CONSERVATION PLAN FOR THE MOUNTAIN PLOVER (*CHARADRIUS MONTANUS*)

Version 1.0

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WHSRN
WESTERN HEMISPHERE SHOREBIRD RESERVE NETWORK

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Mountain Plover (*Charadrius montanus*) is an uncommon terrestrial shorebird found in xeric shrublands, shortgrass prairies, and other sparsely vegetated plains (including agricultural fields) of the western Great Plains of the United States, southern Canada, and northern México. Over the last 150 years, changes in land use and in the grassland herbivore community have altered the abundance, habitat use, and distribution of Mountain Plovers. Precise and accurate information about the current population size of and trend in Mountain Plovers is lacking.

Bare ground, short vegetation, and flat topography are typical nest site characteristics for Mountain Plovers; they winter in similar habitats, primarily in California, northern México, and Texas. Although California is thought to support most wintering Mountain Plovers, little is known about their winter range use in other areas. Virtually nothing is known about how Mountain Plovers use spring and fall stopovers.

The most crucial conservation threats facing Mountain Plovers, not necessarily in priority order, include: 1) the inability to manage agricultural lands in the Imperial Valley, California, to provide consistent winter habitat, and the loss or inadequate management of other known wintering areas in California; 2) the lack of comprehensive information on the wintering distribution of Mountain Plovers and the threats plovers face in these areas; 3) information gaps on the factors responsible for apparent low Mountain Plover survival during migration and the ability to define and identify stopover habitat; 4) an historically reduced number of active black-tailed, Gunnison, and Mexican prairie dog colonies in the United States, México, and Canada, which results in less high-quality Mountain Plover habitat; 5) the inability to comprehensively mange landscape components (prairie dog colonies, native grasslands, and agricultural fields) that support breeding Mountain Plovers; and 6) the lack of understanding how large-scale landscape changes brought about by energy development and climate change will affect Mountain Plover habitats.

Some of the short-term conservation actions for Mountain Plovers include: 1) developing a functional Mountain Plover Working Group whose members are active in sharing information and finding collective solutions to plover conservation issues; 2) refining a preliminary demographic model to guide decisions about allocation of range-wide resources for Mountain Plover conservation actions and adjust suggested actions; 3) developing and implementing

methods to map the abundance of wintering Mountain Plovers across their range, particularly in Texas and México; 4) developing specific land management strategies in the Imperial Valley to provide consistent wintering habitat; 5) expanding partnerships with Natural Resources Conservation Service to develop special incentives for private agriculture producers and ranchland owners; 6) continuing to secure easements and management plans on private lands that support prairie dog colonies, 7) determining brood survival among breeding habitat types, particularly determining if agricultural fields provide adequate food resources; 8) initiating research to understand how Mountain Plovers will be affected by energy development projects in the Intermountain West and western Great Plains, and 9) continuing to develop conservation and management agreements with ejidos, and other private land owners, to conserve grasslands in northern México.

PURPOSE

The U.S. Shorebird Conservation Plan (Brown *et al.* 2001, U.S. Shorebird Conservation Plan 2004) identified more than 20 shorebird species in peril. Those that are not federally listed as endangered or threatened, such as the Mountain Plover, require some other form of conservation attention if their population declines are to be reversed. Due to a lack of a comprehensive and organized treatment of conservation threats and actions for these species, the Western Hemisphere Shorebird Reserve Network (WHSRN) identified the development of species-specific conservation plans as a means to provide guidance to conservation practitioners. The purpose of this plan is to synthesize information known to date about the status and needs of the Mountain Plover, and identify the most appropriate conservation actions to take in the near term.

The Mountain Plover (*Charadrius montanus*) is an uncommon terrestrial shorebird found in xeric shrublands, shortgrass prairies, and other sparsely vegetated plains (including agricultural fields) of the western Great Plains of the United States, southern Canada (rarely), and northern México. Over the last 150 years, changes in land use and in the grassland herbivore community have altered the abundance, habitat use, and distribution of Mountain Plovers. Precise and accurate information about the current population trend in Mountain Plovers is lacking.

In the United States, the Mountain Plover was proposed for listing under the Endangered Species Act in 1999 but was withdrawn from consideration in 2003 because "threats to the species as identified in the proposed rule are not as significant as earlier believed, and current available data do not indicate that the threats to the species and its habitat are likely to endanger the species in the foreseeable future throughout all or a significant portion of its range" (U.S. Fish and Wildlife Service 2003). Regardless of the decision whether or not to provide protection under the Endangered Species Act, the general rarity of the species and the continued alterations to grassland environments warrant diligent and coordinated conservation attention.

This plan provides a general framework for conservation threats and subsequent actions that are needed to achieve long-term Mountain Plover conservation. General information on Mountain Plover natural history is presented briefly, and a broad set of conservation actions to be implemented in the next 5 to 10 years is identified. Our ultimate goal is to provide natural resource and land management agencies, scientists, public land trusts, policy makers, funding

organizations, natural resource educators, law enforcement, and other interested parties with information and a set of actions necessary to maintain or increase the continental population of Mountain Plovers.

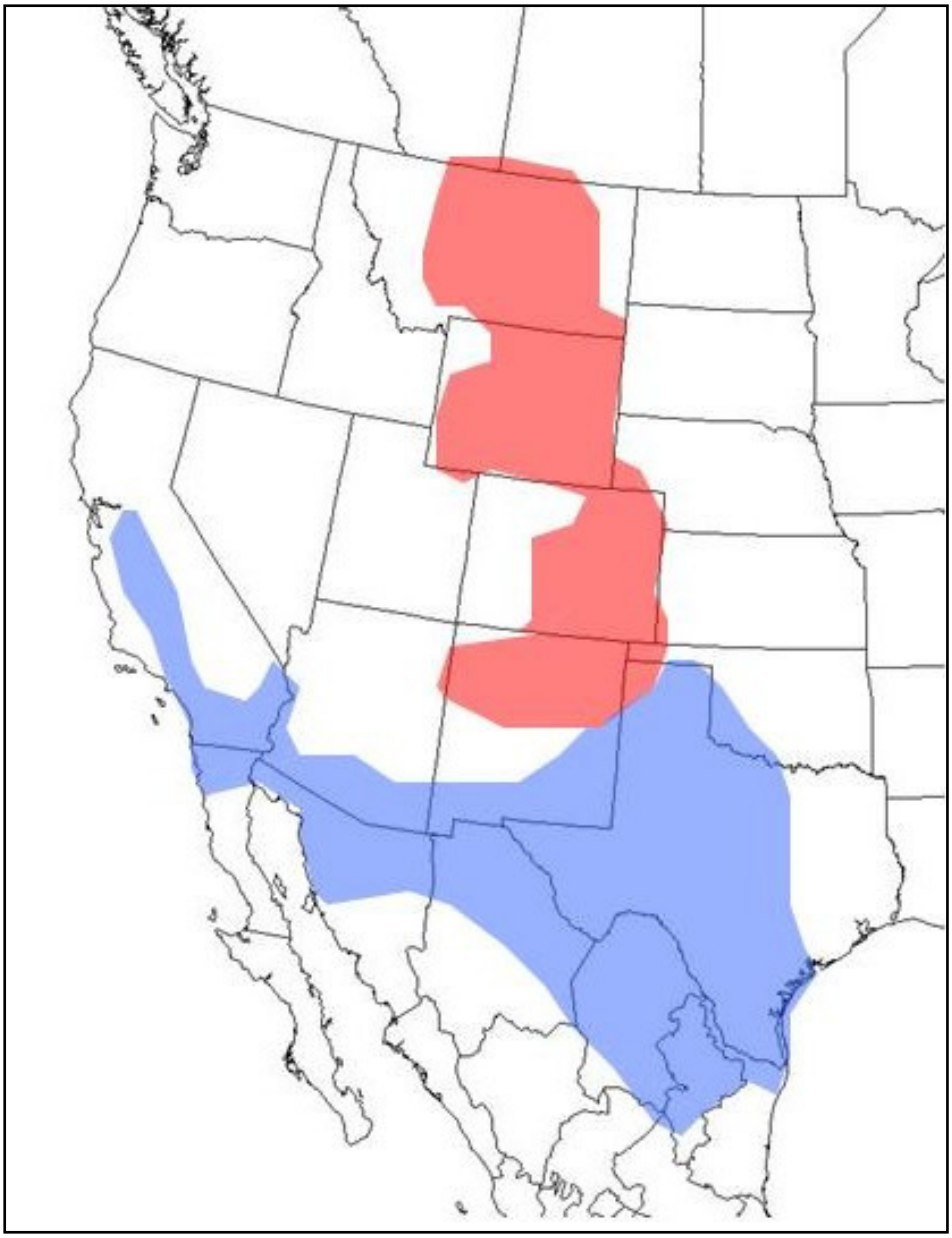

Figure 1. General range of the Mountain Plover [red indicates breeding, blue indicates wintering and migration] (Based on Knopf and Wunder (2006) and information presented here).

Parallel with producing the species conservation plan is the development of a Mountain Plover Working Group, which will include biologists representing the entirety of the plover's range. Functions of the group will be to: 1) share and compile new research information from across the Mountain Plover's range; 2) build on past monitoring and research information to cooperatively develop a set of information needs and range-wide conservation and management strategies; 3) transmit information and strategies to conservation stakeholders; and 4) track and evaluate outcomes of research results and conservation actions, and use the evaluation to collectively adapt conservation strategies. The working group will also periodically develop work plans to update specific conservation actions, costs, and the stakeholders responsible for implementation.

