actively support, through the El Paso County planning effort, establishment of a genetic linkage, but this would need to be accomplished on lands that fall outside USAFA jurisdiction. All of the areas designated as Zone 2 within USAFA boundaries are intended to be population linkages.

The two most significant areas designated as Zone 2 are Deadmans Creek and Lehman Run. Each of these creeks contains almost two miles of stream reach that have been impacted to such a degree that upstream mice are likely entirely isolated from downstream mice. In both cases, the primary cause of disturbance is recreational development. Restoration of linkages among these habitat areas is critical to the long term viability of each sub-population and creates a lower risk to the overall USAFA mouse population.

Conservation Focus: Establish connections between adjacent Zone 1 MMAs.

Recommendations:

1. Enhance habitat and eliminate threats to PMJM within Zone 2 to the extent that the area can effectively link currently disparate populations.
2. Monitor PMJM annually to determine success of habitat enhancement efforts. Alter management techniques as necessary, based on results of monitoring.

Zone 4: Potential Restoration

Zone 4 identifies areas that are not currently suitable for occupation by PMJM, but that may be restorable to high quality PMJM habitat. Zone 4 also identifies areas that may be inhabited by PMJM, but to a greatly reduced extent. These areas can be acting as a linkage when they have the full potential to support the entire life history of PMJM. If restored, these areas could significantly increase the potential number of mice in adjacent populations. If these areas are not restored, they will continue to function as barriers or limitations to movement between populations. Inability to restore the Zone 4 sections of Deadmans Creek and Lehman Run, in particular, will severely reduce the long term viability of upstream populations in these drainages, and increase risk to the Monument Creek population.

The USAFA is currently exploring a formal arrangement with the Colorado State Forest Service nursery to harvest willow shoots from the USAFA and generate root stock from USAFA progeny for mitigation and habitat enhancement. If this project is successful, it will greatly enhance restoration efforts by providing local material for revegetation.

Conservation Focus: Restore altered habitat to riparian vegetation with density and structural diversity sufficient to support PMJM at levels believed to be within the range of natural variability.

Recommendations:

1. Investigate feasibility of restoring natural riparian vegetation patches in altered areas.
2. If possible, restore patches in suitable size, density, and configuration to increase the USAFA habitat area, and to facilitate movement between upstream and downstream PMJM populations.
3. Monitor to evaluate success.

PART 5: MOUSE MANAGEMENT AREAS

MMA 1: Monument Creek

CNHP identifier: AMAFH01011*023*CO and AMAFH01011*072*CO

Unit description:

This is the largest MMA on the Academy, covering portions of eight streams, totaling approximately 16 linear miles. Included are: Monument Creek from the northern USAFA boundary to the southern boundary (approximately 6.5 miles), West Monument Creek (approximately 3.5 miles), and approximately 1 mile of Stanley Creek from its confluence with West Monument. Also included in this MMA are reaches of the following tributaries from their confluence with Monument Creek: Kettle Creek (approx. 1.5 miles from confluence), Deadman Creek (approx. 1.5 miles), Black Squirrel Creek (approx. 0.5 miles), un-named tributary north of Black Squirrel (approx. 0.5 miles), Monument Branch (approx. 0.5 miles), and Smith Creek (approx. 0.5 miles).

This MMA is composed of a nearly continuous band of thick riparian vegetation, including a mosaic of coyote willow, peachleaf willow, crack willow, and snowberry, with a limited overstory of narrowleaf cottonwood and a very dense herbaceous understory. In terms of size and quality of continuous PMJM habitat, the Monument Creek MMA is rivaled only by the Plum Creek complex in Douglas County.

Habitat along the Stanley Creek portion of this MMA is atypical of that found elsewhere. Stanley Creek is the highest elevation stretch, reaching up to 7340 feet, and is comprised primarily of scrub oak, chokecherry, willow, maple, river birch, ponderosa pine, and douglas fir. This site is unusual in that the riparian zone is very narrow, with conifers approaching the edges of the creek. This site also contains dense herbaceous ground cover.

PMJM status: Abundance estimates are not available for individual MMAs, but the Monument Creek MMA is thought to contain at least $\frac{3}{4}$ of the individuals that are estimated to occur installation-wide.

Issues: Habitat degradation, isolation of populations

In general, although human modification of the local hydrology and adjacent landscapes has obviously taken place, this MMA seems to have retained hydrological function that sustains healthy riparian vegetation. However, PMJM habitat in some portions of the MMA has been degraded by current land use practices and historic construction impacts (e.g., Northgate bridge).

The proximity of human activity in the southern portion of the MMA around Ice Lake is greater than that present in other areas. In particular, the Santa Fe Trail is in very close proximity to Monument Creek here. Adverse impacts to PMJM have not been observed, but this should be confirmed. Maintenance of the status quo, at least, will be very important.

The USAFA sewage treatment plant has a tendency to overflow during high volume flood events. Impacts to PMJM and riparian habitat are unknown. Potential negative impacts such as downstream sedimentation and nutrient loading should be investigated.

Connectivity is an issue in several places. Historical disruption of bank structure and vegetation near Northgate Boulevard has created a barrier to movement along Monument Creek. This area is heavily encroached by Russian olive and knapweed. Mice have been known to re-colonize disturbed areas where sufficient riparian vegetation exists, but this area still needs additional willow regeneration. Restoration goals should, at a minimum, achieve status of a linkage.

Part of Kettle Creek is diverted through an underground pipe instead of the original stream channel. Vegetation is good in this area, but it is separated from upper Kettle Creek east of I-25. Restoring stream flow to the original channel would gain approximately 0.5 miles of good PMJM habitat and improve connectivity.

Additional trapping is needed to confirm presence of continuous, occupied habitat along West Monument Creek between the stables and Stanley Creek. The Pine Valley housing complex is adjacent to West Monument Creek along this stretch, and may be adversely impacting PMJM habitat there. The potential for disturbance to PMJM from domestic predators, recreational traffic, and hard surface run-off exists. This section of the USAFA has the greatest potential for such conflicts. Presence of these or other conflicts should be investigated.

Recreational developments have created barriers between Monument Creek and upstream reaches of Lehman Run and Deadmans Creek. Connectivity between Monument Creek and Smith and Black Squirrel Creeks is currently under investigation.

Conservation Focus:

1. Re-establish connection between Monument Creek and the tributaries on USAFA, where possible.
2. Avoid further fragmentation of PMJM habitat within the USAFA portion of the Monument Creek watershed.
3. Cooperate with neighbors to encourage the maintenance or restoration of connectivity along Monument Creek, and with tributaries across USAFA boundaries, to the maximum extent practicable.
4. Minimize site-specific impacts to PMJM and its habitat from installation facilities (i.e., housing, sewage treatment, travel corridors, and recreation).
5. Maintain the hydrological integrity of Monument Creek as it passes through the USAFA.

