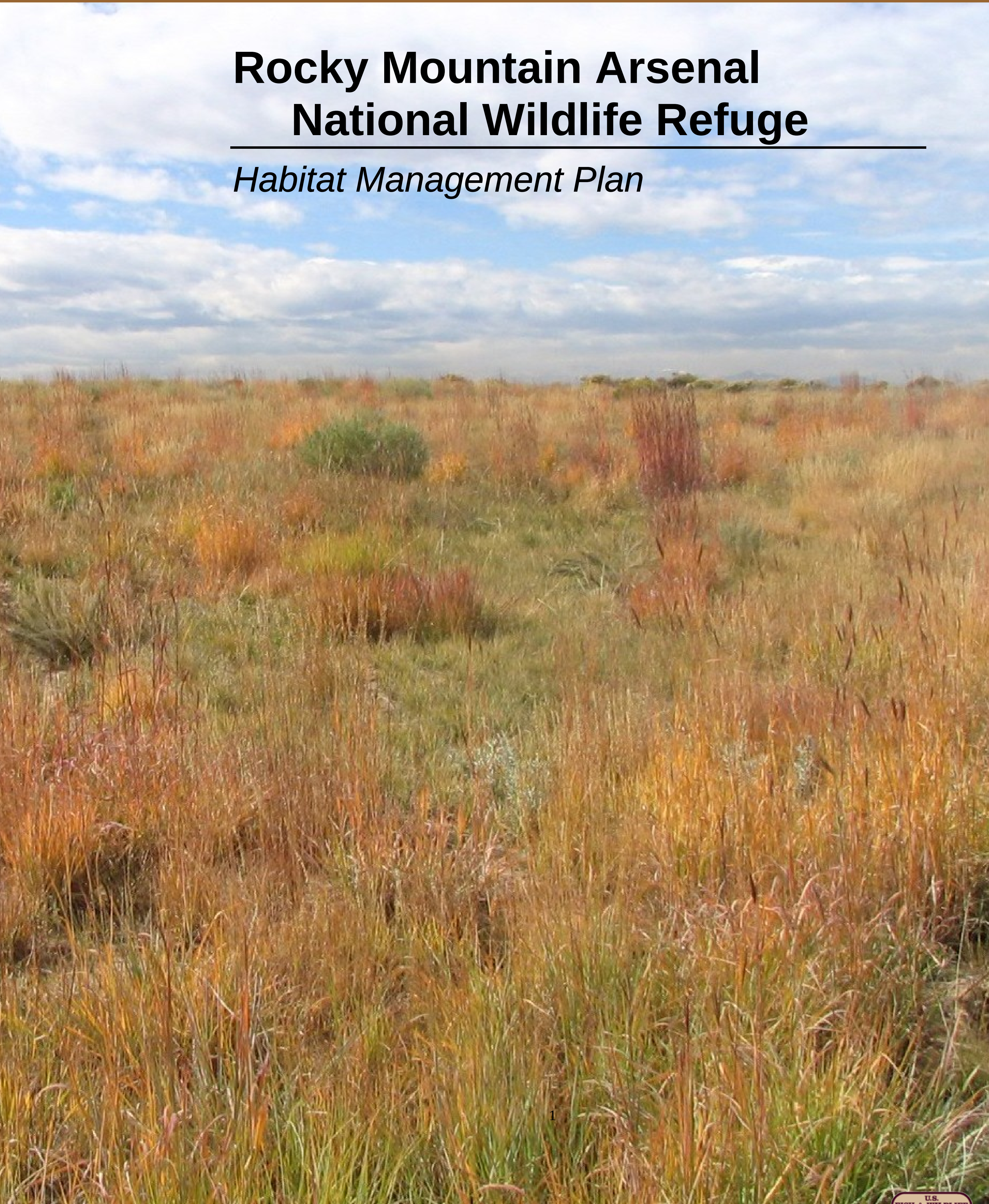
U.S. Fish & Wildlife Service

Rocky Mountain Arsenal National Wildlife Refuge

Habitat Management Plan



The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations.

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Executive Summary

Located approximately ten miles from downtown Denver, the land (15,988 acres) within the acquisition boundary of Rocky Mountain Arsenal National Wildlife Refuge (RMANWR) has a well-documented history of significant environmental disturbance and contamination. The primary causes of degradation were the manufacture of chemical weapons by the U.S. Army from the World War II through Vietnam eras and the production of pesticides by Shell Oil Company in the 1980's. Given the extent and type of degradation, the Environmental Protection Agency (EPA) identified the need for these lands to be remediated in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, also commonly known as Superfund) to ensure standards for human health and the environment are met prior to transferring ownership to the National Wildlife Refuge System (NWRS) for management as a National Wildlife Refuge. Remediation activities mandated under CERCLA will result in restoring approximately 67% (10,739 acres) of RMANWR lands to native short- and mixed-grass prairie. Other habitats that will be present on RMANWR include shrublands, forested lands, riparian areas, and numerous manmade features (irrigation lakes, ditches, homesteads, etc.), many of which are of cultural or historic importance.

The Habitat Management Plan (HMP) is a "step-down" plan from the RMANWR Comprehensive Management Plan (CMP) completed in 1996. Guidance for developing an HMP is based on relevant Service laws and policies, including the RMANWR Act of 1992 (PL 102-402), the National Wildlife Refuge System Improvement Act of 1997 (Improvement Act), and the Service policy on Biological Integrity, Diversity, and Environmental Health (BIDEH) (U.S. Fish and Wildlife Service 2001). The RMANWR Act stipulates eight purposes for establishment of the Refuge, the Improvement Act mandates the environmental health of refuge lands be evaluated and analyzed to "ensure that biological integrity, diversity, and health of the System are maintained for the benefit of present and future generations of Americans", and BIDEH directs managers to employ management that "restores or mimics natural ecosystem processes or functions to achieve Refuge purposes." Collectively, these and other documents stipulate that refuge managers should implement the most appropriate management actions to restore degraded systems to the extent possible and prevent further degradation of systems, which will depend on many factors including funding and staffing.

Significant restoration of RMANWR habitats has occurred since completion of the CMP and, in addition, a new Comprehensive Conservation Plan (CCP) will be developed beginning in 2013 to replace the CMP. Therefore, although the goals and principles outlined in the CMP are used to the extent possible, many habitat management recommendations have been revised to better reflect current habitat conditions and to incorporate knowledge gained during the past 17 years of RMANWR management. These revised recommendations will also be incorporated in the new CCP. Given the 15-year lifespan of the HMP, the principles of adaptive management will be used to evaluate and modify management strategies following completion of all restoration efforts.

The HMP identifies important wildlife resources on RMANWR and the management strategies that will be implemented during the next 15 years to help ensure the appropriate life-cycle needs of these species are met at the appropriate spatial scale. More than 300 species of wildlife have been documented on RMANWR, but many of these species occur in low numbers or are not observed frequently. To identify priority resources of concern, refuge staff compiled a list of species documented as priorities in various plans developed by national, regional, local, state, and private organizations and compared this list to species that currently use, or potential could use RMANWR habitats. Species that exhibited significant overlap were selected as priority resources of concern and the habitat requirements (e.g., food, cover, area requirements) of these species formed the basis for HMP goals, objectives, and management strategies. However, habitat resources are limited given the size and isolated nature of the refuge; therefore, RMANWR staff used published scientific literature and professional expertise to identify potential conflicts and optimize conditions for these species within the context of BIDEH.

Specifically, the goals and objectives of this HMP are designed to accomplish the following during the next 15 years (2013-2028):

- Promote successful long-term establishment and maintenance of seeded restoration sites, as well as existing native prairies and shrublands, to provide habitat for the resources of concern.

- Maintain the importance of RMANWR as a priority nesting site for burrowing owls (*Athen cunicularia hypugaea*) along the Front Range of Colorado.

- Preserve a historically representative population of black-tailed prairie dogs (*Cynomys ludovicianus*; hereafter referred to prairie dogs in the context of RMANWR).

- Provide additional nesting opportunities for resources of concern, including relevant grassland-dependent bird species exhibiting population declines.

- Maintain a bison (*Bison bison*) population that contributes to the Department of the Interior's Bison Conservation Initiative and helps maintain the structure and composition of native and restored prairies necessary to support priority grassland bird species.

- Provide habitat in the Educational Zone of the refuge for neo-tropical migratory bird species that are losing suitable stop-over areas to urban development in the Denver-metro area.

- Provide long-term quality nesting and roosting habitat for the bald eagle (*Haliaeetus leucocephalus*).

- As the nation's premier urban wildlife refuge, the RMANWR provides a variety of unique public education opportunities. This includes how one of the most environmentally contaminated sites in the United States can be restored to a native prairie ecosystem.

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Chapter 1 – Introduction

Scope and Rationale

The HMP is a step-down management plan of the Comprehensive Conservation Plan (CCP) or, in the case of Rocky Mountain Arsenal National Wildlife Refuge (RMANWR), the Comprehensive Management Plan (CMP) that was approved in 1996. The intent of the HMP is to provide additional details regarding specific strategies and implementation schedules for meeting goals and objectives set forth in the CCP/CMP during a 15-year period. In addition, an HMP provides an opportunity to evaluate the applicability of goals and objectives previously established in the CCP/CMP and determine if changes are required based on available data and other information. HMPs are dynamic documents that are modified using an adaptive management process that is based on monitoring progress toward achieving goals and objectives. In addition, the HMP is evaluated when a refuge considers revisions to the CCP (at least every 15 years) or at 5-year intervals using a peer review process (U.S. Fish and Wildlife Service 2002b). The RMANWR will begin the process of revising its CMP in May 2013.

The RMANWR encompasses 15,988 contiguous acres. As the nation's premier urban national wildlife refuge, the RMANWR is host to a robust environmental education program and a various forms of wildlife-dependent outdoor recreation. The refuge provides catch-and-release recreational fee fishing, nearly ten miles of trails, a nine mile Wildlife Drive auto tour, wildlife viewing opportunities and site tours for the public. Due to contamination from the production of chemical munitions and pesticides, significant portions of this land underwent environmental cleanup as stipulated in the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) administered by the Environmental Protection Agency (EPA). With the exception of about 1,084 acres that will be retained by the U.S. Army[1],

[1] This HMP is a 15-year document. To facilitate long-term planning, the Service will utilize acreage under the administrative jurisdiction of the U.S. Army (1,084 acres). For example, there are currently 102.5 acres of land listed on the National Priorities List, where remedy is complete, that are not identified as retained by the U.S. Army. These acres are managed by the Service in accordance with Section

the balance of land, approximately 14,904 acres, within the boundary has been transferred to U.S. Fish and Wildlife Service's (Service) jurisdiction following completion of remediation activities (U.S. Fish and Wildlife Service 2012a). Although most environmental cleanup was completed by the fall of 2011, native plant restoration activities continue on most lands. The success of these habitat restoration efforts, particularly in recently disturbed cleanup areas, will be difficult to ascertain for possibly a decade from when they were initially seeded.

The scope of this HMP is to:

1. Identify important resources of management concern on RMANWR.

2. Develop goals and objectives that, once achieved, will ensure perpetuation of those resources.

3. Identify management strategies necessary to attain stated goals and objectives.

4. Identify appropriate monitoring strategies to measure progress toward achieving goals and objectives.

Legal Mandates

The mission of the Service is "working with others to conserve, protect, and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people."

The Rocky Mountain National Wildlife Refuge Act

The Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 (Public Law 102-402) stipulates the following eight purposes for establishment of the Refuge (purposes in bold refer specifically to habitat management):

- To conserve and enhance populations of fish, wildlife, and plants within the refuge, including populations of waterfowl, marsh birds, waterbirds, raptors, and passerines.

- To conserve species that are threatened, endangered, or candidates for listing under the Endangered Species Act.

- To provide maximum fish and wildlife oriented public uses at levels compatible with the conservation and enhancement of wildlife and wildlife habitat.

- To provide opportunities for compatible scientific research.

- To provide opportunities for compatible environmental and land use education.

- To conserve and enhance the land and water of the refuge in a manner that will conserve and enhance the natural diversity of fish, wildlife, plants, and their habitats.

- To protect and enhance the quality of aquatic habitat within the refuge.

2(a)(1)(B) of the RMANWR Act. Regardless of administrative jurisdiction, the Service will work cooperatively on habitat management of all RMANWR lands, including those retained and maintained by the U.S. Army.

- To fulfill international treaty obligations of the United States with respect to fish and wildlife and their habitats.

The RMANWR Act also gives the Service authority to manage RMANWR as if it were a National Wildlife Refuge during the remediation or cleanup process as stated in Section 4 (b) (1): "The Secretary of the Interior shall manage the refuge in accordance with the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd et seq.)".

The National Wildlife Refuge System Improvement Act of 1997 & U.S. Fish and Wildlife Service Policy on Biological Integrity, Diversity, and Environmental Health

Section 4(a) and 4(b) of the National Wildlife Refuge System Improvement Act (Improvement Act) directs the Secretary, when administering the National Wildlife Refuge System (NWRS), to "ensure that the biological integrity, diversity, and health of the System are maintained for the benefit of present and future generations of Americans…" The Improvement Act clearly mandates the use of sound professional judgment when determining the relationships between refuge purposes and biological integrity, diversity, and environmental health (BIDEH). Further, the BIDEH policy (U.S. Fish and Wildlife Service 2001) clearly emphasizes management that restores historical ecosystem processes and functions as they are directly related to biological integrity and health. Collectively, these mandates instruct refuge managers to evaluate the potential to restore BIDEH when critical elements have been lost or severely degraded. The RMANWR HMP plays a key role in this process by defining historical ecosystem functions and to what degree they can be restored and maintained.

Other Legal Mandates

Several additional legal mandates also govern the management of units within the NWRS. With respect to RMANWR, these mandates include, but are not limited to, the following acts and policies:

- The Migratory Bird Treaty Act (1918)
- Bald and Golden Eagle Protection Act (1940)
- Fish and Wildlife Act (1956)
- National Wildlife Refuge System Administration Act (1966)
- Endangered Species Act (1973)
- North American Waterfowl Management Plan (1994)
- Migratory Non-Game Birds of Management Concern in the U.S. (2002)
- The National Environmental Policy Act (NEPA, 1970)

Relationship to Other Plans/Memoranda

The Habitat Management Plan (HMP) is a "step-down" plan of the Comprehensive Management Plan (CMP) (U.S. Fish and Wildlife Service 1996a). The process of revising the CMP will begin in 2013 and will require several years to complete.

Thus, the goals, objectives, and management strategies in this HMP will form the foundation for management in the interim. Relevant goals and information from the CMP, completed in 1996, were considered in the development of the HMP to the extent possible. However, many habitat management recommendations in the CMP are outdated and have been revised to better reflect current habitat conditions. When the new Comprehensive Conservation Plan (CCP) is initiated, the HMP will be examined as part of the CCP and information from the HMP will be revised and incorporated into the CCP as appropriate.