Based on deliberations with colleagues, we decided it would be useful to organize the discussion of Mountain Plover biology, conservation threats and actions into five general regions (Table 1). Much of the following discussion refers to these regions.

Table 1. Regions designated within Mountain Plover range and their corresponding location in Bird Conservation Regions.

Mountain Plover Region	Areas Included	Bird Conservation Regions	Key Sites	Other Sites
Northern Prairie	Breeding: Montana, eastern Wyoming, Alberta, Saskatchewan	Badlands and Prairies (17) Prairie Potholes (11)	Phillips County, Montana	Albany, Campbell, and Converse Counties, Wyoming
Shortgrass Prairie	Breeding: e. Colorado, sw. Nebraska, sw. Kansas, nw. Oklahoma, nw. New Mexico	Shortgrass Prairie (18)	southeastern Colorado, northeastern New Mexico	Weld County, Colorado; Kimball County, Nebraska
Intermountain Basins	Breeding: western and central regions of Colorado, New Mexico, and Wyoming	Southern Rockies/Colorado Plateau (16) Northern Rockies (10)	South Park, Colorado; western and central Wyoming	Taos County, New Mexico
California/ Sonoran- Mojave Deserts	Wintering: California, Arizona, Baja California, and Sonora	Sonoran and Mojave Deserts (33) Coastal California (32)	Imperial, Sacramento, and San Joaquin Valleys, California	Carrizo Plain, California
Chihuahuan Desert/Texas	Wintering/Breeding: Chihuahua, Nuevo León, Zacatecas, San Luis Potosí, Tamaulipas, and s. and w. Texas	Chihuahuan Desert (35), Sierra Madre Occidental (34) Tamaulipan Brushlands (36) Gulf Coast Prairie (37) Oaks and Prairies (21) Edwards Plateau (20)	Janos, Nuevo Casa Grandes, Llano de La Soledad, Chihuahua; western and southern Blackland Prairies, agricultural lands in BCR 21, Texas	Edwards Plateau, southern Texas plains

STATUS AND NATURAL HISTORY

Relative to many North American shorebirds, the Mountain Plover has a fairly rich literature, particularly regarding the breeding period; far less is known about its ecology during the migration and wintering seasons. Knowledge about population trends and survival across the entire annual cycle, including specific factors that influence survival, remain incomplete. The Mountain Plover appears to have evolved in response to major ecological drivers of western Great Plains — drought and grazing pressure (Askins *et al.* 2007). The role of fire in their evolution is less certain (Askins *et al.* 2007). Mountain Plover productivity appears to be influenced by drought cycles (Wunder 2007). Annual juvenile survival rate is relatively high (0.48), but annual adult survival is relatively low (0.74–0.96) and could be limiting population growth (Dinsmore *et al.* 2003, Dinsmore 2008); however, more information on adult survival is needed across the annual cycle and from the Mountain Plover's entire range. Black-tailed prairie dog colonies (*Cynomys ludovicianus*) are an important provider of Mountain Plover nesting habitat throughout the plover's range (Dinsmore 2003, Augustine *et al.* 2008, Knopf 2008, Tipton *et al.* 2008), and plovers regularly use agricultural fields for nesting (Knopf and Rupert 1996, Shackford *et al.* 1999, Dreitz *et al.* 2005, Bly *et al.* 2008).

MORPHOLOGY

The Mountain Plover averages 21 centimeters (8 inches) in body length. It is similar in size and appearance to a Killdeer (*C. vociferus*) but has longer legs and a more upright posture (Knopf and Wunder 2006). It is light brown above with a lighter colored breast but lacks the contrasting breast band or collar common to most other *Charadrius* plovers. Like other plovers, its forehead darkens in the breeding season, and a dark loral stripe appears. Although the sexes are considered monomorphic, males generally have a somewhat brighter breeding plumage.

TAXONOMY

No subspecies are recognized, and there is considerable mixing among populations, which results in high genetic variability within populations (Oyler-McCance *et al.* 2005, 2008; Wunder 2007). The closest related species are two Old World plovers — the Oriental Plover (*C. veredus*) and the Caspian Plover (*C. asiaticus*).

POPULATION ESTIMATE AND TREND

The population of the Mountain Plover was suggested recently to range from 11,000 to 14,000 individuals (Plumb *et al.* 2005b). However, work by Tipton (2007) suggests that numbers of breeding Mountain Plovers in eastern Colorado are somewhat higher and could range from 8,577 individuals, under a conservative estimation method, to 21,103 plovers, under a liberal estimation method. Under all of Tipton's estimation scenarios, confidence intervals were large and included values four times greater than the estimated total, so confidence in the actual number of Mountain Plovers breeding in eastern Colorado remains low. Using just the mean values from Tipton's (2007) assessment, Mountain Plovers may number between 12,500 and 28,000 individuals across their range. We will assume a population size, albeit only a coarse estimate, of about 18,000 individuals (Table 2). A range-wide assessment of population size, using similar methods, would be useful to determine overall population size and the importance of specific breeding areas.

In making the decision to withdraw the proposal to list the Mountain Plover under the U.S. Endangered Species Act, the U.S. Fish and Wildlife Service determined that the Breeding Bird Survey (BBS) data were inconclusive about trends in the species over the last decade, citing potential roadside bias and low detectability as limiting the usefulness of the BBS to track changes in populations. Information from the BBS suggested that Mountain Plovers declined at a rate of 2.7% per year from 1966 to 2007 across the entire survey area, although the data are characterized as having some deficiencies (Sauer *et al.* 2008). Christmas Bird Count data show a similar decline (2.8%), but reliability is also low (Butcher and Niven 2007). At a local scale, Mountain Plovers have decreased dramatically on the Pawnee National Grassland, Colorado, since 1994 (Knopf 2008), likely because of increases in grass height and density and predator populations. Population dynamics are likely driven, in part, by drought cycles that influence reproductive success and adult survival (Wunder 2007, Dinsmore 2008); drier years appear to provide better habitat conditions (i.e. more bare ground) and more food resources (Wunder 2007).

Table 2. Approximate, and likely minimal, numbers of breeding Mountain Plovers by state or province. Information comes from sources herein.

Country/State/Province	Number
Canada	
Alberta	<50
Saskatchewan	<50
United States	
Colorado	11,000
Wyoming	3,400
Montana	1,600
New Mexico	500
Nebraska	500
Kansas	200
Oklahoma	200
Arizona	100
Utah	<50
México	
Chihuahua	<50
Cohuila	100
Nuevo León	100
San Luis Potosí	<50
Range-wide	≈18,000

DISTRIBUTION AND ABUNDANCE

Breeding Range

The extent of the continental breeding range of the Mountain Plover has been greatly reduced from pre-European settlement times (Knopf and Wunder 2006). Mountain Plovers nest from southeastern Alberta and southwestern Saskatchewan, Canada, (Werschler and Wallis 2002) south to San Luis Potosí, Mexico (Esparza *et al.* 2008) (Figure 1). The numbers of Mountain Plovers nesting in the southern and northern edges of their distribution is low; most breeding likely occurs in Montana, Wyoming, and Colorado, and probably fewer plovers breed in Arizona, Kansas, Nebraska, New Mexico, Oklahoma, and Utah. Mountain Plovers historically bred in western Texas, and a few may still breed in the shortgrass prairie of the Texas

panhandle. Breeding has been confirmed or suspected in the States of Chihuahua, Cohuila, Nuevo León, and San Luis Potosí, México.

Nonbreeding (Wintering) Range

The main wintering area for Mountain Plovers is thought to be in California, with most of the birds occurring in the Sacramento, San Joaquin, Panoche, and Imperial Valleys and on the Carrizo Plain (Wunder and Knopf 2003, Hunting and Edson 2008). In recent years, fewer Mountain Plovers have been found in the Central Valley (Wunder and Knopf 2003). However, counts from California account for <50% of the population estimate presented here. Outside of California, the nonbreeding range is generally poorly known. Smaller numbers of wintering Mountain Plovers are annually reported in Arizona, Nevada, and Texas, although Texas may support greater numbers of wintering plovers than is currently documented (Lockwood and Freeman 2004; C. Shackelford, pers. comm.). Wintering Mountain Plovers also occur in northern and Central México, from the States of Baja California to San Luis Potosí. Recently, flocks of 1,600–3,500 individuals have been recorded in El Llanos de la Soledad in Nuevo León (M. Cruz Nieto, unpubl. data) (Figure 1). Mountain Plovers appear to be highly nomadic during the wintering season.

Potential Year-round

A resident population may also exist in parts of México, particularly in the area of El Llanos de la Soledad, Nuevo León.

MIGRATION

Mountain Plovers undergo annual, relatively short-distance migrations, although detailed information on migration movements is lacking.

Northbound Migration

Northbound migrants begin moving in early March and likely proceed quickly to their breeding grounds. They arrive on breeding grounds in New Mexico and eastern Colorado by mid-March and in Montana and central Colorado by mid-April (Knopf and Wunder 2006). The

route to breeding grounds may be directly over the Sierra Nevada, Great Basin, and Rocky Mountains; however it is more likely to be east across Arizona and New Mexico, then north along the eastern flank of the Rocky Mountains (Knopf and Wunder 2006). Mountain Plover migrants are also observed in western, central, and northern Texas (Lockwood and Freeman 2004; K. Bryan, pers. comm.), and a flock has been observed on burned prairie in eastern Kansas (C. Braun, pers. comm.). Flocks of more than 50 individuals are rarely encountered during spring migration (Knopf and Wunder 2006).