Recommendations:

1. Conduct trapping surveys along West Monument Creek to determine extent of occupied habitat between Monument Creek and Stanley Creek. Restore habitat where necessary to remove any barriers to PMJM movement that may exist, and evaluate potential impacts from the Pine Valley housing complex. (supports Strategies 1A and 2A)
2. Restore the riparian vegetation along Monument Creek at the North Gate Blvd. overpass through revegetation techniques and control of Russian olive. (supports Strategy 1A)
3. Conduct impact assessments on USAFA projects proposed within the MMA to ensure that adverse effects on PMJM and its habitat are avoided or minimized. Develop and implement a system to measure cumulative impacts across all proposed projects to avoid future fragmentation of the MMA. (supports Strategy 3A)
4. Investigate the nature and magnitude of any impacts to PMJM or its habitat resulting from the Santa Fe Trail and the sewage treatment plant. If necessary, cooperate in the development and implement of mitigation plans. (supports Strategy 3A)

5. Encourage the El Paso County planning team to protect the hydrological integrity of Monument Creek to the maximum extent practicable. (supports Strategy 4A)
6. Move flow of Kettle Creek back into original channel from I-25. (supports Strategy 1A)

MMA 2: Deadmans Creek

CNHP identifier: AMAFH01011*075*CO

Unit description:

This unit is comprised of approximately 500 meters of Deadmans Creek upstream of Academy Drive, west to Deadmans Lake. The habitat is composed of thick riparian vegetation, including cottonwood, willow, scrub oak, chokecherry, river birch, and snowberry, along with a dense, diverse understory. Dominant shrubs are scrub oak and chokecherry. Elevation is approximately 7200 feet.

PMJM status: 2 individuals (one lactating female, one male) were caught in 120 trap nights in 1998.

Issues: Isolation of population, habitat destruction

This small MMA has been isolated from the downstream reach of Deadmans Creek by conversion of habitat to mowed lawn by the athletic field. Habitat conditions upstream of Deadmans Lake have not been evaluated. The lake is used for recreational fishing, but no conflicts with PMJM have been observed.

Conservation Focus:

1. Maintain high quality habitat currently present west of Academy Drive.
2. Restore connectivity to Monument Creek mainstem population by enhancing degraded habitat east of Academy Drive.

Recommendations:

1. Ensure that road maintenance and other activities do not damage or degrade the dense cover that currently exists along either side of the dirt road to Deadman Lake and Jacks Valley. (supports Strategies 1A and 3A)
2. Improve shrub cover along creek between Stadium Boulevard and Academy Drive to ensure linkage between upstream and downstream mice. If linkage can not be restored, investigate options for moving individuals to maintain genetic diversity. (supports Strategy 1A)
3. Determine the extent of the PMJM population in Deadmans Creek west and east of Parade Loop Road. (supports Strategy 2A)

MMA 3: Goat Camp Creek

CNHP identifier: AMAFH01011*073*CO

Unit description:

This site is a remnant stretch of Goat Camp Creek left after the creek was rerouted through an underground manmade drainage to Lehman Run. There is no above ground connection downstream of the capture point. The vegetation is composed of very sparse willow and young ponderosa pine. Although the stream has produced some saturated areas with cattail and rushes, the area is of very marginal habitat value, and may dry out at any time. Elevation 7380 ft.

PMJM status: Only one adult male. Extensive trapping upstream has not located any additional mice.

Issues: Habitat destruction, isolation of population

Conservation Focus:

This location is unlikely to support or play a significant role in a viable population. Although restoration might produce additional habitat, the total amount would be insufficient for a viable population. There are no realistic options for connecting this location to other occupied areas.

Recommendation: Direct conservation resources toward other MMAs where viability is more feasible.

MMA 4: Upper Lehman Run

CNHP identifier: AMAFH01011*074*CO

Unit description:

This MMA is a one-mile stretch of Lehman Run upstream of Cross Drive to approximately 0.25 miles west of Academy Drive. The habitat west of Academy Drive is quite different than that found east of Academy Drive. On the west side, vegetation is quite thick, consisting of willow, river birch, chokecherry, ponderosa pine, douglas fir, scrub oak and various herbaceous ground covers. Dominant species are willow and birch. There are also numerous grassy areas along the stream. To the east of Academy Drive, patches of willow are interspersed with cattail marsh and dry grassland. Elevation is approximately 7350 feet.

PMJM status: west of Academy Drive, caught 3 adult mice (2 female, one male) in 540 trap nights. East of Academy Drive only one mouse was caught in thousands of trap nights.

Issues: Isolation of population, habitat destruction, habitat degradation

Drainage from the cadet parking lot immediately upslope of the MMA feeds Lehman Run downstream of Faculty Drive. High flows running off this impervious surface exacerbate erosion problems, which may in turn be limiting regeneration of the willows and the understory. Potential impacts to mice and vegetation from chemical pollutants in the run-off are unknown. We do not know the pre-road condition of the vegetation downstream of Academy Drive. It is probable that installation of the roads, class buildings, and chapel may have altered the local hydrology such that some areas are wetter or dryer, creating the current patchiness in the riparian vegetation east of Academy Drive. Numerous trails exist in the area, including some that cross through the creek. Although we have not observed adverse impacts from trails in healthy riparian systems, there may be some concern in portions of this MMA where riparian vegetation is less well developed.

Upper Lehman Run is isolated from the Lower Lehman Run MMA by two 18-hole golf courses built on both sides of the creek. The resulting unsuitable habitat creates a barrier stretching almost two miles between these two MMAs.

Conservation Focus:

1. Mitigate adverse impacts of run-off from the cadet parking lot.
2. Restore connectivity to Lehman Run East MMA.
3. Mitigate adverse impacts from trails through the riparian vegetation.

Recommendations:

1. Complete stormwater/erosion control project currently underway based on Section 7 consultation with USFWS which will:
 - ◆ Reduce rate of storm flows through Lehman Run.
 - ◆ Retain water to increase potential for expansion of riparian vegetation.
 - ◆ Supplement natural regeneration of riparian system through revegetation techniques. (supports Strategy 1A)
2. Investigate feasibility of restoring natural riparian vegetation patches along the stretch of Lehman Run that flows through Eisenhower Golf Course. If possible, restore patches in suitable size, density, and configuration to facilitate movement between upstream and downstream PMJM populations. (See additional considerations under Lower Lehman Run MMA.) (supports Strategy 1A)

3. If connection can not be restored, investigate options for moving individuals to maintain genetic diversity.

MMA 5: Lower Lehman Run

CNHP identifier: AMAFH01011*063*CO

Unit description:

This MMA is a quarter mile stretch of Lehman Run from the eastern edge of the golf course downstream to the stadium parking access road. In general, the vegetation consists of dense cover of coyote and peachleaf willow and some narrowleaf cottonwood, with ponderosa pine upslope. There are pockets of high quality riparian habitat upstream of the access road and again at Stadium Boulevard. The section between these two pockets is dominated by ponderosa pine and contains very little riparian vegetation. Elevation is approximately 6680 feet.

PMJM status: One sub-adult mouse caught in 565 trap nights.