The goals and objectives in the HMP will help achieve refuge purposes, fulfill the System mission, meet other Service mandates, and comply with all applicable laws, regulations, and policies governing the management of Service lands. Further, HMP goals and objectives were developed to be consistent with other geographically relevant conservation plans to ensure management direction contributes to conservation at multiple spatial scales. Specific plans consulted included threatened and endangered species recovery plans, North American Waterfowl Management Plan (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986, U.S. Fish and Wildlife Service et al. 1994;2012), Northern States Bald Eagle Recovery Plan (U.S. Fish and Wildlife Service 1983), Playa Lakes Joint Venture Implementation Plan (Playa Lakes Joint Venture 2008), Multi-State Conservation Plan for the Black-Tailed Prairie Dog (*Cynomys ludovicianus*) in the United States (Luce 2003), Platte/Kansas Rivers Ecosystem Plan (U.S. Fish and Wildlife Service 2008), the Colorado State Wildlife Action Plan (Colorado Division of Wildlife 2006), Conservation Plan for Grassland Species of Colorado (Colorado Division of Wildlife 2003), Partner In Flight Colorado Bird Conservation Plan (Beidleman 2000), and The Nature Conservancy's Central Shortgrass Prairie Ecoregion Conservation Plan (The Nature Conservancy 2006). Important ecosystem attributes (wildlife species, habitats) identified in these plans was evaluated relative to refuge purposes and management capabilities to identify resources of concern for inclusion in the HMP.

In addition to the HMP, other step-down plans guide management and stewardship of Service lands, including the Fire Management Plan, Integrated Pest Management Plan, Inventory and Monitoring Plan, Cultural Resources Management Plan, and Visitor Services Plan. Components of these plans are interrelated with the HMP; thus, information in existing step-down plans, or appropriate personnel responsible for these plans, was consulted during development of the HMP to ensure consistency.

Due to past soil contamination, management of refuge lands also is guided by several additional documents and memoranda. The Habitat Restoration Plan (U.S. Fish and Wildlife Service 1999) specifies detailed vegetative restoration goals, techniques, and success criteria necessary to remediate past environmental damage. The HRP was agreed to by the Service, U.S. Army, and Shell Oil Company to provide compensatory mitigation for habitat disturbed during implementation of the remediation process administered by the EPA. In addition, a Conceptual Plan for First Creek (McLaughlin Water Engineers Ltd. 1994) at the Rocky Mountain Arsenal that provides recommendations for restoration of First Creek and protection of bald eagle habitat was incorporated in the CMP (U.S. Fish and Wildlife Service 1996a). A detailed summary of the goals and objectives of these three plans is provided in Appendix C.

To assist with the task, in 2006, the Service endorsed a new adaptive management business model appropriately coined Strategic Habitat Conservation. "SHC" recognizes that future conservation of fish and wildlife species must utilize new tools, at broader scales, and rely upon landscape approaches. The key to this model is the designation of "priority species" as a guide for conservation design (National Ecological Assessment Team 2006). The selection of priority species remains a valid tool to assist with prioritization of conservation effort as the first step in protecting habitat.

Most recently, the Service has further refined its SHC approach to focus conservation design on creating functional landscapes capable of supporting self-supporting populations of fish and wildlife species (U.S. Fish and Wildlife Service 2012b). This approach is based on the selection of surrogate species which Caro (2010) defined as "species that are used to represent other species or aspects of the environment." This guidance is still under development, but holds hope for systematic approach to landscape conservation design capable of addressing essential limiting factors of certain species, acting as surrogates for others, necessary to preserve biodiversity.

Other memoranda provide explicit directions regarding operations and maintenance activities that impact the ability to implement certain management strategies. For example, the following memorandum provides specific protocols that are to be followed prior to undertaking actions that may involve grading or removal of surficial soils at RMANWR:

To:	*All Service Employees, Rocky Mountain Arsenal NWR*
From:	*Refuge Manager, RMANWR*
Date:	*December 13, 2005*
Subject:	*Grading and Removal of Surficial Soils at RMANWR*

All refuge personnel should be aware that extensive grading and removal of surficial soils in some areas of Rocky Mountain Arsenal has the potential to uncover low level contamination that does not pose a risk to humans, but may pose a risk to biota.

These risks associated with grading or other soil removal or disturbance activities are not uniform across the refuge. In most areas, there is no risk. However, all personnel will consult appropriate references, such as the Remedial Investigation/Feasibility Study, remedy maps, Institutional Control Plans and/or knowledgeable personnel such as Remediation Venture Office (RVO) Project Engineers prior to conducting any extensive grading or soil removal projects. Particular care must be exercised in investigating and planning any soil disturbance work in any lake sediments.

Although the characterization of contamination at Rocky Mountain Arsenal is extensive and we have an excellent remediation of environmental contamination here, refuge staff will remain cognizant of the history of the site. We understand that the cleanup is being conducted pursuant to models and that every square meter of the site has not been sampled. We have very high confidence that we know where remediation and/or institutional controls are required. However, we must remain aware that it is not impossible that small areas of contamination may remain unknown. Refuge staff will report any unexpected sites with odors, stained soils, or other unusual or unexplained variations in the refuge environment to their supervisor and the safety officer immediately if those conditions are encountered.

Chapter 2 – Background

Inventory and Description of Habitat

Location

The refuge encompasses a 25-mi^2 contiguous area (15,988 acres) located about 10 miles northeast of Denver, Colorado in Adams County (Figure 1). The State of Colorado experienced a 16.9% growth increase from 2000 to 2010, and the population of the Denver-Metro area (Denver, Adams, Jefferson, Douglas, Arapahoe, Boulder, and Broomfield counties) was 2,543,482 people according to the 2010 census (U.S. Census Bureau 2012). Commerce City borders the refuge to the west and north. On the west side of RMANWR at the site of the West Gate (72nd Avenue and Quebec St), construction of a new 56-acre high school/community college campus was completed in August 2009. Quebec Street, which is adjacent to the western boundary of the refuge, has been expanded from a two-lane highway to a six-lane parkway. The southwest corner of the refuge is adjacent to the Prairie Gateway Project, which currently includes an 18,000-seat soccer stadium and 22 full-sized soccer fields. In the future, the Prairie Gateway North Campus, which is the area north of the Klein Water Treatment Plant, will be commercially developed north to Highway 2.

At the northwest corner of RMANWR is the Eagle Creek housing subdivision (intersection of Highway 2 and 96th Avenue). Within 3 to 5 years, 96th Avenue will be widened to four lanes. The refuge boundary fence on the north was moved inward 200-250 feet in 2008 and approximately 100 acres of the 350-acre Shell Property bordering the north boundary was transferred to Commerce City in 2010. Of the remaining 250 acres, approximately 100 acres is used for long-term off-post ground water treatment and the remaining 150 acres is used for grazing. At some point in the next 10 years, this area may be sold for development or open space use. It is also expected that Commerce City will approach Shell Oil Company for additional acreage to facilitate realignment of Peoria Street further to the west. A storm water treatment facility and associated flood control pond are proposed for construction just north and west of the present north gate of the refuge. To the east of the Shell Property along 96th Avenue, the Reunion Housing Development will continue to expand, paralleling refuge property.

The City of Denver borders the refuge to the south and east, and also owns property immediately to the west of C Street, which extends from the south entrance gate of the refuge north to 6th Avenue. Adjacent to the southern border is 56th Avenue, which will be widened to at least a four-lane, or possibly a six-lane, highway. Denver International Airport borders the refuge to the east and the property that extends from 56th Avenue on the south to 80th Avenue on the north serves as an area for potential future expansion of the airport runways if necessary. The property to the west likely will be developed for residential, single-family homes in the near future by the Stapleton Re-Development Corporation.

Management Zones

The CMP divided RMANWR into broad management zones: the Northern Management Zone, Southern Management Zone, and Western Management Zone. Some of the 800 acres comprising the Western Management Zone (primarily in Section 4) was sold to Commerce City in 2004 as part of an agreement incorporated into the 1992 Rocky Mountain Arsenal National Wildlife Refuge Act. Therefore, only two management zones are considered in this HMP and these zones have been renamed to better represent their management direction. The boundaries of each has been re-configured to better delineate future habitat types and intended uses (Figure 2).

Short- & Mixed-grass Prairie Zone (Prairie Zone)

The Prairie Zone includes approximately 12,361 acres, or 77% of refuge land[2]. This zone includes the Central Remediation Area (CRA) where most of the cleanup activities occurred and will encompass the vast majority of restored shortgrass and mixed-grass prairie following completion of mitigation seeding. In the CMP, portions of Sections 3, 4, 5, 6, 7, and 8 were considered part of the Educational Zone. However, these areas have been, or will be, restored to native short- and mixed-grass prairie. Thus, the Prairie Zone was expanded to include these areas because they are contiguous with restored prairies in the Prairie Zone and should be managed to achieve similar objectives. In addition, this zone also includes approximately 1,084 acres of remediation structures referred to as "caps and covers," including the Integrated Cover System (ICS), Hazardous Waste Landfill (HWL), Enhanced Hazardous Waste Landfill (ELF), and Basin F.

The primary purpose of the Prairie Zone will be to provide suitable habitat for wildlife. This zone supports the largest area of prairie dog towns and the majority of historic burrowing owl nesting sites. It also will support the RMANWR bison herd. The caps and covers have been revegetated to native prairie by the U.S. Army, and will remain under their permanent management jurisdiction. Wildlife and habitat management activities on caps and covers, though yet to be determined, will be conducted cooperatively between the U.S. Army and the Service, utilizing approved habitat management goals, objectives, and strategies that are consistent with regulatory agency requirements designed to maintain the integrity of the structures and the health of the restored prairies.

Environmental Education Zone (Educational Zone)

In the CMP, the original Southern Management Zone was about 6,000 acres and included all refuge lands south of 7th Avenue. Significant portions of this area have been significantly altered from a pre-settlement native shortgrass prairie and include U.S. Army infrastructures, homesteads, irrigation infrastructures (e.g., reservoirs, ditches) used by past farmers, and stands of trees that were planted around homesteads. The extensive fragmentation caused by these features currently precludes use by area-sensitive grassland bird species and many areas cannot be restored to pre-settlement conditions due to

[2] The Service owns 317 acres of lands outside of its fences. This includes lands on the western edge of Section 4 and buffers along the eastern, northern, and southern boundaries.

federal regulations (see Section IV, Habitat Goals and Objectives, Educational Zone for specific regulations). However, this boundary also included areas that would be restored to native prairie. Therefore, the boundary of the Educational Zone was reduced to include only those areas that will not be restored to native prairie, including lands in sections 11, 12, and major portions of Sections 1, 2, 3, 7, and 35 (Rattlesnake Hill) (Figure 2). This equates to an area of approximately 3,299 acres, or slightly more than 20% of the refuge. A primary purpose of this zone will be to provide visitor services, including environmental education and interpretation activities for the public.

Physical or Geographical Setting

Ecoregion

Ecoregions are relatively large geographic areas that are similar in climate, soils, vegetation, geology and other ecological and environmental patterns (The Nature Conservancy 1999). The EPA has divided the United States into four levels (I to IV) of ecological regions that differ based on degree of detail (I = general, IV = most detail). RMANWR is in the High Plains Ecoregion (Level III) and, more specifically the Flat to Rolling Plains (Level IV, Figure 3) (Omernik 1987), which includes a general land use description of rangelands with areas of irrigated crops nearby. The physiography of the region consists of flat to rolling plains, intermittent streams, with a few large perennial streams, silty and sandy substrates, and small depressional wetlands scattered throughout the region. The geology is Quaternary loess, alluvial deposits, and some thin residuum. Natural vegetation includes shortgrass prairie, including blue grama (*Bouteloua gracilis*) and buffalograss (*Bouteloua dactyloides*) with threadleaf sedge (*Carex filifolia*), fringed sage (*Artemisia frigida*), Junegrass (*Koeleria macrantha*), and western wheatgrass (*Pascopyrum smithii*). Riparian areas contain cottonwood (*Populus* spp.) and various shrub and herbaceous species.

Physiographic Province

RMANWR is located within Kuchler's (1964) Grama-Buffalo Grass vegetation type. Lauenroth and Milchunas (1992) further subdivide this type into 'shortgrass steppe', an area of approximately 108,109 mi² that extends from the foothills of the Rocky Mountains east to the panhandle of Oklahoma (approximately 100 degrees west latitude) and from the Colorado/Wyoming state line south to Texas (Figure 3). RMANWR is located in a transition area, or ecotone, between southern and northern shortgrass steppe prairie. Interstate 70 is the rough "dividing line" between these two communities (William Lauenroth, University of Wyoming, personal communication 2004) and refuge lands can support species characteristic of both plant communities (Carl Mackey, URS Washington Group, personal communication 2004).

Watershed

RMANWR lies within several drainage basins that are tributaries of the South Platte River, which is located less than two miles from the northwest boundary of the refuge. These basins include Irondale Gulch, First Creek, Second Creek, and several small areas that originally drained directly into the South Platte River. Due to human alterations, some of these areas now are tributaries of either the Irondale Gulch or First Creek basins.

The Irondale Gulch drainage flows through Sections 33, 34, 35, 27, 28, and 22 in the Prairie Zone. Several reservoirs have been constructed in this drainage that alter hydrology. First Creek, an intermittent stream, flows from the southeast to the northwest and eventually drains into the South Platte River. Within the refuge, it enters the Educational Zone in the east-central portion of Section 8 and proceeds through Sections 5, 31, 30, 25, and 19 before leaving the refuge at the northern edge of Section 24. Collectively, these two watersheds encompass more than 91 percent of refuge lands.

In the Educational Zone, water flows primarily through a network of man-made ditches and reservoirs. All surface flows are intermittent and sources of input include direct precipitation, runoff, released or diverted flows, groundwater pumping, and groundwater discharge. Localized flooding occurs following thunderstorms that produce high intensity rainfall. In drainages without diversions and inflows from controlled releases, highest monthly flows occur in late spring to early summer and lowest flows occur in winter. However, daily and monthly stream flows vary widely and a large proportion of surface flow onto the refuge is lost due to groundwater seepage, evaporation, and vegetative transpiration (U.S. Fish and Wildlife Service 1996b).

Soils

The refuge is located in the Denver Basin, a north-south geologic fold extending along the Front Range from Colorado Springs to Cheyenne, Wyoming. Surface geologic deposits consist primarily of alluvium (unconsolidated river sediments) deposited by the South Platte River that are partially covered by eolian (wind-blown) sediments. Most of the alluvial deposits on the refuge are fine-textured, except for remnants of cobble alluvium on Rattlesnake Hill, Henderson Hill, and in the North Plants area (James P. Walsh & Associates Inc. 1991).

Most soils in the Prairie Zone vary in texture from clay to loam. In contrast, soils in the Educational Zone are typically sandy in texture. Consequently, most shortgrass prairie will be in the Prairie Zone, whereas most of the sand prairie will be in the Educational Zone (Figure 4).