Southbound Migration

Southbound migration of Mountain Plovers, like many shorebirds, appears to be relatively prolonged, with breeders leaving as soon as breeding attempts have either failed or resulted in successfully fledged young. Post-breeding flocks begin to form in eastern Colorado and New Mexico by late June to mid-July, and flocks remain into September and October in southeastern and central Colorado, New Mexico, Oklahoma, and Nebraska (Knopf and Wunder 2006, Bly *et al.* 2008). Flocks numbering in the hundreds or even low thousands occur annually in southeastern Colorado (D. Nelson, pers. comm.). The earliest Mountain Plovers arrive on nonbreeding grounds in California during these same months. Although not completely known, Mountain Plovers appear to migrate south along flanks of the Rocky Mountains into New Mexico, Texas, and México, and then west across Arizona into California (Knopf and Wunder 2006).

MAJOR HABITATS

Breeding

The Mountain Plover is associated with disturbed sites in dry grasslands and shrub-steppe tablelands throughout its breeding range. Historically, Mountain Plovers occurred on nearly denuded prairie dog colonies (Knowles *et al.* 1982, Olson-Edge and Edge 1987) and in areas of major bison concentrations (Askins *et al.* 2007). Dinsmore (2003) suggested that Mountain Plovers currently use four types of habitats for nesting: 1) native short- and mixed-grass prairie, 2) semi-desert sites, 3) prairie dog colonies, and 4) agricultural lands, mainly in the southern part of their range. No matter where they occur, breeding Mountain Plovers are associated with natural and artificial habitats that contain bare ground.

In many areas of the United States, nesting Mountain Plovers are strongly associated with prairie dog colonies (Tyler 1968, Knowles *et al.* 1982, Knowles and Knowles 1984, Olson and Edge 1985, Shackford 1991, Samson and Knopf 1994, Dreitz *et al.* 2006, Augustine *et al.* 2008, Childers and Dinsmore 2008, Tipton *et al.* 2008), and Mountain Plovers respond to changes in area occupied by prairie dogs (Dinsmore *et al.* 2005). Mountain Plovers' association with prairie dog colonies appears to be weakest in the grasslands and deserts of Wyoming, although this could be an effect of the association with white-tailed prairie dogs (*Cynomys leucurus*) (Plumb *et al.* 2005a). The size of the colony may positively influence breeding Mountain Plover density (Knowles *et al.* 1982, Olson-Edge and Edge 1987). Mountain Plover use of prairie dog colonies likely increases in wet years, when grasses in the surrounding landscape are taller. In northeast México, breeding Mountain Plovers and observations of probable breeding birds were associated with Mexican prairie dog (*Cynomys mexicanus*) colonies (Knopf and Rupert 1999, Gonzalez-Rojas *et al.* 2006). Tipton (2007) estimated that more Mountain Plovers nested on native grassland and dryland agriculture than on prairie dog colonies in eastern Colorado, but plover density on prairie dog colonies was 5–10 times greater than in either other habitat.

Bare ground (≥30%), short vegetation (<7.5 centimeters), and a flat topography (slope <5^{o}) are typical nest site characteristics for Mountain Plovers (Graul 1973, 1975, Knopf and Miller 1994, Knopf and Rupert 1996, Beauvais and Smith 2003). Like other plovers, Mountain Plovers in rangeland may locate nests near clumps of manure or rocks (Graul 1975, Knopf and Miller 1994). In areas where prickly pear cacti occur, Mountain Plovers select nest sites where cactus density is lower than in the surrounding landscape (Knopf and Miller 1994). Mountain Plovers nesting in semi-deserts use sites vegetated by dispersed, short shrubs (Parrish 1988, Day 1994, Ellison-Manning and White 2001b, Wunder *et al.* 2003, Plumb *et al.* 2005a).

In some parts of their range, Mountain Plovers are attracted to burned grasslands in breeding areas for nesting and in nonbreeding areas for foraging and night roosting (Wunder and Knopf 2003, Knopf 2008). Mountain Plover response to burns is often quick, with birds appearing on fields where fires are still smoldering (Knopf and Wunder 2006). After extirpation of prairie dogs in west Texas, fire scars likely provided the only local nesting habitat (K. Bryan, pers. comm.).

Mountain Plovers also use fallow or recently planted fields for nesting and brood rearing, which has been reported from several of the states where they nest (Knopf and Rupert 1996,

Shackford *et al.* 1999, Dreitz *et al.* 2005, Knopf and Wunder 2006, Bly *et al.* 2008). Nest success was found to be similar between cropland and rangeland in eastern Colorado, although sources of mortality differed (Dreitz and Knopf 2007). Recent information indicates that chick survival is higher on prairie dog colonies, in eastern Colorado, than on rangelands or agricultural fields (Dreitz, unpubl. manuscript). Mountain Plovers nesting in agricultural fields in southwest Nebraska, however, had much higher nest success than field-nesting plovers in Colorado (Bly *et al.,* unpubl. manuscript). Mountain Plovers have also nested on prescribed grassland burns (USDA Forest Service 2005) and lands abandoned after being cleared for residential development (Hicks-Anderson and VerCauteren 2006). In short, Mountain Plovers require some bare ground for nesting and avoid heavily vegetated areas of shrubland or grassland. In contemporary prairie landscapes, areas of soil disturbance are either those frequented for watering and loafing by cattle or agricultural fields (Knopf and Rupert 1996).

Migration

During migration, Mountain Plovers use habitats similar to those on breeding and wintering grounds, although detailed information is lacking. Mountain Plovers will also use sod farms and edges of playa lakes during migration (Knopf and Wunder 2006).

Nonbreeding (Wintering)

Mountain Plovers use nonbreeding (wintering) habitats that are similar to those they use on breeding grounds: heavily grazed pastures, burned fields, fallow fields, and tilled fields (Hunting *et al.* 2001, Knopf and Wunder 2006). Mountain Plovers were historically associated with kangaroo rat (*Dipodomys*) precincts and California ground squirrel (*Spermophilus beecheyi*) colonies within the Central Valley of California (U. S. Fish and Wildlife Service 2003). In California's Imperial Valley, they preferentially use alfalfa fields that have been harvested and grazed by domestic sheep as well as Bermuda grass fields that have been burned post-harvest (Wunder and Knopf 2003). Habitats used in San Joaquin Valley, California, include tilled fields, grazed pastures, and alkaline flats, and, for roosting, burned fields (Knopf and Rupert 1995). Mountain Plovers also use coastal prairies, alkaline flats, plowed fields (usually without furrows), and similar open habitats in Texas (B. Ortego, pers. comm.; Oberholser 1974). Mountain Plovers use grazed pastures and prairie dog colonies in Nuevo León, México.

CONSERVATION STATUS

In 1982, the U.S. Fish and Wildlife Service (USFWS) designated the Mountain Plover as a Category 2 candidate species under the U.S. Endangered Species Act, because more information was necessary to determine whether the species' status was declining, stable, or improving (U.S. Fish and Wildlife Service 1982). A status report was subsequently prepared (Leachman and Osmundson 1990), and the Mountain Plover was elevated to a Category 1 species in 1994. In 1997, the USFWS received a petition to list the Mountain Plover under the Endangered Species Act and published a proposed rule to list the Mountain Plover as threatened in 1999 (U.S. Fish and Wildlife Service 1999) and again in 2002 (U.S. Fish and Wildlife Service 2002). In September 2003, the USFWS withdrew the listing, because new information indicated that the threats to the species that had been included in the proposed listing were not as significant as earlier believed (see U.S. Fish and Wildlife Service 2003)

The Mountain Plover is protected by the Migratory Bird Treaty Act (MBTA), which prohibits direct mortality and the destruction of active nests. Other federal laws that currently provide for conservation of Mountain Plovers include the Federal Land Policy and Management Act of 1976; National Forest Management Act of 1976; Federal Onshore Oil and Gas Leasing Reform Act; Federal Insecticide, Fungicide, and Rodenticide Act; and Federal Agriculture Improvement and Reform Act. Some federal agencies, such as the Bureau of Land Management and the USDA Forest Service, have also adopted policies to promote conservation of sensitive species.

At the state level within the United States, the Mountain Plover is classified as threatened in Nebraska; a species of special interest, concern, or need in California, Colorado, Kansas, Montana, Oklahoma, and Wyoming; and a sensitive taxa in New Mexico. The Mountain Plover is considered as highly imperiled in the U.S. Shorebird Conservation Plan (2004) and Canadian Shorebird Conservation Plan (Donaldson *et al.* 2000); a species of global conservation concern in the American Bird Conservancy and National Audubon Society's 2007 Watchlist; and as a USFWS Bird of Conservation Concern (U.S. Fish and Wildlife Service 2008). Mountain Plovers have been addressed in the development of The Nature Conservancy's ecoregional plan for the central Shortgrass Prairie (Neely *et al.* 2006) and in Colorado's conservation plan for grassland species (Colorado Division of Wildlife 2003).

The Mountain Plover was designated as a threatened species by the Mexican federal government in 2001 (Nom-059-SEMARNAT-2001). The Canadian federal government designated the species as endangered in 1987; a status that was confirmed in 2000. The Mountain Plover is listed as a sensitive species in Alberta. Cooperation for Mountain Plover conservation among the three governments could be accomplished through the Trilateral Committee for Wildlife and Ecosystem Conservation and Management.