Issues: Isolation of population, habitat destruction

This MMA contains a small population that is isolated both upstream and down. Lower Lehman Run is separated from the Upper Lehman Run MMA by two 18-hole golf courses. Reservoir 1 and the concrete culvert that links the reservoir to Monument Creek create a barrier between Lower Lehman Run and the large PMJM population at Monument Creek. Development has fragmented presumably previously connected habitat, resulting in isolated patches of habitat that cannot be re-connected to the mainstem of Monument Creek without great difficulty and expense. If this MMA can be connected with the upstream reach of Lehman Run, the resulting area may be large enough to sustain a minimum- sized PMJM population. If this connection cannot be made, the value of this MMA even as refugia is questionable.

Conservation Focus:

1. Increase the viability of the MMA by restoring connection to the Upper Lehman Run MMA.

Recommendations:

1. If possible, restore continuity of shrub and herbaceous cover to appropriate densities through the Eisenhower Golf Course to ensure connectivity with Upper Lehman Run MMA. (See recommendation 4 under Upper Lehman Run.) (supports Strategy 1A)
2. Determine potential viability of connected Lehman Run population if connection to Monument Creek cannot be restored. (supports Strategy 2A)
3. Evaluate feasibility and relative value of restoring connectivity between Lehman Run and Monument Creek. (supports Strategies 1A and 2A)
4. If neither upstream nor downstream connections can be restored, investigate options for moving individuals to maintain genetic diversity. Note this is a higher risk conservation option.

MMA 6: Douglass Valley

CNHP identifier: To be determined

Unit description:

This MMA is approximately a one-mile stretch of the unnamed creek that runs through the Douglass Valley housing complex from the eastern crossing of Douglass Drive to Douglass Valley School. In general, the vegetation consists of dense cover of coyote and peachleaf willow with some narrowleaf cottonwood. This MMA bisects the housing complex, with houses in close proximity on both sides of the creek. The quality of habitat east of Douglass Drive to Monument Creek is patchy willow shrub with dense grass and forb cover in the understory. Upslope habitat is primarily scrub oak and Ponderosa pine with grass/forb understory.

PMJM status: One adult mouse caught in 300 trap nights.

Issues: Isolation of population, habitat degradation

This MMA contains a small population that is isolated both upstream and down. The mice along this creek are separated from Monument Creek population by a one-mile stretch of patches of willow shrub habitat interspersed in a matrix of grass/forb. This lower stretch was trapped in 1997 with negative results. The habitat in much of this lower stretch is present, but patchy. In some places erosion has created downcutting of the canyon. Restoration is feasible, but will be more difficult in areas where slopes are excessively steep. If this MMA can be connected with the main stem of Monument Creek, the stability of this sub-population will greatly increase.

Adverse impacts from Douglass Valley housing have not been observed. However, only one mouse has been captured, and proximity to housing is theorized as a potential limiting factor in PMJM abundance. In addition, direct and indirect impacts from residential development are known to degrade riparian habitats. These issues should be investigated further.

Conservation Focus:

1. Increase the viability of the MMA by restoring connection to the Monument Creek MMA

Recommendations:

1. Restore continuity of shrub and herbaceous cover to appropriate densities from Douglass Drive to Monument Creek. (supports Strategy 1A)
2. Evaluate further the status of PMJM at this site, as well as potential adverse impacts from the housing complex. (supports Strategy 2A)
3. If the downstream connection cannot be restored, investigate options for moving individuals to maintain genetic diversity. Note that this is a higher risk conservation option.

MMA 7: Pine Creek

CNHP identifier: AMAFH01011*058*CO

Unit description: This MMA is a one-mile stretch of Pine Creek, which runs through the extreme southeast corner of the USAFA. I-25 runs along the west edge of the MMA. The creek is a very small drainage that has been moved and channelized in recent decades due to construction on I-25. The stream is culverted at Academy Boulevard, but upstream there is a section approximately 300 meters long with well-developed vegetation. Vegetation is dominated by willows (*Salix exigua* and *S. monticola*). Currant (*Ribes* sp.) and snowberry (*Symphoricarpos occidentalis*) are also present, along with scattered cottonwood overstory (*Populus* sp.) There is a broad, sloping grassland on one side (Meaney et al. 1998).

PMJM status: 12 mice caught in 867 trap nights.

Issues: Isolation of population, habitat destruction, habitat degradation

This MMA is isolated from other MMAs on the Academy. The effectiveness of any connection to the Monument Creek South MMA (outside Academy boundaries) is doubtful, as the potential area for connection is a vertical bank channel approximately 0.5 miles long with no riparian vegetation. There is no opportunity to connect this MMA to any other MMA on the Academy.

Carron Meaney is currently engaged in a three-year vegetation monitoring project for the Colorado Department of Transportation. The project is scheduled for completion in 2000.

Conservation Focus:

1. Maintain existing PMJM habitat to ensure population survival.
2. Work with agencies and other entities to maintain an effective linkage along downstream reaches of Pine Creek to Monument Creek.

Recommendations:

1. Participate in the El Paso County subarea of the statewide PMJM conservation planning effort with a goal of protecting linkage between the USAFA reach of Pine Creek and Monument Creek. (supports Strategy 4A)
2. Maintain or enhance the PMJM habitat in the USAFA reach of Pine Creek. (supports Strategy 1A)
3. If linkage cannot be achieved, investigate options for moving individuals to maintain genetic diversity. Note that this is a higher risk conservation option.

Table 1: Implementation Table – Objectives, Tasks, and MMA Recommendations

Task	Description
Objective 1: Maximize extent, quality and connectivity of PMJM habitat within the USAFA.	
1.1	Ensure availability of adequate habitat (riparian and upland).
1.2	Enhance or restore degraded habitat patches.
1.2.1	Monument Creek: Restore riparian habitat 1km north of Northgate Bridge.
1.2.2	Smith Creek: Enhance habitat from Monument Creek to I-25.
1.2.3	Smith Creek: Restore habitat from I-25 to USAFA east boundary.
1.2.4	Deadmans Creek: Remove equipment and restore/enhance riparian habitat from Parade Loop to Academy Drive.
1.2.5	Lower Lehman Run: Investigate connecting riparian habitat from Non-Pot. 1 to Monument Creek.
1.2.6	Lehman Run: Explore feasibility of enhancing riparian habitat through Eisenhower Golf Course.
1.2.7	West Monument Creek: Return stream flow to original channel below junction with Stanley Creek.
1.3	Maintain, restore, or emulate natural hydrologic regime. Monitor and mitigate alteration. Control sedimentation and runoff.
1.3.1	Un-named Creek at Aardvark Emergency Airstrip: Construct erosion control dams.
1.3.2	Jacks Valley: Stabilize road bank upstream of railroad bridge.
1.4	Identify and control noxious weeds.
1.4.1	Control Russian olive along Monument Creek 1km north and south of Northgate overpass. Remove/control knapweed and other weeds along Monument Creek at NP-1.
1.4.2	Remove/control noxious weeds along Monument Creek at Aardvark Emergency Airstrip.
Objective 2: Conduct research and monitoring projects to increase understanding of PMJM life history and habitat requirements.	
2.1	Inventory all potentially suitable habitat for new PMJM populations and confirm status of known populations.
2.1.1	Monument Branch: Conduct walk-through habitat assessment from confluence to east boundary. Trap for presence if habitat is suitable.
2.1.2	Un-named tributary north of Black Squirrel Creek: Conduct walk-through habitat assessment, and re-trap for presence if habitat is suitable.
2.1.3	Black Squirrel Creek from Santa Fe Trail to USAFA boundary: Conduct walk-through habitat assessment and trap for presence if habitat is suitable.
2.1.4	Douglass Road: Conduct walk-through habitat assessment from Douglass Road to Monument Creek main stem. Trap for presence if habitat is suitable.
2.2	Research and document PMJM habitat and life history requirements.
2.2.1	hibernacula locations and characteristics
2.2.2	diet and habitat use
2.2.3	survival (overwinter and active season) and mortality factors
2.2.4	correlation between vegetation and PMJM abundance, including patch size, composition, and spatial distribution
2.2.5	fluctuation patterns in population size from year to year
2.2.6	system dynamics (e.g., beaver, flood, fire) and response to stochastic disturbance
2.2.7	response to human alterations (e.g., cats, weed control, development)
2.2.8	behavior patterns, including seasonal changes in movement patterns and feeding
2.2.9	genetics
2.3	Investigate relationship between hydrological alteration and maintenance of riparian vegetation.
2.4	Develop and implement PMJM population and habitat monitoring protocol.
2.4.1	Kettle Creek: Conduct long-term monitoring over the life of scheduled projects.
Objective 3: Eliminate or minimize threats to PMJM and its habitat within USAFA boundaries.	
3.1	Develop programmatic Biological Assessment to define potential impacts and mitigation techniques for foreseeable USAFA management activities.