Topography

The land surface of RMANWR has been shaped largely by erosional and depositional processes associated with the South Platte River and its tributaries. These processes resulted in a landscape dominated by nearly level to gently sloping terraces (0-3%) with some terrace escarpments that have steeper slopes (up to 10%) (U.S. Fish and Wildlife Service 1996a). In general, the land surface slopes to the northwest. Rattlesnake Hill (located in section 35) and Henderson Hill (located in section 19) are the two highest points on the refuge (U.S. Fish and Wildlife Service 1996a).

Climate

The climate of RMANWR is characterized as semi-arid with wide variations in seasonal and daily temperatures. January is the coldest month with an average high temperature of 43 degrees Fahrenheit (°F) and an average low of 16 °F. July is the hottest month with an average high temperature of 88 °F and an average low of 59 °F (U.S. Fish and Wildlife Service 1996b).

The Rocky Mountains to the west form a “rain shadow” and storms forming over the mountains often dissipate before reaching the refuge. Precipitation varies from 12-16 inches annually, with 80% occurring from April to September. Average annual precipitation actually *increases* as one travels eastward from RMANWR onto the eastern Colorado plains. May is normally the wettest month, averaging 2.5 inches. Summer precipitation is largely the result of convective thunderstorms, oftentimes accompanied by hail. Precipitation from these storms can be quite variable, although 60% of the rainfall events occurring from May to August produce less than 0.8 inches per event. In contrast, January is normally the driest month, averaging 0.5 inches (1.2 cm) (U.S. Fish and Wildlife Service 1996b). Winter precipitation (December-February) constitutes a relatively small proportion of the total annual precipitation (Lauenroth and Milchunas 1992).

Potential Effects of Climate Change at RMANWR

Scientific evidence indicates the global climate is changing and most scientists agree this will result in a concomitant change in the abundance and distribution of wildlife and their habitats. In the event of a rapid warming trend, some species may be able to adapt, some may struggle, and others may disappear forever. The Service is dedicated to the conservation of wildlife and their habitat, which includes reducing, to the extent possible, the impacts that climate change may impose on Nation’s natural heritage (U.S. Fish and Wildlife Service 2013a).

The direction and magnitude of ecosystem change in response to climate change will depend on the type and intensity of the disturbance (Backlund et al. 2008). However, the potential effects of even small changes in climate could be significant on RMANWR due to a history of severe soil disturbance and the abundance of invasive species. The potential is further increased because many native plants and animals that currently inhabit the refuge are already near the extent of their current known ranges; thus, small changes in climate may provide a competitive advantage to invasive and non-native species already established on refuge lands. For example, species that were once limited by elevation or drought tolerances may be able to inhabit new areas (Backlund et al. 2008).

Given these concerns, restoring and maintaining native plant communities is, and will continue to be, a primary focus of management on RMANWR. Native communities tend to be more resilient than synthetic communities and, therefore, likely represent the best approach for addressing potential long-term climate changes (U.S. Fish and Wildlife Service 2013a). In addition, native plant communities provide suitable habitat for wildlife, which is the primary mission of the Service.

Proximity to Other Protected Areas

RMANWR is entirely surrounded by urban development. The closest protected area of public land is Barr Lake State Park, which is located about eight miles north of the refuge. Figure 1 illustrates the location of RMANWR relative to other public lands in the Denver-Metro area.

Habitat Condition of the Refuge

Pre-Settlement

Prior to settlement, the area that is now RMANWR was short and mixed-grass prairie (or steppe) that likely included xeric shrubs, such as sand sagebrush (*Artemisia filifolia)* and rubber rabbitbrush (*Ericameria nauseosa*), and succulents like yucca (*Yucca glauca)* and prickly-pear cactus (*Opuntia polyacantha*). It is interesting to note the description of shortgrass prairie near Brighton, Colorado, which is adjacent to RMANWR, as described in the 1932 soil survey (Harper et al. 1932):

> The Brighton area lies in the region of shortgrass vegetation, grama and buffalo grasses predominating on the well-drained soils of medium or heavy texture and in most places forming a dense sod. A bunch grass, sand bluestem (*Andropogon* sp.), is a tall grass which grows on the well-drained sandy lands [same as RMANWR ‘sand’ prairie]. Yucca and prickly pear grow on light or medium-textured droughty soils. Bottlebrush squirreltail (*Elymus elymoides*) or foxtail *(Hordeum jubatum*) is common on seepy areas and is usually an indicator of the presence of excess salts. Rabbitbrush (*Chrysothamnus nauseous*) and sand sage are among the common shrubs; and wire grass (*Eleusine indica*), a few sedges, and many weeds are of common occurrence.

Other historical accounts clearly note extensive areas of shortgrass prairie covered with a hardened sod of buffalo grass. Traveler James Pattie described the prairie near the Platte River in 1824 as “covered with a short, fine grass, about four inches high, of such a kind, as to be very injurious to the hoofs of animals…” (Hart and Hart 1997).

Woody vegetation in the area of RMANWR likely was limited because the occurrence of flood events associated with cottonwood regeneration was infrequent, with intervals between significant floods ranging from 50-200 years (Jonathan Friedman, USGS, personal communication 2002; Joseph Capesius, USGS, personal communication 2003). For example, First Creek was an ephemeral, meandering, warm-water stream located in the eastern third of the refuge (Sellards & Grigg Inc. Aquatic and Wetland Company 1997) that flowed only for about six weeks in the spring and early summer before becoming mostly dry (Joseph Capesius, USGS, personal communication 2003). Given these characteristics, First Creek likely was not a densely vegetated riparian stream prior to settlement because flows were insufficient to scour soils and create conditions for tree regeneration and establishment. This is supported by an examination of archival aerial imagery from 1937 to 2003, which shows very little riparian vegetation (Mark Kalitowski, URS Washington Group, personal communication 2007).

The major ecological drivers of this ecosystem were 1) random, nomadic grazing by large herds of native ungulates, 2) disturbance caused by the activities of black-tailed prairie dogs (*Cynomys ludovicianus*), including the expansion and contraction of colonies, and 3) climate (William Lauenroth, University of Wyoming, personal communication 2007). Although physical evidence of historical fire frequency is generally lacking for most of the Great Plains (Scheintaub et al. 2009), wildfires in the shortgrass prairie likely were relatively small and infrequent due to extensive bison grazing and prairie dog disturbance that resulted in patchy and limited fuels. For example, lightning strikes at RMANWR generally result in smaller wildfires, which typically occur 3-4 times over the course of a summer (Lorenz Sollmann, USFWS, personal communication 2006) and one assessment estimated the fire return interval in Kuchler's Grama – Buffalo Grass type at 74.3 years (Leenhouts 1998). Therefore, wildfire is not considered a significant ecological driver of shortgrass prairie (Paige and Ritter 1999, Lauenroth, personal communication 2004).

From 1806 to 1859, at least nine expeditions were sent by the U.S. War Department into eastern Colorado (Rockwell 1909). Led by U.S. Army officers and comprised of enlisted men, most of these expeditions also contained a person or persons who by trade were either botanists, naturalists, zoologists, or skilled artists. Most kept fairly accurate records of their observations and recorded latitude and longitude at regular intervals. One of the most significant expeditions was undertaken by Major Stephen Long in 1820, who described the vast area of shortgrass steppe as he crossed "the Great American Desert". On June 23rd, Dr. Edwin James, the botanist accompanying Major Stephen Long's expedition, described the Platte River near present-day Ft. Morgan, Colorado (James et al. 1822):

> Intermixed in the narrow fringe of timber, which marks the course of the river, are very numerous trees, killed by the action of the beaver or by the effects of old age…affording a support to the nests of the bald eagle…Large herds of bison were seen in every direction…prickly pears [cactus] became more and more abundant as we ascended the river, and here they occurred in such extensive patches as considerably to retard our progress, it being wholly impracticable to urge our horses across them.

The extensive number of bison in the shortgrass prairie is further supported by eyewitness accounts from the late 1800's that describe large herds of bison (*Bison bison*) moving slowly across the prairie, consuming most of the vegetation in their path. One historical account in 1889 states that bison "at times so completely consumed the herbage of the plains that detachments of the United States Army found it difficult to find sufficient grass for their mules and horses" (Hornaday and Smithsonian Institution Board of Regents 1889). Grazing pressure from these large herds could most likely be categorized as short-duration/high intensity because bison are not as selective as other ungulates in their choice of forage, have a greater preference for warm-season grasses, and are able to make greater use of the total available herbage in any given area (Peden et al. 1974). Extensively grazed areas, and those areas disturbed by prairie dogs, were initially re-colonized by native forbs that were utilized by pronghorn (*Antilocapra americana*). As native grasses replaced early successional forbs and cool-season grasses, bison were attracted back to these areas because the grasses were high in nitrogen, highly palatable, and easily digestible. This "niche separation" created a relatively large, nomadic ungulate population in the shortgrass steppe (Lauenroth and Milchunas 1992).

James (1822) also noted that whenever they came to a prairie dog town, "small owls were observed moving briskly about…with us the owl never occurred but in the prairie-dog villages, sometimes in a small flock, much scattered and often perched on different hillocks, at a distance, deceiving the eye with the appearance of the prairie-dog itself, in erect posture". Subsequent journal entries noted "immense herds of bison, blackening the whole surface of the country through which we passed." As the expedition came closer to the mountains, prairie dog towns became larger in size, with mounds "several yards in diameter, overgrown with scant herbage, which always marks the area of the prairie-dog villages. Indeed, we have observed several large villages, with scarce a trace of vegetation about them" (James et al. 1822). The bare appearance of prairie dog towns was not unique to Long's course through the plains. Lauenroth (University of Wyoming, personal communication 2005) also reported many of the older, well-established prairie dog towns on the Pawnee National Grasslands had either bare dirt between mounds or little to no vegetation.

Although the pre-settlement area occupied by black-tailed prairie dogs is difficult to determine due to incomplete data (Miller et al. 2007), estimates vary from 32 to 100 million hectares (Vermeire et al. 2004, Hoogland 2006). Further, some estimates of historical occupancy specific to a certain locale or across a large landscape also have been reported. Knowles et al. (2002) reviewed data that suggests black-tailed prairie dogs occupied from 2-15% of the total area in landscapes of more than 400,000 hectares. Flath and Clark (1986) reviewed Northern Pacific Railway land surveys in Montana from 1908-1914, prior to the onset of large-scale prairie dog control programs, and determined a mean colony size of 60.5 acres representing 2.8% of the total landscape. Whicker and Detling (1988) suggested that the historical occupancy of black-tailed prairie dogs represented more than 20% of the potential area occupied by short-and mixed-grass prairies. Hoogland (2006), citing Knowles (2002) and Vermiere et al. (2004), suggests that prairie dogs inhabited about 19% of their geographic range 200 years ago. Colony sizes likely fluctuated in response to environmental and ecological factors, including climate extremes, variable bison grazing patterns, predation, or a combination of these factors (Knowles et al. 2002).

The shortgrass steppe also supported a unique assemblage of grassland birds that evolved in response to natural processes that created a dynamic, structurally diverse plant community. Variability in climate patterns, bison grazing, and prairie dog colony distribution resulted in a variety of vegetative mosaics and seral stages ranging from almost completely bare ground to relatively undisturbed grass. A diversity of grassland birds adapted to this shifting vegetation mosaic and used vegetation in a variety of succession stages for breeding and brood-rearing (Knopf 1996, Beidleman 2000). For example, heavily grazed areas were likely used for nesting by species such as Mountain plover (*Charadrius montanus*) and long-billed curlew (*Numenius americanus*), whereas less grazed areas were likely used by species such as lark bunting (*Calamospiza melanocorys*).

Influence of European Settlement

By 1850, humans following established trails into Colorado along the upper Platte, Arkansas, and Republican rivers were causing damage to riparian vegetation and the surrounding prairie. The 60-mile stretch of the "big timbers of the Arkansas" - ancient cottonwood trees that Zebulon Pike had noted in 1805 - had all but disappeared by 1853. The South Platte River, once abundant in trees and wildlife as late as 1835, had been so denuded that by 1849 an army officer noted that a tree "might be looked on as a curiosity" (White et al. 2005). Freighters often could not find suitable pasture for oxen along these major trails and would have to move miles inland to find suitable forage (White et al. 2005). The pre-European settlement condition of Colorado's shortgrass steppe was beginning to disappear.

Thousands of people inundated the Denver region with the discovery of gold on Clear Creek in 1859. By the 1870's, homesteaders were well-established in the vicinity of the present-day RMANWR (Hoffecker 2001) and the conversion of native shortgrass prairie to cropland began in earnest. Attempts to improve the area for agricultural production were initiated as early as 1883 with the construction of the Sand Creek lateral irrigation canal, which eventually was expanded into an intricate system of irrigation canals, lakes, and ponds. In addition, between 1910 and 1920, portions of First Creek were channelized, the Highline Canal system and Ladora Reservoir were constructed, and the dam forming Derby Lake was built (Hoffecker 2001; Mark Kalitowski, URS Washington Group, personal communication 2007). Homesteaders and farmers also planted plains cottonwood, New Mexico locust (*Robinia neomexicana*), Siberian elm (*Ulmus pumila*), white poplar (*Populus alba*), lilac (*Syringa vulgaris*), Ponderosa pine (*Pinus ponderosa*), Colorado blue spruce (*Picea pungens*), northern catalpa (*Catalpa speciosa*), and other species around farmstead buildings for protection from inclement weather or beautification.

Collectively, the activities of homesteaders resulted in significant loss and modification of native shortgrass prairie on present-day refuge lands, particularly south of 7th Avenue in the Educational Zone. Construction of the irrigation infrastructure, coupled with the flood events of 1933, 1965, and 1973 created conditions that allowed establishment of plains cottonwood (*Populus deltoides*) in the floodplain of First Creek (Jonathan Friedman, USGS, personal communication 2002). Normal operation of the irrigation infrastructure also promoted establishment of woody vegetation adjacent to canals and on the shorelines of created lakes. Such changes resulted in the formation of woodland communities that support a diversity wildlife not associated with shortgrass prairie. For example, the large cottonwood galleries that support the existing bald eagle (*Haliaeetus leucocephalus*) nest were likely the result of a major flood that was documented in the Denver area in 1933 (Jonathan Friedman, USGS, personal communication 2002). In contrast, the northern portion of the refuge contains small acreages (<1 acre/site) of trees, mainly from 26 past homestead sites.

By the start of World War II, several hundred agricultural families occupied the present-day refuge (Hoffecker 2001). Most of the original shortgrass prairie had already been converted to farmland by this time and was intensively cultivated for production of crops such as milo, corn, millet, oats, and alfalfa. Areas that were too rocky, dominated by sandy soils, or could not be irrigated remained unplowed and were grazed or dryland farmed. Today, these grazed areas exist as small unique remnant vegetative communities in Sections 4, 19, 8, and 35.