POPULATION OBJECTIVE

Participants in a Structured Decision Making Workshop in July 2008 suggested that the broad population objective for the Mountain Plover is to maintain or increase populations (i.e. $\lambda \geq 1$) in each of the identified Mountain Plover regions over the next 30 years (2009–2039). The long-term target established for Mountain Plovers in the U.S. Shorebird Conservation Plan (Brown *et al.* 2001) is to increase the population to 20,000 individuals. This target is based on an initial population estimate of 9,000 individuals and constructed using a BBS trend of a 2.07% decrease over 30 years. If the initial population estimate was actually 15,000 individuals, then a similar recovery target would be 33,000 individuals. Because of the variability and uncertainty in current population estimates, we suggest adopting an objective to maintain or increase populations over the next 30 years.

CONSERVATION SITES

Because Mountain Plovers are dispersed on their breeding grounds, using the standard Western Hemisphere Shorebird Reserve Network approach of site-based conservation does not apply well. Therefore, we identified the U.S. counties, Canadian provinces, and Mexican states where Mountain Plovers occur, particularly in high numbers, during breeding (Table 3) and nonbreeding (wintering) periods (Table 4).

BREEDING SITES

More surveys have been recently initiated to determine the local abundance of Mountain Plovers, but a comprehensive, range-wide survey has not been conducted. Information on the

numbers and locations of breeding Mountain Plovers comes from a variety of studies or inventories — those from the known key areas, efforts to gain baseline information in areas along the fringe of the range, or areas that have appropriate habitat conditions. Most biologists believe that the majority of the Mountain Plover breeding population has been located, although unknown pockets of birds (≤1,000 individuals) may exist somewhere within their broad range. If there are major concentrations of breeding Mountain Plovers that have not yet been discovered, they probably occur in México.

The continental stronghold for Mountain Plovers is Colorado, where over 60% of the population is believed to breed. In Colorado, Tipton (2007) confirmed that the majority of breeding Mountain Plovers occur on the eastern plains (≥8,600 individuals), with the greatest numbers currently occurring south of Interstate 70 (Kuenning and Kingery 1998, Knopf and Wunder 2006). On the eastern plains, Mountain Plovers are distributed, approximately, among prairie dog colonies (18%), native grasslands (43%), and agricultural fields (39%). Although the Pawnee National Grassland in Weld County, Colorado, was long thought to be the epicenter of Mountain Plover breeding (Graul and Webster 1976), recent changes have caused plovers to virtually abandon the site (Knopf 2008). Mountain Plovers in Park County breed at the highest density recorded in their range (Wunder *et al.* 2003) and number about 2,300 individuals. Small numbers breed in the San Luis Valley in Costilla County (<100 individuals) (Hicks-Anderson and VerCauteren 2006).

In Montana, the largest number of breeding Mountain Plovers occurs on a large complex of black-tailed prairie dog colonies in the contiguous Phillips and Blaine Counties (Knowles and Knowles 1984, Dinsmore *et al.* 2003, Childers and Dinsmore 2008). Additional Mountain Plovers are scattered across 14 other counties; most occur in the central portion of the state (Knowles and Knowles 1996, Faunawest 2004).

In Wyoming, Mountain Plovers have been documented from every county (Smith and Keinath 2004), and the greatest concentrations are found in the Laramie and Shirley Basins and in portions of the Washakie, Great Divide, and Big Horn Basins. Local densities in Wyoming are generally lower than Montana (Plumb *et al* 2005b, Childers and Dinsmore 2008) but higher than eastern Colorado (Tipton 2007). Wyoming supports the highest number of breeding Mountain Plovers outside of Colorado.

In Nebraska, Mountain Plovers are mainly restricted to Kimball, southwest Cheyenne, and southwest Banner Counties, where they nest primarily in cultivated millet and wheat fields; breeding density is highest in Kimball County (Bly *et al.* 2008).

In Kansas, Mountain Plovers are restricted to counties in the southwestern part of the state and have been reported on the Cimarron National Grassland (Fellows and Gress 1999). Attempted relocations of Mountain Plovers from Colorado to Wallace County, Kansas, were unsuccessful (Schulenberg 1983).

In Oklahoma, breeding Mountain Plovers are only found in the most western portion of the panhandle in Cimarron and Texas Counties (Shackford and Leslie 2000, McConnell *et al.* 2005, McConnell 2006).

In New Mexico distribution of breeding Mountain Plovers is not well known, although plovers appear to be concentrated in the northeastern and western counties (Craig *et al.* 1985, Sagar 1996). More recently, Hawks Aloft (2003) found 80 individuals in Taos County in 2001 and 2003 and suggested that many more could occur there.

In Utah, the only known breeding site occurs in Duchesne County (Day 1994, Ellison-Manning and White 2001a).

Although Mountain Plovers historically bred in western Texas, there have been no confirmed breeding records there since 1993 (K. Bryan, pers. comm.), but appropriate habitat may still exist (Holliday 2004). Mountain Plovers are regularly seen during the summer in the shortgrass prairie of northern Texas (Seyffert 2001), and a few nests have been recently found there (B. Howe, pers. comm.).

In México, there have been observations of individuals in breeding plumage or performing breeding displays in April through July in various portions of Nuevo León, usually near or in Mexican prairie dog colonies — in 1994 and 1997 near San Juan del Prado and in 1998 near the town of Hediondilla and 89 kilometers south of Saltillo (Knopf and Rupert 1999). Breeding was confirmed in 1999 on a Mexican prairie dog colony near La India, Cohuila (Desmond and Ramirez 2002), and another breeding record in the same area was documented in 2004 (Gonzalez-Rojas *et al.* 2006). Breeding behavior was also observed between a pair of Mountain Plovers at El Tapado, San Luis Potosí in 2008 (Esparza *et al.* 2008). These observations could indicate that there is a resident Mountain Plover population in northeastern México.

In Canada, nesting habitat is restricted to southeastern Alberta and southwestern Saskatchewan. Nesting has not been documented in Canada since 1990, although a small number of breeding birds may occur there in some years (Wershler and Wallis 2002).

MIGRATION SITES

The migration routes of breeding Mountain Plovers to and from their wintering grounds are not really known. Birds may move south through the Great Plains to New Mexico and then turn west toward California (Knopf and Wunder 2006)

Northbound Migration

There are no known large aggregation areas between wintering and breeding areas, although some Mountain Plovers may use the lower Colorado River Valley during spring migration (Knopf and Wunder 2006). Migrant Mountain Plovers are annually found in Texas (Lockwood and Freeman 2004; K. Bryan, pers. comm.).

Southbound Migration

Large post-breeding flocks are often encountered in southeastern Colorado and in north central New Mexico (Knopf and Wunder 2006). Flocks in southeastern Colorado can number in the thousands (D. Nelson, pers. comm.).

NONBREEDING (WINTERING) SITES

Perhaps 50% of wintering Mountain Plovers occur in California, mostly in Imperial County. Although a recent decrease in their use of the Central Valley has occurred (Wunder and Knopf 2003), Mountain Plovers can still be found in the western San Joaquin Valley, in Solano and Yolo counties in the Sacramento Valley, and on the Carrizo Plain. Loss of grassland habitats to urbanization may have displaced Mountain Plovers, as it historically did on the coastal plain of California. The availability of agricultural lands used by Mountain Plovers in the Imperial Valley is relatively recent (i.e. since 1940) (Wunder and Knopf 2003). Smaller numbers of Mountain Plovers occur in the lower Colorado River Valley, southern Arizona, Hudspeth, Ector, Willacy, and possibly Pecos Counties of west Texas (Knopf and Wunder 2006, K. Bryan, pers.

comm., B. Ortego, pers. comm.). The southern Blackland Prairie region of Texas and the extensive agricultural lands of southern Texas also support wintering Mountain Plovers (B. Ortego, pers. comm.; C. Shackelford, pers. comm.; Lockwood and Freeman 2004). In México, nonbreeding distribution is generally not well known, although recent information suggests that flocks of 1,600–3,500 occur in the vicinity of El Llano de la Soledad in northeastern Nuevo León. Nonbreeding Mountain Plovers have also been recorded in the states of Chihuahua (Dieni *et al.* 2003), Coahuila, San Luis Potosí, Sonora, Tamaulipas, and Zacatecas.

Table 3. Locations of Mountain Plover breeding sites in Canada, the United States, and México. U.S. counties with the highest abundances of Mountain Plovers within each state are bolded.

Northern Prairie
Canada
Alberta
Saskatchewan
Montana
Big Horn
Blaine
Fergus
Golden Valley
Hill
Musselshell
Petroleum
Phillips
Rosebud
Treasure
Valley
Wheatland
Wyoming
Campbell
Converse
Crook
Sheridan
Weston
Intermountain Basins
Montana
Broadwater
Carbon
Jefferson
Madison
Wyoming
Albany
Bighorn
Carbon
Fremont
Lincoln
Natrona
Park
Sublette
Sweetwater
Washakie
Utah
Duchesne

Intermountain. Basins – cont'd
Colorado
Costilla
Jackson
Moffat
Park
New Mexico
Bernalillo
Cibola
Guadalupe
Lincoln
McKinley
Sandoval
San Juan
Santa Fe
Socorro
Taos
Torrance
Valencia
Arizona
Apache
Navajo
Shortgrass Prairie
Nebraska
Banner
Cheyenne
Kimball
Colorado
Adams
Arapahoe
Baca
Bent
Cheyenne
Conejos
Crowley
El Paso
Elbert
Fremont
Huerfano
Kiowa
Kit Carson
Larimer
Las Animas

Shortgrass Prairie – cont'd
Colorado
Lincoln
Logan
Morgan
Otero
Prowers
Pueblo
Washington
Weld
Yuma
Kansas
Greeley
Hamilton
Morton
Stanton
Oklahoma
Cimarron
Texas
Dallam
Hartley
Oldham
New Mexico
Colfax
De Baca
Harding
Mora
Union
Chihuahuan Desert/Texas
Texas
Jeff Davis
New Mexico
Catron
Chaves
Hidalgo
México
Chihuahua
Nuevo León
Coahuila
San Luis Potosí
California/Sonora-Mojave Deserts
Arizona
La Paz
Maricopa

Table 4. Locations of Mountain Plover nonbreeding (wintering) sites in the United States and México. U.S. counties with the highest abundances of Mountain Plovers within each state are bolded, as are states in México. (Very) approximate numbers wintering in each state are provided.