Task	Description
3.2	Limit cumulative disturbance impact to no more than 2% of the USAFA PMJM population per year. Avoid creation of barriers in currently connected habitat and net loss of habitat.
3.3	Ensure that emergency actions follow established protocol.
3.3.1	Immediately initiate consultation with USFWS and keep the agency informed throughout emergency actions.
3.3.2	Implement best management strategy as described in the INRMP.
3.3.3	Minimize short-and long-term impacts to PMJM habitat.
3.4	Comply with all post-construction monitoring and mitigation protocols required by USFWS.
Objective 4: Encourage maximum protection of PMJM populations and associated habitats on adjacent lands.	
4.1	Promote solutions that offer sufficient opportunity for gene flow and refugia between the USAFA population and populations outside installation boundaries.
4.2	Encourage El Paso County planning team to implement conservation strategies that minimize alteration of the hydrology of Monument Creek and degradation of USAFA habitat.
MOUSE MANAGEMENT AREAS	
MMA 1: Monument Creek	
1.	Survey West Monument Creek to determine extent of occupied habitat between Monument Creek and Stanley Creek. Restore habitat where necessary and evaluate potential impacts from the Pine Valley housing complex.
2.	Restore riparian vegetation along Monument Creek at the North Gate Blvd. overpass and control Russian olive.
3.	Conduct impact assessments on USAFA projects, and minimize adverse impacts. Implement system to measure cumulative impacts to avoid future fragmentation.
4.	Investigate impacts from Santa Fe Trail and sewage treatment plant. Cooperate in implementation of mitigation plans.
5.	Encourage El Paso County planning team to protect hydrological integrity of Monument Creek.
6.	Move flow of Kettle Creek back into original channel from I-25.
MMA 2: Deadmans Creek	
1.	Ensure road maintenance and other activities do not damage existing habitat along dirt road from Deadman Lake to Jacks Valley.
2.	Improve shrub cover along creek between Stadium Blvd. and Academy Dr.
3.	Determine extent of PMJM population in Deadmans Creek west and east of Parade Loop Rd.
MMA 4: Upper Lehman Run	
1.	Complete stormwater/erosion control project currently underway.
2.	Investigate feasibility of restoring natural riparian vegetation patches along Eisenhower Golf Course. Restore if possible.
3.	If connection cannot be restored, investigate options for moving individuals to maintain genetic diversity.
MMA 5: Lower Lehman Run	
1.	Restore continuity of shrub and herbaceous cover through Eisenhower Golf Course.
2.	Determine potential viability of connected Lehman Run population if connection to Monument Creek cannot be restored.
3.	Evaluate feasibility and value of restoring connectivity between Lehman Run and Monument Creek.
4.	If neither upstream nor downstream connection can be restored, investigate options for moving individuals to maintain genetic diversity.

Task	Description
MMA 6: Douglass Valley	
1.	Restore continuity of shrub and herbaceous cover from Douglass Drive to Monument Creek.
2.	Further evaluate status of PMJM and potential impacts from housing complex.
3.	If downstream connection cannot be restored, investigate options for moving individuals to maintain genetic diversity.
MMA 7: Pine Creek	
1.	Participate in El Paso County subarea planning with goal of protecting linkage between USAFA reach of Pine Creek and Monument Creek.
2.	Maintain or enhance PMJM habitat in USAFA reach of Pine Creek.
3.	If linkage cannot be achieved, investigate options for moving individuals to maintain genetic diversity.

REFERENCES

- Adler, G.H., L.M. Reich, and R.H. Tamarin. 1984. Demography of the meadow jumping mouse (*Zapus hudsonius*) in eastern Massachusetts. *The American Midland Naturalist* 112:387-391.
- Armstrong, D.M., M.E. Bakeman, N.W. Clippinger, A. Deans, M. Marseilles, C. A. Meaney, C. Miller, M. O'Shea-Stone, T.R. Ryon and M. Sanders. 1997. Report On Habitat Findings of the Preble's Meadow Jumping Mouse. Report to U.S. Fish and Wildlife Service and the Colorado Division of Wildlife. Edited by M.E. Bakeman.
- Blair, W.F. 1940. Home ranges and populations of the jumping mouse. *American Midland Naturalist* 23:244-250.
- Boonstra, R. and J.A. Hoyle. 1986. Rarity and coexistence of a small hibernator, *Zapus hudsonius*, with fluctuating populations of *Microtus pennsylvanicus* in the grasslands of southern Ontario. *Journal of Animal Ecology* 55: 773-784.
- Corn, J.G., C.A. Pague, A.R. Ellingson, M. Sherman, T. Zwięjacz, G. Kittel, and C. Fleming. 1995. Final report on the geographic extent of the Preble's meadow jumping mouse population on the United States Air Force Academy. Presented to the U.S. Air Force Academy. 44pp.
- Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's Wildlife Habitat Conservation System – recommendations to meet minimum conservation goals for declining wildlife species and rare plant and animal communities. Office of Environmental Services, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.
- Federal Register. 1998. Final Rule to List the Preble's Meadow Jumping Mouse as a Threatened Species. *Federal Register* Volume 63, Number 92, May 13, 1998.
- Goodman, G.J. and C.A. Lawson. 1995. Retracing Major Stephen H. Long's 1820 Expedition. University of Oklahoma Press. 366 pp.
- Laven, R.D., P.N. Omi, J.G. Wyant, and A.S. Pinkerton. 1980. Interpretation of fire scar data from a ponderosa pine ecosystem in the central Rocky Mountains, Colorado. *In*: M.A. Stokes and J.H. Dieterich (eds.). *Proceedings of the Fire History Workshop*; 1980 Oct. 20-24; Gen. Tech. Rep. RM-81; Tucson, AZ: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Meaney, C.A., N.W. Clippinger, A. Deans, and M. O'Shea-Stone. 1996. Second year survey for Preble's meadow jumping mouse (*Zapus hudsonius preblei*) in Colorado. Prepared for Colorado Division of Wildlife. 21pp. + appendices.
- Meaney, C.A., A. Ruggles, and A. Deans. 1998. First year monitoring survey for Preble's meadow jumping mice at Pine Creek at Academy Boulevard, Colorado Springs, El Paso County, Colorado. Prepared for Colorado Department of Transportation.
- Meaney, C.A., A. Ruggles, B. Lubow, N.W. Clippinger, and A. Deans. 1999. Preliminary Results: second year study of the impact of trails on small mammals and population estimates