Shortly after the start of World War II, the U.S. Army selected 19,883 acres as the site of the Rocky Mountain Arsenal, which encompassed present-day refuge lands. All families living in the area were required to relocate immediately and crops planted in the spring of 1942 were simply abandoned. Except for the Egli homestead, most of the vacated farmhouses were demolished and removed. However, trees planted by homesteaders were left and allowed to expand. Hundreds of acres of land, primarily in the current Educational Zone, were developed into new chemical facilities and related infrastructure to manufacture chemical weapons and incendiary ordnance for the war effort. Construction started in June 1942, just six months after the Pearl Harbor attack, and was completed in record time (Helms and Fowler 1994). In the Late 1940's and early 1950's, the need for chemical weapons diminished and the U.S. Army leased portions of the Arsenal to private companies, including Shell Oil Company which manufactured agricultural pesticides. However, as Cold War tensions increased the U.S. Army reactivated the Arsenal and constructed the North Plants to manufacture white phosphorous bombs, artillery shells with distilled mustard, incendiary cluster bombs, and a highly toxic chemical product known generally as 'nerve agent'. The North Plants were operated from 1953 until 1969. Cold War fears kept the Arsenal an active military base until 1982 when manufacturing operations at the Arsenal ceased (U.S. Fish and Wildlife Service 1996a).

During U.S. Army ownership, thousands of acres of abandoned cultivated land were allowed to revegetate naturally and a diversity of trees and shrubs were planted adjacent to existing infrastructure. Species planted included Colorado blue spruce, Ponderosa pine, northern catalpa, green ash (*Fraxinus pennsylvanica*), plum (*Prunus* spp.), chokecherry (*Prunus virginiana*), lilac, Rocky Mountain juniper (*Juniperus scopulorum*), and one white oak (*Quercus alba*). In combination with trees planted by homesteaders, these plantings resulted in an inimitable tree community that provided beneficial habitat for many wildlife species. For example, New Mexico locust shrubs expanded and formed thickets that provided habitat for white-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus*) (winter and loafing cover and high-quality fawning areas) and unique species of native birds such as long-eared owls (*Asio otus*). Similarly, planted exotic trees dispersed into nearby areas dominated by planted grasses and weeds, forming a type of "savannah" that provided suitable habitat for neotropical migrants and many other species.

By 1948, problems associated with weeds and blowing soils were causing problems and the U.S. Army initiated a land management program that included an aggressive grass seeding program. Although details of the program could not be located, the site was divided into three management areas and planted species included crested wheatgrass (*Agropyron cristatum*), alfalfa (*Medicago sativa*), and 'native grass'. For example, Area 2 was described as containing approximately 1,100 acres of 'native grass,' 500 acres of alfalfa, about 600 acres of crested wheatgrass, and 12,940 acres of weeds, "predominantly annual brome and cheatgrass" (U.S. Army Chemical Corps 1951). Although records of exact acreages planted could not be located, the Chemical Warfare Service Arsenal Area Plan map of 1964 indicates that as much as 6,200 acres were seeded with crested wheatgrass to control broadleaved annual weeds and prevent soil blowing. This represented almost 40% of the present-day refuge acreage.

Effect of Contamination and Remediation

The impact of manufacturing ordnance and pesticides on refuge wildlife and habitats, and the subsequent plans that were developed to clean up contaminants, is well documented in the 1996 Record of Decision (ROD) (Foster Wheeler Environmental Corporation 1996). In summary, disposal practices typical of that era included treating and discharging waste products into evaporation basing. However, by the early 1950's, chemical wastes were leaching through the soil into ground water and were affecting wildlife. In 1983 the U.S. Environmental Protection Agency listed the site as a Superfund Cleanup site. Subsequent cleanup activities have included construction of borrow areas, caps, covers, landfills, and other remediation structures that disturbed thousands of acres on the present-day refuge. These activities have been on-going since 1988 and were concluded in the fall of 2011. In some cases (e.g., Section 36), the surface topography of an entire section was completely recontoured to facilitate cleanup and drainage from the ICS, whereas in other sections borrow areas had to be excavated to depths ranging from 1 to more than 20 feet (e.g., Borrow Area 10).

Current Condition

Natural processes on RMANWR have been altered to an extent that many plant and animal communities that once existed in pre-settlement shortgrass steppe likely cannot be restored to their original ecological condition. In the Educational Zone, native communities largely have been converted to a woodland/riparian habitat type intermixed with mixed-grass prairies. A similar phenomenon has occurred throughout the Great Plains, where modern flood control, irrigation, and water management practices have favored woody colonization along most major drainages (Knopf 1994). Collectively, these changes have resulted in wooded corridors that facilitate the range expansion of eastern forest and grassland bird species onto western prairies, many of which displace native species. With so many eastern species present, the western Great Plains has been ornithologically identified as the 'Great Plains Hybrid Zone' (Rising 1983, Knopf 1994). Conditions in the Prairie Zone are somewhat different. Although the area was subjected to the same perturbations, this area also has suffered excessive soil disturbance as a result of cleanup activities. Woody vegetation is limited and, in some cases, soils and topography of entire sections have been permanently changed.

Restoration of native prairie on the majority of these lands is part of the remediation process to mitigate past damage, but the extent to which the composition and structure of prairie communities can be restored is unknown. However, recent restoration efforts have met the criteria for success established in the HRP, which include at least 30% relative live cover of desirable plant species 5 years after seeding, a minimum of 70% total ground cover, at least 50% of the seeded grass species present on the site, and no single species contributes more than 45% of the live vegetation cover except when a few species provides suitable habitat appropriate for long-term wildlife management (U.S. Fish and Wildlife Service 1999). Although additional sites require restoration, and previously seeded sites will require additional management, it is anticipated that future RMANWR lands will consist of the following five general habitat types: native prairie (short- and mixed-grass), shrubland, upland tree and shrub savannah, and aquatic (lacustrine, riparian, and wetland) (Figure 5). The current area encompassed by savannah and aquatic habitats are not projected to change, but the area of prairie will increase and the area of shrubland will decrease following completion of restoration activities (Table 1).

Table 1. Current (2013) acreages of habitat types found at the Rocky Mountain Arsenal NWR

Native Perennial Grassland					*Aquatic Habitats*	
Shortgrass Prairie	***Mixed-grass Prairie***	***Shrubland***	***Upland Tree & Shrub Savanna***	***Riparian***	***Wetland***	***Lacustrine***
4,583	8,104	1,373	89	384	119	169

[excludes 1,084 acres of U.S. Army lands]	[excludes 16 acres of dams and levees]

Native Prairie

Due to extensive soil disturbance and contamination from past activities, any native prairie on the RMANWR was limited at the time of refuge establishment. Remnant native areas are often dominated by sand dropseed (*Sporobolus cryptandrus*) and western wheatgrass on more finely-textured soils and needle-and-thread grass (*Hesperostipa comata*), often in association with rubber rabbitbrush and yucca, on hills and ridge tops. There also are small inclusions of cobble soil that support a unique combination of native species, including Fendler's three-awn (*Aristida purpurea* Nutt. Var. *fendleriana* (Steud) Vasey) and yellow violet (*Viola nuttallii*). In addition, sand sagebrush occurs as a remnant shrub community in areas of loamy sand soils. Unfortunately, many of these native grasslands are being degraded by invasive/noxious weeds (Table 2) and will require active management.

Table 2. Noxious weeds found at the Rocky Mountain Arsenal NWR

Common Name	***Scientific Name***	***Listing***	***Occurrence on Refuge***
Rush skeletonweed	*Chondrilla juncea*	List A[1]	
Absinth wormwood	*Artemisia absinthium*	List B[2]	
Bull thistle	*Cirsium vulgare*	List B	Infrequently occurring
Canada thistle	*Cirsium arvense*	List B	Moderately abundant, small patches throughout refuge
Dalmation toadflax	*Linaria dalmatica*	List B	Infrequently occurring
Yellow toadflax	*Linaria vulgaris*	List B	Infrequently occurring
Diffuse knapweed	*Centaurea diffusa*	List B	Was moderately abundant, now infrequently occurring
Hoary cress/ whitetop	*Cardaria draba*	List B	Abundant in wetter areas, found all along First Creek corridor
Houndstongue	*Cynoglossum officinale*	List B	Was common in NM locust thickets, now moderately abundant due to on-going control efforts
Leafy spruge	*Euphorbia esula*	List B	Infrequently occurring due to control efforts
Musk thistle	*Carduus nutans*	List B	Commonly occurs throughout refuge, but abundance significantly decreasing due to control efforts
Russian knapweed	*Acroptilon repens*	List B	Infrequently occurring due to control efforts
Russian olive	*Elaeagnus angustifolia*	List B	Common along First Creek and in wetland areas. Control efforts have resulted in significant reduction
Salt cedar	*Tamarix chinensis, T. parviflora, and T. ramosissima*	List B	Infrequently occurring, small areas, controlled
Scotch thistle	*Onopordum acanthium*	List B	Highly abundant in certain years throughout refuge. Generally decreasing due to control efforts.
Spotted knapweed	*Centaurea maculosa*	List B	Infrequently occurring due to control efforts
Yellow toadflax	*Linaria vulgaris*	List B	Infrequently occurring
Chicory	*Cichorium intybus*	List C[3]	Was found for the first time in 2009, Sec 26
Common mullein	*Verbascum thapsus*	List C	Abundant throughout refuge as single plants and in patches up to 50 acres in size
St. Johnswort	*Hypericum perforatum*	List C	Infrequently occurring due to control efforts
Downy brome	*Bromus tectorum*	List C	Highly abundant, in every section of refuge

(cheatgrass)			
Field bindweed	*Convolvulus arvensis*	List C	Highly abundant in disturbed areas such as PD towns, restoration seedbeds, found throughout Refuge
Jointed goatgrass	*Aegilops cylindrica*	List C	Infrequently occurring
Perennial sowthistle	*Sonchus arvensis*	List C	Infrequently occurring
Puncturevine	*Tribulus terrestris*	List C	Common along certain refuge roads and trails
Velvetleaf	*Abutilon theophrasti*	List C	Came in with soil amendment in 2007, believe eradicated from refuge by hand removal
Russian thistle	*Salsola kali*	Not Listed	
Annual ryegrass	*Lolium perenne*	Not Listed	
Reed canarygrass	*Phalaris arundinacea*	Not Listed	
Crested wheatgrass	*Agropyron cristatum*	Not Listed	

[1] List A species in Colorado that are designated by the Commissioner for eradication (Colorado Department of Agriculture 2013).
[2] List B weed species are species for which the Commissioner, in consultation with the state noxious weed advisory committee, local governments, and other interested parties, develops and implements state noxious weed management plans designed to stop the continued spread of these species (Colorado Department of Agriculture 2013).
[3] List C weed species are species for which the Commissioner, in consultation with the state noxious weed advisory committee, local governments, and other interested parties, will develop and implement state noxious weed management plans designed to support the efforts of local governing bodies to facilitate more effective integrated weed management on private and public lands. The goal of such plans will not be to stop the continued spread of these species but to provide additional education, research, and biological control resources to jurisdictions that choose to require management of List C species (Colorado Department of Agriculture 2013).

The extent of disturbed prairie at the time of refuge establishment was extensive and the Weedy Forbs and Grasses vegetation type occurred on approximately 10,739 acres (65%) of the refuge (U.S. Fish and Wildlife Service 1996a). Morrison-Knudsen (1989) estimated the distribution of specific sub-types of this vegetation on refuge lands as follows: 16% Weedy Forbs, 20% Cheatgrass and Weedy Forbs, 10% Cheatgrass and Perennial Grass, and 19% Crested Wheatgrass. The majority of this area has been, or is, targeted for restoration to native prairie. The Service, in consultation with ecologists from Colorado State University and URS Corporation, developed seed mixes of grasses and forbs that are specific to soil types on the refuge to improve restoration success (Appendix E). In general, these mixes conform to plants characteristic of the shortgrass and mixed-grass prairie associations. When restoration is complete, native prairie will comprise approximately 12,680 acres (79%) of refuge lands.

The shortgrass prairie association occurs primarily on Satanta and Weld loam (Loamy Plains Range Site), Nunn clay (Clayey Plains Range Site), Petrocalcic (Gravel Breaks Range Site), and the cobble soil types. The texture and drainage properties of these soils vary considerably; therefore, specific seed mixes were developed for the following soil areas:

Blue grama/western wheatgrass prairie. The primary plant species of this type are better adapted to heavier textured soils, such as the Satanta and Weld loam soils. While dominated by blue grama and western wheatgrass, buffalograss and sideoats grama (*Bouteloua curtipendula*) are common associates. There are remnant blue grama communities in the north half of Section 33 (approximately 200 acres) and Section 19 (approximately 50 acres on Henderson Hill) that are of considered areas of special management concern (Morrison-Knudsen Environmental Services Inc. 1989). The area in Section 19 also contains remnant gayfeather (*Liatris punctata*) and penstemon (*Penstemon angustifolia*). The majority of this shortgrass prairie type will be established in the Prairie Zone.

Purple three-awn prairie. This species tends to form pure stands in, and adjacent to, abandoned prairie dog colonies, but also occurs in active colonies. It is commonly associated with other native species such as bottlebrush squirreltail , sand dropseed, and scarlet globemallow (*Spharalcea coccinea).* Purple three-awn is considered a short-term, successional species that is eventually replaced by long-term, successional species such as blue grama, sideoats grama, western wheatgrass, and buffalograss (Carl Mackey, URS Washington Group, personal communication 2009).

Western wheatgrass prairie. Western wheatgrass in the Dakotas, Kansas, and Nebraska is generally considered a mid or mixed-grass species. However, at RMANWR, possibly because the refuge is in the rain-shadow of the Rocky Mountains and receives little precipitation, western wheatgrass can function both as a shortgrass and mixed-grass species depending on the amount of annual precipitation. Western wheatgrass tends to form pure stands on heavy textured, clayey soils on RMANWR, including adjacent to First Creek (Section 19) and in swales or other low areas.

Cobble Soil Vegetation. This community occurs on remnants of a South Platte River terrace thought to be at least 100,000 years old. The soil material, which primarily consists of rounded river rock that varies from small pebbles to football-sized rocks, supports a unique plant community that is unique on the refuge. In addition to Fendler's three-awn and yellow violet, other species include Sandberg bluegrass (*Poa secunda*), Ring muhly (*Muhlenbergia torreyi*), and broom snakeweed (*Gutierrezia sarothrae*). Considered an area of special management concern (Figure 6) (Morrison-Knudsen Environmental Services Inc. 1989), locations of this community include Section 35 on Rattlesnake Hill, Section 25 southeast and east of the ELF, and the northwest corner of Section 36. Part of the area in the northwest corner of Section 35 was disturbed by construction activities and is slated for future restoration. Similarly, the area in Section 25 was disturbed by cleanup activities and contains significant amounts of cheatgrass (*Bromus tectorum*) and field bindweed. It is unknown what unique species may still exist in the seedbanks of these areas.

