Draft Recovery Plan
Preble's Meadow Jumping Mouse
(*Zapus hudsonius preblei*)
January 12, 2016

U.S. Department of the Interior, U.S. Fish and Wildlife Service
Mountain-Prairie Region

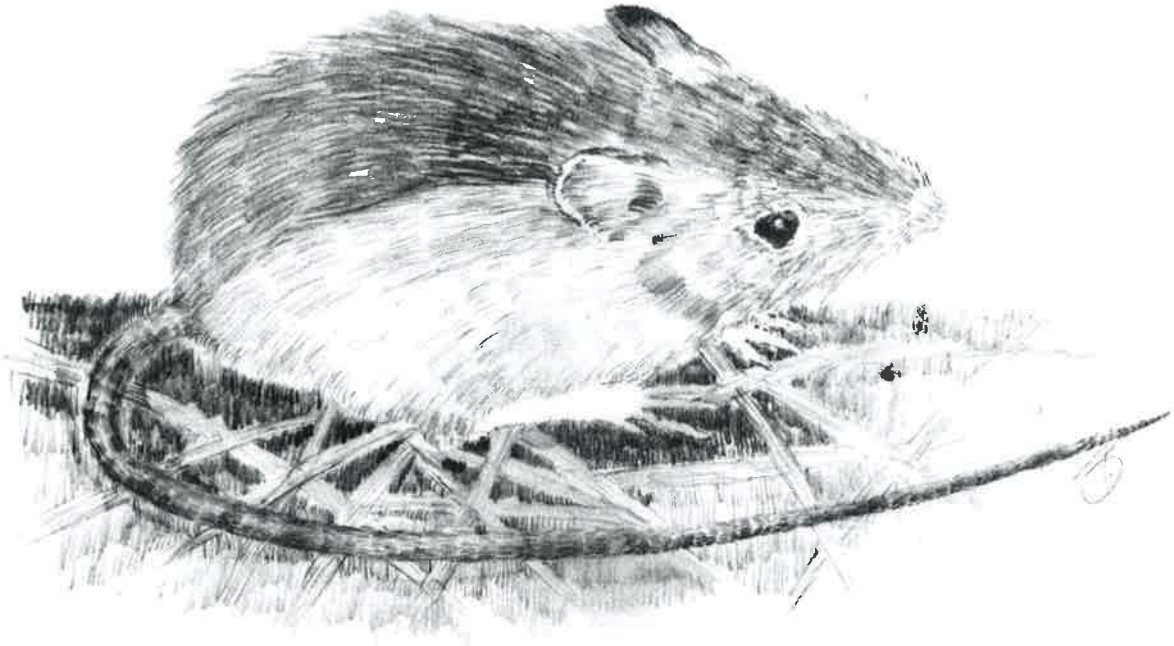

Illustration by David Hesker (ERO Resources)

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U.S. FISH AND WILDLIFE SERVICE'S MISSION IN RECOVERY PLANNING

Section 4(f) of the Endangered Species Act (ESA; 16 U.S.C. 1531 et seq.), as amended, directs the Secretary of the Interior and the Secretary of Commerce to develop and implement recovery plans for species of animals and plants listed as endangered or threatened unless such plans will not promote the conservation of the species. The Fish and Wildlife Service (Service) and the National Marine Fisheries Service have been delegated the responsibility of administering the ESA. Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are reduced, so that its long-term survival in nature can be ensured. The goal of the process is the maintenance of secure, viable wild populations of species with the minimum necessary investment of resources so that Federal ESA protections are no longer necessary and can be removed.

DISCLAIMER

Recovery Plans delineate reasonable actions that are believed to be required to recover and protect listed species. Plans are published by the Service, sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the Service. They represent the official position of the Service only after they have been signed as approved. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

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A copy of the Plan is available online at:

- http://www.fws.gov/endangered/species/recovery-plans.html
- www.fws.gov/mountain-prairie/species/mammals/preble.

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Many of the threats to the Preble's meadow jumping mouse are associated with habitat loss and urbanization of the east slope of the Rocky Mountain Front Range. To aid in the urban and population planning process, several approved recovery plans were reviewed, and we express our thanks to the authors of other recovery plans.

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EXECUTIVE SUMMARY

Current Species Status: The Preble's meadow jumping mouse (*Zapus hudsonius preblei*) was listed as threatened in 1998, pursuant to the ESA. No range-wide population estimates exist for the subspecies. Numerous surveys conducted in the last decade have documented the subspecies' presence or absence at locations of suitable habitat; some locations were historically known to be occupied and other locations had no known previous surveys. It is believed that there are sufficient populations present today to allow recovery of the subspecies; however, many of these populations face threats to their persistence.

Habitat Requirements and Limiting Factors: The Preble's meadow jumping mouse (Preble's mouse) is found in foothills riparian habitat from southeastern Wyoming to south central Colorado. The subspecies is often found in dense, herbaceous riparian vegetation, which may have an over story canopy layer. Preble's mice regularly use upland grasslands adjacent to riparian habitat, and they may be dependent upon some amount of open water. The subspecies hibernates near riparian zones from mid-October to early May. Loss of riparian habitats and other factors associated with urbanization appear to be the major threat to the subspecies.

Recovery Goal: The goal of this plan is to sufficiently reduce threats such that we can remove the Preble's mouse from the list of threatened species. This plan proposes five criteria for delisting that when met, and following an analysis of the ESA listing factors by the Service, should ensure that protection of the subspecies under the ESA will no longer be necessary.

Criteria for Delisting:

The Preble's mouse will be considered recovered and eligible for delisting when:

1. Two large and five medium populations distributed across the range maintain stable or increasing trends over a 20-year period based on data obtained from standardized monitoring methods. Population sizes are defined on page 27 of this plan. The recovery populations will be distributed among two Recovery Units (on page 24).

2. Sufficient numbers of small populations are protected to provide for representation, resiliency, and redundancy. In each of the 10 HUCs that are not occupied by a large or medium population and that contain suitable Preble's mouse habitat, an additional three small populations are maintained over a 20-year period based on data obtained from standardized monitoring methods.

3. At least the minimum stream mileage for each population (large population = 57 miles, medium population = 11 miles, small population = 3 miles, see Section 5 under Recovery Strategies of this plan) is protected and under a management plan that addresses conservation of Preble's mouse; priority is given to public lands and lands that provide connectivity. The plan for each recovery population must, at a minimum, manage for the threats as outlined in Table 2.

4. County or local government regulations or other protection mechanisms, as set forth in the de-listing criteria for Factor D, have adequate compliance and enforcement.

5. As required by the ESA, a post-delisting management plan for the Preble's mouse and its habitat is completed, in cooperation with state and local governments, to ensure the designated recovery populations are maintained at self-sustaining levels.

Cost and Duration of Recovery: Recovery is anticipated to take 40 years and cost $47,155,000.

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BACKGROUND

Listing History

The Preble's meadow jumping mouse (*Zapus hudsonius preblei*; herein referred to as Preble's mouse) was listed as a threatened subspecies under the ESA in May of 1998 (63 FR 26517). A special 4(d) rule provides exemption from take protections for certain activities related to rodent control, ongoing agricultural activities, landscape maintenance, and existing uses of water. The current critical habitat designation was completed in 2010, designating approximately 411 miles of rivers and streams and 34,935 acres in Colorado; no critical habitat has been designated in Wyoming. This rare subspecies of meadow jumping mouse was added to the State of Colorado's list of "threatened" species by the Colorado Division of Wildlife (now Colorado Parks and Wildlife) on November 12, 1998 (Colorado Parks and Wildlife Regulations, Chapter 10, Article III, #1003.A.3). The Preble's mouse is designated as Native Species Status 4 by the Wyoming Game and Fish Department, because population size and distribution are restricted and limiting factors due to human activity are moderate and likely to increase in severity (WGFD 2010). The Wyoming Game and Fish Commission (1998) provides protection for the species (*Zapus hudsonius*) by requiring permits for take and possession as well as for educational and scientific purposes.

The Preble's mouse is considered critically imperiled in Colorado by the Colorado Natural Heritage Program (1999a) and in Wyoming by the Wyoming Natural Diversity Database (Keinath *et al* 2003). In their evaluation of the conservation status of rodents of North America, Hafner *et al.* (1998) classified Preble's mouse as "endangered" in the IUCN Red List.

Species Description

Since the Preble's mouse was listed by the Service in 1998, knowledge about distribution, population dynamics, abundance, taxonomy and habitat of the subspecies has grown substantially. Some aspects of the biology and ecology of Preble's mouse remain poorly understood. Where gaps in knowledge exist, scientists have relied on information from closely-related subspecies whose biology and ecology are believed to be similar to the Preble's mouse. Information that is specific to Preble's mouse will be described as being relevant to the subspecies ("Preble's mouse"), but when information is gleaned from what is known about other subspecies it will be described as pertinent to the species ("meadow jumping mouse").

The Preble's mouse is a relatively small rodent (0.53 – 1.1 ounces as an adult) with a long tail, and large hind feet (Figure 1). The tail is not strongly bicolored, lightly-furred and typically twice as long as the body. The hind feet can be twice as large as those of other mice, such as the deer mouse (*Peromyscus maniculatus*), that are found in the same habitat. The Preble's mouse has a distinct, dark, broad stripe on its back that runs from head to tail and is bordered on either side by lighter tan to orange-brown fur. The hair on the back of all jumping mice appears coarse compared to other mice. The underside fur is white and much finer in texture. Total length of adult Preble's mice is approximately 7-10 inches, with the tail constituting 4-6 inches of that length (Armstrong *et al.* 2011).

Figure 1. Photograph of Preble's meadow jumping mouse

Typically, juveniles weigh less than 0.46 ounces and adults weigh 0.53 ounces or more (Whitaker 1963). Upon emergence from hibernation, adult Preble's mice can weigh as little as 0.50 ounces (Meaney *et al.* 2003). In a 2003 study from Boulder County, the mean weight of 78 adult male Preble's mice captured prior to June 18 was 0.65 ± 0.07 ounces, and of 47 adult females was 0.65 ± 0.1 ounces; ten of the females were pregnant or lactating and weighed more than 0.79 ounces (Meaney *et al.* 2003). Through late August into mid-September, adult Preble's mice gain weight in preparation for hibernation and typically attain weights up to 1.13 ounces or more (Schorr 2001).

Taxonomy

The Preble's mouse is a member of the family *Dipodidae* (jumping mice and jerboas; Armstrong *et al.* 2011), which contains six subfamilies (Wilson and Reeder 2005). Two genera, *Zapus* and *Napaeozapus*, are found in North America (Krutzsch 1954). The three species within the genus *Zapus* are *Z. hudsonius* (meadow jumping mouse), *Z. princeps* (western jumping mouse), and *Z. trinotatus* (Pacific jumping mouse) (Krutzsch 1954). Meadow jumping mice were first documented from Colorado by Edward A. Preble (1899). The Preble's mouse was described as a separate subspecies of meadow jumping mouse by Krutzsch (1954). The Preble's mouse is now recognized as 1 of 12 subspecies of meadow jumping mouse (Hall 1981).

Two subspecies of meadow jumping mouse occur in Colorado: Preble's mouse and *Z. h. luteus*. The subspecies *Z. h. luteus* was previously known as *Z. princeps luteus*, but was subsequently assigned to *Z. hudsonius* by Hafner *et al.* (1981). Although *Z. h. luteus* mainly occurs within central New Mexico and eastern Arizona, it was recently discovered in southern Colorado by Jones (1999) and Frey (2008). *Z. h. luteus* is listed as an endangered species under the ESA throughout its range (79 FR 33119). Two subspecies of meadow jumping mouse also occur in Wyoming: Preble's mouse and *Z. h. campestris* (Hall 1981, Clark and Stromberg 1987). The subspecies *Z. h. campestris* was described from northeastern Wyoming, southeastern Montana, and western South Dakota (Hall 1981); it is not listed under the ESA.

The range of the western jumping mouse (*Z. princeps*) overlaps that of the Preble's mouse (Hall 1981), and the two species are similar in appearance. Compared to western jumping mice,

Preble's mice are generally smaller, have a more distinctly bicolored tail, and a less obvious dorsal stripe. However, field identification of western jumping mice and Preble's mice where their ranges overlap is difficult due to their similarity in size and color. Consequently, a number of techniques have been used to differentiate between Preble's mice and western jumping mice, including dental and cranial morphology (Conner and Shenk 2003a; Klingener 1963; Conner and Shenk 2003b) and genetic analyses (Riggs *et al.* 1997; King *et al.* 2006a, b; Ramey *et al.* 2004). Currently, where the species overlap, genetic analyses are the preferred and accepted method for identification (King *et al.* 2006a). Debate has and continues to surround the validity of the subspecies designation and conservation priority for the Preble's mouse (e.g., Malaney and Cook 2013); however, the most recent review of these debates concluded that available data are broadly consistent with the current taxonomic status of the Preble's mouse as a valid subspecies (SEI 2006).

Distribution

The Preble's mouse is found in both the North and South Platte River basins, from the eastern flank of the Laramie Mountains and the Laramie Plains in southeastern Wyoming south along the eastern flank of the Front Range in Colorado and into the headwaters of the Arkansas River Basin near Colorado Springs, Colorado (Long 1965; Hall 1981; Clark and Stromberg 1987; Armstrong *et al.* 2011; Clippinger 2002). The most recent knowledge regarding the distribution of the Preble's mouse comes from live-trapping locations and specimens from site-specific research efforts, range-wide survey efforts, and numerous additional surveys conducted in Colorado and Wyoming since the mid-1990s (summarized within Service Preble's mouse distribution database, Figure 2). Most specimens collected in recent years are housed at the Denver Museum of Nature and Science; survey reports from live-trapping efforts are filed with the Service Field Offices in Colorado and Wyoming. Museum specimens from Colorado Springs mark the southern distributional limit of the Preble's mouse. The northern end is marked by museum specimens from the southern notch of Converse County, but trapping records of *Zapus* are recorded as far north as Douglas, Wyoming (Williams and Rogers 1999), where a single Preble's mouse was confirmed in 1999 (King *et al.* 2006a).

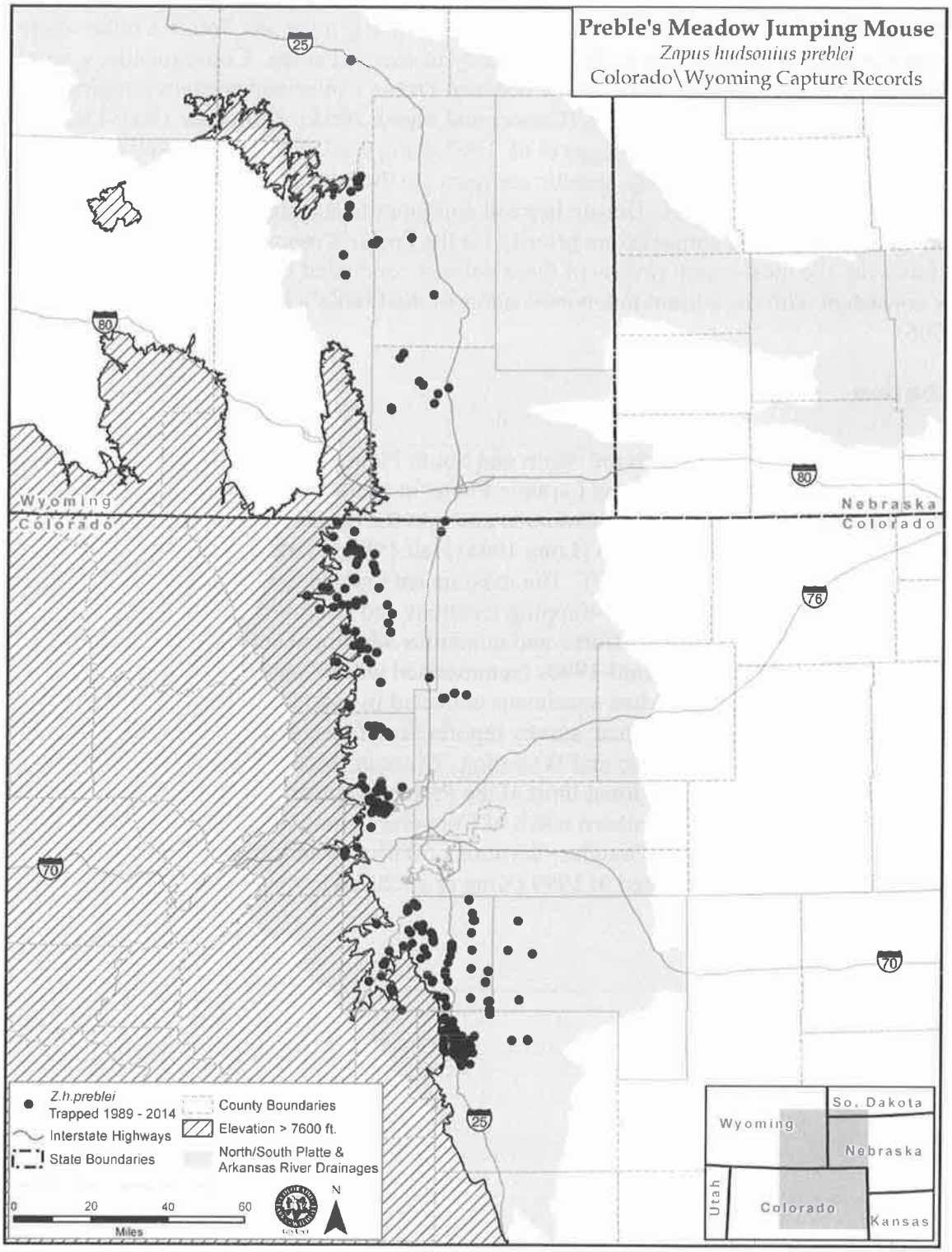

Figure 2. Distribution of museum specimens as identified by Conner and Shenk (2003b), and capture localities of the Preble's meadow jumping mouse (*Z. h. preblei*) in Colorado and Wyoming. Due to overlap with Western jumping mice in Wyoming, all Wyoming capture locations represented have been confirmed by genetic analysis.

The Preble's mouse is generally found at elevations between 4,650 feet and 7,600 feet. At the lower end of this elevation gradient, the semi-arid climate of southeastern Wyoming and eastern Colorado limits the extent of riparian corridors and restricts the range of the subspecies (Beauvais 2001). The Preble's mouse is likely an Ice Age relict; once the glaciers receded from the Front Range of Colorado and the foothills of Wyoming and the climate became drier, the Preble's mouse was confined to riparian systems where moisture was more plentiful (Armstrong *et al.* 2011; Smith *et al.* 2004).

In Colorado, the distribution of the Preble's mouse forms a band along the Front Range from the Wyoming border southward to Colorado Springs, with the eastern margin delineated by captures in western Weld County, western Elbert County, and north-central El Paso County. The eastern boundary for the Preble's mouse is defined ecologically by the dry, short grass prairie, which may present a barrier to eastward expansion (Beauvais 2001). In Wyoming, the Preble's mouse has not been found east of Slater, Platte County (Beauvais 2001). Habitat modeling and trapping suggest the subspecies does not occur in Wyoming's Goshen, Niobrara, and eastern Laramie counties (Keinath 2001). In Colorado, the Preble's mouse has not been found on the extreme eastern plains (Clippinger 2002). The western boundary of the Preble's mouse range in Colorado appears related to elevation along the Front Range, with 7,600 feet as an approximate upper limit (USFWS 2004).

At higher elevations, discerning the status of the Preble's mouse is complicated by the overlap in the ranges of the Preble's mouse and the western jumping mouse (Long 1965; Clark and Stromberg 1987; Schorr 1999; Bohon *et al.* 2005; Schorr *et al.* 2007). Generally, the western jumping mouse occurs in the montane and subalpine zones and the Preble's mouse occurs lower in the plains and foothills (Smith *et al.* 2004). However, meadow jumping mice have been found at elevations typically associated with western jumping mice (Smith *et al.* 2004), leading to difficulty in making identification based on elevation. Identification is further complicated by the ability of the Preble's mouse to travel long distances and tolerate other jumping mice (see Behavior for further discussion). Drainages where overlapping ranges have been verified include: the Lower Laramie and Horse Creek drainages in Wyoming (Meaney 2003; King *et al.* 2006a; King *et al.* 2006b); and the Cache La Poudre, Big Thompson, and Upper South Platte River drainages in Colorado (Bohon *et al.* 2005; T. King, USGS, pers.comm.; King *et al.* 2006a; King *et al.* 2006b; Schorr *et al.* 2007).