for Preble's meadow jumping mice on City of Boulder Open Space. Draft report for Greenways Program, City of Boulder Transportation Department, City of Boulder Open Space, and U.S. Environmental Protection Agency, Region 8.

- Mehl, M.S. 1992. Old-growth descriptions for the major forest cover types in the Rocky Mountain Region. *In*: Old-Growth Forests in the Southwest and Rocky Mountain Regions - Proceedings of a workshop. U.S. Dept. of Agriculture Forest Service. General Technical Report RM-213.
- Muchlinks, A.E. 1988. Population attributes related to the life-history strategy of hibernating *Zapus hudsonius*. *Journal of Mammalogy* 69(4): 860-865.
- Quimby, D.C. 1951. The life history and ecology of the jumping mouse, *Zapus hudsonius*. *Ecological Monographs* 21:61-95.
- Ryon, T.R. 1996. Evaluation of the historic capture sites of the Preble's meadow jumping mouse in Colorado. MS thesis, University of Colorado, Denver. 65 pp.
- Sheldon, C. 1934. Studies on the life histories of *Zapus* and *Napaeozapus* in Nova Scotia. *Journal of Mammalogy* 15:290-300.
- Shenk, T. 1998. Conservation Assessment and Preliminary Conservation Strategy for Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*). Unpublished report. Colorado Division of Wildlife, Fort Collins, Colorado.
- Whitaker, J.O. Jr. 1963. A study of the meadow jumping mouse, *Zapus hudsonius* (Zimmerman), in central New York. *Ecological Monographs* 33:3.
- Whitaker, J.O. 1972. *Zapus hudsonius*. *Mammalian Species* 11:1-7.
- Wright, H.A. and A.W. Bailey. 1980. Fire ecology and prescribed burning in the Great Plains - a research review. USDA Forest Service, General Technical Report INT-77.
- Wunder, B.A. 1998. Water balance and kidney function in Preble's meadow jumping mouse (*Zapus hudsonius preblei*): Inferences from kidney structure. Report submitted to Colorado Division of Wildlife.

APPENDIX A: Situation Analysis

Situation Analysis Based on Issues Related to Conservation of Preble's Meadow Jumping Mouse in Colorado

Based in part on discussions by the PMJM Science Advisory Team, 1998-1999

compiled by: Lee Grunau, Chris Pague, Rob Schorr, John Armstrong
August 1999

General consensus exists among researchers and experts that the historic range and distribution of PMJM have declined in recent decades. In order to preserve remaining self-sustaining populations, the natural and human-related factors influencing PMJM decline must be identified and managed. Then persistence can be attained through reserve design principles and management. To assist wildlife agencies and local stakeholders in devising appropriate protection strategies, the Science Team conducted an evaluation of all potential conservation issues brought forth in three forums: 1) the USFWS documentation on the listing decision, 2) input from local stakeholders in each sub-area, and 3) the science team's analysis of PMJM ecology and field observations of habitat integrity/land use.

Given the complexity of the wildland/urban interface that exists along Colorado's Front Range, and the rapid pace at which land use patterns are changing, it is not surprising that the conservation issues for this species involve numerous, highly interrelated factors and conditions. The following discussion presents a synopsis of the most significant issues that are widespread and influencing PMJM populations across their Colorado Range.

Each of these issues is operating to a greater or lesser degree in each sub-area; likewise, different issues emerge as primary factors in different PMJM drainages. From a rangewide perspective, however, we believe that implementation of conservation strategies that address the following issues should largely serve to protect this species in Colorado.

In order to present this complex information as clearly and concisely as possible, we have broken it down into three steps. Step one identifies those processes or events that have direct deleterious ecological or physiological impacts on PMJM. These processes and events are referred to as "stresses". Step two identifies general landscape conditions, often related to the quality and viability of PMJM habitat, which are considered to be direct causes of one or more stresses. These conditions are termed "proximate sources". Step three identifies the primary human activities that ultimately give rise to the proximate sources, and therefore the stresses. We call these activities "ultimate sources". It should be reiterated that these stresses and sources are not evenly distributed across the landscape, and that each may act alone or in concert to limit individual PMJM populations.

Stresses to PMJM Populations and Habitat

The PMJM Science Advisory Team thoroughly reviewed all available information on the biology, ecology, and habitat use of PMJM in Colorado. Interpretation of these data in light of commonly accepted conservation biology principles indicates that Colorado's PMJM populations may be stressed by any one, or a combination, of the following conditions:

- Small population loss
- Decreased genetic variability
- Altered population structure (sex/age ratios)
- Decreased reproductive success
- Increased mortality rate
- Increased immigration or decreased emigration

Rangewide (in Colorado), each of these conditions play some role in limiting PMJM populations. These stresses are interrelated, and for each population, different stresses may be acting in concert to affect viability of that particular population, and thus persistence of the subspecies as a whole.

The complexity of PMJM population stability is not limited to the interrelationships of stresses on populations and habitat. Colorado's Front Range is a patchwork of human-dominated and natural landscapes, and that patchwork continues to undergo rapid land use change and ecological alteration. Because of this, any one stress may be caused or exacerbated by a variety of direct (proximate) and indirect (ultimate) sources. We have further found that most sources actually result in more than one stress.

Proximate Sources of Stress

We have identified six immediate sources that currently are, or have potential to be, causing the previously listed stresses to PMJM populations or habitat. These sources are:

- habitat destruction
- habitat degradation
- succession of riparian vegetation
- direct mortality to PMJM
- isolation of populations
- catastrophic events

Habitat destruction refers to the conversion of natural riparian and upland vegetation to other uses. Conversion may be permanent and essentially irreversible (as in the case of residential, commercial, and industrial development, parking lots associated with recreation facilities, flood control structures, and roads), or it may be at least partially reversible (as in the case of agricultural development, construction of utility lines, mining operations, trails, etc.). The greatest cause for concern in PMJM protection is permanent, irreversible land conversion.