The mixed-grass prairie association typically occurs on Ascalon and Bresser soil types (Sandy Plains Range Site). On RMANWR, these soil types tend to support taller warm-season grasses intermixed with traditional mixed-grass and shortgrass species, all of which are adapted for growth on sandier soils. A 10-acre remnant of sand prairie, which is considered an area of special management concern (Morrison-Knudsen Environmental Services Inc. 1989), still exists in Section 4 and is dominated by sand bluestem, prairie sandreed (*Calamovilfa longifolia*), blue grama, bracted spiderwort (*Tradescantia bracteata*), and bush morning-glory (*Ipomoea carnea*). However, because of the unique combination of taller grasses, the term 'mixed-grass prairie' is the best descriptor of these communities. The species composition of seed mixes for these sites were modeled by Shell Oil Company restoration ecologists during the 1980's to identify adapted plant species that would grow on Sandy Plains range sites which required restoration. Specific seed mixes include:

Needle-and-Thread Prairie. Needle-and-thread typically forms pure stands on sandier, drier ridge tops throughout the refuge, but also occurs in dense stands associated with yucca and rubber rabbitbrush. Many areas of needle-and-thread grass have lost their vigor, are becoming decadent, and contain significant amounts of cheatgrass.

Sand Dropseed Prairie. Sand dropseed is an early to mid-succession species occurring in areas with a history of disturbance. Large areas of sand dropseed occur throughout the refuge, but they differ in quality. Some stands are relatively dense and pure (Section 29), whereas others are sparse and contain large quantities of annual forbs and cheatgrass. Some are slated for eventual restoration to other mixed-grass communities.

Prairie and Shrubs Association. Prairies containing 5-25% absolute live cover of shrubs are found throughout the refuge. Common shrubs include rubber rabbitbrush, sand sagebrush, and four-wing saltbush (*Atriplex canescens*). In addition, Yucca also provides a shrub-like function for some grassland birds and is found in both the shortgrass and mixed-grass prairie associations primarily along ridgelines. Current distribution of this habitat includes Section 20 (sand dropseed interspersed with rubber rabbitbrush) and the eastern half of Section 7 (warm-season grasses interspersed with four-wing saltbush and rubber rabbitbrush). The existing condition of these communities varies from good to poor based on the abundance of exotic grasses such as crested wheatgrass, cheatgrass and weedy forbs.

Shrubland

Shrublands are defined as areas greater than 5 acres that support at least 25% live cover of shrubs (Chuck Loesch, personal communication 2004). Primary species include rubber rabbitbrush, four-wing saltbush, and sand sagebrush. Yucca, although classified as a sub-shrub, was considered part of the shrubland habitat type at RMANWR. Winterfat (*Krascheninnikovia* *lanata*), another sub-shrub, is also found on the refuge, but only occurs in small areas of Sections 19 and 35 (Rattlesnake Hill). Based on this definition, specific areas that support shrublands include:

Sand sagebrush shrublands. Sand sagebrush (approximately 70 acres) present on Truckton loamy sand soils in the northeast and southwest quarters of Section 8 are remnant communities of special management concern (Morrison-Knudsen Environmental Services Inc. 1989). This area likely was grazed until the 1940's, but has not been actively managed since. Although prairie sandreed, needle-and-thread, and bush morning glory can still be found, weedy forbs have invaded and the stand has become decadent and dense. Another area (approximately 30 acres) of sand sagebrush exists in Section 1 and is intermixed with prairie sandreed with an understory of blue grama. The history of this stand is unknown, but it is in relatively good condition with the exception of cheatgrass in the understory of some areas.

Four-wing saltbush shrublands. Located in Section 4, this shrubland was established as a restoration seeding (Project 56B).

Yucca shrublands. Stands of yucca in association with needle-and-thread grass are located primarily along ridge tops in Sections 27 and 28. These stands are considered unique remnant vegetative communities of special management concern (Morrison-Knudsen Environmental Services Inc. 1989).

Rubber rabbitbrush shrublands. Scattered stands of rubber rabbitbrush located in Sections 11, the northeast portion of Section 20, and the central portion of Section 31. The grasslands associated with many of these areas will be restored to the appropriate native prairie association.

Mixed Shrublands. Scattered shrublands comprised of rubber rabbitbrush, four-winged saltbush, sand sagebrush, winterfat, and yucca in Sections 11, 12, and 7.

Woodland

Located in the Educational Zone, primarily in Sections 11 and 12, the savannah habit type on RMANWR is the result of past land-use activities that involved conversion of native prairie to agriculture and the planting of trees around homesteads by settlers. Following transfer of ownership to the U.S. Army, additional trees were planted around new infrastructure and agricultural lands were abandoned and allowed to revegetation naturally. During this time, additional trees became established as scattered individuals or as small groups of trees in abandoned agricultural fields. Following acquisition by the Service, grasslands have been, or will be, restored to native prairie by seeding appropriate species based on soil type, but, in general, trees were not removed. The term "woodland" is used to characterize interspersion of planted trees and shrub thickets with patches of grassland. The woody component of this habitat type can be classified based on the following species associations:

New Mexico Locust Thickets. Planted by early homesteaders, New Mexico locust did not occur on pre-settlement refuge lands. However, the Service considers this a native shrub because it occurs naturally within 30 miles of the present-day refuge (Bruce Hastings, USFWS, and Carl Mackey, URS Washington Group, personal communication 2008). Since planting, the species has expanded to form dense thickets; however, locust borer infestations in the mid-1990s and 2007 top-killed older trees and left numerous dead stems. Although re-sprouting has occurred, many thickets have so many dead branches and downed debris that they are virtually impassable by wildlife. Currently, 35 New Mexico locust thickets, ranging from less than one acre to over nine acres, occur on the refuge. The condition of thickets varies from good to poor based on the amount of dead/down material.

American Plum and Chokecherry Thickets. Historically, plum (*Prunus americana*) and chokecherry did not occur in Adams County, Colorado, but both species were documented in nearby Denver County. Therefore, the Service considers both species to be native shrubs. Currently, about 25 plum or chokecherry thickets occur on the refuge, varying in diameter from 20 to 50 feet. However, most thickets have been so heavily browsed by deer that they are losing their ability to resprout and are beginning to disappear.

Homestead Site Trees and Planted Groves. There are dozens of homestead sites located in the Educational Zone that still contain native and non-native trees planted by settlers and the U.S. Army. Typical species include Siberian elm, cottonwood, white poplar, Colorado blue spruce, Rocky Mountain juniper, green ash, basswood (*Tilia americana*), honey locust (*Gleditsia triacanthos*), at least one white oak, American plum, chokecherry, northern catalpa, Siberian peashrub (*Caragana arborescens*), and lilac.

Russian Olive. Originally planted primarily around the perimeter of homesteads as an ornamental for shade, Russian olive (*Elaeaganus angustifolia*) has systematically invaded ditches, canals, wetlands, and edges of existing cottonwood stands. This species is listed as a weedy species by the State of Colorado and the Service considers it a highly invasive exotic.

Riparian, Lacustrine, and Wetland Habitats

The more prominent aquatic features occur in the Educational Zone and are man-made. The only historic aquatic habitat on the refuge is First Creek; however, the Army channelized the stream and the irrigation infrastructure significantly altered stream hydrology. Although the Service restored flow to about 0.3 miles of the original First Creek channel in 2003, the hydrology of the stream remains altered. Specific wetland habitats on RMANWR include:

Riparian. Plant communities in riparian zones include both herbaceous and woody species. Currently, the herbaceous community is dominated primarily by noxious grass and forb species, including Canada thistle (*Cirsium arvense*), white top (*Cardaria draba*) and smooth brome (*Bromus inermis*). Reed canarygrass (*Phalaris arundinacea*) is also found along the lower portions of First Creek, forming pure stands in some areas. Woody species are dominated by plains cottonwood, peach leaf willow (*Salix amygdaloides*), and coyote willow (*Salix exigua*). The age of most cottonwood stands varies from 35 years (Section 12) to 70+ years (First Creek, Upper Derby Lake) and most likely established following significant flood events in 1973, 1965, and 1933 that created bare, moist substrates. The future of riparian communities is uncertain at this time. Cottonwood is considered “old growth” at 80 years of age (Kindscher and Holah 1998); thus, some existing stands on the refuge likely will degrade during the life of this HMP. In addition, cottonwoods along the Highline Canal may be in jeopardy because the canal has been decommissioned and water no longer flows to Upper or Lower Derby Lakes. Mortality may occur if the water table drops during a severe, prolonged drought because survival depends on proximity to the water table (Jonathan Friedman, USGS, personal communication 2002; Joseph Capesius, USGS, personal communication 2003). Some cottonwood regeneration is occurring, particularly along the margins of seasonal wetlands in Sections 5, 7, and 8, but survival is limited to small areas. Regeneration also may be more likely along First Creek because base flow is expected to substantially increase in future years (Tom Jackson, USFWS, personal communication 2007). However, the extent of natural regeneration likely will not replace current stands during the next 50 years.

Lacustrine. Lacustrine habitat consists of five artificially created lakes and ponds: Lower Derby (73 surface acres), Upper Derby (0 surface acres), Ladora (48 surface acres), Mary (9 surface acres), and Havana Pond (39 surface acres). Derby and Ladora were constructed between 1910 and 1919 for cropland irrigation and domestic water purposes. The U.S. Army constructed Lake Mary and installed a dam to subdivide Derby Lake into Upper and Lower Derby lakes. At this time, the primary use of water was industrial, although the stocking of fish was initiated in 1960 as a recreational fishery for employees. Upper Derby has not functioned as a lake for many years and only receives water following major storm events; thus, a plan has been developed to breach the dam. Havana Pond was constructed in 1979 to assist with urban flood control and drainage after the extension of Stapleton airport runways. With the exception of Upper Derby, water sources for these lacustrine habitat are varied and include precipitation, flows from drainage interceptors (Uvalda, Peoria, Havana, and Joliet) that channel storm water discharge, natural groundwater discharge, and pumped water from wells. Surface water also can be transferred between some lakes via gravity flow. Water and bottom substrates of lakes were regularly monitored as part of cleanup activities and all contaminants were below State of Colorado and EPA thresholds for human health and the environment. However, suspended sediment in Lake Mary has recently increased due to erosion of constructed peninsulas and islands and Havana Pond receives inputs of sediment from storm water received from the Joliet and Havana Inerceptors. In 2012, the Havana Pond dam was reconstructed. Recently, a master planning effort is in progress for the Urban Drainage District that would include construction of a new retention pond immediately upstream of where the Uvalda and Joliet interceptors merge. This pond would limit inputs of sediments and debris into Havana Pond, but likely would not reduce inputs of dissolved solids (Tom Jackson, personal communication 2011). The plant communities of lakes vary depending on the timing and extent of water level fluctuations. The Upper Derby basin, which only receives water periodically, is dominated by noxious weeds. The remaining lakes support emergent vegetation, primarily cattail (*Typha* spp.), in shallow water along shorelines and various rooted and floating-leaved aquatic species in deeper portions of the basins that never dry. The lakes serve multiple purposes, including providing irrigation water (Lower Derby) for restoration of native prairie, public fishing opportunity, and habitat for wetland-dependent wildlife.

Related to the final cleanup of the RMANWR, Section 9.1 of the Record of Decision for the On-Post Operable Unit (Foster Wheeler Environmental Corporation 1996) states that "water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems." To further assist with defining this requirement, the U.S. Army, Shell Oil Company, Environmental Protection Agency, and Colorado Department of Public Health and Environment agreed to the following (U.S. Fish and Wildlife Service et al. 2006):

> Lake Ladora and Lake Mary: This plan is designed to maintain sufficient quantity and quality of water in the Lake Ladora and Lake Mary to support a warm water recreational fishery. The Lakes will be managed to provide an ecosystem that sustains populations of green sunfish, bluegill sunfish, largemouth bass and other native or desirable naturalized game and forage fish species, as determined by the Service.
>
> Lower Derby Lake: This plan is designed to maintain sufficient water quality and quantity in Lower Derby Lake to support a minimum of 50,000 use-days by migratory waterfowl during the period of October - April, annually. While the primary ecological function of Lower Derby Lake, for the duration of the surface remedy, is to provide waterfowl habitat, the Service may also conduct fishery management activities.
>
> Maintenance of the following minimum lake levels will insure that adequate water quantity is available to support the desired aquatic ecosystem. Lower Derby Lake (full pool 454 ac. ft.) may be reduced 85% to approximately 68 ac. ft. The minimum elevation of the pool is 5,237' msl. Lake Ladora (full pool 415 ac. ft.) may be reduced 27% to approximately 300 ac. ft. The minimum elevation of the pool is 5,217' msl. Lake Mary (full pool 66 ac. ft.) may be reduced 10% to approximately 60 ac. ft. The minimum elevation of the pool is 5,202.5' msl.

Wetlands. The majority of the 119 wetland acres on RMANWR are created with only Wetlands 2 and 4 being enhanced on natural basins. Having been constructed for varied purposes (stormwater retention, wildlife, public viewing) or as a result of topographic alteration that occurred as a result of cleanup activities that altered topography (Figure 7). Primary wetland habitats include Bald Eagle Shallow in Section 5, Wetlands 3, 4, 5 and Parkfield Ponds in Section 7, Wetland 1 in Section 8, Rod and Gun Club in Section 12, Lorri's Ponds in Section 26, and Mackey Pond in Section 35. Although most wetland construction was done in natural wetland basins, Wetland 5 in Section 7 was an inter-dune basin constructed in sandy soils and does not hold water. In addition, although water sources for wetlands were included in the original design plans, changes in management and infrastructure over time have significantly reduced or eliminated the ability to manage hydroperiods in many wetlands. For example, the wetlands in Sections 7 and 8 no longer can be flooded due to the decommissioning of the Highline Canal. Plant community composition is varied, but dominant species in many wetlands include cattail, cottonwood saplings, and noxious weeds.

Chapter 3 – Resources of Concern

Approximately 332 species of wildlife have been documented on the refuge (U.S. Fish and Wildlife Service 1996a); however, habitat conditions (food, cover, etc.) that provide the needs of all these species cannot be provided simultaneously nor can they be provided consistently and reliably. Therefore, the Service endorses the identification of 'resources of concern' to focus management on the highest priorities of the NWRS and the refuge as set forth in applicable laws and policies. This approach is consistent with the Service's recent direction to begin using "surrogate species" as guides for conservation design. The following steps were used to guide decisions in selecting priority species, species groups, and communities:

- Include species that are specifically mentioned in the establishing legislation of the refuge, relevant species that are listed as threatened, endangered, or candidates for listing under the ESA, and species that are trust resources of the Service. In addition, evaluate species and habitats mentioned in the 1996 CMP as they relate to the establishing legislation and include those that remain relevant given information developed since plan completion.

- Consult published plans applicable to the geographic setting of the refuge to identify species and communities that are considered priority conservation needs. Examples include, but are not limited to, national and regional bird plans, endangered species recovery plans, and conservation plans and state fish and wildlife agencies.

- Identify habitat requirements (composition, structure, area, distribution) of potential priority species and assess the potential contribution of refuge lands to meeting these needs. This consideration is extremely important given the urban setting of RMANWR because habitat islands, while essential to the survival of many species, generally support fewer species than an area of the same size located within contiguous habitat (Montana State University 2008). In addition, wildlife populations, particularly non-migratory species, inhabiting the refuge may become genetically isolated. As a result of reduced gene flow, some populations may experience reduced fitness over the coming decades, which could potentially lead to further population declines. For example, the refuge deer herd may begin to suffer from genetic isolation after 100 years (Dan Baker, CDOW, retired, personal communication 2005).