At least two specimens of both Preble's mice and western jumping mice have been collected from three drainages where both species appear to occur within a distance of approximately 8 miles: Upper South Platte in Douglas and Teller counties, Colorado, and the Laramie River and Horse Creek drainages in Wyoming (Shenk 1998; Schorr 1999; Ensight Technical Service 2001b; Bowe and Beauvais 2012). Trout Creek originates in the Rampart range, flows north through rolling hills, and empties into the South Platte River. In Wyoming, the Laramie River and Horse Creek provide access for the Preble's mouse to the Laramie Plains. Whereas most of the Laramie Mountains have a "divide" along the top which restricts the Preble's mouse to the eastern flank, the Laramie River flows through a low saddle enabling the Preble's mouse to occur upstream on the Laramie Plains. (Smith *et al.* 2004) The western jumping mouse

population likely also extends downstream from the higher-elevation headwaters in the mountains of Larimer County, Colorado.

Zones of co-occurrence raise the question of hybridization (Beauvais 2001). In New Mexico and Arizona, *Z. hudsonius* and *Z. princeps* coexist in narrow zones of contact where limited hybridization between the two species may occur (Hafner 1998). However, Krutzsch (1954) examined areas of potential hybridization and found no evidence of hybridization at the species level. Future genetic studies will likely clarify this issue.

Although there is little information on the past distribution or abundance of the Preble's mouse, surveys have identified various locations where the subspecies was historically present but is now absent (Ryon 1996). Despite increased trapping effort, the Preble's mouse has not been found in Denver, Adams, and Arapahoe counties in Colorado in the past decade (USFWS 2004).

Natural History and Ecology

Reproduction

Little research has been done on the number or size of Preble's mouse litters, but researchers assume that they are similar to other subspecies of meadow jumping mouse. Meadow jumping mice usually have two litters per year (Whitaker 1963), but Quimby (1951) reports the possibility of three litters per year. The size of a litter can range from two to eight young but averages five young (Quimby 1951; Whitaker 1963), and Preble's mouse nest with six young was found in Jefferson County, Colorado (Ryon 2001). After 4 weeks of age, meadow jumping mouse young are independent and resemble adults (Whitaker 1963). First reproduction can occur at 2 months of age for young of early litters (born in June); young of later litters appear to have their first reproduction in the next year (Quimby 1951).

Longevity and Mortality

The annual survival rate of the Preble's mouse is low, and varies seasonally (Schorr *et al.* 2009). The Preble's mouse is fairly long-lived for a small mammal, with some individuals documented as living at least 3 years (Meaney et al. 2003). The Preble's mouse seems to survive better during winter hibernation (but see Schorr *et al.* 2009), and most mortalities probably occur when the subspecies is active during the summer. Summer survival rates, defined as June through August or October, ranged from 5 to 46%. Overwinter survival rates, defined as August or October to May or June, ranged from 13 to 54% (Shenk and Sivert 1999b; Ensight Technical Services 2001a; Schorr 2001; Meaney *et al.* 2003; Schorr *et al.* 2009). A model was fit to these data to account for the different lengths of time between trapping sessions in each study and in order to include Shenk and Sivert's (1999b) estimates for summer only. Based on this fitted model, Preble's mouse average summer survival standardized to 4 months was 11.0% (5.6% standard error) and average winter survival over 8 months was 83.4% (8.8% standard error). The average annual survival rate (summer rate x winter rate) based on the full data set was 9.1% (5.2% standard error) (Bruce Lubow, Colorado Division of Wildlife, unpublished data). Mark-recapture analysis of the U.S. Air Force Academy, Colorado Springs, Colorado, population showed dramatic annual variability in sex-specific seasonal survival rates, with overwinter

survival being best predicted by individual body mass and winter conditions (Schorr *et al.* 2009). The geometric mean survival rate for the Preble's mouse over a 7-year period at the Academy was 0.10 (range = 0.03 - 0.27) (Schorr 2012). These annual survival rates are based upon limited field observation, and may change as additional information is obtained.

Causes of Mortality

The Preble's mouse has a host of known predators including garter snakes (*Thamnophis* spp.), prairie rattlesnakes (*Crotalus viridus*), bullfrogs (*Lithobates catesbiana*), foxes (*Vulpes vulpes* and/or *Urocyon cinereoargenteus*), house cats (*Felis catus*), long-tailed weasels (*Mustela frenata*), and red-tailed hawks (*Buteo jamaicensis*) (Shenk and Sivert 1999a; Schorr 2001). Other potential predators of jumping mice include coyotes (*Canis latrans*), barn owls (*Tyto alba*), great horned owls (*Bubo virginianus*), western screech owls (*Otus kennicottii*), long-eared owls (*Asio otus*), northern harriers (*Circus cyaneus*), northern pike (*Esox lucius*), and creek chub (*Semolitus atromaculatus*) (Whitaker 1963; Poly and Boucher 1997; Trainor 2004).

Other mortality factors for the Preble's mouse include drowning and occasional losses associated with vehicles (Shenk and Sivert 1999a; Schorr 2001). Shenk and Sivert (1999a) assumed starvation, exposure and disease to be additional causes of death. Mortality factors known for other subspecies of meadow jumping mice, which are also likely causes of Preble's mouse mortality, include cannibalism (in captivity) and insufficient fat stores for hibernation (Sheldon 1934; Whitaker 1963; Schorr *et al.* 2009).

Diet

Although fecal analyses have provided the best data on the Preble's mouse diet to date, they overestimate the components of the diet that are less digestible and underestimate food items that are digested more completely, such as vegetation. Based on fecal analyses, Preble's mice eat arthropods, fungus, moss, pollen, willow, lamb's quarters (*Chenopodium* sp.), Russian thistle (*Salsola* sp.), sunflowers (*Helianthus* spp.), sedge (*Carex* spp.), mullein (*Verbascum* sp.), grasses (*Bromus, Festuca, Poa, Sporobolus* and *Agropyron* spp.), bladderpod (*Lesquerella* sp.), rushes (*Equisetum* sp.), and assorted seeds (Shenk and Eussen 1998; Shenk and Sivert 1999a). Willows were present in 38% of scats from Larimer County, Colorado (Shenk and Eussen 1998). The diet shifts seasonally, consisting primarily of arthropods and fungus after emerging from hibernation and fungus, moss, and pollen during mid-summer (July-August), with arthropods added again in September (Shenk and Sivert 1999a). The shift in diet along with shifts in mouse movements suggests that the Preble's mouse may require specific seasonal diets, especially with the physiological demands of hibernation (Shenk and Sivert 1999a). If we assume the Preble's mouse eats similar vegetation as documented for *Z. h. luteus*, then the Preble's mouse may consume seeds of threesquare (*Schoenoplectus* spp.), spikerush (*Eleocharis* spp.), saltgrass (*Distichlis* spp.), foxtail barley (*Hordeum* spp.), wildrye and wheatgrass (*Elymus* spp.), brome (*Bromus* spp.), and knotgrass (*Paspalum* spp.) (Wright and Frey 2015) where similar plant species overlap the two jumping mouse subpsecies' ranges.

Hibernation

The Preble's mouse is a true hibernator, usually entering hibernation in September or October and emerging the following May, after a potential hibernation period of 7 or 8 months (Whitaker 1963; Meaney *et al.* 2003). Adults are the first age group to enter hibernation because they accumulate the necessary fat stores earlier than young-of-the-year (Wunder and Harrington 1996). Adults reach weights that enable them to enter hibernation by the third week in August, whereas young-of-the-year typically enter hibernation in September and October (Meaney *et al.* 2003). The earliest Preble's mouse capture in Colorado was May 5 and the latest was October 27; both were captured at Rocky Flats Environmental Technology Site (Harrington 1996). As with other subspecies of meadow jumping mouse, the Preble's mouse does not store food, but survives on fat stores accumulated prior to hibernation (Whitaker 1963).

Meadow jumping mice may dig their own hibernation burrows and hibernate alone or in pairs; separate hibernacula, or hibernation nests, may be located close together (Whitaker 1963). Fifteen apparent Preble's mouse hibernacula have been located through radio-telemetry, all found between 3.3 feet and 335 feet of a perennial stream bed or intermittent tributary (Shenk and Sivert 1999a; Schorr 2001; Ruggles *et al.* 2004; T. Ryon, Greystone Consultants., pers. comm.). Those hibernating outside of the 100-year floodplain may be less vulnerable to flood-related mortality. Apparent hibernacula have been located under willow (*Salix* spp.), chokecherry (*Prunus virginiana*), snowberry (*Symphoricarpos albus*), skunkbrush (*Rhus trilobata*), sumac (*Rhus* spp.), clematis (*Clematis* spp.), cottonwood (*Populus* spp.), Gambel's oak (*Quercus gambelii*), thistle (*Cirsium* spp.), and alyssum (*Alyssum* spp.) (Shenk and Sivert 1999a). One confirmed Preble's mouse hibernaculum, located at Rocky Flats Environmental Technology Site, occurred in leaf litter 11.8 inches below the surface in coarse textured soil (Bakeman 1997).

Behavior

Knowledge of a species' behavior is an essential component of developing a successful conservation program (Caro 1998, Gosling and Sutherland 2000), yet very little is known about the behavior of meadow jumping mice. The Preble's mouse is primarily nocturnal or crepuscular but also may be active during the day, when they have been seen moving around or sitting still under a shrub (Shenk 1998). The Preble's mouse can move over 0.6 miles along streams within a 24-hour period, with maximum recorded movements of 1 mile (Ryon 1999; Shenk and Sivert 1999a).

Meadow jumping mice are not antagonistic toward one another (Quimby 1951; Whitaker 1972). Meadow jumping mice compete with meadow voles (*Microtus pennsylvanicus*) and may be kept at low densities by these voles (Boonstra and Hoyle 1986). A meadow jumping mouse was killed by a meadow vole when the two were confined together (Quimby 1951). Based on mark-recapture data, the Preble's mouse may experience reduced survival during years with high deer mouse (*Peromyscus maniculatus*) abundance and higher recruitment during years with high meadow vole abundance (Schorr 2012).

Little is known about the interaction among social behavior, social strategies, and survival in this subspecies. However, E. A. Preble (1899) described globular nests built above ground in late summer that are inhabited by two individuals, presumably a pair. Jones and Jones (1985) described lively social interactions in which several meadow jumping mice were observed jumping into the air and squeaking in close proximity to one another suggesting that they formed a gregarious unit. At Woodhouse Ranch in 1999 and 2000, three radio-collared Preble's mice came from different day-nest locations to meet at one particular spot every night for the month that their radio-collars were active (T. Shenk, Colorado Division of Wildlife, pers. comm.).

Habitat

Typical habitat for the Preble's mouse is composed of well-developed riparian vegetation, relatively undisturbed adjacent grassland communities, and a nearby water source (Bakeman 1997); White and Shenk (2000) determined that the amount of these attributes are good predictors of Preble's mouse densities. At the U.S. Air Force Academy, Preble's mouse densities were correlated with vertical vegetation density and total grass cover (Schorr 2001). In addition, Trainor *et al.* (2007) found that high-use areas for the Preble's mouse tended to be close to creeks and were positively associated with the percentage of shrubs, grasses, and woody debris. Well-developed riparian vegetation includes a fairly dense combination of grasses, forbs, and shrubs with the possible inclusion of a taller tree and shrub canopy (Bakeman 1997; Meaney *et al.* 1997a; Shenk and Eussen 1998; Schorr 2001). The shrub canopy is often willow (*Salix* spp.), although other shrub species, such as snowberry (*Symphoricarpus* sp.), chokecherry (*Prunus virginiana*), hawthorn (*Crataegus* sp.), Gambel's oak (*Quercus gambelli*), alder (*Alnus incana*), river birch (*Betula fontinalis*), skunkbrush (*Rhus trilobata*), wild plum (*Prunus americana*), lead plant (*Amorpha fruticosa*), and dogwood (*Cornus sericea*) may occur (Bakeman 1997; Shenk and Eussen 1998). Montane riparian woodlands where Preble's mice have been found are characterized by spruce (*Picea pungens*) and occasionally aspen (*Populus tremuloides*), with lush and diverse understories of shrubs and forbs (Ruggles *et al.* 2001). Occasionally, riparian patches with thick cover interspersed with more open areas may provide important movement corridors between dense vegetation (Bakeman and Meaney 2001).

In a comparison of existing habitat data within Preble's mouse range in Colorado, Clippinger (2002) found that subshrub cover and plant species richness are higher at most sites where meadow jumping mice are present versus where they are absent, particularly at 49 to 82 feet from streams. In a study comparing Preble's mouse capture locations on the Rocky Flats Environmental Technology Site and the U.S. Air Force Academy (Academy), the Academy sites had lower plant species richness at capture locations but considerably greater numbers of Preble's mice (Schorr 2001). It may be that the density of the Preble's mouse is not driven by the richness of plant species alone, but also by the density and abundance of riparian vegetation (Schorr 2001). However, the Academy sites had higher densities of both grasses and shrubs. Trainor *et al.* (2007) looked at habitat use of the Preble's mouse in sites throughout Douglas County, Colorado. They found that areas with three times more grass cover than forb cover and a greater proportion of wetland shrub and grass cover were the most frequently used by the Preble's mouse.

Habitat for the Preble's mouse ranges from large perennial rivers such as the South Platte River (Armstrong 1972; Colorado Natural Heritage Program 1999b) to small ephemeral drainages only 3 to 10 feet in width such as those found at Rocky Flats Environmental Technology Site (Bakeman 1997) to montane habitats, low moist areas, dry gulches (T. Shenk, Colorado Division of Wildlife. pers. comm.), agricultural ditches (Meaney *et al.* 2003), and wet meadows and seeps near streams (Ryon 1996).

Although the Preble's mouse has rarely been trapped in uplands adjacent to riparian areas (Corn *et al.* 1995; Bakeman 1997; Dharman 2001), radiotelemetry studies have documented individuals using these habitats for feeding and resting (Schorr 2001). These studies suggest that Preble's mice use uplands at least as far out as 328 feet beyond the stream edge (Shenk and Sivert 1999b; Ryon 1999; Schorr 2001). Adjacent upland habitats used by the mouse are extremely variable, and range from open grasslands to ponderosa pine (*Pinus ponderosa*) woodlands (Corn *et al.* 1995; Pague and Grunau 2000).

Hayfields are used by the Preble's mouse in some situations (Bakeman and Meaney 2001). Additional areas used by the Preble's mouse include shrub patches set back from the drainage (T. Shenk, Colorado Division of Wildlife, unpublished data), and downed woody debris, which creates good cover for day nests (Trainor 2004).

Preble's mice can have multiple day nests in both riparian and grassland communities (Schorr 2001), which are composed of grasses, forbs, sedges, rushes, and other available plant material (Bain and Shenk 2002). These nests may be globular in shape or simply raised mats of litter, and are most commonly above ground but also can be below ground (Ryon 2001; Bain and Shenk 2002). They are typically found under debris at the base of shrubs and trees, or in open grasslands (Shenk and Sivert 1999a; Ryon 2001; Schorr 2001). Ryon (2001) found day nests to be abandoned after approximately 1 to 3 weeks of use.

One definite and 14 possible Preble's mouse hibernacula have been located; they were all between 3 and 394 feet from a main drainage or tributary (Shenk and Sivert 1999a; R. Schorr, Colorado Natural Heritage Program, unpublished data). Hibernacula have been located under willow, chokecherry, snowberry, skunkbrush sumac (*Rhus* sp.), clematis (*Clematis* sp.), cottonwoods (*Populus* sp.), Gambel's oak, thistle (*Cirsium* spp.), mullein (*Verbascum thapsus*), and alyssum (*Alyssum* sp.; Shenk and Sivert 1999a).

Changes to Preble's mouse habitat can be caused by flooding events, plant succession, native and nonnative herbivory (grazing or browsing), water table fluctuations, fire, invasive noxious weeds, and other natural and human-caused impacts (Busch and Scott 1995). Extensive urbanization in Adams, Arapahoe, and Denver counties, Colorado, has reduced, altered, or completely eliminated the riparian habitat needed for Preble's mouse occupancy (Ryon 1996).

Flooding and fire are common and natural events in riparian systems along the Front Range of Colorado and in Wyoming, and as a consequence, Preble's mouse habitat naturally fluctuates. These periodic natural disturbances help to create a dense vegetative community by stimulating resprouting from willow shrubs and allowing forbs and grasses to take advantage of newly-deposited soil (Schmidt 1983). Sources of the flooding can be winter snow melt and/or summer

rain events. Major flooding events occurred at least once every 5 to 20 years with some of the most severe and frequent flooding events occurring within Preble's mouse habitat along the South Platte and Arkansas River drainages along the Front Range (Follansbee and Sawyer 1948).

Reasons for Listing and Threats to Recovery

The following factors have been identified as potential threats to Preble's mouse populations and recovery. Much of the following comes from the Preble's mouse Science Team's Threat Assessment (Pague and Grunau 2000), the May 13, 1998, rule listing the mouse under the ESA (63 FR 26517), the July 10, 2008, rule amending the previous listing under the ESA (73 FR 39789), and the May 24, 2013, 12-month finding on petitions to delist the Preble's mouse (78 FR 31680).

Factor A. The Destruction, Modification, or Curtailment of the Species' Habitat or Range

Changes in habitats and their component plant communities affect the composition of the mammalian community found within them (Andersen *et al.* 1980; Honeycutt *et al.* 1981). The Preble's mouse is closely associated with riparian ecosystems that are relatively narrow and represent a small percentage of the landscape. If habitat for the Preble's mouse is destroyed or modified, populations in those areas will decline or be extirpated. Habitat fragmentation also limits the extent and abundance of Preble's mouse populations. Smaller patches of habitat are unable to support as many Preble's mice as larger patches of habitat (see Section 3, Recovery Strategies, of this plan). If the threats to persistence are the same, larger populations are believed to be more secure from extinction than smaller ones (Primack 2002).

The decline in the extent and quality of Preble's mouse habitat is considered the main factor threatening the subspecies (Bakeman 1997, Hafner *et al.* 1998; Shenk 1998; Pague and Grunau 2000). As stated in the rule listing under the ESA (63 FR 26517), Preble's mouse populations face continued threats due to loss and fragmentation of their habitat from human land uses, including urban, suburban, and recreational development; highway and bridge construction; water development; instream changes due to increased runoff and flood control efforts; sand and gravel mining; and overgrazing. These human land use activities affect the Preble's mouse by directly destroying its protective cover, nests, food resources, and hibernation sites; disrupting behavior; or acting as a barrier to movement. Since 1999, the Service has recommended that projects within 300 feet of the 100-year flood plain of rivers and streams, and projects that may have secondary impacts to such areas be assessed for their potential to impact the Preble's mouse and its habitat.

i. Residential and Commercial Development

Residential and commercial development has both direct and indirect impacts on Preble's mouse habitat. The direct impact of development is in the removal and alteration of habitat making it unsuitable for the Preble's mouse. Private land ownership typically follows valley bottoms, thus disproportionately impacting areas favored by the Preble's mouse (Riebsame *et al.* 1996; Theobald *et al.* 2001).

The indirect effects of human settlement have resulted in declines in native trees and shrubs, greater canopy closure, increases in non-native predators and competitors, and a more open understory with reduced ground cover within riparian habitat (Miller *et al.* 2003; see Factor E vi. Secondary Impacts of Human Development, of this plan). An open understory does not favor the Preble's mouse, which prefers dense ground cover of grasses and shrubs and is less likely to use open areas where predation risks are assumed to be higher (Trainor *et al.* 2007; Clippinger 2002).

Fragmentation is another impact of development, limiting the extent and size of Preble's mouse populations by disrupting movement throughout the habitat. As populations become fragmented and isolated, it becomes more difficult for them to persist (Primack 2002) due to the risks associated with demographic stochasticity, environmental stochasticity, and loss of genetic diversity. On a landscape scale, maintenance of dispersal corridors linking patches of Preble's mouse habitat may be critical to the subspecies' conservation (Shenk 1998).