California/Sonoran-Mojave Deserts	***Chihuahuan Desert/Texas***
California (10,000)	*Texas* (1,500)[1]
Fresno	Atascosa
Yolo	Aransas
Solano	**Bexar**
San Joaquin	**Cameron**
Stanislaus	Concho
Merced	Ector
Fresno	Frio
Kings	**Guadalupe**
Kern	**Hidalgo**
San Luis Obispo	**Hudspeth**
Imperial	Kleberg
Tulare	La Salle
Arizona (500)	Medina
La Paz	Milam
Maricopa	Nueces
Pima	Pecos
Yuma	San Patricio
México (800)	Schleicher
Baja California	Starr
Sonora	Tom Green
	Uvalde
	Val Verde
	Willacy
	Williamson
	Arizona (200)
	Santa Cruz
	México (5,000)
	Chihuhua
	Coahuila
	Nuevo León
	Tamaulipas
	San Luis Potosí
	Zacatecas

[1] Winter distribution in Texas is not precisely known and abundance could be much greater.

CONSERVATION CHALLENGES

We used the standard lexicon of Salafsky *et al.* (2008) to assess conservation threats and actions for Mountain Plovers. This unified classification taxonomy organizes threats and actions in a hierarchy, and we indicated highest priority actions in the Conservation Timeline. All conservation threats identified in the unified classification system were considered, but only those that currently apply to Mountain Plovers are presented here. Below are listed the most crucial conservation threats facing Mountain Plovers, not necessarily in priority order:

- The inability to manage agricultural lands in the Imperial Valley, California, to provide consistent winter habitat, and the loss or inadequate management of other known wintering areas in California;
- The lack of comprehensive information on the wintering distribution of Mountain Plovers and the threats plovers face in these areas;
- Information gaps on the factors responsible for apparent low Mountain Plover survival during migration and the ability to define and identify stopover habitat;
- An historically reduced number of active black-tailed, white-tailed, and Mexican prairie dog colonies in the United States, México, and Canada, which results in less high-quality Mountain Plover habitat;
- The inability to comprehensively mange landscapes components (prairie dog colonies, native grasslands, and agricultural fields) that support breeding Mountain Plovers; and
- Lack of understanding how large-scale landscape changes wrought by energy development and climate change will affect Mountain Plover habitats.

Below, we use the two-level threat hierarchy (Salafsky *et al.* 2008) to discuss stresses to Mountain Plovers across their entire range or within one of the regions previously identified.

RESIDENTIAL AND COMMERCIAL DEVELOPMENT

California/Sonoran-Mojave Deserts. Most former nonbreeding habitat for Mountain Plovers in southern coastal California has been replaced by residential expansion (Hunting and Edson 2008). Agriculture continues to expand in the Imperial Valley and the human population has been growing there at 2.7% per year (see http://www.calmis.ca.gov/file/cosnaps/impersnap.pdf; http://www.fhwa.dot.gov/ planning/econDev/ caimpcor.htm). In the Central Valley of California, scrublands and grasslands were originally converted to farmland, which is now being urbanized (see http://www.ucop.edu/cprc/documents/sokolow.pdf). How these changes to wintering habitats will affect Mountain Plovers are unknown.

Shortgrass Prairie. Currently, more native prairies are being converted to urban and suburban development than for cultivated agriculture. The conversion rate on Colorado's eastern plains is 33,000 acres/year (Theobold *et al.* 2007). However, current Mountain Plover distribution in eastern Colorado generally lies east and south of areas projected to undergo the greatest urbanization, so this is not a current threat to the species.

Intermountain Basins. Aesthetic surroundings, nearby recreational opportunities, and close proximity to urban centers provide incentives to develop high-elevation areas like South Park, Colorado. Ranchland in South Park has begun to be subdivided in recent years, and subdividing a few large ranches could negatively affect Mountain Plovers breeding habitats.

Chihuahuan Desert/Texas. The conversion of grasslands in Chihuahua, México, has been identified as a conservation threat to North America's largest remaining black-tailed prairie dog colony in the Janos-Nuevo Casa Grandes complex (Manzano-Fischer *et al*. 1999), which supports breeding and wintering Mountain Plovers.

AGRICULTURE

Annual and Perennial Crops

Shortgrass Prairie. In the United States, México, and Canada, conversion of grassland habitats to croplands greatly altered traditional Mountain Plover habitats, particularly in the eastern part of its historical range. Although conversion of rangeland to cropland has represented only a small proportion of overall rangeland in recent years (U.S. Fish and Wildlife

Service 2003), demand for bio-fuels could accelerate conversion in the future. Because Mountain Plovers are able to use cultivated lands with similar, but perhaps compensatory, success (Dreitz and Knopf 2007), cultivation is suggested to not be detrimental to Mountain Plovers, at the population level, in Colorado. In Nebraska, however, overall nest success was higher than is Colorado, and tilling represented a continued source of nest loss throughout the breeding season (Bly *et al.*, unpubl. manuscript). Recent information indicates that chick survival is lower in agricultural fields than on prairie dog colonies, but is the same as ranchland (Dreitz, unpubl. manuscript). How shifting agricultural practices may affect site fidelity, and sequential site use and reproductive success, is not known.

Non-native grass species are sometimes introduced in the shortgrass prairie to increase soil moisture retention, reduce soil erosion, and provide a greater amount of forage; patches of taller grasses are unusable for nesting by Mountain Plovers. Selecting tall grass seed mixes for planting highly erodible lands under the U.S. Department of Agriculture's Conservation Reserve Program (CRP) does not benefit Mountain Plovers, although these CRP plantings benefit other bird species. The Colorado Division of Wildlife has been attempting to encourage landowners to plant native species of grass through Farm Bill Programs by working with the State Technical Committee, Wildlife Sub-committee, and the Natural Resource Conservation Service's district offices and Soil Conservation Districts.

Because Mountain Plovers will initiate nests in fallow or short-stature agricultural fields — primarily wheat, corn, sorghum, millet, and sunflowers — nests can be susceptible to destruction by farm equipment during cultivation, planting, and weed control operations. Nest success is related to the particular operation applied to a field; mechanical methods are the most destructive to nests (B. Bly, unpubl. data). In eastern Colorado, mechanized practices destroyed fewer nests than anticipated, and nest mortality was similar to predation losses on native grasslands (Dreitz and Knopf 2007), which was much higher than agricultural fields in Nebraska (B. Bly, unpubl. data). Mountain Plovers have also successfully re-nested on tilled fields (Dreitz and Knopf 2007). Tipton (2007) estimated that more Mountain Plovers nested on native grassland and dryland agriculture than on prairie dog colonies in eastern Colorado, but plover density on prairie dog colonies was 5–10 times greater than in either other habitat.

Chihuahuan Desert/Texas. Although potato cultivation has greatly increased in northern México, information on whether or not nonbreeding Mountain Plovers will use these converted

fields during for foraging and roosting is unknown (A. Chavez-Ramirez, pers. comm.). In Texas, Mountain Plovers use fields where turfgrass, cotton, cereal grains, and truck-farm crops are planted, but the value of these fields for providing quality foraging habitat for Mountain Plovers is unknown (B. Ortego, pers. comm.).

California/Sonoran-Mojave Deserts. Although cultivated fields are abundant in the Central and Imperial Valleys, only a small proportion may be suitable in any given year. Economic forces in any given year dictate crop selection and livestock operations, which can positively or negatively affect Mountain Plover habitat. Natural variation in precipitation, which results in differences in vegetation growth, adds to the stochastic availability of winter Mountain Plover habitat in the Central Valley. Future population growth in the Central and Imperial Valleys could cause major changes in land use patterns. Perhaps more importantly, water transfers from rural to urban areas could negatively affect natural and cropland wintering habitats of Mountain Plovers. Because wintering Mountain Plovers use harvested agricultural fields that have been burned, the tightening of burning restrictions to manage air quality and shifting of burning schedules, could possibly decrease the amount of habitat available to wintering Mountain Plovers (Wunder and Knopf 2003; C. Roberts, pers. comm.). The ability to provide an adequate and consistent amount of wintering habitat for Mountain Plovers is, or could become, a major challenge.

Livestock Ranching

Shortgrass Prairie. Drought is the principal ecological driver of the shortgrass prairie, which was secondarily maintained through grazing by black-tailed prairie dogs, bison (*Bison bison*), elk (*Cervus elaphus*), and, to a lesser extent, pronghorn antelope (*Antilocarpa americana*; Askins *et al.* 2007). Breeding Mountain Plovers are strongly associated with heavy grazing pressure and soil disturbance (Knopf and Miller 1994, Knopf and Wunder 2006). Introduction of cattle to the shortgrass prairie changed the structure of the prairie by homogenizing grass coverage and height and increasing the amount of standing grass cover (Fuhlendorf and Engle 2001, Askins *et al.* 2007, Knopf 2008), which resulted from decreasing stocking rates and grazing pressure, fencing, and the feeding action of cattle (Knopf 2008). In some areas, such as the Pawnee National Grassland, increased grazing intensity, in some units, will likely be needed to reduce grass cover and increase the amount of bare ground, which will improve nesting

conditions for Mountain Plovers (Knopf 2008). Private and public range managers face a challenge to balance variable habitat needs among wildlife species and to provide range conditions that maximize livestock weight gain.