Plant Communities

Historically, shortgrass prairie, with inclusions of mixed-grass prairie and shrubland, were the dominant plant communities on refuge lands. However, past activities resulted in the significant degradation of this community or the conversion of the communities to artificial habitats such as lakes, created wetlands, homesteads, buildings, and shelterbelts. Similar losses and conversions have occurred throughout the Great Plains; statewide losses of presettlement short- and mixed-grass prairie range from 29-79% and 30-75%, respectively (Knopf 1994). Future threats to this ecosystem include continued loss due to agriculture and other developments, encroachment of nonindigenous species, and loss of genetic diversity (Knopf 1994, Bachand 2001). These prairie ecosystems provide critical habitat for many priority bird species identified by the Service and other conservation entities; therefore, native prairie was selected as a community of concern. This decision is supported by the CMP and HRP, which stipulate restoration of much of this area to stable, native short- and mixed-grass prairie to attain cleanup goals, and the Service BIDEH policy that directs biologists and managers to replicate*, to the degree possible,* pre-settlement habitats and ecosystem processes.

Many artificial habitats on the refuge cannot be restored due to Service policies and mandates or limited funding. For example, some features are cultural resources and provide education and interpretive opportunities or provide valuable recreational opportunities that contribute to the purpose of the refuge. Some of these features located in the Educational Zone will be retained and managed (passively or actively) to provide important visitor services, habitats for resources of concern, and ancillary benefits to other wildlife species such as deer, waterfowl, shorebirds, wading birds, and neotropical migrants. The concept of maintaining the existing habitat value of the Educational Zone also was identified in the CMP. In contrast, most of the artificial features in the Prairie Zone will be restored to native prairie.

Wildlife Communities

Migratory birds are trust resources of the NWRS and the Service is committed to landscape-scale bird conservation (U.S. Fish and Wildlife Service 2012c). In 2008, the Service's Division of Migratory Bird Management consolidated information from the Partners in Flight Landbird Conservation Plan, U.S. Shorebird Conservation Plan, and the North American Waterbird Conservation Plan into the *Birds of Conservation Concern,* a document that identifies migratory and non-migratory bird species in greatest need of conservation at three spatial scales: National, Service Regions, and Bird Conservation Regions (BCR, Figure 8). RMANWR staff used this list along with species identified in the Conservation Plan for Grassland Species of Colorado (Colorado Division of Wildlife 2003), the North American Waterfowl Management Plan (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986, U.S. Fish and Wildlife Service et al. 1994;2012), Playa Lakes Joint Venture (Playa Lakes Joint Venture 2008), the Colorado State Wildlife Action Plan (Colorado Division of Wildlife 2006), and the Nature Conservancy's Central Shortgrass Prairie Ecoregion Conservation Plan (The Nature Conservancy 2006) to construct a comprehensive list of priority bird species (Appendix E). This list was compared to point counts, annual raptor breeding and wintering surveys, other refuge records, and the Colorado Breeding Bird Atlas (1998) to identify which of these species currently, or potentially could, occur on refuge lands. Refuge staff subsequently reviewed this subset of species and determined that the greatest contribution of refuge lands to migratory bird conservation would be to provide habitat for species known to breed at RMANWR with an emphasis on species that currently are exhibiting declining population trends. These species include the lark bunting, grasshopper sparrow (*Ammodramus savannarum*), Cassin's sparrow (*Peucaea cassinii*), Swainson's hawk (*Buteo swainsoni*), and burrowing owl (Table 3). The bald eagle, though recently de-listed as an endangered species, was also selected for inclusion because it is protected under the Bald and Golden Eagle Protection Act and the refuge has an active nest and communal winter roost. Refuge staff selected black-tailed prairie dogs as a resource of concern because the species is considered a keystone species of shortgrass prairie (Luce 2003). The species is an important prey base for raptors and other carnivores, influence plant species composition and structure, and create habitat that is used by other species, including burrowing owl (Desmond et al. 2000, Colorado Division of Wildlife 2003, Klute et al. 2003). The management of the refuge to preserve a representative community of black-tailed prairie dog and providing suitable habitat for grassland birds was also mentioned in the CMP.

The CMP also recommended the reintroduction of greater prairie-chicken, plains sharp-tailed grouse, bison, and pronghorn. However, feasibility studies conducted by the Service in 2005 recommend against reintroduction of greater prairie-chicken (*Tympanuchus cupido*) and sharp-tailed grouse (*Tympanuchus phasianellus*) at this time, because the area of native prairie is not sufficient. Bison were reintroduced on RMANWR in March 2007 and the herd now numbers 70 (Table 6). Pronghorn are still considered a possibility for reintroduction, but only after restoration of prairie has been completed and stands are capable of supporting an additional herbivore.

Table 3. Habitat needs for resources of concern & associated species

Resource of Concern	***Associated Species***	***Desired Vegetation Structure***
bald eagle	osprey	riparian gallery cottonwoods
Swainson's hawk	red-tailed hawk, ferruginous hawk, golden eagle, American kestrel, western and eastern kingbirds, loggerhead shrike	isolated trees or small groups of trees in open perennial grasslands
burrowing owl	black-tailed prairie dog	perennial grasslands with prairie dog towns
Cassin's sparrow	loggerhead shrike, lark bunting, western meadowlark, grasshopper sparrow, Swainson's hawk, short-eared owl, vesper sparrow	perennial grassland & some shrubs
lark bunting	Swainson's hawk, western meadowlark, mountain plovers, long-billed curlew, short-eared owl, horned lark, ferruginous hawk	perennial grassland
grasshopper sparrow	upland sandpiper, vesper sparrow, western meadowlark	perennial grassland
black-tailed prairie dog	burrowing owl, prairie rattlesnake, mountain plover, American bison, black-footed ferret	perennial grassland
American bison	black-tailed prairie dog, burrowing owl, ferruginous hawk	perennial grassland

Black-footed ferrets

The historical distribution of black-footed ferrets included the eastern plains of Colorado (Black-footed Ferret Recovery Implementation Team 2009). Within this area, habitat capable of supporting ferrets was restricted to prairie dog colonies (Biggins et al. 2006a). Spatial distribution of colonies is a key component of ferret dispersal and re-population. Smaller and more widely separated prairie dog colonies results in a reduction of total ferret population that can be supported (Bevers et al. 1997). It should be noted that reintroduction of an endangered species raised in captivity has a high risk of failure when it comes to creating a self-sustaining population. This is due to persistent environmental factors that result in population declines, the effects of inbreeding in small populations, and various other behavioral and physiological consequences of their captive up-bringing (Grenier et al. 2007). Reintroduction of black-footed ferrets will be explored in the revision of the RMANWR comprehensive conservation plan and any release would occur when appropriate thereafter.

Habitat Requirements for Resources of Concern

Bald eagle (*Haliaeetus leucocephalus*)

Range

Breeding ranges are linked to aquatic habitats (rivers, lakes, reservoirs and coastal areas) with wooded shorelines or cliffs in North America (Buehler 2000). The breeding range extends from the Aleutian Islands through southeast Alaska and the southern sections of all Canadian provinces, south to central Mexico, and along the Gulf Coast states. Nests have been found in all states except Vermont and Rhode Island with substantial populations nesting in coastal areas of the southeastern and northwestern United States. Eagles are expanding their range in the Rocky Mountain States. The wintering range extends from the southern portions of Canada and Alaska to the southwestern United States.

Population status

Two subspecies are recognized based on geographic variations in size and mass; the larger northern subspecies, *H. leucocephalus var. alascanaus* which breeds north of 40^{o} N and *H. leucocephalus*. The species has experienced impressive population fluctuations ranging from extremely common in Alaska during the early 1900's to rare in the contiguous United States in the mid 1900's. Both subspecies are protected by the Bald Eagle Protection Act of 1940 (now the Bald and Golden Eagle Protection Act) and the southern subspecies by the Endangered Species Act of 1973 (Buehler 2000). Throughout their range, bald eagles have faced human persecution, egg shell thinning from DDT exposure and habitat loss, but have recovered enough to be downlisted to threatened on both federal and state lists in 1995. Complete delisting was proposed in 1999 (Federal Register 1999) and occurred in 2007 (Federal Register 2007). In Colorado, 33 pairs were known to occupy active nest sites in 1995 (Winternitz 1998) and 51 occupied territories were documented during the 2001 breeding season. An eagle pair initiated nest building along First Creek in Section 5 of RMANWR in 1996 and has fledged young since 2002. In Colorado, the annual midwinter count verifies a consistent statewide population of over 800 eagles (Colorado Parks and Wildlife 2012a). A winter communal roost was discovered on RMANWR in 1986 and peak annual counts of birds utilizing the roost on a single night range from 21 in 1987 and 2003 to 81 in 1998 (RMANWR Annual Narratives unpublished). The Post-delisting monitoring plan calls for monitoring population status over 20 years with sampling events occurring every 5 years, which basically is a continuation of state monitoring.

Phenology and demographics

Migration times are dependent on the availability of food and the age of the bird. Eagles do not reach sexual maturity until five years of age and immature birds disperse from occupied nest territories by August, migrating farther south than adult birds (Buehler 2000). Conversely, adult breeders will migrate north earlier than young to establish or defend nesting territories. Individual survival, particularly of first-year birds, is highly dependent on wintering ground conditions in the Intermountain West and Pacific Northwest, which includes RMANWR (Steenhof 1978). Adults are monogamous through the breeding season, frequently bond for life, and construct massive nests that are reused annually (Sibley et al. 2001). Refurbishing the nest occurs prior to egg laying. Incubation is by both adults and, for birds on the Front Range of Colorado, typically starts in mid-February with fledging occurring around the 3rd week of June (Rocky Mountain Bird Observatory 2010).

Habitat Requirements

Eagles frequently form large communal nightly roosts in the winter. Roost site characteristics include super-canopy trees that are open and accessible with stout horizontal branches (Steenhof et al. 1980). Tree species is not important so long as structural characteristics are met. Other factors affecting roost site selection are protection from prevailing winds, distance from human development (Buehler et al. 1991), and proximity to food resources (U.S. Fish and Wildlife Service 1983). Breeding site characteristics are similar to roosts and include mature, large, tall trees with some habitat edge, preferably near water with suitable food source or other quality foraging area (Buehler 2000). The Northern States Bald Eagle Recovery Plan (1983) general guidelines for essential breeding habitat are 640 acres, including aquatic and terrestrial habitats for foraging.

Area and Landscape Considerations

Maintain cottonwoods of different age cohorts and protect trees and the nest from fire. Maintain 640 acres of suitable nesting habitat and foraging sites(U.S. Fish and Wildlife Service 1983), and protect and maintain hunting perches and roost sites within ¼ mile of nest site (U.S. Fish and Wildlife Service 1983). Within ½ mile of water, protect and preserve mature trees that may serve as future roost or nest sites (U.S. Fish and Wildlife Service 2007). Known winter roost sites should have a buffer zone of ¼ mile with restricted human activity from mid-November through mid March (David Klute, CPW, personal communication 2011).

Summary of Key Habitat Needs

Cottonwoods of various heights with nearby lakes and shorelines to provide suitable roosting areas. Maintain a sufficient area (640 acres or more) to provide solitary nesting and protection from urban development.

Associated Species

Osprey (*Pandion haliaetus*)

Swainson's hawk (*Buteo swainsoni*)

Range

Swainson's hawks breed from the southern Yukon Territories through western British Columbia to southern Alberta, Saskatchewan, and southwestern Manitoba and south from Washington, Idaho, Montana, and North Dakota to California, Arizona, and New Mexico, and east to western Minnesota, northwestern Iowa, northwestern Missouri, Nebraska, central Oklahoma, and central Texas (National Geographic Society (U.S.) 1999). Colorado is in the center of the breeding range with the greatest densities in the Great Plains, North Park and the San Luis Valley (Preston 1998). Primary winter range is located in southeastern South America, specifically the pampas of Argentina (Nicholoff 2003, Bechard et al. 2010).

Population status

Species of conservation concern, on the Partners in Flight watch list due to small population size (460,000), and threats in non-breeding areas (Rich et al. 2004).

Phenology and demographics

Large concentrations of Swainson's hawks leave Argentina in mid-February (Bechard et al. 2010) and arrive at the Pawnee National Grasslands in northeastern Colorado in late March (Olendorff 1973). They arrive at RMANWR in north-central Colorado beginning the first week of April (Kingery 1998). Nesting begins in April and May, the typical number of eggs is 2 (sometimes 3 or 4), and young leave the nest by June or July (Gillihan and Hutchings 1999). Nests are often reused from year to year.

Habitat Requirements

Open grassland for foraging with scattered trees or with small clumps of trees or shrubs for nesting (Baron et al. 1998, Gillihan and Hutchings 1999). Others report usage in all types of grasslands, riparian areas, shelterbelts, woodlots, prairie dog colonies, hay fields and croplands (Dechant et al. 2001). It seems tree species of any kind are adequate for nests and, when trees are absent, shrubs will be utilized. Open areas are necessary for foraging, and one study found <30% usage in cultivated croplands (Nicholoff 2003). In Colorado about 70% of atlas reports were in blocks with rural, shortgrass prairie, lowland riparian woodlands, and cropland habitats (Preston 1998). On the Pawnee National Grasslands, Olendorf (1973) reported 61% of occupied nests in creek bottoms, 25% in pure grasslands, and 14% in cultivated lands. They will nest in trees or shrubs that are isolated, clumped, or part of a shelterbelt, and occasionally on the ground or an artificial structure (Dechant et al. 2001).

Area and Landscape Considerations

Known for its highly gregarious nature, Swainson's hawks will forage and migrate collectively in sizeable flocks (Bechard et al. 2010). The Swainson's hawk has the second longest raptorial migration from temporal North America to southern South America.

Associated Species

Red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*Buteo regalis*), golden eagle (*Aquila chrysaetos*), American kestrel (*Falco sparverius*), Western and Eastern kingbirds (*Tyrannus vertocalis* and *T. tyrannus*), loggerhead shrike (*Lanius ludovicianus*) (Gillihan and Hutchings 1999)

Burrowing owl (*Athene cunicularia hypugaea*)

Range

The breeding distribution of the Western burrowing owl encompasses western North America, extending from the Great Plains west to the southern California coast and south-central British Columbia and southern Saskatchewan to the north. The burrowing owl inhabits the southwestern U.S. and northern Central America year round (Haug and Oliphant 1990).

Population Status

Breeding Bird Survey (BBS) data suggests a generally declining population in the northern half of the Great Plains region; the only areas experiencing some increase are the northwestern portions and some southwestern deserts (Sauer et al. 2002). The species appeared on the 1995 Service list of migratory nongame birds of management concern, the 2002 birds of conservation concern list, and the 2005 Service focal species list. In Colorado, they no longer occur in some historic urban Front Range sites (Jones 1998). A 1999 survey in Colorado conducted by the Rocky Mountain Bird Observatory indicated the burrowing owl was in thirty counties with 23.7% of the locations in Weld County and 2.3% in Adams County where RMANWR is located (VerCauteren et al. 2001). In 2005, a record 86 nests were documented on RMANWR (RMANWR Annual Narrative 2006 unpublished data).