Clippinger (2002) concluded that the likelihood of successful trapping of Preble's mouse was reduced by either low- or high- density residential developments within 690 feet of the trapping sites. These data suggest that nearby development increases the risk of local extirpation of Preble's mouse from occupied sites. A study in Boulder County found that as the degree of proximity to urban environments increased, the number of small mammals captured decreased (Bock *et al.* 1998).

There are multiple historic records from Denver and Colorado Springs, but despite numerous surveys, Preble's mouse has not recently been found in these metropolitan areas, and is believed to be extirpated as a result of extensive urban development. In recognition of the impact of urban development on Preble's mouse populations, the Service has established "block clearance" zones in the Denver metropolitan area, along Monument Creek through downtown Colorado Springs, and along the majority of Cottonwood Creek, El Paso County, Colorado, and its tributaries, where the Preble's mouse is no longer believed to exist and where no further surveys are needed to determine its absence. Consequently, residential and commercial development constitutes a substantial threat to Preble's mouse populations.

ii. Transportation, Recreation, and Other Rights-of-Way through Habitat

Transportation corridors frequently cross Preble's mouse habitat and may negatively affect adjacent populations. As new roads are built and old roads are maintained, habitat can be destroyed and possibly fragmented. Roads, and other linear development features, have also been identified as partial or complete barriers to dispersal (63 FR 26517). Train and truck accidents within riparian areas may release spills of chemicals, fuels, and other substances that can impact the Preble's mouse or its habitat.

Trail systems frequently parallel or intersect riparian communities within Colorado (Meaney *et al.* 2002). The development of trail systems can impact the Preble's mouse by modifying its habitat, nesting sites, and food resources in both riparian and upland areas. Humans and pets using an area for activities such as hiking may alter activity and feeding patterns (Theobald *et al.*

1997) of Preble's mouse and cause a decrease in survival and reproductive success. Meaney *et al.* (2002) suggest fewer Preble's mice were found on sites with trails than on sites without trails.

Many utility lines (sewer, water, communications, gas, electric, municipal water ditches) cross Preble's mouse habitat. Current and future utility rights-of-way through these habitats represent a threat from habitat destruction and fragmentation from new construction and periodic maintenance. However, utility corridors are currently short-term disturbances, due to project review and reclamation required since listing in 1998. Consequently, transportation, recreation, and other rights-of-way constitute a threat to Preble's mouse populations.

iii. Hydrologic Changes

Establishment and maintenance of riparian plant communities are determined by the interactions between surface water dynamics, groundwater, and river channel processes (Busch and Scott 1995). Changes in hydrology can alter the channel structure, riparian vegetation, and valley floor landforms (Gregory *et al.* 1991; Busch and Scott 1995). Thus, changes in the timing and abundance of water may be detrimental to the persistence of the Preble's mouse in these riparian habitats due to resultant changes in vegetation (Bakeman 1997). Such changes in hydrology may occur in many ways, but two of the more prevalent are the disruption of natural flow regimes below dams, diversions, and alluvial wells and excessively high and excessively low runoff cycles in watersheds with increased areas of paved or hardened surfaces (Schorr 2012).

Similarly, depletion of groundwater via wells and water diversion or capture affects Preble's mouse habitat by replacing riparian vegetation with more xeric plant communities. The conversion of these habitats from mesic, shrub-dominated systems to drier grass- or forb-dominated systems makes the areas less suitable for the Preble's mouse.

Bank stabilization, channelization, and other methods of hardening stream banks can increase the rate of stream flow, narrow riparian areas, and destroy riparian vegetation (Pague and Grunau 2000). These impacts can alter plant composition, soil structure, and physiography of riparian systems to the point where Preble's mouse populations can no longer persist there. Consequently, hydrologic changes constitute a threat to Preble's mouse populations.

iv. Aggregate Mining

Alluvial aggregate extraction may produce long-term changes to Preble's mouse habitat by altering hydrology and removing shrub and herbaceous vegetation. Often, mined pits are constructed with impervious liners and converted to water reservoirs after aggregate is removed. This conversion precludes restoration of riparian shoreline vegetation and alters adjacent groundwater flow. Armstrong speculated that mining impacts the deposits of alluvial sands and gravels that may be important hibernation locations for Preble's mice (D. Armstrong, University of Colorado, pers. comm.). Consequently, aggregate mining constitutes a threat to Preble's mouse populations.

v. Oil, Gas, and Mineral Exploration and Extraction

Energy development activities have the potential to destroy and fragment habitat through exploration for and extraction of oil, natural gas, and minerals, including coal. However, the Preble's mouse range does not overlap any potential coal fields in Colorado, and overlap of coal fields is minimal in Wyoming. In Colorado, habitat is only minimally impacted by current oil and gas development areas, and, in Wyoming, much of the range of the Preble's mouse overlaps areas that represent low potential for oil and gas, and only one oil and gas field currently occurs within the Preble's mouse range in the state. Additionally, when developed, well pads tend to be placed in upland areas and infrastructure can be located to minimize potential impacts to Preble's mouse habitat. However, although oil and gas potential throughout the range of the Preble's mouse is variable, it is also widespread (Copeland *et al.* 2009) and, given the increasing demand for natural resources, is likely to lead to increased production. Consequently, we consider oil, gas, and mineral exploration and extraction to pose a medium threat to Preble's mouse populations.

vi. Agriculture

The Preble's mouse uses native grass and alfalfa hayfields that are in or adjacent to suitable riparian habitat. Mowing of hay may directly kill or injure Preble's mouse, reduce food supply, and remove cover. Additionally, hay production close to floodplains may limit growth of willows and other shrubs that are important as hibernation habitat for the Preble's mouse. However, some Preble's mouse populations have persisted in areas hayed for many years (Taylor 1999), but it is unclear if populations have been altered. Haying operations that allow dense riparian vegetation to remain in place are likely compatible with persistence of Preble's mouse populations.

Compton and Hugie (1993) found that human activities, including conversion of grasslands to farms and livestock grazing had adversely impacted the Preble's mouse. They also concluded that development of irrigated farmland had a negative impact on Preble's mouse habitat and that any habitat creation it produced was minimal (Compton and Hugie 1993). However, because overall loss of habitat to farmland is minimal and haying practices have been shown to be compatible and occasionally beneficial for Preble's mouse populations (Taylor 1999), we consider agriculture to constitute a low threat to Preble's mouse populations.

vii. Livestock Grazing

Impacts to riparian habitat from poorly managed livestock are well documented in the scientific literature (Kauffman and Krueger 1984; Armour *et al.* 1991; Fleischner 1994; Belsky *et al.* 1999; Freilich *et al.* 2003). Adverse impacts of overgrazing include changes to stream channels (downcutting, trampling of banks, increased erosion), flows (increased flow and velocity, decreased late-season flow), and vegetation (loss to grazing, trampling, altered hydrology) (Kauffman and Krueger 1984). Such impacts from cattle grazing to other jumping mice have been documented by Frey (2005), Giuliano and Homyack (2004), and Medin and Clary (1989). Ryon (1996) cited livestock grazing as a contributor to the lack of structural habitat diversity he observed on historical Preble's mouse sites. On a working ranch in Douglas County, Preble's

mice were detected within cattle exclosures, but not on grazed areas. Previous trapping had documented the Preble's mouse upstream and downstream, but not on the ranch (Ensight Technical Services 2004).

Alternatively, when grazing has been managed at appropriate levels, populations of the Preble's mouse have been documented on sites with a long history of grazing. For example, jumping mice were trapped at 18 of 21 sites on True Ranches properties (mice from 14 of these sites have since been confirmed as Preble's mouse (King *et al.* 2006a)), primarily within sub-irrigated hay meadows that have been subjected to livestock grazing and hay production for approximately 100 years (Taylor 1999). Grazing and haying, used as land management tools, continue on Boulder Open Space sites currently supporting the Preble's mouse. In their study of small mammals on Boulder Open Space, Meaney *et al.* (2002) found no adverse effects of limited grazing on abundance of individual small mammal species or on species diversity. As suggested by Bakeman (1997) and Pague and Grunau (2000), and as supported by the examples above, grazing is compatible with Preble's mouse when timing and intensity are appropriately managed. Consequently, livestock grazing constitutes a low threat to Preble's mouse populations.

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The Preble's mouse is not collected for commercial or recreational reasons. Some collection of specimens has occurred for scientific and educational purposes, but only through permits issued by the Service, CPW, and WGFD. Although unintentional mortalities have resulted from capture and handling of Preble's mice by permitted researchers, the Service has concluded that the level of take associated with this activity does not rise to the level that would affect populations of the Preble's mouse and, consequently, does not pose a threat.

Factor C. Disease or Predation

i. Disease

As with most small mammals, the Preble's mouse carries parasites and diseases that may reduce vigor, curtail reproductive success, and cause death. There is no evidence that any disease has caused a significant impact to Preble's mouse populations. Schorr and Davies (2002) documented the first case of a Preble's mouse parasitized by a grey flesh fly (*Wohlfahrtia vigil*); the Preble's mouse was later euthanized due to the infection. Between 1998 and 2003 Ruggles (2003) documented 18 animals with unexplained alopecia (hair loss) in the South Boulder Creek floodplain; molting, fleas, mites, fungus, and general skin irritation were ruled out in all cases. Currently, known parasites and disease are not considered to be a threat to this subspecies.

ii. Predation

Predation is a natural occurrence in Preble's mouse populations and would not normally be considered a threat. However, the increasing presence of humans near Preble's mouse habitats may result in an increased level of predation that may pose a threat to the mouse. Striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*) and domestic and feral cats (*Felis catus*) are found in greater densities in and around areas of human activity and all of

these species feed opportunistically on small mammals (Churcher and Lawton 1987; Rosatte *et al.* 1991). Therefore, Preble's mouse populations that are near suburban settings likely are subjected to greater predation. The predation pressure from domestic cats can be particularly difficult to mediate since these predators will hunt regardless of their need to sustain themselves (Adamec 1976). Introduction of non-native aquatic species, such as bullfrogs (*Lithobates catesbiana*), has resulted in additional predation on the subspecies (Trainor 2004). The fact that summer mortality is higher than overwinter mortality, as discussed under *Longevity and Mortality*, underscores the impact that predators can have on the Preble's mouse and other small mammals. Consequently, predation constitutes a low threat for Preble's mouse populations, but is likely most pronounced in those areas with a high abundance of human-associated predators.

Factor D. The Inadequacy of Existing Regulatory Mechanisms

Various federal, state, and local regulations have the potential to impact Preble's mouse status and habitat. The Service found that, even though many of these regulations currently provide some protections for the Preble's mouse, it is not ensured that those protections will continue after delisting of the subspecies.

Federal laws that provide some protections for the Preble's mouse and its habitat include the Clean Water Act (33 U.S.C. 1251 et seq.), the Sikes Act Improvement Act of 1997 (16 U.S.C. 670a et seq.), the National Forest Management Act (16 U.S.C. 1600 et seq.), and the Federal Land Policy and Management Act (43 U.S.C. 1701 et seq.). Sections 404 and 303 of the Clean Water Act (CWA) provide protections to some of the habitat needed by the Preble's mouse. Section 404 generally requires avoidance, minimization, and mitigation of adverse impacts to jurisdictional wetlands and waters of the United States. These protections do not extend to non-jurisdictional riparian and upland areas that may be used by the Preble's mouse. Section 303 establishes water quality and Total Maximum Daily Load standards through the states. These standards can lead to the creation of watershed plans, which in turn may provide some protections to riparian areas. In general, watershed plans are not mandatory and do not cover the entire range of the Preble's mouse. Thus, the CWA provides only limited protection to the habitats of the Preble's mouse and is not capable of substantially reducing threats to the subspecies.

Federal lands provide some protections to the Preble's mouse and its habitat through the Sikes Act Improvement Act, the National Forest Management Act, and the Federal Land Policy and Management Act. Currently, the Preble's mouse is found on the following Federal lands – the Medicine Bow/Routt National Forests/Thunder Basin National Grassland, the Arapaho/Roosevelt National Forests/Pawnee National Grassland, the Pike/San Isabel National Forests/Cimarron/Comanche National Grasslands, the Air Force Academy, and the Rocky Flats National Wildlife Refuge. The Land and Resource Management Plans (LRMP) for these National Forests/Grasslands contain standards and guidelines that pertain to the Preble's mouse and its habitats in various contexts. Only the LRMP for the Medicine Bow National Forest contains standards and guidelines specific to the Preble's mouse. All of the LRMPs contain standards and guidelines applicable to riparian habitats. These standards and guidelines are designed to manage for healthy functional riparian systems. Much of the current protections on these properties would likely remain after delisting of the Preble's mouse.

The Preble's mouse also receives some protection throughout the listed range due to Service-approved Habitat Conservation Plans (HCPs). HCPs are set up to provide private, local, and state land managers with incidental take permits, which require management measures that protect, restore, and enhance the habitat for the Preble's mouse. HCPs are voluntary in nature and may be terminated by the permittees.

Colorado Parks and Wildlife currently lists the Preble's mouse as Threatened in Colorado, as well as a non-game species and a Tier 1 Species of Greatest Conservation Need under the Colorado State Wildlife Action Plan. Non-game designation requires that personnel obtain a permit to legally take Preble's mouse in Colorado. The Preble's mouse is classified as a Tier II Species of Greatest Conservation Need in Wyoming. Additionally, the Wyoming Game and Fish Department classifies all meadow jumping mice (*Zapus hudsonius*) as "nongame species," which are protected under the Wyoming Game and Fish Commission (1998) Nongame Wildlife Regulations and thus require state permits for take for scientific and educational purposes. There are also numerous lands protected by state, local, and private conservation organizations that provide Preble's mouse habitat. Finally, Preble's mouse research and habitat protection can receive funding through the Great Outdoors Colorado Trust Fund and the Species Conservation Trust Fund.

Existing regulatory mechanisms at the local level provide limited protections to Preble's mouse and its habitat. Many local jurisdictions require land development proposals to be reviewed for impacts to wildlife, wetlands, and other natural habitats, but have no mandatory measures requiring avoidance or mitigation of impacts. These regulations seldom deal specifically with the Preble's mouse. It is difficult to determine the effectiveness of these local regulations due to the flexibility with which they are applied. It is also unlikely that these regulations effectively control land uses, such as grazing, mowing, or burning, that may have secondary effects on Preble's mouse habitat. Consequently, the lack of adequate existing regulatory mechanisms constitutes a threat to Preble's mouse populations.

Factor E. Other Natural or Manmade Factors Affecting the Species' Continued Existence

i. Floods

Flooding is a natural component of the Colorado and Wyoming foothills and plains where the Preble's mouse is found. Flood events are believed to impact Preble's mouse populations and their habitat, though these impacts may be temporary. Flooding may also provide benefits to Preble's mouse by maintaining the vegetative communities that provide suitable habitat. An increase in impervious surfaces and denuding of vegetation caused by human activity can result in increased frequency and severity of flood events and prevent the re-establishment of riparian communities (Schorr 2012). Increased flood severity has the potential to eliminate an entire Preble's mouse population, especially if the impacted population is small and isolated. Consequently, floods may constitute a threat to Preble's mouse populations, although the impacts of floods are likely variable.

The compound impacts of alternating extremes in flooding and drought can exacerbate Preble's mouse habitat degradation. For example, frequent, extreme flooding can incise floodplains, creating cutbanks and lowering the water table. When such events are followed by drought that desiccates soils and further reduces stream flows, riparian vegetation may be too removed from the hydrology that once supported it to flourish. The two extremes in hydrologic events work to create inhospitable conditions for the riparian habitat that would support the Preble's mouse.

ii. Wildfire

Fire is a natural component of the Colorado Front Range and Wyoming foothill systems, and Preble's mouse habitat naturally adjusts with fire events. Overall, fire may be one of the methods needed to maintain riparian, transitional, and upland vegetation within Preble's mouse habitat. In a review of the effects of grassland fires on small mammals, Kaufman *et al.* (1990) found a positive effect of fire on meadow jumping mice in one study and no effect of fire on the species in another study. An additional report found that approximately 4 months after a fire at the Rocky Flats Environmental Technology Site, two adult Preble's mice were captured in a trap located approximately 6 feet from a burn area and another adult was observed within the burned area itself (DOE 2003). Upland fire adjacent to Preble's mouse populations appeared to have no impact on populations at the U.S. Air Force Academy (R. Schorr, CNHP, pers comm.; B. Mihlbachler, USFWS, pers comm.).

As human presence has increased in and near Preble's mouse habitat, significant effort has been made to suppress fires. Long periods of fire suppression may result in a build-up of fuel and result in a catastrophic fire. Although there are no records of fire killing a Preble's mouse, it is possible that fire may take a limited number of individuals. Catastrophic fire in particular can alter habitat dramatically, changing the structure and composition of the vegetation communities such that Preble's mice may no longer persist. Precipitation falling in a burned area may degrade Preble's mouse habitat by causing greater levels of erosion and sedimentation along creeks. Consequently, wildfire constitutes a threat to Preble's mouse populations, although the impacts are likely variable depending on the scope and severity of fires.

iii. Drought

Drought may be another factor that can have a negative effect on the Preble's mouse. Drought lowers stream flows and the adjacent water table, in turn impacting riparian habitat on which the Preble's mouse is dependent. Frey (2005) found that drought had a major influence on the status and distribution of the New Mexico jumping mouse (*Z. h. luteus*) in New Mexico. In 2002, a year with regional drought conditions, Bakeman (2006) failed to capture Preble's mice at two sites where substantial populations had previously been documented. Conversely, at the U.S. Air Force Academy precipitation did not predict seasonal and annual survival (Schorr 2012). While Preble's mouse populations have coexisted with periodic drought, significant increase in frequency or severity of drought could impact the persistence of small, isolated populations. Consequently, drought constitutes a threat to Preble's mouse populations.

As mentioned in Section E i. *Floods* (above), the compound impacts of alternating extremes in drought and flooding can exacerbate Preble's mouse habitat degradation. For example, frequent,

extreme flooding can incise floodplains, creating cutbanks and lowering the water table. When such events are followed by drought that desiccates soils and further reduces stream flows, riparian vegetation may be too removed from the hydrology that once supported it to flourish. The two extremes in hydrologic events work to create inhospitable conditions for the riparian habitat that would support the Preble's mouse.

iv. Nonnative Plants

Invasive, noxious plants can encroach upon a landscape, displace native plant species, form monocultures of vegetation, and negatively impact cover and food for the Preble's mouse. The control of noxious weeds may entail large-scale removal of vegetation and mechanical mowing operations, which also may impact the Preble's mouse. The tolerance of the Preble's mouse for invasive plant species is not well understood. Leafy spurge (*Euphorbia esula*) may be of particular concern, since it can form a monoculture, displacing native vegetation and thus reducing available habitat (Selleck *et al.* 1962). Within Larimer and Weld counties of Colorado, Russian olive (*Elaeagnus angustifolia*) occurred in six (33%) of the areas where no jumping mice were found, while it was absent in areas where jumping mice were captured (Shenk and Eussen 1998). However, Russian olive was present in Wyoming sites where jumping mice were captured (R. Taylor, True Ranches, pers. comm.). Consequently, nonnative plants constitute a low threat to Preble's mouse populations.

v. Pesticides and Herbicides

It remains unknown to what extent Preble's mouse populations are affected by point and non-point source pollution (sewage outfalls, spills, urban or agricultural runoff) that degrades water quality in their habitat. From an examination of their kidney structure, it is not clear whether the Preble's mouse obtains water through dew and their diets or if they drink from open water sources (Wunder 1998). It is also unclear whether the pesticides and herbicides commonly used in the range of the Preble's mouse have any direct or indirect effects on the populations or their habitat. Consequently, whether and to what degree pesticides and herbicides constitute a threat to Preble's mouse populations likely requires further evaluation.

vi. Secondary Impacts of Human Development

Introduced animals associated with human development may displace, prey upon, or compete with the Preble's mouse. Domestic cats have been found to prey upon the Preble's mouse in Colorado (Shenk and Sivert 1999a). Feral cats and house mice (*Mus musculus*) were common in and adjacent to historic capture sites where Preble's mice were no longer found (Ryon 1996). While no cause-and-effect relationship was documented, the Preble's mouse was 13 times less likely to be found at sites where house mice were present (Clippinger 2002). Bullfrogs also have been known to prey on the Preble's mouse (T. Shenk, Colorado Division of Wildlife, pers. comm.).