Northern Prairie. In Montana, recent decreases in cattle and sheep ranching have resulted in local reductions in Mountain Plover numbers (Faunawest 2004).

In Canada, the scarcity of large areas of short, sparse grassland vegetation may limit use by Mountain Plovers; the relatively small patches of more heavily grazed grassland are generally too restricted for the establishment and maintenance of suitable breeding habitat (Werschler and Wallis 2002). Current range management in Canada emphasizes conservative stocking rates and moderately grazed grassland.

Chihuahuan Desert/Texas. In some areas of the Chihuahuan Desert, overgrazing has greatly reduced grass cover, which has resulted in an almost complete denuding of the landscape (A. Chavez-Ramirez, pers. comm.). Reducing grazing pressure in these areas would likely enhance Mountain Plover habitat.

ENERGY PRODUCTION AND MINING

Oil and Gas Production

Recently, U.S. policy has emphasized the expansion of domestic petroleum exploration and development; oil and gas production generally causes loss and fragmentation in most wildlife habitats. In the Powder River Basin of northeast Wyoming, for example, thousands of coal-bed methane wells have been drilled in the last decade, an extensive network of gas pipelines connecting the wells has been built, and a series of pressurization plants and power lines to provide electricity have been constructed. However, Mountain Plovers could respond favorably to the decrease in sagebrush cover and may nest on gravel drill pads and roads (F.L. Knopf, pers. comm.). Water produced during coal-bed methane production in Wyoming increases the potential for invasive plant species to become established and reduce the suitability of Mountain Plover habitat (Good *et al.* 2002). The overall effect of oil and gas development on breeding Mountain Plovers is unknown.

Mining and Quarrying

Mountain Plovers are thought to abandon breeding sites during mining activities in Montana and Wyoming (U.S. Fish and Wildlife Service 2003). Mining activities permitted on prairie dog colonies would reduce Mountain Plover breeding habitat.

Renewable Energy

A major threat to grassland-dependent bird species could be the combined effects of collisions and the infrastructure associated with wind power generation facilities, particularly in terms of habitat fragmentation. Although few studies have focused on Mountain Plovers, it appears that construction and operation of wind farms may temporarily disrupt and displace breeding plovers (Young *et al.* 2007). In Europe, breeding shorebirds were found to be particularly vulnerable to wind development and were easily displaced (Winkelman 1990 *in* Johnson *et al.* 2000, Pederson and Poulsen 1991 *in* Johnson *et al.* 2000). The effects of developing wind power generation facilities on Mountain Plovers are unknown, although there appears to be little risk from collisions with rotors (Young *et al.* 2007).

TRANSPORTATION INFRASTRUCTURE

Roads

The construction of roads to support suburban or semi-rural development (e.g., South Park, Colorado) as well as support for oil, gas, and wind energy development in rangelands might increase collision-caused mortality of adult and juvenile Mountain Plovers (U.S. Fish and Wildlife Service 2003). However, road collisions do not likely have a population-level effect. New roads can also create invasive plant pathways into shortgrass habitats, rendering it less suitable for Mountain Plovers (Good *et al*. 2002). Gravel used in road development could actually increase nesting sites for Mountain Plovers (F. Knopf, pers. comm.).

Utility and Service Lines

Because Mountain Plovers are low-flying birds, collisions with utility lines are likely not a major conservation issue.

USE OF BIOLOGICAL RESOURCE

Historically, Mountain Plovers were shot for human consumption on the Great Plains (Knopf and Wunder 2006). Mountain Plovers were easy targets because they are highly approachable and do not fly long distances when disturbed (Knopf and Wunder 2006). In the United States and Canada, contemporary shooting is not a conservation threat (Knopf and Wunder 2006), although it could still be an issue in some areas of México (e.g., Nuevo León and Chihuahua; A. Chavez Ramirez, pers. comm.).

HUMAN INTRUSIONS AND DISTURBANCE

Because Mountain Plovers are relatively tolerant of disturbance, human intrusion and disturbance have not been identified as a major conservation threat, although response varies for individual birds. Use of Mountain Plover habitats by off-highway vehicles, bikers, and hikers could be locally detrimental, but the population-level effect of these activities across the entire breeding range is likely minimal. Mountain Plovers have been described as extremely tolerant of machinery, including off-road vehicles, tractors, and military aircraft. Individuals will quickly leave nest sites or roost areas when approached by walking humans, and often they are not even detected (Knopf and Wunder 2006). Eggs, however, can overheat from solar radiation if disturbance keeps adult off the nest for a prolonged period, and un-shaded chicks can also suffer from heat exposure (Graul 1973).

NATURAL SYSTEM MODIFICATIONS

Prairie Dogs

Northern Prairie/Shortgrass Prairie. Direct removal of native grazers greatly altered natural grassland systems in the United States and Canada. Although the magnitude and extent of historical prairie dog populations are debatable (see Augustine *et al.* 2008), prairie dogs were clearly much more abundant and widely distributed in the past. Coverage of prairie dog colonies may have been reduced by >98% between 1900 and 1960 (Marsh 1984). How grazers structured grassland systems is not completely known, and the effect of historic prairie dog herbivory on maintaining grasslands may be underappreciated (Askins *et al.* 2007), including their role in nutrient cycling and soil formation (Samson and Knopf 1994).

Prairie dogs are still being killed in some parts of their range, and sylvatic plague, which is caused by the bacterium *Yersinia pestis* and transmitted by fleas, is a major factor controlling their abundance and distribution. Because Mountain Plover use of prairie dog colonies tracks plague-induced changes in prairie dog abundance (Augustine *et al.* 2008), measures to reduce or mitigate plague effects (Rocke *et al.* 2008) would indirectly benefit Mountain Plovers. The role that prairie dogs play in providing Mountain Plover breeding habitat is much broader than previously thought (Augustine *et al.* 2008).

In Colorado, about 2% of the eastern portion of the state is currently occupied by black-tailed prairie dog colonies (White *et al.* 2005, Odell *et al.* 2008). Between 2002 and 2006, the Colorado Division of Wildlife documented a 29% increase in the acreage occupied by prairie dogs in eastern Colorado, despite poisoning and plague events affecting the overall distribution of the species (Odell *et al.* 2008). Because Mountain Plovers reach their greatest densities on prairie dog colonies throughout the region (Augustine *et al.* 2008), maintaining and enhancing prairie colonies will greatly benefit Mountain Plovers.

Chihuahuan Desert/Texas. The largest remaining black-tailed prairie dog colony in North America is found in northern México and partially includes the Janos-Nuevo Casa Grandes complex (Ceballos *et al.* 1993). Much of the complex is privately owned, and prairie dogs are susceptible to poisoning and shooting. The complex has lost 24,710 acres (10,000 hectares) of black-tailed prairie dog colonies to cattle ranches (see Manzano-Fischer *et al.* 1999). Although the Mexican prairie dog is listed as endangered by the Mexican government, eradiation efforts and shooting for sport continue in the few areas where it remains, such as portions of Nuevo León — an area supporting breeding and nonbreeding Mountain Plovers.

Predation

Northern Prairie/Shortgrass Prairie. Predation was the highest cause of nest mortality on rangelands in eastern Colorado (Knopf and Rupert 1996, Dreitz and Knopf 2007), Montana (Dinsmore *et al.* 2002), and Nebraska (B. Bly, pers. comm.), and many researchers believe brood predation may also be relatively high. Predators include badgers (*Taxidea taxus)*, skunks (*Spilogale* spp., *Mephitis* spp.), ground-squirrels (*Spermophilus* spp.), swift foxes (*Vulpes velox*), coyotes (*Canis latrans*), bullsnakes (*Pituophis catenifer*), Swainson's Hawks *(Buteo swainsoni*), Common Ravens (*Corvus corax*), Great-horned Owls (*Bubo virginianus*), and Burrowing Owls

(*Athene cunicularia*). Predation could become a local conservation threat if fragmentation of native grasslands concentrates predators in remaining blocks. Control of predators in such situations would likely be economically and politically infeasible, and positive effects on Mountain Plover survival would be uncertain.

Fire suppression

Northern Prairie/Shortgrass Prairie. Fire may not have been an ecological driver in the shortgrass and northern prairies but may have created favorable conditions for Mountain Plovers on a local scale. Fire likely acted in combination with other factors such as drought and intensive herbivore grazing to structure the prairie community. Thus, fire can be used to manage for Mountain Plovers on a local scale.

INVASIVE AND OTHER PROBLEMATIC SPECIES AND GENES

Shortgrass Prairie. Non-native plant stands tend to have a taller stature, increases soil moisture, and decreased amount of bare ground, all which reduce habitat quality for Mountain Plovers. Invasion of non-native plants into fallow, tilled fields certainly decreases suitability for Mountain Plovers, and some native and non-native plants used to seed lands enrolled in the Conservation Reserve Program (CRP) create vegetation conditions unusable to plovers (Askins *et al.*2007). Current CRP management does not allow grazing, except under emergency conditions, which could benefit Mountain Plovers; however, numerous other grassland species benefit by not grazing CRP lands. Techniques to effectively restore native shortgrass prairie are mainly undeveloped (Askins *et al.*2007).