Phenology and demographics

Band recoveries do not indicate precisely where owl populations are wintering (Haug and Oliphant 1990), but individuals and pairs arrive in Colorado in late March and early April (Jones 1998). Females lay eggs from late March to early May (Zarn 1974) with incubation lasting 28 – 30 days by the female only. Young were seen at the burrow entrance from 7 May through 5 August in Colorado (Jones 1998) and typically are first seen on RMANWR the first week of June (Mindy Hetrick, USFWS personal communication 2008).

Habitat Requirements

Burrowing owls prefer various open, well-drained grassland habitats with sparse vegetation usually less than 4 inches in height, including prairie, desert, shrub steppe, agricultural fields and manmade grassy areas. Breeding Bird Atlases reported 70% of burrowing owl sightings occur in shortgrass prairie habitat and band returns suggest nest site fidelity (Teaschner 2005). Highest concentrations in Colorado occur in the southeast (Jones 1998), but range from locally uncommon to fairly common summer residents on the eastern Plains and rare to uncommon in western valleys and mountain parks (Andrews and

Righter 1992). Fragmented prairie habitat is detrimental for burrowing owl nesting because it may allow predators to find nests more easily (James et al. 1997). Warnock (1997) also reported increasing habitat continuity led to greater extirpation of burrowing owls. Three main factors for selecting nesting habitat are the 1) number of available nest burrows, 2) amount of short or sparse vegetation, and 3) amount of open terrain (Murray 2005). Burrowing owls sometimes concentrate nests at the edges of prairie dog colonies(Butts 1973, Desmond and Savidge 1996, Toombs 1997). Reasons are unknown, but they may benefit from increased perch availability, higher insect populations, and close proximity to better foraging areas (Butts 1973, Rich 1986, Dechant et al. 2002). A study in southeast Colorado found that nest sites were not placed on sandy soils, likely due to the fact that sandy soils are an unsuitable substrate for burrows (Toombs 1997, Dechant et al. 2002). Nest sites are characterized by 40-50% bare ground that is well-drained and support abundant prey. Gillihan and Hutchings (1999) and Dechant et al. (2002) reported suitable foraging habitat included taller vegetation at least 12 inches tall. In Colorado, the species are tightly linked to prairie dog colonies in the east and prairie dogs (Nicholoff 2003), rock, and ground squirrels in the Midwest portion of the state. Eighty percent of burrowing owl locations in Colorado are associated with prairie dog colonies (VerCauteren et al. 2001); however, non-active or abandoned prairie dog towns are unsuitable as burrows collapse and vegetation grows unchecked (Zarn 1974). The density of burrowing owl nests in black-tailed prairie dog colonies in Nebraska and Colorado was positively related to the percent of active burrows, with 1.15 owls/acre in colonies with over 90% active burrows compared to 0.23 owls/acre in colonies with 70-80% active burrows (Hughes 1993). In Nebraska, burrowing owl density in towns were negatively correlated with density of inactive burrows, and positively correlated with density of active burrows (Colorado Division of Wildlife 2003). Burrowing owls were found to nest in prairie dog colonies from 0.77 to 68 acres in size (Hughes 1993, Dechant et al. 2002). In Nebraska, colonies ≥ 14 acres appeared to provide adequate space requirements for nesting owls (Desmond 1991, Desmond and Savidge 1996, Desmond and Savidge 1999, Dechant et al. 2002). Owls likely have lower rates of nest success in smaller colonies or in colonies with lower densities of prairie dogs (Butts 1973, Desmond and Savidge 1996, Toombs 1997, Desmond and Savidge 1998;1999, Dechant et al. 2002). Mean inter-nest distance in active black-tailed prairie dog colonies in north-central Colorado was 10 meters (Colorado Division of Wildlife 2003). Within a given prairie dog colony, burrowing owls were observed to aggregate nests into clusters (Butts 1973, Desmond 1991, Desmond et al. 1995, Desmond and Savidge 1996, Dechant et al. 2002). This behavior may reduce the risk of predation by allowing owls to alert one another more readily.

Burrowing owl diets consist largely of insects and small rodents. Common prey in Nebraska and Colorado are ground and dung beetles, crickets, grasshoppers, deer mice (*Peromyscus maniculatus*), meadow voles (*Microtus pennsylvanicus*) and cottontail rabbits (*Sylvilagus* sp.), with invertebrates constituting 92% of the prey (Colorado Division of Wildlife 2003). Burrowing owls have various methods of hunting, including walking, hopping, running, or flying (Haug and Oliphant 1990).

Requirements for Nesting

Mean Vegetative Height. In Colorado, mean vegetation height was 3 inches around nest sites (Plumpton 1992, Dechant et al. 1999). They prefer nesting in grasses ≤ 4 inches (Dechant et al. 2002).

Grass Cover. Grass cover at nest sites was 12% in Colorado (Plumpton 1992, Dechant et al. 2002), 24-30% grass and sedge in Wyoming (Thompson 1984, Dechant et al. 2002), and 35% grass and sedge in South Dakota (MacCracken et al. 1985, Dechant et al. 2002).

Forb Cover. Forb cover at nest sites averaged 30% in Colorado (Plumpton 1992, Dechant et al. 2002), 29-37% in Wyoming (Thompson 1984, Dechant et al. 2002) and 45% in South Dakota (MacCracken et al. 1985, Dechant et al. 2002).

Shrub Cover. Shrub cover at nest sites ranged from 1% in South Dakota (MacCracken et al. 1985, Dechant et al. 2002) to 4% in Wyoming (Thompson 1984).

Litter Cover. In South Dakota shortgrass prairie, sites had 16% litter cover (MacCracken et al. 1985), whereas nesting sites in

Wyoming had 6-10% litter cover (Thompson 1984, Dechant et al. 2002).

Bare Ground. In Colorado, nest sites had 58% bare ground (Plumpton 1992, Dechant et al. 2002). In South Dakota and Wyoming, bare ground at nest sites was 42% and 25-33%, respectively (Thompson 1984, MacCracken et al. 1985, Dechant et al. 2002).

Area and Landscape Considerations

Habitat fragmentation and isolation of prairie dog colonies threatens small populations (Playa Lakes Joint Venture 2008). Traditional nesting sites should be preserved (Butts 1973, Zarn 1974, Haug 1985, Ratcliff 1987, Warnock 1997) and a mosaic of habitats should be maintained to provide nesting, foraging, and roosting sites in close proximity. No pesticide should be applied within 400-600 meters of nests during breeding season (Haug 1985). If lethal control of prairie dogs is necessary, timing of control activities should be restricted when burrowing owls are nesting. Keys to management are the provision of short, sparse vegetation with abundant prey populations and burrowing mammals to ensure availability of burrows as nest sites.

Associated Species

Swainson’s hawk, red-tailed hawk, ferruginous hawk, golden eagle, migrating mountain plover, and nesting horned lark (*Eremophila alpestris*) (Gillihan and Hutchings 1999)

Cassin’s sparrow (*Aimophila cassini*)

Range

Breeding range is central and eastern Colorado, southeastern Wyoming, western Nebraska, western Kansas, and central Oklahoma. Both breeding and wintering range continues south in eastern New Mexico, southern Texas, southern Arizona, northern Sonora, and south on the Mexico Plateau (Rising 1996). BBS data indicates the relative abundance of Cassin’s sparrow is highest from southeastern Colorado through eastern New Mexico and adjacent portions of Texas (Sauer et al. 2002). Annual fluctuations in breeding densities in the core of the breeding range are a response to summer precipitation (Dunning Jr. et al. 1999). In Colorado, Cassin's sparrows are least numerous during wet years when the grassy vegetation becomes too tall (Andrews and Righter 1992), but are more prevalent in southwestern deserts when rainfall increases past drought stages. As a short distance migrant, their winter range includes the southwestern United States, where relative abundance is highest on Christmas Bird Counts in southeastern Arizona and southwestern New Mexico (National Audubon Society 2009).

Population status

The species is considered to be of regional concern by Partner’s in Flight, a Regional Stewardship species in BCR 18 (38.6% of population occurs in this BCR), a species of concern in Colorado, a focal species by the Service. A prairie endemic (Samson and Knopf 1996), BBS trend estimates for 1966-2005 show a significant decline ($P < 0.1$) in Region 6 of the Service. Cassin's sparrows peaked in Colorado during 1974 and then declined through the mid-1980s (Sauer et al. 2002). The chief cause of decline has been attributed to habitat disturbance and degradation (Ruth 2000). The Cassin’s sparrow has been declining nationally at an average annual rate of 2.3% based on BBS data from 1966-1999 (Bachand 2001). A 2.6% decline/year has been observed for the Cassin’s sparrow in central U.S. from 1966-1996, but a significant positive trend (2.6%/yr.) occurred in Colorado from 1980 to 1996. Population dynamics are poorly understood for this species (Dunning et al. 1999). Breeding densities are highly variable and very responsive to precipitation patterns (Ruth 2000). In fact, due to the fluctuations in annual numbers in many locations, population estimation and trends are difficult to determine (Ruth 2000).

Schnase (1998) found in a 2-year study in west central Texas that there was an average of 4.5 pairs on a 100 acre area (Dunning Jr. et al. 1999).

Phenology and demographics

Arrival in Colorado begins around mid-April (Andrews and Righter 1992), but singing and courtship flights are typically delayed until mid-May (Melcher 1998). Primary nesting begins in late May or early June and lasts through mid-July (Beidleman 2000, Ruth 2000). Clutches contain 3-5 eggs and incubation time is 9-11 days. Brown-headed cowbirds (*Molothrus ater*) are known to parasitize nests (Kingery and Julian 1971). Young fledge by July and leave for wintering grounds by September. The mean territory size in south-central TX was 6.4 acres (Schnase 1984 fromWest 1998). The Cassin's sparrow is a ground forager and diet consists primarily of beetles, grasshoppers, crickets, and other insects during nesting season, and weed and grass seeds during the non-breeding season (Dunning Jr. et al. 1999, Beidleman 2000). The diet of young sparrows is composed almost entirely of insects (Ruth 2000). This species has also been known to eat sorghum during the winter (Dunning Jr. et al. 1999).

Habitat Requirements

During the breeding season, Cassin's sparrow inhabits shortgrass prairie with scattered shrubs (including sand sagebrush, yucca, and rabbitbrush) that are used for song perches and nest cover. During the breeding season, sparrows will accept shrub densities as long as grass cover exists (Beidleman 2000). They avoid pure grassland and pure shrubland habitats (Sauer et al. 2002). Greatest densities in BCR 18 were in areas with >10% shrub cover (n=665) and 41-50% grass cover that was >5.9 in height (n=228) (Sparks et al. 2005). In eastern Colorado, the species occurred in Breeding Bird Atlas blocks that were comprised of shortgrass prairie (50%) and sand sage shrublands (25%) (Melcher 1998). Nests are built on the ground at the base of a shrub, yucca, cactus, or clump of grass, or less than one foot above the ground in a shrub or cactus (Bent 1968). Conservation Reserve Program (CRP) fields in Texas had an average density of 0.7 nests/acre. Field types varied, but all were dominated by blue grama (Berthelsen and Smith 1995). Preliminary estimates of breeding density from a study in Sueco, Mexico and Tinaja Verde, Mexico 0.16 pairs/acre and 0.14 pairs/acre, respectively (Ruth 2000).

In Colorado, Cassin's sparrows are found in sandy rabbitbrush grasslands in Logan County and along the South Platte River. Common grasses in this area include purple three-awn and needlegrass (Faanes 1979 from Dunning Jr. et al. 1999). Andrews and Righter (1992), Rising (1996), and Ruth (2000) state Cassin's sparrows in Colorado are found primarily in rabbitbrush and sand sage grasslands. At RMANWR, Cassin's sparrows were most abundant in plots dominated by yucca (Preston et al. 1994).

Requirements for Nesting

Mean Vegetative Height. In Arizona, mean vegetative height of nesting habitat was 11.4 in (Bock and Webb 1984, Ruth 2000).

Grass Cover. At Comanche National Grasslands in southern Colorado, 14.8% of nesting grassland consisted of 37.8% shortgrass and 37.8% midgrass (Gillihan and Hutchings 1999, Ruth 2000). Studies in Arizona and Mexico found grass cover raned from 37.71% to 68.8% (Bock and Webb 1984, Ruth 2000).

Forb Cover. At Comanche National Grasslands, forb cover was 8.5% (Gillihan and Hutchings 1999, Ruth 2000). In Arizona and Mexico, herbaceous vegetation cover ranged from 0.22% to 2.9% (Bock and Webb 1984, Ruth 2000).

Shrub Cover. Shrub cover on nesting areas was 0.9% low shrub and 4.1% tall shrub at Comanche National Grasslands in southern Colorado (Gillihan and Hutchings 1999, Ruth 2000) and ranged from 0.88 to 10.3% in Arizona and Mexico (Bock and Webb 1984, Ruth 2000). Another study in Arizona found that Cassin's sparrows rarely occupied plots with <6% shrub canopy cover (Ruth 2000).

Litter Cover. Little information exists. Two studies, one in Sueco, Mexico, the other in Tinaja Verde Mexico, documented use of areas with 38.6% and 34.5% litter cover, respectively (Ruth 2000).

Bare Ground. Bare ground accounted for 27% of cover in Colorado (Gillihan and Hutchings 1999) and 23% in Arizona (Bock and Webb 1984). Another study in Arizona found that Cassin's sparrows rarely occupied plots >35% bare ground and in Mexico the species occupied areas that ranged from 17.9% to 26.3% bare ground (Ruth 2000).

Area and Landscape Considerations

Cassin's sparrows are highly responsive to vegetation structure and grass/shrub composition. Research suggests the species has a mixed response to grazing (Ruth 2000), although a negative response to grazing was thought to be due to the need for taller vegetation (Gillihan and Hutchings 1999). Cassin's sparrows also avoid burned sites for 1-2 years, but the long-term benefits of burning include shrub cover reduction and invigorated plant growth (Ruth 2000).

Associated Species

Loggerhead shrike, lark bunting, Western meadowlark (*Sturnella neglecta*), grasshopper sparrow, Swainson's hawk, short-eared owl (*Asio flammeus*), vesper sparrow (*Pooecetes gramineus*) (Gillihan 1999, Ruth 2000).

Lark Bunting (*Calamospiza melanocorys*)

Range

Breeding occurs in grasslands from southern Alberta through Southern Manitoba, south to western New Mexico and western Texas, and east to eastern South Dakota and northwestern Missouri (Dechant et al. 2001). Colorado's eastern plains host a large portion of the breeding population with a few breeding pairs occurring in western grassland basins. Winter range includes the southwestern United States to central Mexico (Kingery 1998). Occasionally, small numbers winter in Baca County in southeastern Colorado (National Audubon Society 2009).