Human development may also lead to secondary impacts due to increased human presence, noise, increased lighting, and the degradation of air and water quality. These secondary impacts

may interact with and result from other threats identified in this section and, as a result, constitute a threat to Preble's mouse populations.

vii. Instability of Small Populations

Colorado's State Wildlife Action Plan lists "scarcity" as a threat to the Preble's mouse that may lead to inbreeding depression (CDOW 2006). Small populations can be threatened by stochastic, or random, changes in a wild population's demography or genetics (Brussard and Gilpin 1989; Primack 2002). A stochastic demographic change such as a skewed age or sex ratio (e.g., a loss of adult females) can negatively affect reproduction, especially in a small population. Isolation of populations may disrupt gene flow and create unpredictable genetic effects that could impact Preble's mouse persistence in a given area. While stochastic events are not known to be an immediate threat to Preble's mouse populations, the tendency for Preble's mouse numbers to vary widely over time heightens concern for small and isolated populations. Consequently, the instability of small populations constitutes a threat to Preble's mouse populations.

viii. Interspecific Competition

The relative ranges, abundances, and relationship between the Preble's mouse and the western jumping mouse are not yet clearly understood. In Wyoming, Preble's mouse and western jumping mouse ranges overlap substantially, and individuals of both species have occasionally been captured during the same survey session (Cudworth and Grenier 2014). It is unknown whether western jumping mice are actively competing with Preble's mice, affecting Preble's mouse population size, and possibly limiting distribution, or if the general lack of coexistence is unrelated to their interaction. Consequently, we do not consider interspecific competition a threat to Preble's mouse populations at this time.

ix. Global Climate Change

The Service's latest 12-month finding (78 CFR 31680) provides an updated general global climate change discussion and potential global climate change impacts to the Preble's mouse. The 12-month finding is provided herein by reference. In summary, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that greenhouse gas emissions (GHG) will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions. Based on climate records and projections for western North America, Wyoming and Colorado, climate models predict a trend of continued warming, with hotter summers, warmer winters, decreased snowpack, earlier spring melts, increased evaporation, more droughts, and reduced summer flows throughout the Preble's mouse's range. Overall, climate change will decrease the quality and quantity of the Preble's mouse's riparian habitats, and as a result, the Preble's mouse is especially vulnerable when faced with a changing climate. Therefore, the effects of climate change are a threat to the Preble's mouse. Please see Factor E, Section i. *Floods* and iii. *Drought* (above) for more details on how extremes in hydrologic events, such as those that might accompany climate change, can work to degrade Preble's mouse habitat.

Management and Conservation Efforts

Starting in the early 1990s, federal, state, local, and private groups have conducted research, managed habitat, and developed conservation plans. These efforts form the basis for the listing of the subspecies and development of this Recovery Plan.

Research

Research efforts for the Preble's mouse increased in the early 1990s. Research conducted by numerous independent researchers was compiled by Bakeman (1997) into one document that provided the state of knowledge on Preble's mouse habitat. Research also was conducted by Bruce Wunder of Colorado State University to help clarify the physiology of the Preble's mouse (Wunder and Harrington 1996; Wunder 1998). Many presence/absence surveys contributed to knowledge of the subspecies' distribution and can be found at Service offices, CPW offices, WGFD offices, Colorado Natural Heritage Program, and Wyoming Natural Diversity Database. Recent research has focused on population demographics at a number of different sites (White and Shenk 2000). Other studies include the impact of recreational trails (Meaney *et al.* 2002), morphometric analyses (Conner and Shenk 2003b), radio-telemetry studies of movement patterns (Dharman 2001; Ryon 1999; Shenk and Sivert 1999a; Schorr 2001), and nest descriptions (Ryon 2001; Bain and Shenk 2002). Most of the information gathered through this research appears in the Background Section of this Plan.

Habitat Conservation and Restoration

In Colorado, conservation of Preble's mouse populations and conservation and restoration of their riparian habitats have occurred through land easements and other acquisitions by non-governmental organizations, public agencies, and private landowners. Examples include restoration of groundwater levels and connectivity on 0.54 miles of Preble's mouse habitat on East Plum Creek, Douglas County, as well as additional restoration on Cherry Creek in Douglas County; protection of approximately 120 acres of riparian and adjacent upland habitats in El Paso County; protection and management of 13.5 miles of stream on the U.S. Air Force Academy in El Paso County; and protection and management of 1,227 acres of habitats on the Rocky Flats National Wildlife Refuge in Jefferson County.

In addition, we have approved 22 single-species HCPs for the Preble's mouse, all in Colorado. These 22 HCPs and their associated permits allow approximately 696 acres of permanent or temporary impacts to Preble's mouse habitat in exchange for the preservation and enhancement of habitats. For example, the HCP for Douglas County and the Towns of Castle Rock and Parker allows impacts of up to 430 acres, in exchange for the acquisition of 15 miles of stream (1,132 acres of habitat) acquired and preserved for the long-term benefit of the Preble's mouse.

RECOVERY

The recovery planning approach is based upon the assumption that if specific criteria are met for certain existing populations, the Preble's mouse can be delisted. These criteria require that populations are maintained in designated habitats distributed throughout the existing range, the

populations and habitats are secure from decline due to the threats listed above, the populations are self-sustaining and persistent, a long-term management plan and cooperative agreement is completed, and there is effective public involvement.

When the recovery criteria are met, it is anticipated that protection of the subspecies under the ESA will no longer be necessary. The decision on whether to delist will be made by the Service after analysis of the five ESA listing factors (destruction of habitat, overutilization, disease or predation, inadequacy of existing regulatory mechanisms, and other natural or manmade factors affecting the subspecies' persistence).

It is believed that there are adequate numbers and distributions of Preble's mouse populations present today to allow recovery of the subspecies; however, many of these populations face threats to their persistence. Further analysis of the extent and stability of these populations, as well as management of the threats to habitat, is needed to achieve recovery.

Throughout the development of this Recovery Plan, the following Guiding Principles and Recovery Strategies have been employed.

Guiding Principles

The recovery team found the following principles to be useful in the development of this plan. These Guiding Principles ensured that the team members remained focused on the long-term success of this plan and ultimate recovery of the Preble's mouse. These principles are also intended to guide the recovery activities necessary to implement this plan.

1. Achievability

This recovery plan should be an achievable document that will feasibly lead to recovery of the Preble's mouse in a meaningful time frame.

2. Research

Many important aspects of Preble's mouse ecology and management are not known. Thus, continuing research in conjunction with adaptive management is crucial.

3. Monitoring and Adaptive Management

Designated Preble's mouse recovery populations and habitats will be monitored for a period of time that will be determined by the approved Population and Habitat Monitoring Methodologies. The results of such monitoring efforts and their implications will be evaluated within an adaptive management framework, and the management goals will be modified accordingly. This process will continue until management efforts allow the achievement of self-sustaining populations. Unless scientific evidence points to the contrary, the recommended initial management strategy for each area occupied by the Preble's mouse is to continue the existing land uses at current levels.

4. Local Involvement

The plan encourages all aspects of local involvement, particularly by those entities that own or manage lands on which Preble's mouse populations may exist. Examples of entities that should be involved with the recovery of the Preble's mouse include state wildlife management agencies, state park and natural resource agencies, state land boards, county and city open space programs, public water boards, water conservation districts, private landowners, non-governmental organizations, and other elements of federal, state, county, and local governments.

5. Cooperative Management

Numerous agencies, landowners, and organizations (listed above) have responsibility for lands that contain Preble's mouse habitat. These entities need to continue to be involved in recovery efforts, and cooperative management will be fostered wherever possible.

6. Incentives

Incentives should be developed to encourage participation, build partnerships, and foster cooperation with recovery efforts. These can include incentives at the federal, state, or county level to encourage active conservation measures on private lands, or the establishment of a recognition system for participation in recovery programs.

7. Education Programs

Education programs that focus on Preble's mouse populations and habitat protection can benefit recovery objectives. Education programs are encouraged, and should focus on the loss of habitat near urban centers. Educational messages should also describe what funding sources are available to implement this recovery plan.

Goal and Objectives

The goal of this recovery plan is to remove the Preble's meadow jumping mouse from the federal list of Endangered and Threatened Wildlife (50 CFR 17.11). The recovery plan's objectives are:

1. To ensure long-term persistence of multiple self-sustaining populations across the geographic range of the subspecies;
2. To conserve sufficient landscape complexes to support these populations;
3. To reduce known threats to the extent possible;
4. To develop and distribute educational materials on the natural history of the Preble's mouse, its habitat requirements, funding opportunities for habitat protection projects, and appropriate management guidelines for the subspecies and its habitat.

Recovery Strategy

As described in the Services' recovery planning guidance (NMFS and USFWS 2010), the recovery strategy provides "a logical construct that identifies the assumptions and logic underlying the selection of one path over another to achieve the objectives and goal." Thus it

constitutes the framework linking key facts and assumptions about the species' biology, threats, and environmental constraints with the recommended recovery actions.

The major threats and constraints affecting the Preble's mouse, as stated in the rule listing the mouse under the ESA (63 FR 26517), include habitat alteration, degradation, loss, and fragmentation resulting from urban development, flood control, water development, agriculture, and other human land uses, which have adversely impacted Preble's mouse populations. Strategically, these issues can be reduced to two overriding concerns: loss, degradation and fragmentation of habitat and the instability of small/isolated populations. Therefore, while our recovery strategy for the Preble's mouse broadly addresses threats abatement, population management, research, and monitoring, our recovery criteria are designed specifically to meet objectives (outlined in the following section) for reducing negative impacts associated with habitat loss, degradation, and fragmentation and small/isolated populations. Throughout, we emphasize conserving self-sustaining populations within dispersed population units that represent the genetic diversity of a species necessary to provide adaptive flexibility and avoid inbreeding; or multiple population sources in a dynamic ecosystem subject to unpredictable stochastic events such as floods or wild-fires.

In the development of the Recovery Plan, the following processes were developed to implement this strategy:

1. Establishing Site Conservation Teams

Site Conservation Teams will help guide and implement this Plan at the local level. They will be formed from a wide range of stakeholders, including federal, state, and local agencies, as well as private landowners. The Preble's mouse Site Conservation Teams may work with more than one designated recovery population, and could be closely tied to existing Habitat Conservation Plan groups. Site Conservation Teams will develop Site-specific Threat Abatement Plans.

2. Establishing Recovery Units

A Recovery Unit is a special unit of the listed entity that is geographically identifiable and is necessary to conserve genetic robustness, demographic robustness, and important life history stages of the Preble's mouse. Recovery units were selected to represent the full range of the subspecies, provide for redundancy, and resiliency of occurrences within and between units. Because the Preble's mouse populations north and south of the Denver metro area are isolated from each other, genetic composition of the subspecies has been documented (King *et al.* 2006a) as different, and the threats in each of these areas differ in type and intensity, the Preble's mouse will be most effectively managed by considering them separately. To ensure conservation of the breadth of Preble's mouse genetic variability and to protect the current population and habitat distribution, the populations north of the Denver metro area will be managed as the Northern Recovery Unit and the populations south of the Denver metro area will be managed as the Southern Recovery Unit. By designating these recovery units, emphasis is placed on the importance of both recovery units to the long-term sustainability of the subspecies, as recovery will be final when all recovery units meet the criteria established in this plan.

3. Selecting Hydrologic Unit as the Scale for Recovery

The scale of recovery needs to protect both the genetic diversity and core populations of the Preble's mouse. Because the Preble's mouse is a riparian-associated subspecies, river drainages provide an appropriate geographic scale and unit for addressing its conservation. Species well-distributed across their historic range are less susceptible to extinction and more likely to reach recovery than species confined to a small portion of their range (Abbitt and Scott 2001). Distributing populations throughout different drainages reduces the risk that a large portion of the range-wide population will be negatively affected by any particular natural or anthropogenic event at any one time. Spreading the recovery populations across hydrologic units throughout the range of the subspecies also preserves the greatest amount of the remaining genetic variation and may provide some genetic security to the range-wide population.

Disjunct or peripheral populations have often diverged genetically from central populations due to isolation, genetic drift, adaptation to local environments, or some combination of these factors (Lesica and Allendorf 1995). Therefore, conservation of these outlying populations protects genetic diversity. Data on endangered mammals also show that many species have declined from the centers of their ranges outward, which also suggests that protecting both core populations and those more widely distributed is important (Lomolino and Channell 1995).

To address these conservation issues, hydrologic units (corresponding to stream or watershed size) were selected as the basis for determining appropriate locations for the recovery populations. The United States is divided and sub-divided into successively smaller hydrologic units, which are designated by hydrologic unit codes (HUCs) developed by the U.S. Geological Survey. There are 21 two-digit, 222 four-digit, 352 six-digit, and 2,150 eight-digit HUCs found within the United States. In this Plan, the distribution of recovery populations is based upon the eight-digit HUC. The geographic units for designation of recovery populations are HUCs within the Platte and Arkansas River drainages that have known or potential populations of the Preble's mouse (Figure 3).

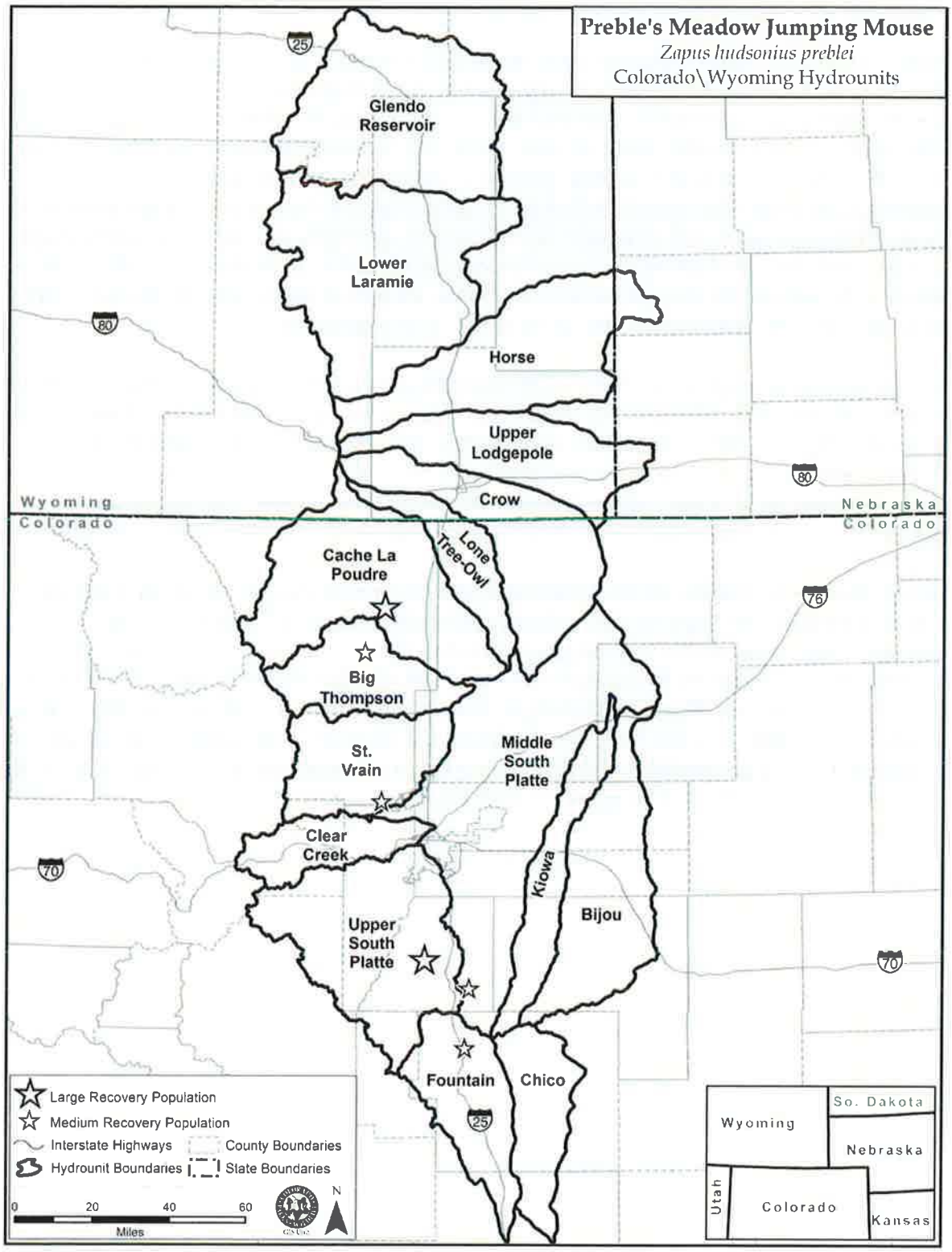

Figure 3. Eight-digit Hydrologic Unit Codes (HUCs) in Colorado and Wyoming with Location of Potential Large and Medium Sized Preble's Meadow Jumping Mouse (*Z. h. preblei*) Recovery Populations. Small-sized Recovery Populations have yet to be designated.

4. Designating Small, Medium, and Large Recovery Populations

Recovery population sizes, extent, and distribution were selected to provide a reasonably high probability of persistence for each individual population as well as for the entire subspecies. The sizes were based upon general conservation biology theory regarding population viability as well as input from biologists with knowledge of Preble's mouse distribution, habitat condition, and life history. Probability of persistence is enhanced by combining population size with redundancy in the development of this recovery strategy. Historical population sizes of this subspecies are not documented; although, it is expected that some hydrological units contained large populations, some medium and some small due to habitat variability in time and space. Based on the literature described below, recovery population sizes are defined as follows:

Large populations are self-sustaining, naturally occurring populations that demonstrate June abundance estimates of 2,500 adult Preble's mice, with no long-term significant negative trend in percent occupancy. Population abundance and trend are determined using the Population Monitoring Plan (see task 2.2.1). Larger population sizes provide greater physical diversity of habitats and less vulnerability to natural or anthropogenic catastrophic events, while reducing the per unit area management costs. Due to the size of the habitat required to support these populations, large populations should incorporate most of the landscape-level ecological processes associated with the subspecies.

Medium populations are self-sustaining, naturally occurring populations that demonstrate June abundance estimates of 500 to 2,499 adult Preble's mice, with no long-term significant negative trend in percent occupancy. Population abundance and trend are determined using the Population Monitoring Plan (see task 2.2.1). Based upon conservation theory (Groom *et al.* 2006; Primack 2002), medium populations are at greater risk than large populations, but have a higher probability of persistence than small populations. For maximum protection of this subspecies, most medium populations identified by this plan should be as large and numerous as possible to increase the probability of the subspecies' persistence.

Small populations are defined as those that demonstrate a continued long-term presence of the Preble's mouse within 3 miles of connected stream habitat. Although small populations are expected to be approximately 150 adults, no minimum population size is required for small populations. Population abundance and trend are determined using the Population Monitoring Plan (see task 2.2.1). Small populations are intended to provide geographic distribution throughout the existing range, and are expected to conserve the existing range of genetic diversity in the subspecies.

The numbers identified above for large, medium and small populations are based on the best available science and represent estimations. It must be recognized that these numbers may be altered in the future if changes are supported by new scientific information and approved by the Service.

Conservation biology literature suggests various numbers of individuals may be necessary to support long-term viability. The general rule of thumb used in conservation biology has been the

50/500 rule: isolated populations need to have a genetically effective population size of at least 50 individuals for short-term persistence, and a genetically effective population size of about 500 for long-term survival (Franklin 1980). The genetically effective population size designates that part of the population in which all individuals have an equal probability of mating and having offspring. In most natural populations the effective population of breeding individuals is often much smaller than the total population size (CSIESA 1995). An effective population size of about 500 individuals translates into a total population size of several times this number (CSIESA 1995; Lacy 1995; Soule 1987).