Habitat degradation refers to changes in habitat composition, structure, or function that individually, or in combination, hamper the ability of PMJM to feed, reproduce, hibernate, or disperse. Habitat degradation may result from effects to vegetation, stream bank structure, or both. Changes to vegetation are sometimes caused by introduction and spread of weeds (especially stand-replacing invasives), or reduced density of cover from incompatible grazing. Long-term incompatible grazing can also lead to destabilization of stream banks.

Succession of riparian vegetation is closely related to hydrologic regime, including the amount of surface and ground water, as well as the timing and magnitude of flood events. Landscape changes that greatly increase or decrease any aspect of the hydrologic regime may hamper the regeneration of riparian systems, or cause them to convert to dryland systems. Conditions that commonly result in severe changes to hydrology include increased stormwater runoff from

expansion of hard surfaces (such as buildings, parking lots, and roads), and flood control and water retention measures (such as impoundments and stream channelization). Changes to water quality have not been shown to adversely impact PMJM or its habitat at this time. Note that upland shrub systems may also succeed to unsuitable forested environments in the absence of periodic fire. Succession of either riparian or upland vegetation could negatively impact PMJM through reduced availability of food resources and cover habitat.

Direct mortality to PMJM refers to the death of individual mice. Direct mortality can result from construction (of building, roads, or infrastructure), increased rates of predation (from changes in predator numbers associated with human development, or reduced cover), or starvation (including overwinter mortality) from reduction in food resources. Of the other potential causes of mortality, disease is not known to impact PMJM, there is no economic value to stimulate over-collection, and trap mortality from scientific research has been minimal.

Population isolation results from the introduction of barriers into previously connected landscapes such that mice are not able to leave one population and join another. Common causes of PMJM population isolation include human developments, roads and other infrastructure, in-stream mining, and hydrologic alteration that leads to drying up of streams. Isolation may result in loss of genetic variability or increased vulnerability to catastrophic events.

Catastrophic events are chance occurrences of sudden environmental change that result in destruction of a large percentage of a PMJM population. Possible events include catastrophic fire, accidental spills of hazardous materials, and floods. Because these catastrophes are unpredictable, and therefore impossible to manage for, PMJM conservation efforts must provide for protection of multiple populations, as well as for additional habitat to serve as refugia against such events.

Ultimate Sources of Stress

While the proximate sources have been identified as those factors leading directly to stresses on PMJM and its habitat, the proximate sources are ultimately responses to, or effects of, direct or indirect actions from some ultimate source. The ultimate sources of the stresses on PMJM as they currently exist along the Front Range of Colorado can be traced to four primary human activities:

- residential or commercial development
- transportation corridors (construction and maintenance)
- recreational development
- agricultural land use (especially the maintenance of livestock on parcels of 40 acres or less)

Each of these ultimate sources may interact with the others, but should respond to different strategies for resolution. Also, each source can occur independently of the others. Identifying the relationships between these sources is important in prioritizing conservation strategies that can make the greatest difference in ameliorating the stress(es).

Residential and Commercial Development

Riparian habitat and adjacent lands important for PMJM may be lost or altered through housing and commercial/industrial development. This typically occurs either as direct loss from replacement of natural vegetation with buildings and hard surface landscapes, or from habitat degradation from secondary causes. The growth of Colorado's Front Range communities suggests that housing construction and commercial/industrial development will increase throughout the Colorado portion of the mouse's range for the foreseeable future. Although specific causes of mouse losses are poorly documented, there is a strong negative association between presence of PMJM and dense human housing. Possible causes of mouse extirpation from such areas include the presence of the Norway rat, house mouse, and non-native predators such as house cats. In addition, the urban landscape often compromises the habitat of PMJM, especially upland areas. In addition to direct and indirect effects on habitat, there is some evidence that the decline of small mammal faunas in urbanizing landscapes does not occur in a linear fashion. Instead, the faunal response may show a threshold effect where essentially no impact could be detected until the threshold level is surpassed.

Residential/commercial development is considered to have by far the most potential to degrade or destroy PMJM habitat. These types of developments often have significant impacts in terms of magnitude, geographic scope, and irreversibility. Direct impacts include mortality of PMJM individuals from construction activities or destruction of PMJM habitat. Residential and commercial developments are also associated with more indirect impacts than the other three ultimate sources (roads, recreation, and agriculture). Indirect impacts are most likely to affect PMJM by altering the quality, amount, or connectivity of its habitat through degradation, fragmentation, destruction, or succession of the riparian vegetation upon which PMJM depends. Indirect impacts can include:

- Alteration of the amount of surface or ground water, or the timing of hydrologic flows. These impacts may be caused by:
 - flood control measures (impoundments and channel manipulation),
 - efforts to meet water demand (impoundments, wells),
 - increased hard surface leading to increased flows from storm water runoff
- Alteration of the quality of surface or ground water caused by:
 - pollution from leachfields, sewage plants, or weed control measures,
 - erosion or sedimentation (another common result of increased flow amounts from flood control and water development or increased hard surface)
- Alteration of natural composition of flora/fauna communities
 - introduction of noxious or invasive weeds which can alter the composition, structure, or density of riparian vegetation.
 - introduction or supplementation of domestic animals which may either compete with PMJM for food resources (e.g., house mice, rats) or prey upon PMJM (e.g., domestic cats and possibly Norway rats).
- Where new construction increases the transportation infrastructure, there are other indirect impacts:
 - introduction of barriers that isolate populations
 - rock/sand extraction leading to destruction of habitat or direct PMJM mortality
 - on-going habitat disturbance associated with maintenance of utility corridors
 - increased potential for catastrophic fire because of fire suppression typically associated with human development

Transportation Corridors

Roads, highways, and interstate superhighways all constitute a critical component of human communities. Direct and indirect impacts to PMJM or its habitat can result from new construction as well as the improvement or maintenance of current infrastructure (e.g., adding lanes, rebuilding bridges). Construction can have short-term and long-term impacts on riparian ecosystems. Short-term issues include direct impacts such as loss of habitat, temporary barriers to dispersal, degradation of riparian habitat from sedimentation, changes in stream morphology that alters the spatial arrangement and species composition of riparian vegetation, and pollution of waterways from chemical run-off associated with vehicles and road maintenance. Indirect impacts include:

- in-stream mining of rock, sand, or gravel to provide construction materials
- introduction or spread of weeds, and unintentional destruction of native vegetation from weed control measures
- increased hard surface area which increases run-off, and can further lead to accelerated erosion and increased sedimentation of streams
- potential for catastrophic accidents such as hazardous spills from road or railroad stream crossings

It should be noted that evidence from the USAFA I-25 interchanges suggests that PMJM adapts well to restored riparian habitats where sufficient ecosystem integrity exists to support a mouse population and both habitat and mice are present on both sides of the disturbance. However, alteration of dispersal patterns and increasing rates of habitat alteration (e.g., encouraging additional housing and commercial/industrial development) which result from roadway construction are long-term issues, and are ultimately of equal or greater concern.