Intermountain Basins. West Nile Virus, a viral disease transmitted by mosquitoes, has affected wild birds within the range of the Mountain Plover, but has not been detected in the plover. An increased number of ground watering ponds associated with coal-bed methane development could increase exposure to mosquitoes infected with the virus (C. Keefe, pers. comm.)

POLLUTION

California/Sonoran-Mojave Deserts. Mountain Plover risk of exposure to pesticides in California is thought to be minimal, because of timing and location of applications (U.S. Fish and Wildlife Service 2003). However, organochlorine residues in Mountain Plovers collected in 1991–1992 in three California counties (Imperial, San Luis Obispo, and Tulare) ranged from 1.0 to 10.0 parts per million (ppm); high levels of DDE for an upland species usually range between 0 and 0.36 ppm (Knopf and Wunder 2006). No abnormalities in bird behavior or eggshell thickness were observed in subsequent nesting efforts (Knopf and Wunder 2006), although further analysis suggested that some eggs collected in Montana may have had detectable levels of DDE (U.S. Fish and Wildlife Service 2003). Cholinesterase levels differed widely between the Central Valley and Carrizo Plain in California, although there were no differences in Mountain Plover body condition (Iko *et al.* 2003). Changing pesticide application practices and evolution of new chemicals provides some level of continued threat to Mountain Plovers.

Pesticide control measures can reduce abundance of grasshoppers by >90% and can also reduce abundance in non-target insects (U.S. Fish and Wildlife Service 1999, 2003). Grasshoppers are a primary food source of Mountain Plovers in some areas and reductions their abundance could negatively affect fecundity, nest success, and survival of young and influence body condition in adults and fledged young prior to migration. However, grasshopper spraying is not thought to be a significant threat to Mountain Plovers (U.S. Fish and Wildlife Service 2003).

Intermountain Basins. In Park County, Colorado, DDE levels in eggs from 10 abandoned nests ranged from 0.11 to 115.00 ppm, and there were a few subsequent incidental observations of cracked eggs and egg shells breaking (Knopf and Wunder 2006). It is unknown if young birds are more vulnerable to exposure to pesticides and how exposure in the egg affects recruitment. Therefore, the direct and indirect effect of pesticides and other contaminants needs to be further investigated and monitored.

Chihuahuan Desert/Texas. Application of herbicides and insecticides in México may be more of a conservation concern to Mountain Plovers due to the types of chemicals used, concentration of use, and aerial extent of coverage (A. Chavez-Ramirez, pers. comm.). More information is needed on the effects of pesticides on Mountain Plovers wintering in México.

Northern Prairie/Shortgrass Prairie. There has been a recent increase in the deposition of effluent from human waste treatment facilities and livestock feed yards on agricultural fields in eastern Colorado, which may contain concentrations of heavy metals (R. Lock, pers. comm.); contamination effects of these effluents on Mountain Plovers are unknown. Waste water treatments could also increase vegetation density and height, which could make treated areas unsuitable to nesting Mountain Plovers (F. Knopf, pers. comm.).

CLIMATE CHANGE AND SEVERE WEATHER

Understanding how weather and long-term climatic events affect Mountain Plover survival and reproduction is important to develop adequate conservation strategies that will sustain populations. Weather events can have a negative effect on recruitment of young into the population through variety of mechanisms; hail, rain, and below normal temperatures can all contribute to mortality of Mountain Plovers either through direct kills or hypothermia (Graul 1975, Knopf and Wunder 2006). Future projections for the western United States generally include increased summer temperatures and decreased summer precipitation (Field *et al.* 2007). Predicted drier and hotter conditions could favor the creation of Mountain Plover habitat.

Habitat Shifting and Alteration

Warmer temperatures and a drier growing season will likely influence farming and ranching practices throughout the Mountain Plover's range, which in turn will likely change patterns of plover distribution. However, how the agricultural industry will respond to these changes is difficult predict. Mountain Plovers could expand their range northward and eastward under current climate change scenarios.

Drought

Drought is thought to be the driving ecological force in xeric shrubland, desert, and shortgrass prairie systems, helping to maintain the physical properties that Mountain Plovers depend upon for nesting — patches of bare ground and low-stature vegetation. Mountain Plover productivity appears to be better in drier years (Wunder 2007); in wetter years, nest and chick success is reduced due to higher predation rates and nest flooding (Knopf and Wunder 2006,

Dinsmore 2008). In wetter years, the extent of tillage is increased in some agricultural fields (to reduce weeds), which could increase nest loss (B. Bly, pers. comm.).

High Temperatures

Increased temperatures associated with climate change could benefit Mountain Plovers by creating more semi-desert grasslands. Adults actively shade chicks on hot days, and adults and chicks often seek shade (Graul 1975, Shackford 1996, Knopf and Wunder 2006). It is unknown if higher temperatures projected for the breeding season would negatively affect brood survival.

CONSERVATION STRATEGIES AND ACTIONS

We also used the lexicon and classification hierarchy of Salafsky *et al.* (2008) to organize conservation actions for the Mountain Plover; actions will be prioritized in the *Conservation Timeline* section. The Structured Decision Making workshop held in July 2008 began a process to understand what limits Mountain Plovers during their annual cycle. As this process is refined, conservation actions can be targeted to areas throughout the Mountain Plover's range that will have the most benefit for the population. Because funding sources may only apply to a more limited region, a suite of conservation actions that address breeding, migration, and wintering areas is provided.

On the breeding grounds, a general objective is to ensure that the breeding population continues to be well-distributed among the regions previously identified. The purpose of keeping the breeding population well distributed is to minimize the risk of large-scale mortality of adults, chicks, and eggs caused by stochastic, regional events, such as severe weather and plague outbreaks in prairie dogs, and perhaps to buffer against spatially explicit effects of climate change. Conservation actions on the breeding grounds should mainly concentrate in areas that contribute fairly large numbers of birds to the population — South Park, Colorado; eastern plains of Colorado; northern Montana; and west and central Wyoming. Some proportional effort should also be directed toward other minor breeding areas (e.g., Kansas and Nebraska).

Mountain Plover survival appears to be lowest during the migration season (Wunder 2007), despite their short-distance migration, and we currently lack reliable information on where and how plovers use stopover habitat. Understanding if the migration period is limiting Mountain Plover population growth and what factors are driving survival are needed before effective conservation actions can be implemented.

The location of >50% of the Mountain Plover population during the wintering season is unknown, and much of the population may be highly dispersed. Although over-winter survival appears to be relatively high (Knopf and Rupert 1995), Mountain Plovers have abandoned some traditional wintering areas, and we lack the ability to provide consistent winter habitat in known aggregation areas in California. Understanding the winter distribution and developing a strategy to provide stable winter habitat are priority conservation actions.

LAND PROTECTION

Chihuahuan Desert/Texas. Work with the Mexican government and other partners to get the Janos-Nuevo Casa Grandes Complex recognized as a biosphere reserve (Manzano-Fischer *et al.* 1999) and provide additional protection of habitats used by Mexican prairie dogs in México, notably in Llano de al Soledad and El Tokio, Nuevo de León. In the Janos-Ascención region in Chihuahua, Pronatura Noreste has conserved 9,500 hectares and is currently working on protection for an additional 4,000 hectares. Pronatura has used a variety of conservation and management agreements to protect grasslands in northeastern México. These agreements can allow private and ejido owners to continue cattle ranching in a responsible manner and to promote ecotourism, scientific research, and environmental education. Duration of the agreements range from 10 to 20 years, and conservation efforts in this region should be continued.

Northern Prairie/Shortgrass Prairie. Because private lands support a significant proportion of the current Mountain Plover population, private landowners are critical for providing long-term sustainability of plover populations. Therefore, conservation easements with the appropriate management agreements should be pursued throughout their range, especially on areas with active prairie dog colonies. Developing innovative strategies with the National Resource Conservation Service, as the Colorado Division of Wildlife (CDOW) has done in the Shortgrass Prairie, has the potential to greatly benefit Mountain Plovers. Depending

on funding, the CDOW will continue to focus its grassland easement program on areas that support prairie dogs, which will, in turn, positively affect Mountain Plovers.

Intermountain Basins. South Park, Colorado, which supports >2,300 breeding Mountain Plovers (13% of the continental population; Wunder *et al.* 2003), is being subdivided into small residential parcels. A land protection strategy using easements with appropriate agreements or management plans needs to be developed to ensure maintenance of Mountain Plover breeding habitat.

LAND MANAGEMENT

All Breeding Areas. Reducing or controlling non-native grasses in areas used by Mountain Plovers could likely increase breeding habitat by increasing the amount of bare ground. Within breeding areas of Mountain Plovers, use of native grasses, rather than non-native species or mid-grass species, to restore altered lands would provide more suitable plover nesting habitat; all grasslands would benefit from grazing by cattle, sheep, or prairie dogs.

Northern Prairie/Shortgrass Prairie. Protection and, possibly reintroduction, of prairie dog colonies is likely the most effective way to ensure adequate habitat for Mountain Plovers. Federal and state agency lands have the major role to play in maintaining prairie dog colonies.

Prescribed burning can increase the availability of local Mountain Plover nesting habitat, particularly on lands where taller or non-native grasses occur (Knopf 2008). Burns have been conducted on the Pawnee and Comanche National Grasslands with a positive response from nesting Mountain Plovers (USDA Forest Service 2005, Knopf and Wunder 2006, Knopf 2008). For political and budgetary reasons, it may be difficult to use burning to increase breeding Mountain Plover habitat at a large scale, particularly off of federal lands. Burning can also increase the risk of invasion by non-native plants. Under the right conditions, burning may provide a tool for creating Mountain Plover habitat in a matrix of grasslands managed for other species.