Some biologists have questioned the adequacy of the 50/500 rules. Mangel and Tier (1994) indicate that the probability of environmental catastrophes greatly increases the need for larger populations. Lande (1995) estimated the need for a genetically effective population size of approximately 5,000 for long-term persistence, which may translate to a total population size of 10,000 to 20,000 individuals. However, the generalization that a population size in the low thousands is the smallest number of individuals needed for long-term persistence is widely accepted (Soule 1987; CSIESA 1995) and was used to guide the selection of populations for this Plan.

5. Selecting Emergent Preble's mice for Estimating Population Abundance

Emergent animals are individuals that have survived winter and emerged from hibernation. This segment of the population was selected because it represents the initial number of animals available for reproduction in the current year. Basing conservation strategies on segments of the population present later in the breeding season (July-September) may inflate estimates of the number of individuals that will survive and reproduce. Although the use of emergent mice for sampling purposes does not compensate for all the differences between effective and actual population size, it does help minimize the difference between the two, since all emergent adults are potential breeders and the generation overlap is not as significant as it would be later in the summer.

6. Establishing Guidelines for Estimating Stream Miles Required for Recovery Sites

The associated habitat lengths for the defined size classes of populations were developed with input from researchers with direct knowledge of Preble's mouse populations and habitat. The habitat lengths for a particular category of population size are considered minimum miles of a connected stream network whose hydrology supports riparian vegetation, provides Preble's mouse habitat, and includes mainstem drainages and tributaries.

Because Preble's mice are found in linear riparian communities, the length of riparian habitat required for large, medium, and small populations is based on average density of mice per kilometer or mile of stream corridor. Abundances for a specified length of stream have been estimated for the subspecies in Colorado using capture-recapture techniques as described in Otis *et al.* (1978) and Anderson *et al.* (1983).

A known bias in capture-recapture studies from trapping transects or lines is that the traps tend to attract mice from some unknown distance away from the trapping transect (White and Shenk

1999). Furthermore, study areas have unequal lengths of stream reaches trapped. Therefore, simple density estimates of the number of mice divided by stream length is biased high, more so for shorter transects than for longer ones. To remove this bias, a correction factor was developed using radio-telemetry data to estimate the proportion of time radio-collared mice spent within the original trapline once the traps were removed (White and Shenk 1999). Data from six study sites with radio-collared Preble's mice were used to estimate this correction factor (called "p") for population estimates from linear traplines or grids. Corrections were applied to all study areas with the function relating (p) to trapline length (L) developed from these data. The mean estimate of mice per mile of stream from nine study sites, 1998 to 1999, was 53 mice/mile (standard error = 8 mice/mile, sample size = 15 sites), with a range of 6 to 107 mice/mile (White and Shenk 2000). Shenk reanalyzed the data referenced above with data from 2000 and 2001, for a total sample size of 25 sites; this analysis provided a mean of 44 mice/mile (standard error = 6 mice/mile), and a range of 3 to 107 mice/mile (T. Shenk, Colorado Division of Wildlife, unpublished data; R. Schorr, Colorado Natural Heritage Program, unpublished data; C. Meaney, University of Colorado, unpublished data; T. Ryon, Greystone Consultants, unpublished data; M. Bakeman, Ensight Technical Services, unpublished data; M. Fink, unpublished data). Further analysis with new sites and additional years of data may change the above estimate.

Based upon the current mean density of 44 mice/mile (standard error of 6 mice/mile), the following provides guidelines for estimated stream miles for large and medium recovery populations, and required miles for small populations:

Large populations (June abundances of 2,500 individuals or greater) will likely need a 57-mile (45- to 78-mile) network of functionally connected streams whose hydrology supports riparian vegetation and provides Preble's mouse habitat; this will include the mainstem plus tributaries. Functionally connected is defined in this plan as a stream or riparian corridor with small stretches of less than suitable habitat that the Preble's mouse is capable of traversing and maintaining genetic flow between otherwise fragmented habitat. For the purpose of this plan, streams are functionally connected if the distance of less than suitable habitat (but not bare ground) is less than ¼ mile; approximately two times the documented travel distance (215 m) of Preble's in unsuitable habitat (RFETS 1998). This current estimate of miles to maintain 2,500 mice is based upon the mean number of mice that occur per stream mile as estimated from current data (1999-2001), and may not necessarily apply to a specific site due to variations in habitat quality. The intent is to protect enough stream miles of habitat to support the population goal of 2,500 mice.

Medium populations (June abundances of 500 individuals or greater) will likely need an 11-mile (9- to 16-mile) network of functionally connected streams whose hydrology supports riparian vegetation and provides Preble's mouse habitat; this will include the mainstem plus tributaries. This current estimate of miles to maintain 500 mice is based upon the mean number of mice that occur per stream mile as estimated from current data (1999-2001), and may not necessarily apply to a specific site due to variations in habitat quality. For maximum protection of this subspecies, most medium populations should occupy stream habitats that exceed the minimum to support 500 mice.

Small populations (defined as those showing at least continued presence of Preble's mouse) must have at least 3 miles of connected stream habitat.

It must be emphasized that the recovery goal for large and medium populations is numbers of mice, not numbers of stream miles inhabited. Thus, enough stream miles need to be protected to ensure that numeric population goals for large and medium populations can be maintained. Because the figure of 44 mice/mile is a mean for the current Preble's mouse research populations, at least some populations of any particular size are likely to show a lower density and, therefore, would need a larger stretch of habitat in order to meet population recovery goals. Alternatively, some sites may support higher densities of mice than the estimated mean, and could meet population recovery goals with fewer stream miles.

7. Determining Number and Distribution of Recovery Populations

The distribution of Preble's mouse recovery populations is designed to minimize the impacts of threats such as weather, disease, fragmentation, anthropogenic factors, loss of genetic diversity and other threats to the subspecies. The recommended approach to conserving the geographic and genetic diversity of the Preble's mouse is to conserve at least one recovery population within each HUC within the existing range of the taxon. Recovery populations will be distributed among 13 of the 16 HUCs within the range of the Preble's mouse to maintain redundancy and representation for the subspecies between Recovery Units as follows (Table 1):

North Recovery Unit. One large and three medium populations in four separate HUCs, as well as three small populations within each of the remaining six HUCs within the North Recovery Unit.

South Recovery Unit. One large population and two medium populations in three separate HUCs, as well as three small populations in each of the remaining four HUCs within the South Recovery Unit.

At this time, additional survey data are needed to establish whether some of these HUCs are, or are not, occupied by the Preble's mouse. These HUCs will be assumed to be occupied by the Preble's mouse unless surveys of suitable habitat demonstrate to the Service's satisfaction that a HUC is not occupied. If a HUC is found to support only one or two small populations, then those populations will be designated as recovery populations, and designation of additional recovery populations will not be required in that HUC.

If a HUC is found not to contain any Preble's mouse populations following a survey approved by the Service, no recovery populations will be required for that HUC. In order to remove a HUC from recovery efforts or to designate fewer than 3 small populations in HUCs not containing a large or medium population, a number of factors will need to be evaluated. These factors include targeted surveys in Preble's mouse habitat, assessment of habitat suitability, opportunities for restoration and enhancement, etc. If it is felt that a HUC should be removed or the number of required populations should be reduced, supporting data should be compiled and presented to the Recovery

Team. The Team will then review the results and make a recommendation to the Service who will then make a final determination regarding the classification of currently designated HUCs.

If criteria for protecting the specified large and medium populations of the Preble's mouse have been met for a recovery unit, but the goal of conserving three small or one medium population in each of the remaining HUCs has not been met, the Service will determine whether the geographic and genetic diversity for the Preble's mouse has been adequately conserved in that recovery unit. In making this determination, the Service will consider conservation efforts to date, existing data regarding presence and geographic distribution of the Preble's mouse, potential for conducting additional surveys, opportunities for habitat enhancement or mitigation, any available data regarding genetic diversity, and current and future threats to the geographic or genetic diversity of the Preble's mouse.

As described in strategy 3 (above), the number of recovery populations identified for each recovery unit is based on the best available science. Therefore, this strategy may need to be altered in the future if changes are supported by new scientific information. It is important that a recovery plan incorporates new scientific information as it arises and supports implementation of recovery through adaptive management.

Table 1. Locations of Designated Recovery Populations, 2010.

Recovery Unit	8-Digit HUC	General Location
North Recovery Unit		
1 Large	Cache La Poudre	North Fork Cache la Poudre River
3 Medium	Big Thompson	Buckhorn Creek
	St. Vrain	South Boulder Creek (or St. Vrain River)
	Glendo Reservoir (or Lower Laramie)	To be determined
18 Small	Lower Laramie (or Glendo Reservoir)	To be determined
	Lower Laramie (or Glendo Reservoir)	To be determined
	Lower Laramie (or Glendo Reservoir)	To be determined
	Horse	To be determined
	Horse	To be determined
	Horse	To be determined
	Upper Lodgepole	To be determined
	Upper Lodgepole	To be determined
	Upper Lodgepole	To be determined
	Crow	To be determined
	Crow	To be determined
	Crow	To be determined
	Lone Tree-Owl	To be determined
	Lone Tree-Owl	To be determined
	Lone Tree-Owl	To be determined
	Clear Creek	To be determined
	Clear Creek	To be determined
	Clear Creek	To be determined

Recovery Unit	8-Digit HUC	General Location
South Recovery Unit		
1 Large	Upper South Platte	West Plum Creek and Plum Creek
2 Medium	Fountain	Monument Creek/Air Force Academy
	Middle South Platte - Cherry Creek[1]	Middle South Platte-Cherry Creek
12 Small	Chico	To be determined
	Chico	To be determined
	Chico	To be determined
	Big Sandy	To be determined
	Big Sandy	To be determined
	Big Sandy	To be determined
	Kiowa	To be determined
	Kiowa	To be determined
	Kiowa	To be determined
	Bijou	To be determined
	Bijou	To be determined
	Bijou	To be determined

Note: HUCs listed as "to be determined" have the potential to hold Preble's mouse populations but have not yet been assigned designated sites for recovery populations. Some HUCs contain excellent habitat that either has not been trapped or short-term trapping efforts did not result in any Preble's mouse captures. Additionally, in some cases, the species was captured, but subsequent trapping efforts failed to verify its occupancy.

8. Delineating Preble's mouse Habitat

Preble's mouse habitat includes riparian systems, the intervening slopes between riparian and upland communities, and upland grasslands (Bakeman 1997; Shenk and Sivert 1999a; Schorr 2001). The width of Preble's mouse habitat is defined as the 100-year flood plain plus 328 feet on both sides of the creek. Final habitat delineations for each recovery site will be determined by each Site Conservation Team and approved by the Service. However, alternatives to the 100-

[1] HUC occurs both north and south of Denver, recovery populations occur south of Denver.

year flood plain rule will be considered if:

1) The area delineated provides all the necessary resources for the mice to nest, breed, find cover, travel, feed, and hibernate; i.e., for long-term survival; or

2) The area delineated includes the three contiguous geomorphological components used by Preble's mouse: alluvial flood plain, transition slopes, and pertinent uplands (grasslands for feeding and suitable hibernation sites).

Shenk and Sivert (1999a) observed summer movements in excess of 328 feet outward from the stream, but in most instances upland habitat use was within 328 feet of the 100-year flood plain delineation. Most presumed hibernation sites also were located within 328 feet of the 100-year flood plain delineation of the main stream.

9. Designating Self-sustaining Populations as the Measure of "Recovery"

For this Plan, recovery populations are defined as self-sustaining, naturally functioning populations that are not maintained by "stocking" or captive breeding. Translocations and captive breeding may be difficult and can present potentially high risks, and will only be considered as a last resort for maintaining a population or as a means to maintain genetic diversity.

Restoration of individuals to previously occupied areas, without an understanding of why the area no longer supports the subspecies, would likely result in resources (e.g., animals, time, and money) being lost to establish reintroduced populations that may meet the same fate as the original population that occupied the area. Furthermore, restocking areas with individuals genetically dissimilar from the individuals in the original population does not protect genetic variability.

10. Selecting Public Lands Over Private Lands as Areas for Preble's mouse Recovery

Selecting public lands as areas for recovery may ensure the implementation of timely and effective land management for the mouse. Where possible, recovery sites are designated on public lands because the likelihood of maintaining stable populations is greater on public lands. Managing land for a common purpose and ensuring consistency in land management practices is easier on larger public lands than on a host of smaller private parcels. Also, designating recovery populations on public property minimizes and/or avoids the potential conflict between private landowners' land management strategies and those strategies recommended for conservation of the Preble's mouse; such conflict-avoidance may increase support for achieving recovery. Lastly, many public lands have natural resource management strategies in place to conserve the mouse or its habitat.

11. Collaborating with Private Landowners to Achieve Recovery

Given the expansive private lands in eastern Colorado and Wyoming, it is likely that public lands will be unable to carry the entire burden of recovery efforts. Private landowners in these states

have a long and successful history of conservation efforts. Where designation and protection of Preble's mouse recovery populations will require private landowner collaboration, it will be important to seek incentives for conservation efforts in order to assist private landowners in managing and protecting habitat and offset potential costs associated with recovery. Incentives should be developed to encourage participation, build partnerships, and foster cooperation with recovery efforts. These can include Preble's mouse recovery funds and tax incentives at the federal, state, or county level to encourage active conservation measures on private lands, including but not limited to the establishment of financial award / reward systems for participation in recovery programs, and / or funding for voluntary conservation easements.

12. Populations Not Designated as Recovery Populations

A set number of large, medium, and small populations will be designated as recovery populations. However, many populations within the range of the Preble's mouse will not be designated as recovery populations. When appropriate and feasible, it may be useful to consider protecting these populations in areas outside of designated recovery populations to hasten recovery. Although not required, it may be advantageous to protect additional, non-designated recovery populations as insurance in the event that one or more of the designated populations declines and in order to buffer the subspecies as a whole from threats resulting from a catastrophic event. If a recovery population is lost, it may be possible to use these additional populations to replace a lost population to meet recovery goals.

13. Identifying Additional Research Needs

Previous research on Preble's mouse taxonomy, distribution, demography, ecology, and habitat has been essential in informing the best approaches to its conservation. These descriptive studies have been helpful in understanding the subspecies' biology and suggesting why it uses certain habitats. Research designed to determine cause-and-effect relationships between the mouse and its habitat needs to be conducted. Understanding how habitat factors affect populations is important to ensuring the persistence of this subspecies.

Much additional research is still needed, both descriptive and experimental. This includes research on the systematics, range, and distribution of the mouse; identification of management practices that enhance habitat and populations; identification of threats to the persistence and distribution of populations; further refinement of suitable habitat criteria; and development of threat abatement strategies for habitat. Some specific examples of needed research to facilitate recovery include, but are not limited to, projects identified in Appendix C (Research).

14. Using Adaptive Management

Adaptive management is a process by which policy decisions are implemented within a framework of scientifically-driven experiments to test predictions and assumptions inherent in management plans. There is still much about Preble's mouse biology and habitat management that is not well understood. A well-designed adaptive management program may answer some of these questions and be used to modify existing management strategies. Adaptive management should be a strong consideration in the development of site-specific threat abatement strategies

developed by the Site Conservation Teams.

15. Focusing on Single Species Recovery

The development of this plan focused on a single species strategy for recovery of the Preble's mouse within the Platte and Arkansas River drainages of Colorado and Wyoming. Although the actions recommended by the Plan are focused on the Preble's mouse, the protection of populations and habitat for this subspecies may benefit other listed and declining species within riparian habitats of Colorado and Wyoming. At some time in the future, a multi-species plan for declining Wyoming-Colorado Front Range species may be considered.

16. Managing for Genetic Diversity

The goal of genetic management within this Plan is to preserve and conserve the range of unique morphological, ecological, and behavioral characteristics of the subspecies that are presumed to exist on a population by population basis. Work completed to date on mitochondrial DNA (Riggs *et al.* 1997; King *et al.* 2006a) indicated that Preble's mouse is a distinct genetic lineage. The Recovery Team may consider completing a genetics management plan in the future, based upon information obtained through the completion of genetic research proposed by this Plan.

17. Concentrating Recovery on Delisting Factors

Section 4 of the ESA governs the listing, delisting, and reclassification of species, the designation of critical habitat, and recovery planning. Regulations implementing listing, delisting, reclassification, and critical habitat designation are codified at 50 CFR 424.

The process of delisting a species (or subspecies), is essentially the same as that of listing: a proposed rule describing the justification for the action is published in the Federal Register, a public comment period is opened (including public hearings if requested), and, within 1 year of the proposal, either a final rule delisting the species or a notice withdrawing the proposed delisting is published in the Federal Register.

In considering whether to delist a species, the same five factors considered in the listing process are evaluated:

- Factor A. The presence or threatened destruction, modification, or curtailment of the species' habitat or range.
- Factor B. Overutilization for commercial, recreational, scientific, or educational purposes.
- Factor C. Disease or predation.
- Factor D. The inadequacy of existing regulatory mechanisms.
- Factor E. Other natural or manmade factors affecting the species' continued existence.

It is believed that there are currently sufficient Preble's mouse populations to ensure the subspecies' survival. However, there are substantial threats to many of the populations that, if left unabated, may cause their decline or extirpation in the future. Therefore, this recovery plan focuses on designating enough recovery populations of sufficient size over a broad geographic

range and protecting them from threats to their survival.

The abatement of threats relating to criteria one through five, identified below, are believed to be adequate for delisting Preble's mouse. When these threats are lessened or eliminated for each recovery population, an analysis of the above factors should show the subspecies is no longer in need of protection under the ESA.

Criteria for Delisting

The Preble's mouse will be considered recovered and eligible for delisting when it is demonstrated that:

1. Two large and five medium populations distributed across the range maintain stable or increasing trends over a 20-year period based on data obtained from standardized monitoring methods. Population sizes are defined on pages 34 and 35 of this plan. The recovery populations will be distributed among the following Recovery Units:

North Recovery Unit. One large and three medium (one being in Wyoming) populations in four separate HUCs will be located within the North Recovery Unit.

South Recovery Unit. One large population and two medium populations in three separate HUCs will be located within the South Recovery Unit.

At this time, insufficient survey data exist to establish whether some of these HUCs are, or are not, occupied by the Preble's mouse. These HUCs will be assumed to be occupied by the Preble's mouse unless trapping surveys of suitable habitat demonstrate to the Service's satisfaction that a HUC is not occupied. If a HUC is found to support only one or two small populations, then those populations will be designated and designation of additional populations will not be required in that HUC. If a HUC is found not to contain any Preble's mouse populations following a survey approved by the Service, no recovery populations will be required for that HUC.

2. To protect sufficient numbers of small populations to provide for representation, resiliency, and redundancy, in each of the 10 HUCs that are not occupied by a large or medium population and that contain suitable Preble's mouse habitat, an additional three small populations are maintained over a 20-year period based on data obtained from standardized monitoring methods. At present, this is estimated at 9 of 10 targeted HUCs not holding large or medium populations. If a HUC is found to support only one or two small populations, then those populations will be designated and designation of additional populations will not be required in that HUC. If a HUC is found not to contain any Preble's mouse populations following a survey approved by the Service, no recovery populations will be required for that HUC.

3. At least the minimum stream mileage for each population size (large population = 57 miles, medium population = 11 miles, small population = 3 miles, see Section 5 under Recovery Strategies, page 35 and 36 of this plan) is protected and under a management plan that addresses conservation of Preble's mouse; priority is given to public lands and

lands that provide connectivity. The plans, at a minimum, manage for the threats as outlined in Table 2.

4. County or local government regulations or other protection mechanisms, as set forth in the de-listing criteria for Factor D, have adequate compliance and enforcement.

5. As required by the ESA, a post-delisting management plan for Preble's mouse and its habitat is completed, in cooperation with state and local governments, to ensure the designated recovery populations are maintained at self-sustaining levels.

Table 2. Threat tracking table of the current and previously identified threats for the Preble's meadow jumping mouse, by the five listing factors, with their associated recovery criteria and recovery actions.