Recreational Development

Recreational development is closely associated with residential development, but is typically smaller in scope and overall impacts to natural systems may not be as severe. The effects of trails and bike paths can be quite different from those of more intensively developed facilities such as ball parks and golf courses. Trails may provide corridors of easy access to predators of PMJM, fragment habitat, cause direct loss of habitat, and, with some infrastructure, degrade habitat. There is little evidence to date suggesting that they inhibit PMJM movement or dispersal. In fact, PMJM is known to cross trails, roads, and railroad tracks. However, trails in City of Boulder Open Space along South Boulder Creek are associated with slight (although statistically insignificant) reductions in the number of PMJM trapped (Meaney et al. 1999).

Poorly planned trails in riparian zones may impact habitat through soil compaction, bank erosion, and vegetation damage. Of greater concern may be the resulting increase in human disturbance from pedestrians, cyclists, and equestrians. Such habitat degradation may be the cause of reduced numbers, especially in areas of narrow riparian areas or already compromised habitat.

Impacts from large-scale recreational developments such as ball parks and golf courses are more problematic. While floodplains and riparian zones are often considered hazardous for buildings, these areas are often sought for recreational development. Facilities such as golf courses and ball parks built in or adjacent to riparian areas contribute directly to habitat destruction, habitat degradation, and isolation of populations. Other effects include chemical runoff from fertilizers and herbicides, introduction and spread of weeds, and alteration of local hydrological patterns

from increased hard surface area (parking lots, maintenance structures, and other associated buildings). While PMJM uses grasslands, it is unlikely that groomed playing fields and fairways would provide satisfactory habitat.

Agricultural Development

Agricultural development includes both crop farming and livestock management. In most areas along the Front Range, crop farming and hay production have already reached the maximum expected extent. While land conversions of this sort may have contributed to the historic decline of PMJM, we do not expect farming and hay production to contribute much to future threats. Crops other than hay are probably not used extensively, if at all, by PMJM. There are conflicting effects of hay farming. PMJM is known to occupy alfalfa fields, at least during feeding or travel. However, haying temporarily removes or seriously degrades habitat. Nonetheless, the PMJM science team generally agreed that farming that leaves a riparian buffer strip is unlikely to have major impacts on PMJM.

Commercial and private livestock management occurs at many sites occupied by PMJM. In addition, there are many localities where 40 acre or smaller parcels support livestock, usually horses. There is well documented potential for range management to degrade PMJM habitat. However, grazing is a natural ecological process throughout the range of PMJM. There are examples where livestock management co-occurs with what are apparently high quality occurrences of PMJM. However, incompatible range or pasture management has been observed in Colorado. Poor range condition is commonly observed in small properties where overstocking occurs. In short, the issue of concern here is not livestock, but herbivory that heavily impacts riparian shrublands and to a lesser extent, grasses and forbs. Secondary impacts can cause lowered water tables, stream down-cutting (gullying), and severe changes in geomorphology.

APPENDIX B: Disturbance Allowance

Rationale for Cumulative Area of Disturbance Allowable Per Year in PMJM Habitat on USAFA

October 8, 1999

Compiled by: Rob Schorr and Lee Grunau

Meadow jumping mouse populations are known to fluctuate considerably from year to year (Blair 1940, Whitaker 1972, Adler et al. 1984, Boonstra and Hoyle 1986). Furthermore, the PMJM population estimate for the USAFA is limited to only one field season's data. Therefore, conservative estimates of abundance were used in the following methods to calculate the amount of PMJM habitat that can be disturbed in a given year while still ensuring the long-term persistence of Preble's meadow jumping mouse on USAFA.

1. The population estimate of Preble's meadow jumping mice within USAFA in 1998 was approximately 2521 mice, with a 95% confidence interval from 1513 to 4864 mice. We based the following discussion on the lowest 95% confidence interval of 1513 mice to ensure our estimates are conservative.
2. To estimate the likely fluctuations in population that may occur on the USAFA, we reviewed literature of meadow jumping mouse populations. The most drastic natural fluctuations were from Muchlinski (1988), in which same-season records of minimum numbers alive (an index of abundance), over 3 years of study, had populations that fluctuated approximately 4 times as much between years. Similar fluctuations were documented in Adler (1984) and Boonstra and Hoyle (1986). Thus, we assumed numbers can drop by 75% from year to year. With this assumption, 25% of our conservative estimate of 1513 is 378 individuals.
3. Knowing that the AFA wants to maintain the stability of the existing PMJM population, we assumed we would want to ensure that 98% of the population remained unaffected by alterations to habitat within a given year. Limiting impacts to no more than 2% of the population is a conservative estimate that would ensure any modifications to PMJM habitat would not jeopardize PMJM within USAFA. Two percent of the population is 8 individuals.
4. Extrapolation to the amount of area that can be affected was based on our assumption that 2% of the population could be affected in a given year. We used the estimated home range of 0.61 ha (N=8) based on radio collared PMJM along Monument and Deadmans Creek, and multiplied it by the number of individuals (8). This equals 4.88 ha, or about 12 acres.

Therefore, within USAFA, we recommend that cumulative area of disturbance in PMJM habitat be limited to 12 acres within any one year.

APPENDIX C: Draft Statement of Work 2000-2002

**Study of Preble's Meadow Jumping Mice Populations
(*Zapus hudsonius preblei*) on the United States Air Force Academy, Colorado**

**A Statement of Work to the U.S. Air Force Academy, Colorado Springs, CO
2000 – 2002**

Robert A. Schorr
Colorado Natural Heritage Program

Statement of Purpose

The purpose of this research is to better address conservation of Preble's meadow jumping mice (*Zapus hudsonius preblei*) on the United States Air Force Academy (USAFA) by determining population parameters, movement patterns, and extent of current populations. This subspecies of meadow jumping mouse was listed as "threatened" under the Endangered Species Act (1973) in May of 1998. The Preble's meadow jumping mouse (PMJM) is found along the Front Range of Colorado from El Paso County to Weld County, and north to the southeast counties of Wyoming. One of the larger populations of PMJM is found along Monument Creek and its tributaries within the boundaries of the USAFA, El Paso County. In order to plan for the conservation of this subspecies, it is important to determine the population densities and survival rates throughout its range. By studying the density of mice on the USAFA, scientists can compare similar habitats and assess the potential densities throughout the mouse's range. Survival rates are important to conservation because they provide an understanding of what times of year may be more critical to the persistence of the subspecies. In 1998, population studies were begun on the USAFA, but it is important to continue such efforts to determine over-winter survival estimates and trends in population fluctuations over time.

Study Design

This is a descriptive study of the Preble's meadow jumping mouse populations within the USAFA. In 1998, five density grids were established along Monument Creek within the USAFA. Density grids were chosen randomly and sampled three times throughout the 1998 and 1999 field season. Animals were live-trapped to ensure future stability of the jumping mouse population and individually marked. Each density grid consisted of 70 Sherman live traps set in 7 lines of 10. Traps were spaced 7 m apart, and each grid covered 2646 m² (0.26 ha).