California/Sonoran-Mojave Deserts. Burning appears to provide roosting habitat for Mountain Plovers wintering in Tulare County and on the Carrizo Plain (Wunder and Knopf 2003, Knopf 2008), and burned Bermuda grass fields are used by plovers in Imperial County. Burning of tame or native grasslands may be a tool for providing predictable nonbreeding habitat for Mountain Plovers. Developing a strategy to provide regional predictable, but locally

ephemeral, wintering habitat for nonbreeding Mountain Plovers is a high priority. Land protection could be part of this strategy.

Promoting Integrated Pest Management (IPM) practices that limit chemical applications would likely reduce contaminant exposure and could increase Mountain Plover survival. Initiation of IPM programs in the Imperial Valley, California, might be particularly beneficial.

DIRECT SPECIES MANAGEMENT

Northern Prairie/Shortgrass Prairie. In Nebraska, locating and marking nests in active agricultural fields appears to increase nest survival (B. Bly, unpublished data). The value of this intensive activity is likely affected by the proportion of the population nesting in agricultural fields within a local area. Although nest marking appears to reduce nest loss in Nebraska, it may be difficult to use nest marking to sustain populations at a broader scale.

EDUCATION AND AWARENESS

Where already active, outreach campaigns on the value of prairie dogs as keystone species for prairie ecosystems should continue.

Chihuahuan Desert/Texas. In communities surrounding the Janos-Nuevo Casa Grandes complex in México, establishment of an environmental education program focusing on the importance of prairie dogs to ecosystem function and the sustainable use of natural resources could be beneficial (Manzano-Fischer *et al.* 1999).

Northern Prairie/Shortgrass Prairie. Providing training to farmers on the identification of Mountain Plover nests and how to avoid them while tilling their agricultural fields will help keep these stakeholders involved in Mountain Plover conservation. The Colorado Division of Wildlife and Rocky Mountain Bird Observatory have conducted a successful campaign to educate landowners about Mountain Plovers and their conservation. Supporting educational efforts with farmers on timing of tilling and other agricultural practices could benefit Mountain Plovers. Education about Mountain Plovers and their conservation to the ranching community should continue. For example, the Karval Community Alliance holds a Mountain Plover festival in Colorado, which provides an opportunity for interaction among birders and landowners. The

important role private landowners play in the conservation of Mountain Plovers should continue to be acknowledged and promoted.

LAW AND POLICY

Chihuahuan Desert/Texas. Identify and evaluate the reasons why some wildlife laws are not fully enforced in México. Identify potential and effective strategies to encourage the Mexican federal government to enforce wildlife laws relative to Mexican prairie dogs and persecution of Mountain Plovers. As an endangered species, Mexican prairie dogs are protected and poisoning is prohibited by law. Some biologists working in Nuevo León, however, suspected that poisoning and other eradication efforts were targeting prairie dogs through the late 1990's (Manzano-Fischer *et al.* 1999). There have also been suggestions that Mountain Plovers are shot for sport in México (A. Chavez-Ramirez, pers. comm.).

ECONOMIC AND OTHER INCENTIVES

California/Sonoran-Mojave Deserts. Because wintering habitat conditions for Mountain Plovers in the Imperial Valley are temporally unstable, due to market forces, economic incentives for farmers and ranchers to continue, or enhance, land management practices that provide the right habitat conditions for Mountain Plovers should be evaluated.

All Breeding Areas. Maintaining grazing as an economic activity will help keep undeveloped areas from being converted into urban and suburban areas, which do not support Mountain Plovers. Creating partnerships with organizations such as American Farmland Trust, Farm Bureau, and Cattlemen's Associations could benefit Mountain Plover conservation. Development of dry grassland incentives for Farm Bill conservation provisions would benefit numerous grassland species.

Chihuahuan Desert/Texas. Ecotourism in large, intact grasslands of México, such as Llano de la Soledad in Nuevo León, should be encouraged. The agreement with Los Arrieros Ranch encourages ecotourism along with environmentally responsible cattle ranching.

In México, easement-like incentives are not as developed as in the United States. Increased involvement by the Mexican government to establish landowner incentives for wildlife-oriented practices would greatly benefit grassland wildlife. (Valdez *et al.* 2006).

EXTERNAL CAPACITY BUILDING

Maintaining a functional working group will enable members to better share information about Mountain Plover biology and find solutions to conservation issues facing plovers. Achieving a viable group should lead to more effective and efficient Mountain Plover conservation.

RESEARCH AND MONITORING

Information on age-specific survival throughout the annual cycle and across all regions is critical for determining populations limiting factors and developing conservation investment strategies that yield returns in population-level responses. Estimates of survival need to be precise enough to be able to decide among conservation investment alternatives. Adult survival during pre-, post-, and migration periods are possible foci for immediate work as is habitat-specific estimates of chick survival.

Wintering Areas. Determine the use of wintering habitats and response to management activities so that an effective land protection and management strategy can be developed. There is a need to identify wintering areas used by Mountain Plovers outside of California.

Although some work has been done on the exposure of Mountain Plovers to contaminants (Knopf and Wunder 2006), additional examination of the potential health consequences on Mountain Plover of ingested and inhaled contaminants while on nonbreeding grounds in the Central Valley of California is probably warranted. Because shorebirds have more air sacs than other birds, inhaled organophosphates may have an effect on cholinesterase activity (Iko *et al.* 2003, Knopf and Wunder 2006).

Migration. Little is known about the stopover ecology of Mountain Plovers. The role that abundance and variability of food resources plays in Mountain Plover population dynamics is unknown, particularly during migration periods.

Breeding Areas. Although Mountain Plovers nest in agricultural fields, there is a need to understand if agricultural fields provide adequate brood-rearing habitat. We need to understand how to comprehensively mange landscapes components (prairie dog colonies, native grasslands, and agricultural fields), which support breeding Mountain Plovers.

More information is needed to understand the direct and indirect effects that wind generated power and other energy development, such as coal-bed methane production, will have on Mountain Plover populations. Assessment should occur across the entire suite of conditions present in the Mountain Plover's breeding range.

To reliably determine the status of the Mountain Plover, a range-wide survey, employing similar methods, should be developed. Reliable, spatially explicit population estimates will be useful to determine the need for additional protection for the species and to determine where conservation actions would likely be most effective. The survey should be developed with the notion of a periodic assessment.

Mountain Plovers may be limited in their ability to occupy new breeding areas, especially in the northern part of their range; large prairie dog colonies in southwestern South Dakota, for example, appear to be unoccupied. Understanding if Mountain Plovers are demographically limited in their colonization ability or if some habitat element is missing from potential sites are important for developing effective conservation strategies.

CONSERVATION TIMELINE

SHORT-TERM (2009–2013)

- Develop a **functional Mountain Plover Working Group** whose members are active in sharing information and finding collective solutions to plover conservation issues. The initial step is to determine membership, leadership, and structure of the group.

- **Finalize results of Structured Decision Making (SDM) Workshop** case study using the Mountain Plover.

- **Refine the preliminary demographic model** developed in SDM workshop. Use results to guide decisions about allocation of range-wide resources for Mountain Plover conservation actions and adjust actions suggested herein.

- Because >50% of the population cannot be found during the winter, develop and implement methods to **map the abundance of wintering Mountain Plovers** across their winter range

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- Develop specific land management and protection strategies to provide **regionally predictable wintering habitat in the Imperial Valley**. Innovative approaches may require new incentives that mitigate changes in agricultural practices brought about by market forces and water law.

- Expand partnerships with Natural Resources Conservation Service (NRCS) to develop special **incentives for private ranchland owners**. Support state-based technical assistance to NRCS that focuses on wildlife benefits of conservation provisions of Farm Bill programs that go beyond fee-based hunting programs.

- Continue to secure **easements and develop management plans on private lands that support prairie dog colonies**. Continue to develop land protection tools to enhance core prairie dog colony parcels.

- Determine **brood survival among breeding habitat types**, particularly determining if agricultural fields provide adequate food resources.

- Initiate research to understand **how Mountain Plovers will be affected by energy development projects** in the Intermountain West and western Great Plains.

- Develop broadly applicable methods to **assess range-wide population status** and evaluate the objective of keeping the population well-dispersed among breeding regions. Pursue utility of an occupancy-model approach. Design a survey to account for **periodic assessments that incorporate cyclic environmental conditions** like drought.

- Continue to expand **training and outreach efforts to farmers** to encourage protection of Mountain Plover nests on their cultivated land.

- Initiate, or continue, **vegetation management practices in shrub-steppe habitat of central and western Wyoming**, specifically to expand nesting Mountain Plover use of area.

- Continue to develop conservation and management agreements with ejidos, and other mechanisms, to **conserve grasslands in northern México.**

LONG-TERM, 2014–2018

- **Develop technologies to readily identify and define Mountain Plover habitat** range-wide, especially stopover habitats. At present, habitat availability for Mountain Plovers range-wide cannot be reliably assessed remotely.

- Identify and secure funding needed to **institutionalize periodic surveys** of Mountain Plovers across their range.

- Develop strategies to enforce Mexican wildlife laws **regarding the direct take of Mountain Plovers**. **Initiate control of free-ranging dogs** in prairie dog colonies there.

EVALUATION

Without reliable knowledge on the population status of Mountain Plovers, beneficial changes in population size will be difficult to measure. However, local responses can be measured and should be explicitly defined when further developing specific tasks related to the actions identified here. Annual assessments on progress toward the identified actions should give some measure of the usefulness of the plan.

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