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
A - The presence or threatened destruction, modification, or curtailment of the species' habitat or range				
	Livestock Grazing	3	Glendo Reservior, Lower Laramie, Horse, Upper Lodgepole, Crow, Lone Tree-Owl	In cooperation with local Site Conservation Teams, develop and implement grazing practices that are compatible with Preble's mouse habitat and include minimizing grazing and livestock trampling within the riparian area; Promote incentives to encourage conservation and offset potential costs associated with recovery (Actions: 2.3 - 2.5, 5.0, 5.4)
	Agriculture (row crops, haying, irrigated)	3	Glendo Reservior, Lower Laramie, Horse, Upper Lodgepole, Crow, Lone Tree-Owl	In cooperation with local Site Conservation Teams, develop and implement agriculture practices that are compatible with Preble's mouse habitat that include minimizing agriculture within the riparian area; Where necessary and feasible, provide incentives to slow the conversion to agriculture (Actions 2.3 - 2.5, 5.0, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
	Residential and Commercial Development	3,4	Lower Laramie, Crow, Cache La Poudre, Big Thompson, St. Vrain, Clear Creek, Upper South Platte, Fountain, Middle South Platte, Kiowa, Chico, Lone Tree-Owl	Work with county commissions and land-use planners to identify and protect known and potential Preble's mouse habitat, avoid development in areas of known Preble's mouse populations, promote low-impact development, and develop and implement guidelines that are compatible with Preble's mouse persistence; Evaluate gradations of development on Preble's mouse populations (Actions: 2.2, 2.3, 3.1, 3.8, 4.3, 5.0)
	Hydrologic Changes	3,4	All HUCs	Work with the local water community to improve hydrological function for Preble's mouse within the context of water law and maintain or restore current, suitable hydrologic regimes that maintain habitat of Preble's mouse; Plans should include urban and conservation water uses and ground and surface water; Avoid locating reservoir and diversion projects at known Preble's mouse sites whenever possible; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 1.1, 2.2, 2.3, 2.5, 3.5, 3.8, 4.1, 5.0, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
	Transportation, Recreation, and other Rights-of-way Through Habitat	3,4	All HUCs	Develop and implement compatible practices for Preble's mouse habitat that improve and restore existing infrastructure to minimize impacts and avoid or minimize additional impacts to riparian areas; Prevent or minimize night-time use and lighting in urban areas by adhering to dark-sky compliant lighting (Actions: 2.2 - 2.5, 3.2 - 3.4, 3.8, 5.0)
	Aggregate Mining	3,4	Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Chico, Bijou, Middle South Platte, Kiowa, Crow	Work with the mining industry to develop and implement compatible practices that avoid, minimize, or mitigate actions in Preble's mouse habitat and avoid known Preble's mouse populations; Develop restoration standards to maximize protection and restoration of Preble's mouse and its habitat and return riparian areas to a condition conducive to Preble's mouse (Actions: 1.1, 2.2 - 2.4, 3.6, 3.8, 5.0)
	Oil, Gas, and Mineral Exploration and Extraction	3,4	Upper Lodgepole, Crow, Lone Tree-Owl, Middle South Platte, Kiowa, Bijou, Chico	Work with state and local regulatory agencies and industry to develop guidelines for practices compatible with Preble's mouse habitat and populations that include: mining, roads and other infrastructure, water, and toxicity; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 1.1, 2.2, 2.3, 3.7, 3.8, 5.0, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
C - Disease or predation.				
	Skunk, Raccoon, Domestic/Feral Cats, Bullfrogs	3	Lower Laramie, Crow, Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Clear Creek, Upper South Platte, Fountain, Chico, Bijou, Kiowa, Middle South Platte	Develop and distribute recommendations that encourage adoption of policies to minimize human-associated predators to educate residents and minimize availability of food to mesocarnivores; Remove human-associated predators and bullfrogs where feasible and appropriate (Actions: 4.3, 5.0)
D – The inadequacy of existing regulatory mechanisms				
	Residential and Commercial Development	4	Lower Laramie, Crow, Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Clear Creek, Upper South Platte, Fountain, Chico, Bijou, Kiowa, Middle South Platte	Increase protection of Preble's mouse through the creation, strengthening, and enforcement of regulatory mechanisms to protect riparian systems and minimize or remove identified threats to Preble's mouse on federal and state lands; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 3.1, 3.8, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
	Hydrologic Changes	4	All HUCs	Increase protection of Preble's mouse by creating, strengthening, and enforcing regulatory mechanisms to protect riparian systems; minimize or remove identified threats to Preble's mouse on federal and state lands; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 3.5, 3.8, 5.4)
	Transportation, Recreation, and other Rights-of-way Through Habitat	4	All HUCs	Increase protection of Preble's mouse through the creation, strengthening, and enforcement of regulatory mechanisms to protect riparian systems and minimize or remove identified threats to Preble's mouse on federal and state lands; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 3.2 - 3.4, 3.8, 5.4)
	Aggregate Mining	4	Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Chico, Bijou, Middle South Platte, Kiowa, Crow	Increase protection of Preble's mouse through the creation, strengthening, and enforcement of regulatory mechanisms to protect riparian systems and minimize or remove identified threats to Preble's mouse on federal and state lands; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 3.6, 3.8, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
	Oil, Gas and Mineral Exploration and Extraction	4	Upper Lodgepole, Crow, Lone Tree-Owl, Middle South Platte, Kiowa, Bijou, Chico	Increase protection of Preble's mouse through the creation, strengthening, and enforcement of regulatory mechanisms to protect riparian systems and minimize or remove identified threats to Preble's mouse on federal and state lands; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 3.7, 3.8, 5.4)
E – Other natural or manmade factors affecting the species' continued existence				
	Instability of Small/Isolated Populations	1,2,3	All HUCs	Improve, expand, and promote habitat to increase population sizes and improve and maintain connectivity; Evaluate genetics to determine and protect genetically important populations; Evaluate feasibility and develop protocols for translocation if needed; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 1.1, 1.3, 1.4, 2.2 - 2.5, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
	Non-native Plants	3	Glendo Reservoir, Lower Laramie, Horse, Crow, Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Clear Creek, Upper South Platte, Fountain, Chico, Bijou, Kiowa, Middle South Platte	Implement existing Integrated Pest Management (IPM) policies and develop and implement IPM protocols specific to Preble's mouse habitat; Remove non-native plants whenever possible; Evaluate research needs on the importance of non-native plants on Preble's mouse populations; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 2.4, 5.0, 5.4)
	Drought	3,5	All HUCs	Work with the local water community to improve hydrological function for Preble's mouse within the context of water law and maintain or restore current, suitable hydrologic regimes that maintain habitat of Preble's mouse; Plans should include urban and conservation water uses and ground and surface water and seek to maintain resiliency in light of drought; In drought years, focus on minimizing secondary impacts to riparian areas; Investigate water use policies that might benefit stream hydrology during drought; Utilize natural processes to promote resiliency such as beavers and willows; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 2.3, 2.4, 3.5, 3.8, 4.1, 4.2, 5.0, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
	Global Climate Change	3,5	All HUCs	Implement climate change adaptation and resiliency (Gordon and Ojima 2015, Colorado climate change vulnerability study) (Actions: 3.8, 4.1, 4.2. 5.0)
	Flood	3,5	All HUCs	Encourage maintenance of natural sinuosity of streams and vegetation in an effort to promote resiliency; Look into policies that maintain appropriate habitat for Preble's mouse; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 2.3, 2.4, 3.5, 3.8, 4.1, 4.2, 5.0, 5.4)
	Wildfire	3,5	Glendo Reservoir, Lower Laramie, Crow, Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Clear Creek, Upper South Platte, Fountain, Chico, Bijou, Kiowa, Middle South Platte	Evaluate prescribed burning to reduce fuels if necessary and develop and implement protocols to promote habitat resiliency; Implement post-fire habitat management that addresses vegetation, invasive species, and hydrology to benefit Preble's mouse; Ensure populations of Preble's mouse are prioritized in plans for habitat management; Fire wise communities should consider Preble's mouse habitat needs when implementing control in riparian habitat; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 2.3, 2.4, 3.8, 4.1, 4.2, 5.0, 5.4)

Listing Factor	Threat	Recovery Criteria (point at which the threat is abated)	HUC	Recovery Action
	Secondary impacts	3	Lower Laramie, Crow, Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Clear Creek, Upper South Platte, Fountain, Chico, Bijou, Kiowa, Middle South Platte	Develop and implement education campaigns to make public aware of issues to wildlife from secondary impacts; Work with county commissions and land-use planners to identify and protect known and potential Preble's mouse habitat, promote low-impact development, and develop and implement guidelines that are compatible with Preble's mouse persistence; Develop and distribute recommendations that encourage the adoption of policies to minimize human-associated competitors to educate residents; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 3.1, 4.3, 5.0, 5.4)
	Pesticides / herbicides	3	Lower Laramie, Horse, Upper Lodgepole, Lone Tree-Owl, Cache La Poudre, Big Thompson, St. Vrain, Clear Creek, Upper South Platte, Fountain, Chico, Bijou, Kiowa, Middle South Platte	Conduct research on use of pesticides and herbicides and the level of threat to Preble's mouse populations; Distribute information to and through county weed managers regarding the impacts of pesticides and herbicides on Preble's mouse; Ensure appropriate training and certification is obtained for applying herbicides and pesticides when applicable and that labels are properly followed; On private lands, work with landowners to seek and acquire incentives to promote conservation efforts and offset potential costs (Actions: 4.4, 5.0, 5.4)

Recovery Action Narrative

1. **Monitor status of existing populations of the Preble's mouse**

1.1. **Identify Large, Medium, and Small Preble's mouse Recovery Populations.** Recovery populations will be identified in coordination with the appropriate land management agency or landowner. Priority will be given to lands in federal, state, or other public ownership. Most required large and medium recovery populations within the existing range of the Preble's mouse in the North and South Recovery Units have been identified (Table 1); one medium population still needs to be identified in Wyoming. Some small recovery populations must also still be identified. However, all recovery populations will be delineated within 3 years of the establishment of the Site Conservation Team.

Site Conservation Teams will designate remaining recovery populations in each of the following HUCs (Table 1):

- Bijou, Clear Creek, Crow, Glendo Reservoir, Horse, Kiowa, Lone Tree-Owl, Lower Laramie, and Upper Lodgepole HUCs in the Platte drainage
- Big Sandy and Chico HUCs of the Arkansas drainage

At this time, insufficient survey data exist to establish whether some of these HUCs are, or are not, occupied by the Preble's mouse. These HUCs will be assumed to be occupied by the Preble's mouse unless surveys of suitable habitat demonstrate to the Service's satisfaction that a HUC is not occupied. If a HUC is found to support only one or two small populations, then those populations will be designated as recovery populations and designation of additional recovery populations will not be required in that HUC. If a HUC is found not to contain any Preble's mouse populations following a survey approved by the Service, no recovery populations will be required for that HUC.

If Preble's mice are present within a HUC and recovery populations are not designated within 3 years of the establishment of the Site Conservation Team, the Service will designate the remaining recovery populations.

1.2. **Implement long-term monitoring programs.** Monitoring of designated recovery populations is needed to determine their existing size and trend according to the Preble's mouse Population Monitoring Methodology (see 1.3). Other monitoring methodologies may be considered in the future, if they are found by the Service to be scientifically valid in determining population trend (e.g., occupancy modeling). In Wyoming, for example, it is necessary to conduct genetic testing on captures because of the overlap of Preble's mice and western jumping mice. This additional component adds substantial cost to the effort. In such cases, the monitoring methodology may need to be tailored to ensure that scientifically valid sampling can be conducted in a cost-effective manner. Site-specific threat abatement plans developed by Site Conservation Teams can be adapted depending on documented trends to better promote recovery. Results of the monitoring will be provided to the Service and/or the Recovery Team.

1.2.1. **Establish monitoring program for all known large and medium recovery populations.** Designated large and medium recovery populations will be monitored for June (pre-breeding) population sizes and trends according to the Population Monitoring Methodology (see 1.3). Monitoring will begin within 2 years of delineation of the Preble's mouse recovery population. Results of the monitoring will be used to evaluate and modify the Threat Abatement Plans using adaptive management.

1.2.2. **Establish monitoring program for small recovery populations as needed for recovery to document persistence.** All designated small recovery populations will be monitored at a minimum for presence/absence according to the Population Monitoring Methodology. Monitoring will begin within 2 years of delineation of the Preble's mouse recovery population. Results of the monitoring will be used to evaluate and modify the Threat Abatement Plans using adaptive management.

1.3. **Develop a Peer-Reviewed Preble's mouse Population Monitoring Methodology.** A Population Monitoring Methodology will be developed by experts in population monitoring. This will describe a methodology to assess current population status and identify population trends. This Methodology will be completed within 1 year of the approval of this plan and updated as new scientific information and techniques become available. The Population Monitoring Methodology will be approved by the Service and the Recovery Team and made available on the Service website.

1.4. **Investigate the potential of establishing new populations within historic Preble's mouse range.** Although we do not anticipate the need for population supplementation or reintroduction in order to recover the Preble's mouse, this investigation will allow for the potential to do so should unforeseen events require more intensive population management.

1.5. **Further investigate the genetic variation within and among Preble's mouse populations.** This research will use accepted scientific techniques to further inform the distribution of the Preble's mouse, as well as their genetic diversity and integrity. This research may also be used to refine future recovery strategies.

2. **Identify, protect, evaluate and restore Preble's mouse habitat.**

2.1. **Map and monitor habitat of Preble's mouse recovery populations**. Habitat within delineated Preble's mouse recovery populations will be mapped as described in the approved Preble's mouse Habitat Monitoring Methodology. Site Conservation Teams will complete this mapping within 2 years of delineation of the recovery population. Preble's mouse habitat in all delineated recovery populations will be monitored to determine trends in habitat quantity and quality, according to the Preble's mouse Habitat Monitoring Methodology. Other monitoring methodologies may be considered in the future if they are found by the Recovery Team and Service to be scientifically valid in determining trends in habitat quality and quantity. Results of all habitat monitoring will

be reported to the Service as required by the Habitat Monitoring Methodology. Results of the monitoring will be maintained by the Service.

2.2. **Identify potential Preble's mouse habitat**. Surveys of potential recovery sites are needed to determine Preble's mouse presence to designate small populations. Estimated population size and distribution will be necessary to designate the remaining undesignated medium-sized population. Surveys are still needed in the following HUCs:

- Bijou, Clear Creek, Crow, Glendo Reservoir, Horse, Kiowa, Lone Tree-Owl, Lower Laramie, and Upper Lodgepole HUCs in the Platte drainage
- Big Sandy and Chico HUCs of the Arkansas drainage

Within other HUCs, additional surveys may prove useful for providing options during the designation of recovery populations and when recovery populations are delineated. Where appropriate, newly discovered populations can replace designated recovery populations if they meet the Recovery Criteria

2.3. **Protect existing Preble's mouse habitat on federal, state, local, and private lands.** Habitat protection of designated recovery populations is needed to maintain habitat quantity and quality as required for recovery. Non-designated populations are important because they could contain genetic information not found in designated populations. Protection of non-designated sites also provides additional research locations as well as replacement or alternative recovery populations if needed to meet recovery goals. Site Conservation Teams will work with land management agencies and land owners to identify habit protections needed within populations and to implement these actions.

2.3.1. **Protect and conserve Preble's mouse populations through federal actions.** Section 7 of the ESA mandates that all federal agencies shall utilize their authorities to conserve listed species on their lands. To implement Preble's mouse recovery, federal agencies are responsible for identifying, protecting and mapping all Preble's mouse populations on federal lands, abating threats, and where biologically appropriate, restoring and/or improving habitat on their lands to enhance Preble's mouse populations. When conducting, funding or permitting activities on non-federal land, each federal agency will ensure those activities include measures that support recovery objectives. At federal sites with a history of Preble's mouse research, that research will continue in order to facilitate gathering long-term information on Preble's mouse habitat and ecology.

2.3.2. **Protect and conserve Preble's mouse populations through state and local public agency actions.** State agencies and county and municipality open space programs all manage lands known to support the Preble's mouse. To further Preble's mouse recovery, these agencies are encouraged to identify and protect all Preble's mouse populations, abate threats, and where biologically appropriate, restore and/or improve Preble's mouse habitat on these lands. Cooperative agreements or other mechanisms will be encouraged to protect and conserve the Preble's mouse and its habitat.

Public water boards, water conservation districts and other water management entities are encouraged to evaluate how current management and proposed future actions might affect the Preble's mouse, determine what actions might be taken to minimize impacts or improve conditions, and implement actions to support Preble's mouse recovery.

2.3.3. **Protect and conserve Preble's mouse populations on private lands.** Private lands are important to the recovery of the Preble's mouse throughout its range. To implement Preble's mouse recovery, private landowners are encouraged to identify and protect Preble's mouse populations, abate threats, and where biologically appropriate, restore and/or improve Preble's mouse habitat on their lands. Private landowners must ensure that actions on their properties do not result in unpermitted take as defined by the ESA. Private landowners are encouraged to work with public agencies to implement recovery activities on their lands.

2.4. **Restore riparian systems on federal, state, local, and private lands.** The restoration of habitat is an important component of the recovery of the Preble's mouse. Because of the subspecies' limited habitat preferences, impacts to existing habitat could greatly affect the overall health of populations. Efforts to restore habitat that has been impacted by human activities or natural events should be accomplished to provide the highest quality habitat over its range. Site Conservation Teams will work with land management agencies and land owners to identify habitat needed restoration and to implement such restoration.

2.4.1. **Map riparian systems in need of restoration.** The data developed in Action 2.1 would provide the basis for those riparian systems that are in need of restoration.

2.4.2. **Develop restoration plan for riparian systems.** Each Site Conservation Team will work with land management agencies and land owners with Preble's mouse habitat to develop a restoration plan, if they have not done so already, that defines standards and procedures for conducting riparian restoration projects based on accepted riparian restoration guidelines.

2.4.3. **Develop or update existing restoration guidance for riparian systems on private lands.** Restoration guidance that helps private landowners restore their riparian habitat is important. Develop or update existing documents that describe standard, accepted methods to restore riparian systems, cost associated with these restoration efforts, sources of funding for restoration projects in the form of landowner incentive programs, grants, sources for technical assistance, etc.

2.4.4. **Restore riparian systems.** Restoration projects need to be prioritized and initiated for riparian systems identified in Action 2.4.1 using standards and procedures established in Action 2.4.2. Provide assistance to private landowners seeking to restore their riparian systems.

2.4.5. **Establish a monitoring program to assess the effectiveness of restoration efforts.** Establishing a monitoring program is an important component of any restoration effort. Without developing a monitoring program for restoration efforts, the effectiveness of these efforts would not be known. Monitoring needs to consist of consistent, standardized protocol for measuring the quality of riparian habitat. Part of this monitoring effort could include regular surveys to document Preble's mouse activity in the area.

2.5. **Restore and maintain habitat connectivity.** When restoration and other habitat projects are planned, consideration should be given to areas that maintain or enhance connectivity. Particular attention should be paid to areas that promote connectivity between known populations as well as between a known population and currently unoccupied, but suitable habitat in order to promote genetic exchange and increase access to suitable habitat. Site Conservation Teams will work with land management agencies and land owners to ensure habitat connectivity is maintained and restored during all habitat projects.

2.6. **Minimize and investigate the threat of non-native plants to Preble's mouse and riparian systems.** The importance of non-native plants as a threat to Preble's mouse is currently unknown. When assessing and maintaining habitat, it is important to evaluate this threat on Preble's mouse populations and, where appropriate and necessary, to minimize the threat of non-native plants.

3. **Create, strengthen and enforce regulatory mechanisms to protect riparian habitat and minimize or remove identified threats to the Preble's mouse.**

3.1. **Work with local and county land use planning agencies to ensure protection of Preble's mouse habitat in residential and commercial development.** Regulatory mechanisms need to be implemented to ensure Preble's mouse populations and habitats are considered and protected when planning for residential and commercial development.

3.2. **Work with federal, state, county and local transportation agencies and industry stakeholders to ensure protection of Preble's mouse habitat in transportation corridor planning.** Transportation corridors frequently bisect the riparian habitat upon which Preble's mouse depend. Regulatory mechanisms need to be developed and implemented to ensure Preble's mouse habitat is considered and protected when planning for new corridors and maintaining existing corridors.

3.3. **Work with federal, state, county and local open space/parks and recreation agencies to ensure protection of Preble's mouse habitat in recreational planning.** Designated green spaces and recreation areas can provide habitat for the Preble's mouse. However, development for the purposes of recreation, such as trails, needs to be compatible with the persistence of Preble's mouse populations and ensure Preble's mouse habitats are protected.