Grid size was chosen to encompass as many mouse home ranges as possible, yet still remaining feasible for technicians to set and check traps. Density estimates obtained from studies of *Zapus hudsonius* in the Northeast and Lake States provide valuable information on possible densities in Colorado. Around the Great Lakes area, mouse densities ranged from 0.5 – 12.4 per ha (Michigan, Blair 1940), 4.4 – 29.3 per ha and 83.0 per ha (Minnesota, Quimby 1951, Tester et al. 1993), and 3.5 – 14.1 per ha (Ontario, Boonstra and Hoyle 1985). In Massachusetts, densities ranged from 7.7 – 18.5 per ha (Adler et al. 1984). Grids used in 1998 provided enough captures and recaptures, yet allowed researchers to visit all traps in a reasonable amount of time.

Descriptions of movement patterns have been limited because of available technology (Blair 1940, Getz 1961). Not until recently have accurate assessments of jumping mouse movement been possible. With the availability of radio telemetry technology more accurate descriptions of

home range and habitat use are possible. In 1995, Bruce Wunder of Colorado State University was the first to attempt radio tracking of PMJM. Unfortunately, few PMJM were tracked for any reasonable distances (Wunder pers. comm). In 1997, CNHP was able to track five PMJM for over 3 weeks and were able to assess movement patterns over this time period. In 1998, 15 PMJM were radio collared, but only four were tracked for any length of time. Because of predation, battery expiration, and removal of collars, the 1998 field season produced minimal movement data. However, several predators were identified and a never-before described parasite on jumping mice was discovered. In 1999, 19 PMJM were collared and 12 were tracked for greater than 2 weeks.

Records of hibernacula are primarily anecdotal discoveries (Dilger 1948). With the use of radio telemetry, locating hibernacula has become easier. During the pre-hibernation tracking session, CNHP located four hibernacula in 1997 and three in 1998.

Methods

Traps will be baited with a sweet feed mix and a ball of polyfil batting will be placed in each trap to provide insulating bedding material (IAW US Fish and Wildlife Service protocol). Trapping will be conducted for 7 consecutive nights during June, July, and September of 1999. A passive integrated transponder (PIT) tag will be injected subcutaneously into each Preble's meadow jumping mouse captured. PIT tags are passive radio-frequency identification tags that work in conjunction with a radio-frequency identification reading system (reader). PIT tags are permanent markers that report capture data when scanned by the reader. When a mouse is captured, a reader can be passed over the mouse and the identification number, date of capture, and other relevant data can be received. Compared to other marking means, PIT tags provide a more humane and more permanent method of permanently marking individuals. To determine population parameter estimates, it is critical to be able to positively identify previously marked individuals (White et al. 1982).

From mark/recapture information, Program MARK (developed by Dr. Gary White at Colorado State University) will be used to model population estimates, survival rates, and recapture rates. Program Mark is one of the most complete analytical tools for analyzing mark/recapture information.

Telemetry will be conducted two times throughout the active period for PMJM. Ten mice will be collared in June and 10 mice will be collared in September. The objective of the June tracking will be to assess movement patterns immediately after hibernation. The objective of September tracking will be to assess movement patterns prior to hibernation and to determine location of hibernacula. With both collaring sessions CNHP would like to assess habitat use by comparing amount of time spent within riparian shrub habitats to that time spent in upland grass habitat.

Conservation Benefits of Research

Since Preble's meadow jumping mouse is considered a "threatened" subspecies, it is important to understand its life history characteristics. In particular, it is critical to determine the survival rates and densities of mice throughout their range. By studying densities of mice on the USAFA, population estimates can be attempted throughout the mouse's range. As part of the Endangered Species Act, a Habitat Conservation Plan (HCP) is being compiled to provide future conservation of the subspecies. This study will provide invaluable information about PMJM populations to the conservation scientists working on the HCP. Population parameters such as density and survival estimates are an integral part of understanding what factors are limiting populations of PMJM. From this study, conservation scientists can plan for the protection of critical mouse populations throughout the range and understand the relative importance of the USAFA population.

Furthermore, since a standardized sampling methodology has been established, future studies on the USAFA can assess population fluctuations from year to year. This will provide a platform for modifying conservation strategies if the PMJM populations fluctuate wildly.

Objectives for 2000-2002

1. Determine locations of ten hibernacula per field season.
2. Determine home range of 10 individuals per year.
3. Calculate maximum movement distances for the life of collar batteries for 10 individuals per year.
4. Determine maximum distances moved from waterways for 10 individuals per year.
5. Determine habitat use patterns as proportion of time spent in habitat types for 10 individuals per year.
6. Provide yearly iteration of population densities and population size along Monument Creek.
7. Determine habitat characteristics for PMJM habitat and determine any correlated habitat parameters to PMJM densities (Hypothesis: shrub density and amount of herbaceous cover are correlated with PMJM densities).
8. Survey for or assess habitat for PMJM in two new areas annually. Areas to be evaluated include:
 - Deadmans Creek between Cemetary and Playing Fields
 - Monument Branch under Interstate 25 and east of Interstate 25
 - Unnamed drainage north of Black Squirrel Creek from Monument Creek to east boundary
 - Black Squirrel Creek east of Santa Fe Trail
 - West Monument Creek directly south of Pine Valley Community and west of Stanley Creek
 - Kettle Creek, downstream of Kettle Pond No. 1

Note: The above objectives are what we hope to accomplish. We have found over the past couple of years that capturing enough individuals during a specific time of year is troublesome. It is not always feasible to meet these objectives because of natural biological phenomena.

All necessary permits have been granted by Colorado State University and the U.S. Fish and Wildlife Service.

Literature Cited

Adler, G. H., L. M. Reich, and R. H. Tamarin. 1984. Demography of the meadow jumping mouse (*Zapus hudsonius*) in eastern Michigan. *American Midland Naturalist* 112:387-391.

Blair, W. F. 1940. Home ranges and populations of the jumping mouse. *American Midland Naturalist* 23:244-250.

Boonstra, R. and J. A. Hoyle. 1986. Rarity and coexistence of a small hibernator, *Zapus hudsonius*, with fluctuating populations of *Microtus pennsylvanicus* in the grasslands of southern Ontario. *Journal of Animal Ecology* 55:773-784.

Corn, J. C., C. A. Pague, A. R. Ellingson, M. Sherman, T. Zwięjac, G. Kittel, and C. Fleming. 1995. Final report on the geographic extent of the Preble's meadow jumping mouse population on the United States Air Force Academy. Unpublished.

- Dilger, W. C. 1948. Hibernation site of the meadow jumping mouse. *Journal of Mammalogy* 29:299-300.
- Getz, L. L. 1961. Notes on the local distribution of *Peromyscus leucopus* and *Zapus hudsonius*. *American Midland Naturalist* 65:486-501.
- Quimby, D. C. 1951. The life history and ecology of the jumping mouse, *Zapus hudsonius*. *Ecological Monographs* 21:61-95.
- Tester, J. R., S. Malchow, C. Mclain, and J. B. Lehrer. 1993. Movements and habitat use by meadow jumping mice in northwestern Minnesota. *Prairie Naturalist* 25:33-37.
- White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-Recapture and Removal Methods for Sampling Closed Populations. Los Alamos National Laboratory. Los Alamos, New Mexico. 235 pp.

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