3.4. **Work with federal, state, county and local utility agencies and industry stakeholders to ensure protection of Preble's mouse habitat in utility rights-of-way planning.** Utility corridors frequently bisect the riparian habitat upon which the Preble's mouse depends. Regulatory mechanisms need to be developed and implemented to ensure Preble's mouse habitat is considered and protected when planning for new corridors and maintaining existing corridors.

3.5. **Work with federal, state, county, local and industry stakeholders to ensure protection of Preble's mouse habitat in water planning.** Water use can impact Preble's mouse populations in a variety of ways, including changing stream flows and removing habitat through creation of reservoirs. Regulatory mechanisms need to be implemented to ensure Preble's mouse populations and habitats are considered and protected when planning for water development and use projects.

3.6. **Work with state, county and local agencies and industry stakeholders to ensure protection of Preble's mouse habitat in aggregate mine planning.** Aggregate mining may impact Preble's mouse habitat through changes in hydrology as well as through direct habitat loss. Regulatory mechanisms are needed to ensure that Preble's mouse habitat is considered and protected when planning for aggregate mining operations. These regulatory mechanisms should extend through and beyond the lifespan of the mine to ensure habitat is not lost during reclamation efforts.

3.7. **Work with state, county and local agencies and industry stakeholders to ensure protection of Preble's mouse habitat in oil/gas/mineral exploration and extraction.** Natural resource exploration and extraction is likely to continue throughout the range of the Preble's mouse. Regulatory mechanisms are needed to ensure Preble's mouse populations and habitat are considered and protected when planning for natural resource extraction projects. Regulatory mechanisms should extend through and beyond the lifespan of the extraction operation and should include any associated infrastructure that may impact Preble's mouse habitat in the vicinity of the extraction operation.

3.8. **Encourage landscape level planning to reduce threats and protect/restore Preble's mouse habitat.** Although individual threats may be localized on the landscape, it is important to think broadly when developing regulatory mechanisms. Development plans need to consider potential impacts to Preble's mouse populations and their habitats beyond the boundaries of the project area in order to minimize impacts up and down stream as well as the creation of dispersal barriers.

4. **Remove, minimize or investigate other natural or manmade threats.**

4.1. **Minimize the potential catastrophic effect of drought, flood, wildfire and climate change on the Preble's mouse.** Preble's mice are exposed to a number of landscape level threats, both natural and manmade, that have the potential to negatively impact populations. The spatial and temporal extent of these threats can vary. Although these threats cannot be completely removed, some steps can be taken to minimize the threats. Establishing multiple populations (see Action 1.1) and developing a plan that would set

forth an emergency response would help to minimize the likelihood the populations would be wiped out by a single catastrophic event.

4.2. **Develop and implement emergency response plan, if warranted.** An emergency response plan would consist of steps needed to protect and conserve the affected populations and habitat during the emergency response activities following catastrophic events. This plan should include but not be limited to: restoration of impacted habitat and initiation of survey and monitoring activities post-event.

4.3. **Minimize and investigate the threat of urban/human supported wildlife populations within riparian systems.** The presence of house mice in Preble's mouse habitat has been suggested to pose a competitive threat to the Preble's mouse, and human-associated predators can directly kill the Preble's mouse when present. Quantifying these threats will be important to better understand their impact on Preble's mouse populations within areas that also support human populations.

4.3.1. **Identify if and to what extent human-supported wildlife populations impact Preble's mouse populations and their habitat.** Human-supported wildlife may have varying impacts on Preble's mouse populations. These impacts need to be quantified in order to develop appropriate management actions.

4.3.2. **Work with landowners to remove or minimize factors that attract urban/human-supported wildlife populations, if appropriate.** By eliminating or minimizing factors that attract or benefit house mice and human-associated predators (i.e., abandoned buildings, non-animal proof garbage containers, etc.), these human-supported wildlife populations would be less likely to establish in riparian systems.

4.3.3. **Monitor the effectiveness of reducing the occurrence of urban/human-supported wildlife within Preble's mouse habitat.** A monitoring program needs to be established to monitor the status of human-supported wildlife in Preble's mouse habitat.

4.4. **Minimize and investigate the threat of pesticides and herbicides on the Preble's mouse and riparian systems.** The impact of pesticides and herbicides on the Preble's mouse is currently unknown. Additional investigation is needed to assess the level of this potential threat, and, where appropriate and necessary, actions will need to be taken to minimize this threat to the Preble's mouse and its habitat.

5. **Facilitate stewardship of Preble's mouse recovery through increased public awareness and education.** Education of the general public, private landowners, commercial landowners, etc., can facilitate recovery of the subspecies. The following actions would help to develop an effective outreach plan for a wide range of audiences.

5.1. **Provide information on the Preble's mouse.** Develop and implement strategies for distributing information on Preble's mouse ecology, and conservation.

5.2. **Provide information on threats to the Preble's mouse and minimization strategies.** Develop and implement strategies for distributing information on threats and threat abatement strategies.

5.3. **Provide information on laws and regulations.** Develop and implement strategies for distributing information on the ESA and related laws and regulations.

5.4. **Develop and provide incentives to abate threats and conserve Preble's mouse and its habitat.** Encourage the development of federal, state, and county incentive programs for conservation of the subspecies and its habitat for private and public landowners. Build partnerships and collaborative processes among the public and private entities to leverage resources and achieve economies of scale.

5.4.1. **Encourage the development of Preble's mouse recovery funds.** These funds may be provided by federal, state, and local governments, as well as private sources. All federal, state, and local agencies should investigate methods of funding implementation of Preble's mouse recovery.

5.4.2. **Support efforts to create tax incentives at federal, state, and / or county levels to encourage active conservation measures to recover the subspecies.** Tax incentives should recognize possible loss of use or value of private property caused by designation and requirements of a Site Conservation Team Threat Abatement Plan. Examples include:

- Federal tax benefits to landowners of designated recovery sites
- Tax credits of up to 100% for expenditures for furthering the recovery of the Preble's mouse
- Provide for a property tax credit for private property or a portion thereof that is managed to promote recovery of Preble's mouse
- Deductions from the gross estate of a decedent in an amount equal to the value of real property subject to designation as a recovery site

5.4.3. **Support efforts to establish a system of awards and rewards for participation in voluntary and cooperative Preble's mouse recovery site designation, monitoring, and conservation.** Examples of award and reward programs may include:

- Encourage the development of federal, state, and / or county grants for Preble's mouse recovery sites
- Provide transfer of development rights that are equivalent to the current county zoning
- Streamline, reduce, or eliminate regulations and administrative paperwork to expedite conservation and management of recovery sites

5.4.4. **Support additional incentives to promote recovery efforts on private lands, including establishing conservation easements, safe harbor agreements, or other protective measures.** Most habitat occurs on private lands, and currently

there is a lack of incentives available to assist private landowners in managing and protecting habitat. Additional funding and attention from all involved parties will be needed to successfully implement this recovery plan. Incentives should be developed to encourage participation, build partnerships and collaboration, foster cooperation with recovery efforts, and offset potential costs associated with recovery efforts.

IMPLEMENTATION SCHEDULE

The following implementation schedule outlines the recovery actions with associated time and cost estimates for the Preble's mouse recovery program. This schedule is a guide for meeting the recovery objectives and criteria within this plan. It provides the action number, a description of the action to be performed, and an assigned priority for the recovery action. It also identifies the agency(s) and/or other parties that are the best candidates for accomplishing the recovery action.

The schedule is laid out by the overarching recovery actions and associated actions needed to help achieve the overarching recovery action. Recovery action priorities, time and cost estimates, and responsible parties are not assigned to the overarching recovery actions. The reader should refer to the recovery narrative outline for a full description of all identified recovery actions. Implementation of all actions listed in the implementation schedule will lead to recovery. Initiation of these actions is subject to availability of funds.

Key to Action Priority Numbers (Column 1)

Priority #	Priority Definition
1	Any action that must be taken to prevent endangerment or to prevent the species from declining irreversibly in the foreseeable future
2	Any action that must be taken to prevent a significant decline in the species population, habitat quality, or some other significant negative impact short of endangerment
3	All other actions necessary to provide full recovery

Key to Acronyms for Agencies and Organizations

CDA = Colorado Department of Agriculture
CDOT = Colorado Department of Transportation
COG = Council of Government
Consltnts = Consultants
CPW = Colorado Parks and Wildlife
CNHP = Colorado Natural Heritage Program
CWCB = Colorado Water Conservation Board
DEQ = Wyoming Department of Environmental Quality
DRMS = Division of Reclamation Mining and Safety
FWS = Fish and Wildlife Service
NGO = Non-Governmental Organizations
PUC = Public Utilities Commission
RTD = Regional Transportation District
SCT = Site Conservation Team
TPR = Transportation Planning Region

Univs = Universities
USAFA = United States Air Force Academy
USACOE = United States Army Corp of Engineers
USDA = United States Department of Agriculture
USDOE = United States Department of Energy
USFS = United States Forest Service
WDA = Wyoming Department of Agriculture
WGFD = Wyoming Game and Fish Department
WYDOT = Wyoming Department of Transportation
WYNDD = Wyoming Natural Diversity Database

Key to Definitions for Terms Used

On-going Task is currently being implemented and will continue until actions are no longer necessary for recovery, currently estimated to be 40 years.

Priority Rankings: 1 – High Priority, 2 – Medium Priority, 3 – Low Priority

IMPLEMENTATION SCHEDULE

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
	1	Monitor Status of Existing Populations of Preble's mouse										
1	1.1	Identify large medium and small Preble's mouse recovery populations	1,2	3 years	CPW, WGFD	CNHP, SCTs, WYNDD, USAFA, USFS, FWS, Counties, Cities	240	80	80	80		
2	1.2.1	Establish monitoring programs for all known large and medium recovery populations	1	on-going	CPW, WGFD	FWS, SCTs, USAFA, USDOE, USFS, Counties, Cities	8,000	200	200	200	200	200
2	1.2.2	Establish monitoring programs for small recovery populations as needed for recovery to document persistence	2	on-going	CPW, WGFD	FWS, SCTs, USAFA, USDOE, USFS, Counties, Cities	4,000	100	100	100	100	100
2	1.3	Develop a peer-reviewed Preble's mouse population monitoring methodology	1,2	2 years	FWS	Univs, NGOs, Consltnts, CPW, WGFD	30	15	15			

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
3	1.3	Investigate the potential of establishing new populations within historic Preble's mouse range	1,2	1 year	FWS	CPW, SCTs, WGFD	5			5		
3	1.4	Further investigate the genetic variation within and among Preble's mouse populations	1,2	2 years	FWS	CPW, WGFD, CNHP, WNDD	200		100	100		
	2	Identify, Protect, Evaluate and Restore Preble's mouse Habitat										
2	2.1	Map and monitor habitat of recovery populations	3	on-going	CPW, WGFD	FWS, USAFA, USDOE, USFS, SCTs, Counties, Cities	1,600	40	40	40	40	40
2	2.2	Identify potential Preble's mouse habitat	3	1 year	CPW, WGFD	FWS, SCTs, USAFA, USDOE, USFS, Counties, Cities	50		50			
2	2.3.1	Protect and conserve Preble's mouse populations	3,4	on-going	FWS	USFS, USAFA, USDOE,	2,000	50	50	50	50	50

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
		through federal actions										
2	2.3.2	Protect and conserve Preble's mouse populations through state and local public agency actions	3,4	on-going	CPW, WGFD	Counties, Cities	2,000	50	50	50	50	50
2	2.3.3	Protect and conserve Preble's mouse populations on private lands	3	on-going	CPW, WGFD	CDA, SCTs, WDA, NGOs,	2,000	50	50	50	50	50
2	2.4.1	Map riparian systems in need of restoration	3	on-going	FWS	USFS, USAFA, CPW, SCTs, WGFD, CNHP, WNDD, Counties, Cities	195			10	5	5
2	2.4.2	Develop restoration plan for riparian systems	3	3 years	FWS	SCTs, CPW, WGFD	60	20	20	20		
3	2.4.3	Develop or update existing restoration guidance for riparian systems on private lands	3	3 years	NGO	FWS,	60	20	20	20		

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
2	2.4.4	Restore riparian systems	3	on-going	CPW, WGFD	USFS, USAFA, SCTs, Counties, Cities	20,000	500	500	500	500	500
3	2.4.5	Establish a monitoring program to assess the effectiveness of restoration efforts	3	5 year	FWS	CPW, WGFD, SCTs, Counties, Cities	25	5	5	5	5	5
2	2.5	Restore and maintain habitat connectivity	3	on-going	CPW, WGFD	USFS, USAFA, SCTs, Counties, Cities	2,000	50	50	50	50	50
3	2.6	Minimize and investigate the threat of non-native plants to Preble's mouse and riparian systems	3	on-going	FWS	USFS, USAFA, CPW, WGFD, CNHP, WNDD, Counties, Cities	150	30	30	30	30	30
	3	Create, Strengthen and Enforce Regulatory Mechanisms to Protect Riparian Habitat and Minimize or Remove Identified Threats to Preble's mouse										
1	3.1	Work with local and county land use planning agencies to ensure protection of Preble's mouse habitat in	4	on-going	FWS	CPW, WGFD	200	5	5	5	5	5

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
		residential and commercial development										
1	3.2	Work with federal, state, county, and local transportation agencies and industry stakeholders to ensure protection of Preble's mouse habitat in transportation corridor planning	4	on-going	FWS	CDOT, Counties, TPRs, WYDOT, COGs, RTD	200	5	5	5	5	5
2	3.3	Work with federal, state, county, and local open space/parks and recreation agencies to ensure protection of Preble's mouse habitat in recreational planning	4	on-going	FWS	Counties, Cities, USFS, CPW, WGFD,	200	5	5	5	5	5
3	3.4	Work with federal, state, county and local utility agencies and industry stakeholders to ensure protection	4	on-going	FWS	PUCs,	200	5	5	5	5	5

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
		of Preble's mouse habitat in utility rights-of-way planning										
2	3.5	Work with federal, state, county, local and industry stakeholders to ensure protection of Preble's mouse habitat in water planning	4	on-going	FWS	CWCB, Water Districts, USACOE, County Water Boards	200	5	5	5	5	5
3	3.6	Work with state, county and local agencies and industry stakeholders to ensure protection of Preble's mouse habitat in aggregate mine planning	4	on-going	FWS	DRMS, Mining industry, DEQ	200	5	5	5	5	5
2	3.7	Work with state, county and local agencies and industry stakeholders to ensure protection of Preble's mouse habitat in oil/gas/mineral exploration and	4	on-going	FWS	DRMS, Mining industry, DEQ	200	5	5	5	5	5

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
		extraction										
1	3.8	Encourage landscape level planning to reduce threats and protect/restore Preble's mouse habitat	4	on-going	FWS	CPW, WGFD, Counties, Cities, NGOs	400	10	10	10	10	10
	4	Remove, Minimize or Investigate Other Natural or Manmade Threats										
2	4.1	Minimize the potential catastrophic effect of drought, flood, wildfire, and climate change on Preble's mouse	3,4	on-going	FWS	CPW, WGFD, USFS, USACOE, State Forest, Special Districts, Counties, Cities	400	10	10	10	10	10
3	4.2	Develop and implement emergency response plan if warranted	3,4	1 year	FWS	CPW, WGFD	50	50				
3	4.3.1	Identify if and to what extent human-supported wildlife populations impact Preble's mouse and their habitat	1, 2, 3	2 years	NGO	USDA	60	30	30			

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
3	4.3.2	Work with landowners to remove or minimize factors that attract urban/human-supported wildlife populations, if appropriate	1, 2, 3	on-going	USDA		400	10	10	10	10	10
3	4.3.3	Monitor the effectiveness of management actions to reduce the occurrence of urban/human-supported wildlife within Preble's mouse habitat	1, 2, 3	5 years	USDA		10	2	2	2	2	2
3	4.4	Minimize and investigate the threat of pesticides and herbicides on Preble's mouse and riparian systems	3	on-going	FWS	CPW, WGFD, Univs, Counties, Cities, USFS, USAFA,	220	15	15	5	5	5
	5	Facilitate Stewardship of Preble's mouse Recovery Through Increased Public Awareness and Education										
3	5.1	Provide information on Preble's mouse		on-going	CPW, WGFD	FWS, Consltnts, NGOs, SCTs,	400	10	10	10	10	10

Priority Number	Action Number	Action Description	Recovery Criteria Number	Action Duration	Lead Party	Other Parties	Total Costs ($1,000s)	FY1	FY2	FY3	FY4	FY5
						Counties, Cities						
3	5.2	Provide information on threats to Preble's mouse and minimization strategies		on-going	CPW, WGFD	FWS, Consltnts, NGOs, SCTs, Counties, Cities	400	10	10	10	10	10
3	5.3	Provide information on laws and regulations		on-going	CPW, WGFD	FWS, Consltnts, NGOs, SCTs, Counties, Cities	400	10	10	10	10	10
3	5.4	Provide information on incentives		on-going	CPW, WGFD	FWS, Consltnts, NGOs, SCTs, Counties, Cities, CDA, WDA	400	10	10	10	10	10

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Appendix A. Glossary

Abundance Estimate. An estimate of the number of individuals within a specific area.

Adaptive Management. Refers to a process in which policy decisions are implemented within a framework of scientifically driven experiments to test predictions and assumptions inherent in management plans. In most management situations, there is little past experience, or knowledge is lacking for some aspects of Preble's mouse biology. Although research is recommended in this plan, research may take years to complete. The only practical approach is adaptive management, where some type of management is specified, population responses are monitored, the outcome is evaluated, and management is adjusted accordingly. This process will continue until definitive research is completed, and wild self-sustaining Preble's mouse populations are documented.

Collaborative process. The process of individuals and governmental groups working together to resolve an issue. For example, the Service, Colorado Parks and Wildlife, Wyoming Game and Fish Department, and others will work with local governments and Site Conservation Teams to address tasks identified within the Plan.

Connected Streams. Preble's mouse habitat that lacks a permanent barrier is considered connected. A permanent barrier is any permanent obstacle, structure, or area of nonhabitat that Preble's mouse is highly unlikely to move across. Stream channels with continuous barriers that exceed 300 linear feet in a side-by-side configuration on both sides of the stream channel are considered permanent barriers. Examples of permanent barriers include, but are not limited to: exposed unvegetated riprap, concrete, asphalt, and permanently unvegetated areas that exceed 300 linear feet on both sides of the stream channel. Naturally occurring events and processes are expected to occur that may temporarily form barriers and are not considered a permanent barrier to Preble's mouse movements.

Conservation Status. The status of the preservation, protection, and management of an environment that takes into account recreational and aesthetic needs, in addition to preserving the natural fauna and flora and allowing for harvesting of natural resources and agriculture.

Conserve. In general, to keep natural resources in a safe or sound state, and avoid wasteful or destructive uses. Specific to the ESA, to use all methods and procedures necessary to bring a listed species to the point at which the measures provided pursuant to the ESA are no longer necessary.

Cooperative Agreement. An agreement between governmental agencies, organizations, or private individuals, that outlines responsibilities, authorities, limitations, future actions, and funding within a given time period.

Cross-Site. Having application to more than one Preble's mouse population. For example, the population and habitat monitoring plans will be used for all Preble's mouse populations and will have a cross-site function.

Delineated. For this plan, the process that establishes the exact boundaries of a designated Preble's mouse recovery population.

Demography. The study of populations, size, density, distribution, trend, and other vital statistics of the population.

Designated. For this plan, the selection of recovery populations and sites required to delist the subspecies at the landscape level within river drainages, or hydrological units. For example, a medium Preble's mouse recovery population is designated in the upper Monument Creek drainage.

Distribution. The occurrence of a species over that total area in which it occurs, that is, its range.

Effective Population Size. The number of breeding individuals in a population. The effective population size is usually smaller than the actual population size. For Preble's mouse, the effective population size will be assumed to be estimated by emergent (post-hibernation) population numbers in June. Population sizes for the designated recovery populations for Preble's mouse are based on the estimated effective populations size.

Ecological Process (es). The physical, chemical, and biological processes vital to the integrity of maintaining Preble's mouse habitat (e.g., a hydrological regime that supports a dynamic riparian community, plant succession, and periodic disturbance).

Ecosystem. A dynamic complex of plant, animal, fungal, and microorganism communities and their associated nonliving environment interacting as an ecological unit.

Emigration. The movement of organisms beyond the area they currently inhabit to a new area they inhabit.

Exotic. Introduced from another location. Plants and animals not native to the location where currently found.

Fragmentation. The disruption of extensive habitats into smaller, isolated patches. Fragmentation has two negative components: loss of total habitat area, and isolation of remaining habitat patches.

Front Range. A mountain range on the eastern edge of the Rockies in north-central Colorado and southeastern Wyoming. The term commonly refers to the area where the eastern boundary of the Rocky Mountains meets the western boundary of the Great Plains, the Colorado piedmont. Within Colorado and Wyoming, much of the human population and growth is located in this area, including the cities of Colorado Springs, Denver, and Fort Collins, Colorado, and Cheyenne, Wyoming.

Federal Lands. Land owned, or administered, by the U.S. government agencies. For this plan, this includes, but is not limited to, lands owned by the U.S. Forest Service, Bureau of Land

Management, U.S. Fish and Wildlife Service, Department of Defense, and Department of Energy.

Functionally Connected Streams. A stream or riparian corridor with small stretches of less than suitable habitat that Preble's mouse is capable of traversing and maintaining genetic flow between otherwise fragmented habitat. For the purpose of this plan, streams are functionally connected if the distance of less than suitable habitat (but not bare ground) is less than ¼ mile; approximately 2 times the documented travel distance (215 m) of Preble's in unsuitable habitat.

Habitat. Suite of existing environmental conditions required by an organism for survival and reproduction. The place where an organism typically lives.

Habitat Fragmentation. See Fragmentation.

Habitat Conservation Plan(s) (HCP). Under section 10 of the ESA, a planning document that is a mandatory component of an incidental take permit application. The process is an opportunity to provide species protection and habitat conservation within the context of non-federal development and land use activities. Overall, the HCP process promotes negotiated solutions to endangered species conflicts, and provides an alternative to litigation.

Hibernacula/Hibernaculum. A shelter used during the winter by a dormant animal. For Preble's mouse, hibernating animals enter an underground nest in the fall, where they remain until late spring. Successful Preble's mouse hibernacula appear to be located above the riparian zone, to avoid flooding during the normal spring run-off.

Historic Range. The area known to have been used by an animal within modern times.

HUC (Hydrologic Unit Code). Watersheds are delineated by the U.S. Geological Service using a nationwide system based on surface hydrologic features. This system divided the country into 21 regions (2-digit), 222 subregions (4-digit), 352 accounting units (6-digit), and 2,262 cataloguing units (8-digit). Eight-digit HUCs are used within the Recovery Plan as a means of assessing distribution of populations and assessing risks to populations from storm events.

Hydrology. The science of the properties of water, including the distribution and circulation of water on the surface of the land, in the soil, underlying rocks, and the atmosphere.

Immigration. The movement of individuals from other areas into a given area.

Implement. To give practical effect, and ensure actual fulfillment by concrete measures.

Landscape. As used in the recovery plan, refers to broad heterogeneous geographic areas characterized by diverse interacting ecosystems that also include the interaction of land use, land cover and ecological processes.

Mean. The sum of a set of scores divided by the number of scores, the average. For example, the mean of the numbers 13, 9, 12 and 10 is 11 (sum of 44 divided by 4).

Mesic. Relating to conditions between wet or dry, moderately moist. The specific quality of being adapted to moderate moisture.

Model. A representation of reality, based on a set of assumptions that is developed and used to describe, analyze, and understand the behavior of a system.

Monitoring. The process of collecting information to track changes over time.

Monitoring Plan. A detailed program of action to collect information over time.

Monitoring Methodology. For this plan, the established method of collecting information to track changes in populations and habitat.

Noxious Weeds. Those plants designated by the State of Colorado, the State of Wyoming, or local government under weed control regulations.

Overstory. The highest limbs and foliage of a tree, and consequently extending and relating to the upper layers of a forest canopy.

Occupancy. Within this Plan, the occurrence of Preble's mouse within a given area. One individual within a given area is equal to "occupancy."

Percent Occupancy. The portion of sampling units with presence of at least one Preble's mouse. For example, if 8 of 10 one-kilometer study sites within a Preble's mouse population have at least one Preble's mouse at the time of survey, the population has an 80% occupancy rate for that survey.

Peer Review. Review by others knowledgeable in the subject. For this Plan, the Recovery Team and theService received comments on various aspects of this Plan from knowledgeable experts not involved in the development of this Plan.

Persistence. The capacity of a population to maintain numbers and distribution over time.

Population. A collection of individuals per unit area.

Population viability. The probability that a population will persist for a specific period of time.

Potential Recovery Site. Sites identified in the recovery plan that may support a small or medium population of Preble's mouse; however, the presence of Preble's mouse at these sites was not known at the time the recovery plan was developed.

Prescribed Fire. Prescribed fire is the controlled application of fire under specified environmental conditions (the "prescription") to accomplish specific natural resources management objectives. Fires may be planned or unplanned ignitions. The use of unplanned

ignitions are predicated on an established fire management plan specific to the area, and are usually manned to agency standards as long as they stay within the prescription. Once any prescribed fire exceeds the parameters established in the prescription, it is either controlled immediately, or if it escapes control, becomes classified as an escaped fire which triggers emergency suppression response the same as any other wildfire.

Range. The region to which a plant or animal is native.

Recovery. As provided by the Endangered Species Act and its implementing regulations, the process of returning a threatened or endangered species to the point at which protection under the Endangered Species Act is no longer necessary.

Recovery Plan. As provided by the Endangered Species Act, a plan for management of a threatened or endangered species that lays out the steps necessary to recover a species.

Recovery Team. A team made up of experts appointed by the U.S. Fish and Wildlife Service whose charge is development of a draft recovery plan. The team serves only in an advisory capacity to Service, with Service responsible for producing a final approved recovery plan.

Recovery Unit. Recovery units are individually necessary to conserve genetic and demographic robustness for Preble's mouse. The recovery plan identifies two recovery units: 1) North Recovery Unit and 2) South Recovery Unit. Both recovery units are necessary for the long-term viability of Preble's mouse, and both recovery units need to meet the recovery criteria before Preble's mouse can be delisted.

Recruitment. The addition of individuals to a population from birth and immigration.

Richness. The number of species in a community.

Riparian. Of or relating to a river; specifically applied to ecology, "riparian" describes the land immediately adjoining and directly influenced by streams. For example, riparian vegetation includes any and all plant-life growing on the land adjoining a stream and directly influenced by that stream.

Site Conservation Team. The Site Conservation Team will help guide and implement the recovery plan at the local level, and should include stakeholders from federal, state, and local agencies, and private landowners. A Site Conservation Team may work with more than one designated recovery population.

Stochastic. Random or uncertain.

Subspecies. A variety of organisms distinguished from other varieties of the same species. Often an incomplete tendency toward reproductive isolation is a factor in designating and naming a subspecies.

Succession. The natural, sequential change of species composition of a community in a given area. For example, community development begins with pioneering species, which are replaced by a series of other species, until a relatively stable community is established that is in equilibrium with local conditions. However, the introduction of disturbances (fires, floods, etc) to the existing conditions, may reset the communities to the pioneer species.

Take. As defined in the ESA and implementing regulations, take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a species [listed as threatened or endangered], or attempt to do so." "Harass" and "harm" are further defined in federal regulations and case law as follows:

> "Harass" means an intentional or negligent act or omission that creates the likelihood of injuring wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns that include, but are not limited to, breeding, feeding, or sheltering.
>
> "Harm" means an act that actually kills or injures wildlife. Such acts may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Taxa. Plural of taxon.

Taxon. Any grouping within the classification of organisms, such as species, genus, and order.

Taxonomy. The classification of fossil and living organisms according to knowledge of their evolutionary relationships.

Team. The Preble's Meadow Jumping Mouse Recovery Team.

Transition Slope. The habitat that exists between the riparian zone and the dry upland habitat,.

Upland. For this plan, "upland" habitat refers to the dry habitats that are often grasslands surrounding a riparian zone. The upland habitat, in context with the riparian and transitional habitat, is an important habitat component for Preble's mouse.

Viability. The ability of a population to persist through time.

Wild. Living in a state of nature and not ordinarily tame or domesticated.

Wild Self-Sustaining Population. For this Plan, a population of animals that maintains itself through natural reproduction within its habitat.

Xeric. Of or relating to perennially dry conditions or the specific quality of being adapted to dry conditions.

Appendix B. Threat Assessment

Parameters and Ranking Values

Threat assessment parameters and ranking values were defined as (the value within the parentheses (), below, denotes the corresponding numeric value assigned):

Severity - measure of the degree or level that a stressor poses a threat to the subspecies or its habitat over time under current conditions.

> Level of Impact - degree reference for severity. Level of Impact is defined as the degree at which the stressor poses a threat. Ranking values were: High (4); Medium (3); Low (2); Unknown (1).
>
> Immediacy - temporal reference for severity. Immediacy is defined as a stressor that is occurring now or is a potential stressor in the future. Ranking values were: Current stressor (2); Potential stressor (1).
>
> Likelihood - likelihood is defined as the likelihood the stressor in itself could cause endangerment of the subspecies. This was a way of measuring the degree by which the stressor is an independent stressor or a cumulative/additive stressor. In other words, does it pose an endangerment threat by itself or does it pose an endangerment threat not by itself, but in combination with other stressors? Ranking values were: High (4) - high likelihood that could cause endangerment by itself; Moderate (3) - somewhat likely it could cause endangerment by itself; Low (2) - not very likely it will cause endangerment by itself; Unknown (1).

Scope - the extent, both spatially and temporally, that a stressor poses a threat to the subspecies.

> Spatial Extent - a spatial reference for scope. Spatial extent is defined as the geographic extent for which the stressor poses a threat to the subspecies. For instance, does the stressor only pose a threat to part of the known range or the entire range? Ranking values were: Entire (4) - entire range; Regional (3) - more than one part of the range; Local (2) - one part of the range; Unknown (1).
>
> Temporal Extent - a temporal reference for scope. Temporal extent is defined as the seasonal extent for which the stressor poses a threat to the subspecies. For instance, does the stressor only pose a threat during part of the year (e.g., wildfire) or the entire year (e.g., development)? Ranking values were: Continuous (3) - all the time; Seasonal (2) - part of the year; Unknown (1).

Management - management is defined as a measure of conservation actions taken to preserve, protect, and/or conserve the subspecies.

> Response - the likelihood that a management action(s) to remove the stressor will result in a positive response. Ranking values were: High (4) - high likelihood of responding to

management; Medium (3) - medium likelihood of responding to management; Low (2) - low likelihood of responding to management; Unknown (1).

Feasibility - the measure of our ability to develop management for the stressor. This encompasses technical, fiscal, logistical, legal and/or social roadblocks. Ranking values were: Feasible (3) - Feasible to manage; Possible (2) - Possible to manage; Unknown (1).

The threat assessment parameters for each stressor were then given an overall score based on the ranking values.

Score - Score is a priority rank for each stressor. The priority rank score was calculated by summing the values assigned to each threat assessment parameter for each of the stressors. This score attempts to take into account the overall threat a stressor poses to the subspecies and how well these stressors can be abated. This is an attempt to guide us in addressing which stressors result in the greatest threats for the subspecies.

Threat - Threat priority rank score looks at the overall threat the stressor poses to the subspecies based on severity and scope. By ranking stressors just by severity and scope we are able to identify which stressors are perceived to pose the greatest threat to the subspecies. Management parameters were not figured into this score because it was thought that it would obscure which stressors posed the greatest threat. The overall threat rank was calculated by:

Severity Score = Level of Impact + Immediacy + Likelihood
Scope Score = Spatial Extent + Temporal Extent
Overall Threat = Severity Score + Scope Score

Management = Management priority rank score looks at the overall "value" of addressing the threat with some management action. Threat assessment based on severity and scope measures allows us to identify those stressors that are of greatest threat to the subspecies. The management priority rank score allows subsequent prioritization of those stressors based on which ones would give us the best "bang for the buck". This most notably comes into play when two or more stressors obtain the same priority rank score based on severity and scope measures. The management priority rank score allows those equally scored stressors to be prioritized by which ones would be more effective and feasible to manage. This addresses cost/benefit. The overall management rank was calculated by:

Overall Management = Response + Feasibility

Overall - Overall score is the summation of all severity, scope and management parameter values. This provides the overarching priority of each stressor taking into account the degree of threat and the management of that threat (i.e., the higher the overall score, the higher the priority). The overall rank was calculated by:

Overall = Overall Threat Score + Overall Management Score

Threats Scoring Table

Sources	Listing Factor	Severity			Scope		Management		Score				
		Level of Impact (high, medium, low, unknown)	Immediacy (current, potential)	Likelihood (high, moderate, low, unknown)	Spatial Extent (Entire, Regional, local, unknown)	Temporal Extent (Continuous, seasonal, unknown)	Species response to mgmt (high, medium, low, unknown)	Feasibility of mgmt actions (feasible, possible, unknown)	Severity	Scope	Threat (Severity + Scope)	Mgmt	Overall (Threat + Mgmt)
Hydrologic Changes	A, D	High (4)	Current (2)	High (4)	Entire (4)	Continuous (3)	High (4)	Possible (2)	10	7	17	6	23
Residential and Commercial Development	A, D	High (4)	Current (2)	High (4)	Regional (3)	Continuous (3)	High (4)	Feasible (3)	10	6	16	7	23
Transportation, Recreation, and other Rights-of-way Through Habitat	A, D	Medium (3)	Current (2)	Moderate (3)	Entire (4)	Continuous (3)	High (4)	Feasible (3)	8	7	15	7	22
Aggregate Mining	A, D	Medium (3)	Current (2)	Moderate (3)	Regional (3)	Continuous (3)	High (4)	Feasible (3)	8	6	14	7	21
Instability of Small/Isolated Populations	E	Medium (3)	Current (2)	Moderate (3)	Local (2)	Continuous (3)	High (4)	Possible (2)	8	5	13	6	19
Livestock Grazing	A	Low (2)	Current (2)	Low (2)	Regional (3)	Continuous (3)	High (4)	Feasible (3)	6	6	12	7	19
Oil, Gas and Mineral Exploration and Extraction	A, D	Medium (3)	Current (2)	Moderate (3)	Local (2)	Continuous (3)	Medium (3)	Possible (2)	8	5	13	5	18

Secondary impacts of human development (predation and hydrologic changes that are sources by themselves)	E	Medium (3)	Current (2)	Moderate (3)	Local (2)	Continuous (3)	Medium (3)	Possible (2)	8	5	13	5	18
Flood	E	Unknown/ Variable (1)	Potential (1)	High (4)	Entire (4)	Seasonal (2)	High (4)	Possible (2)	6	6	12	6	18
Skunk, Raccoon, Domestic/Feral Cats, Bullfrogs	C	Low (2)	Current (2)	Low (2)	Entire (4)	Continuous (3)	Low (2)	Possible (2)	6	7	13	4	17
Agriculture (row crops, haying, irrigated)	A	Low (2)	Potential (1)	Low (2)	Local (2)	Continuous (3)	High (4)	Feasible (3)	5	5	10	7	17
Non-native Plants	E	Low (2)	Current (2)	Low (2)	Local (2)	Continuous (3)	Medium (3)	Possible (2)	6	5	11	5	16
Wildfire	E	Unknown/ Variable (1)	Potential (1)	Low (2)	Entire (4)	Seasonal (2)	High (4)	Possible (2)	4	6	10	6	16
Drought	E	Medium (3)	Potential (1)	Low (2)	Entire (4)	Seasonal (2)	Unknown (1)	Unknown (1)	6	6	12	2	14
Global Climate Change	E	Unknown (1)	Potential (1)	Unknown (1)	Entire (4)	Continuous (3)	Unknown (1)	Unknown (1)	3	7	10	2	12
Pesticides and Herbicides	E	Unknown (1)	Current (2)	Low (2)	Local (2)	Seasonal (2)	Unknown (1)	Possible (2)	5	4	9	3	12

Appendix C. Research

A research program on Preble's mouse distribution, demography, and ecology whose primary objectives are to enhance understanding of Preble's mouse biology and to assess how land management practices affect Preble's mouse population viability is needed. Information gained from these studies will facilitate recovery by improving the ability to identify the distribution and range of Preble's mouse, more clearly identify management practices that enhance Preble's mouse populations, and identify threats to the persistence and distribution of populations. The research topics listed below are just suggestions and are not prioritized.

- Distribution of Preble's mouse populations
    - Design and conduct studies to better define elevational and ecological boundaries of the range of Preble's mouse. Current information indicates that the upper elevational limit of Preble's mouse is about 7600 feet; however, more information is needed to verify this assumption.
    - Design and conduct studies to determine the distribution of Preble's mouse in relation to other closely related species. Studies need to be designed and conducted to determine if and where *Z. h. preblei* occurs sympatrically, allopatrically, or parapatrically with *Z. princeps*, *Z. h. campestris*, and *Z. h. luteus*.
    - Develop and evaluate new methodologies for detecting the presence of Preble's mouse (e.g., camera traps, hair traps, fecal DNA analyses). Simpler, faster, more efficient, and inexpensive survey and monitoring methods will be beneficial to conduct efficient and economical surveys.
    - Conduct research to describe the potential differences among populations of *Z. h. preblei* through systematic and molecular genetic studies. Studies of potential differences among various populations of *Z. h. preblei* will help identify the genetic viability of individual populations and will help guide possible future relocations or translocations of the subspecies between populations if needed.
- Demography of Preble's mouse
    - Conduct studies to estimate over-summer survival, over-hibernation survival, densities, and other trends.
    - Investigate possible factors affecting the demographic parameters listed above to provide information on how habitat can be improved to support high fitness populations of Preble's mouse. These factors include, but are not limited to: weight, sex, age, abundance (i.e., density-dependent response), weather, predation, competition, exotic species, parasitism, and disease.
    - Study dispersal behavior of Preble's mouse. Dispersal is a key process in metapopulation theory and maintains genetic diversity between isolated

subpopulations. Key research is needed to describe dispersal of individual Preble's mouse within and between populations This would include, but is not limited to, who disperses, timing of dispersal, and estimates of the rate of dispersal.

  - Design and conduct behavioral and physiological studies to provide information on the mechanisms driving habitat selection.

- Ecology of Preble's mouse populations

  - Does the presence of *Mus musculus* (house mice) and *Rattus norvegicus* (Norway rats) eliminate the presence or suppress the density of Preble's mouse?

  - Does the presence of *Zapus princeps princeps* eliminate the presence or suppress the density of Preble's mouse?

An experimental research program on Preble's mouse habitat is needed. The primary objectives are to enhance our understanding of Preble's mouse habitat and to assess how land management practices affect Preble's mouse population viability. Information gained from these studies will facilitate recovery by improving our ability to more clearly define, qualify, and quantify Preble's mouse habitat elements, more clearly identify management practices that enhance Preble's mouse habitat, and help develop threat abatement strategies for Preble's mouse habitat.

- Preble's mouse habitat

  - Identify and describe habitat used for nesting, breeding, cover, travel, feeding, dispersal, and hibernation.

  - What habitat results in the highest density and survival of Preble's mouse?

  - What dispersal habitat results in the most successful dispersal?

  - What habitat components result in the highest hibernation survival?

  - Design and conduct studies to provide information on the effects of habitat features on the demography of Preble's mouse.

  - Is Preble's mouse density increased with increasing shrub cover?

  - Are Preble's mouse movement patterns and survival influenced by shrub density adjacent to open water? Are the same patterns seen in adjacent upland areas?

  - Are Preble's mouse movement patterns and survival influenced by composition of upland vegetation adjacent to riparian vegetation?

- Evaluate effects of habitat management techniques and threat abatement strategies to maintain and enhance habitat, and the effect on distribution and demography of Preble's mouse.

- Effects of threat abatement strategies
  - Evaluate impacts of non-native predators.
  - Evaluate impacts of urban predators and competitors on abundance and distribution of Preble's mouse.
  - Evaluate impacts of climate change.