Population status

BBS trend estimates for 1966-2005 indicate a significant decline ($P < 0.1$) in Region 6 of the Service (Sauer et al. 2002). Partners in Flight lists the lark bunting as a Stewardship Species with continental importance in the prairie avifaunal biomes (Rich et al. 2004). Hersey and Rockwell (1909) considered the species an abundant summer resident in Adams County, Colorado and Denver Field Ornithologists' trip to RMANWR in May 1965 documented 290 individuals (Andrews et al. 2002). BBS counts on the refuge from 1992 through 2006 have oscillated from 0 to a high of 293 individuals (RMANWR BBS unpublished survey data). In Boulder County, Colorado, "no grassland bird has declined more drastically…over the past century" (Jones and Bock 1992 from Neudorf et al. 2006). However, according to Breeding Bird Atlas abundance codes, they are the fourth most numerous bird in the state on the eastern plains with an estimated 1,600,000 breeding pairs (Kingery 1998). The lark bunting is a Partners in Flight species of Regional Concern and a Stewardship Species in BCR 18 (Gillihan and Hutchings 1999). Lark bunting densities in the Pawnee National Grasslands, Colorado (shortgrass prairie) ranged from 7.2 to 13.8 birds on six 20 acre plots (Giezentanner 1970 from Finch and Anderson 1987).

Phenology and demographics

Peak migration in Baca County, Colorado, occurs between 6 and 16 of May (J.W. Thompson, personal communication in Shane 2000). Since the early 1990s, spring counts conducted the second week of May at RMA have detected low numbers of lark buntings (RMANWR unpublished bird survey data). Male buntings are known for their spectacular singing flight displays to attract a female. In north-central Colorado, territory size was 1.2 to 2.7 acres (Wiens 1970;1971, Finch and Anderson 1987) and at Pawnee National Grasslands in northeastern Colorado territory sizes were estimated at 1.2 to 1.85 acres (Creighton 1971 from Finch and Anderson 1987). Lark buntings typically begin to occupy nests in early June and territoriality ends when nesting begins as both adults are involved in incubation, brooding, and feeding young. The common clutch size is 4-5 eggs placed in a vegetated nest cup built in a ground depression with overhanging vegetative cover (Harrison 1979). With and Webb (1993) found this vegetation provided a moderate windbreak and relative cover for lark buntings.

Habitat Requirements

Lark buntings are one of a small number of passerines endemic to the Great Plains, evolving alongside bison and adapting to the mosaic landscape created by grazing of large ungulates, prairie dogs, and occasional fire (Nicholoff 2003, Neudorf et al. 2006). Lark Buntings in north-central Colorado are commonly found in sand dropseed/rabbitbrush grasslands. Fairbanks et al. (1977) reported 20 and 23 breeding pairs/100 acres in sand dropseed and rabbitbrush, respectively. Optimal habitat consists of native prairie grasses with an upper stratum of mid grasses and a dense understory of short grasses. A thin layer of shrubs, bunchgrasses, or mid grasses provides shade and is assumed to be an important feature of nesting habitat (Finch and Anderson 1987). Nesting habitat can be greatly affected by precipitation patterns, as shortgrass prairie vegetation can respond dynamically to rainfall (Wiens 1973, Neudorf et al. 2006). At RMANWR, 'lark buntings reached greatest densities in plots most distant from the habitat edge' (Preston et al. 1994).

The species uses highly variable vegetation associations (prairie grasslands and shrublands) (Nicholoff 2003), but require open grasslands with a mix of short and tall grass and scattered shrubs**.** Lark buntings prefer areas $\geq$ 10 km^2 dominated by wheatgrass, blue grama, needle and thread, and big sagebrush (*Artemisia tridentata*), and may be area sensitive. Lark buntings utilize grasslands, shrub-steppe and agricultural fields of low to moderate height, 60-70% vegetative cover and 10-15% bare ground. Others indicate a 10-30% cover of shrubs, or tall grasses are preferable for breeding (Gillihan 1999). In Weld County, Colorado, breeding grasslands consisted of purple three-awn, four-winged saltbush, buffalo grass, and rabbitbrush (Shane 2000). The species will not nest in areas with <30% grass cover or more >60% bare ground. In Colorado, distribution of lark buntings was as follows: 42% in shortgrass and 42% in a combination of mixed-grass, tallgrass, and agricultural fields (Kingery 1998). As mentioned above, the vegetative cover is critical for sheltering the nest and song perches while bare ground is important for summer (75% of lark bunting diet in the summer consists of invertebrates, mostly grasshoppers) (Gillihan and Hutchings 1999).

In 1996-98, in southwest Kansas and southeast Colorado, breeding lark buntings avoided black-tailed prairie dog colonies (Winter and Faaborg 1999, Shane 2000). In a Colorado study, nests were placed under protective plants including four-wing saltbush (Baldwin 1969 from Dechant et al. 1999). Heavy grazing can be detrimental, but low to moderate grazing can create habitat patchiness (Nicholoff 2003). Heavy grazing in the summer should be avoided in nesting areas (Neudorf et al. 2006), but heavy winter grazing and light summer grazing may be compatible because they create a habitat mosaic typical of native prairies prior to European settlement (Fuhlendorf and Engle 2001).

The lark bunting is a ground forager and consumes both insects and plant seeds. In CO, 36-38% of their diet consists of plant seeds and 62-64% is composed of invertebrates (Shane 2000). One study found that lark buntings consume 80% animal matter and 20% plant matter during breeding season (Finch and Anderson 1987). High densities of lark buntings have been associated with high densities of grasshoppers, which often with grass cover values >60% (Anderson 1964 from Finch and Anderson 1987).

Requirements for Nesting

Mean Vegetative Height. Vegetation 3-8 inches in height is considered optimal (Finch and Anderson 1987). In Colorado, mean vegetative heights at nest sites were 2.8 inches (Shane 2000, Neudorf et al. 2006) and 3.1 inches (Wiens 1973, Dechant et al. 1999). Most nests are built in vegetation that is 6-11 inches in height. In Colorado short- and mixed-grass prairies, the mean vegetation height surrounding nests was 5.1 inches and nests often were associated with purple three-awn, four-winged saltbush, and rabbitbrush (Creighton 1971, 1974 from Dechant et al. 1999). At Pawnee National Grasslands, Colorado, Wiens (1973) found the greatest nest association (47%) with four-wing saltbush (Finch and Anderson 1987).

Grass Cover. Nests occur in areas with 60-70% low grass cover, but will not nest in areas with <30% grass cover or >60% bare ground (Nicholoff 2003). In Colorado, separate studies reported grass cover to be 81% (Wiens 1970) and 82% on winter grazed sites (Wiens 1973 from Dechant et al. 1999) and he extent of shortgrass and mixed-grass cover was 65.5% and 4.7%, respectively, (Shane 2000, Neudorf et al. 2006).

Forb Cover. Studies suggest 6% to 7.2% forb cover (Wiens 1970 from Dechant et al. 1999, Shane 2000, Neudorf et al. 2006).

Shrub Cover. Cover at nesting sites included 10-30% shrub or tall grass cover for nest protection and song perch sites Wyoming (Nicholoff 2003). Based on habitat suitability models, optimal nesting habitat includes 10-30% canopy cover of vegetation taller than the dominant grass stratum (Finch and Anderson 1987).

Litter Cover. Documented litter cover in nesting areas range from 38% (Wiens 1970, Dechant et al. 1999) to 24% in winter grazed areas (Wiens 1973, Dechant et al. 1999).

Bare Ground. In general, <15% bare ground is optimal (Finch et al. 1987), which is supported by numerous studies (Kantrud and Kologiski 1982 from Finch and Anderson 1987; Creighton 1971, 1974 from Dechant et al. 1999; Wiens 1973 from Dechant et al. 1999, Shane 2000, Nicholoff 2003).

Area and Landscape Considerations

The species is associated with large, contiguous grasslands and will avoid small grassland patches (Wiens 1970;1971) and is potentnially area-sensitive. Large grasslands ($\geq$ 10 km^2) should be provided as densities increase with increasing area of contiguous grasslands (Dechant et al. 1999, Shane 2000). Short-term, rotational grazing should be used to create habitat patchiness, but long-term grazing should be avoided (Neudorf et al. 2006). In shortgrass prairie, heavy summer grazing is often detrimental because it increases bare ground cover, reduces vegetation height, and removes protective cover (Dechant et al. 1999). In tallgrass prairies where vegetation height is >12 inces, grazing can be heavier to provide appropriate breeding and nesting habitat. Mowing should be delayed until late July when nesting is completed (Dechant et al. 1999). Burns should be conducted in the fall to avoid loss of nesting cover and area burned should be small and patchy so that nesting cover is maintained for the next year (Neudorf et al. 2006). Burning to eliminate all shrub cover should be avoided (Bock & Bock 1987 from Dechant et al. 1999).

Associated Species

Swainson’s hawk, Western meadowlark, migratory mountain plovers, long-billed curlews, short-eared owl, horned lark ferruginous hawk (Gillihan and Hutchings 1999, Nicholoff 2003)

Grasshopper sparrow (*Ammodramus savannarum*)

Range

Four subspecies of grasshopper sparrows breed in North America. Although the subspecies are allopatric during the breeding season, the western (*A. savannarum var. perpallidus*) and eastern (*A. savannarum var. pratensi*) subspecies overlap in the Eastern Great Plains. Despite the appearance of an extensive breeding range that encompasses the eastern two thirds of the United States and the west coast of California and parts of the northwest U.S., the grasshopper sparrow is often locally distributed or rare in parts of its range (Vickery 1999). BBS survey data indicate the relative abundance of grasshopper sparrows is highest on the Great Plains from North Dakota south to Kansas and the Texas panhandle area, and eastward into portions of Missouri and Iowa (Sauer et al. 2002). The central-western edge of their distribution extends through the eastern third of Colorado and RMANWR is the most western "confirmed" breeding area (Kuenning 1998) Grasshopper sparrows have been detected on every annual BBS conducted on the refuge since 1991 (RMANWR unpublished bird survey data).

Population status

Populations have declined 69% across the U.S. since the late 1960's (Herkert 1994) and BBS trend estimates for 1966-2005 show a significant decline ($P < 0.1$) in Region 6 of the Service. The grasshopper sparrow was previously listed as a nongame bird of management concern in 1995 because of its dependence on vulnerable or restricted habitats (U.S. Fish and Wildlife Service 1995) and it first appeared as a Service focus species in 2005 (U.S. Fish and Wildlife Service 2012c). In Colorado, the declines largely occurred prior to the late 1970s (Sauer et al. 2002). Partners in Flight considers the grasshopper sparrow a Stewardship Species that has continental importance in the prairie avifaunal biomes (Rich et al. 2004).

Phenology and demographics

Grasshopper sparrows begin arriving on breeding grounds in Colorado during early May (Kuenning 1998). Males arrive first and establish 1-3 acre territories with early morning song that later will be continual during the day and night (Vickery 1999). Andrews and Righter (1992) suggested the species may form loose breeding colonies, but territorial defense is vigorous. Occupied nests in Colorado were found in the first week of June (Kuenning 1998) through mid-July, suggesting second nests do not occur in the state. Nests are characteristic ground nests with a dome of overhanging grasses built by the female that are difficult to spot. Clutch size varies from 4-5. Cowbird parasitism is low where the two species coexist, but predation by loggerhead shrikes appears to be "quite common" in Oklahoma (Vickery 1999). Non-parental attendants to young were observed in grasshopper sparrows in Nebraska. This behavior involves both young and adults from neighboring territories provisioning food to nestlings (Kaspari and O'Leary 1988).

Habitat Requirements

Grasshopper sparrows prefer moderately open grasslands and prairies. During the breeding season, patches of habitat >30acres are used for nesting (Gillihan and Hutchings 1999, Nicholoff 2003). Suitable habitat ranges from intermediate grassland with sparser vegetation to thicker, brushier sites of shortgrass prairies; vegetation often is clumped and interspersed with patches of bare ground (Bent and Austin 1968, Blankespoor 1980, Vickery 1999). In addition, they will use fallow fields with tall weeds and cultivated grasslands (Vickery 1999). They generally avoid grasslands with extensive shrub cover, although some level of shrub cover is important for birds in western regions (Vickery 1999). Grasshopper sparrows are most commonly found in mixed-grass grasslands and moist meadows with continuous tall herbaceous cover and conspicuous singing perches. In BCR 18, the species selected areas characterized by 81-100% cover of grass >6 inches in height and <1% shrub cover and avoids areas with 0-30% cover of grass >6 inches in height and 1-10% shrub cover (Sparks et al. 2005).

Grasshopper sparrows are ground feeders and prefer areas with some bare ground for foraging. Diet is comprised primarily of insects in the summer, with a preference for grasshoppers. In winter, they feed mostly on seeds, preferring *Panicum* species (Vickery 1999).

Requirements for Nesting

Mean Vegetative Height. In Colorado and other plains states, the average vegetative height of used sites was 11 inches (Kantrud and Kologiski 1982), whereas in Arizona the mean grass height was 12 inches (Bock and Webb 1984).

Grass Cover. Grasshopper sparrows used winter-grazed shortgrass pastures with 87% grass cover in Colorado (Wiens 1970) and areas with 72% grass cover in Arizona (Bock and Webb 1984).

Forb Cover. Forb cover documented on used areas range from 0% on winter-grazed pastures in Colorado (Wiens 1970) to 4% in Arizona (Bock and Webb 1984)

Shrub Cover. Rangewide, areas with >35% shrub cover are avoided (Smith 1963) and in Arizona the species used habitat with 5% woody cover (Bock and Webb 1984).

Litter Cover. Little information exists. One study on winter-grazed shortgrass prairie pastures estimated the per cent litter cover at 34% (Wiens 1970).

Bare Ground. Little information exists. In Arizona, habitat with 23% bare ground was used (Bock and Webb 1984) and another study reported the species needs up to 35% bare ground for foraging (Nicholoff 2003).

Area and Landscape Considerations

Grasshopper sparrows are positively associated with habitat size and choose areas that are away from edges (Schroeder and Askerooth 1999). Habitat patches >30 acres are used (Gillihan and Hutchings 1999, Nicholoff 2003), but patches >247 acres are considered optimal (Plumpton 1993). Large tracts are more likely to be occupied than small fragments (Samson 1980, Herkert 1994, Vickery et al. 1994, Chapman et al. 2006). A preference for large tracts could be related to an aversion for habitat edges. In Colorado, Bock (Bock et al. 1999) found grasshopper sparrows were significantly more abundant >656 feet from suburban/habitat edge (Chapman et al. 2006). The average territory size at RMANWR was greatest in perennial shortgrass habitat (3 acres), which supported relatively high densities of grasshopper sparrow (Preston et al. 1994).

Nesting areas should be managed to provide grass height up to 18 inches, 1-2% bare ground, <5% shrub canopy, and a territory size of 10-20 acres/pair (Vickery 1999). Heavy grazing can be detrimental, but low to moderate grazing and light burning can be beneficial (Saab 1995 from Vickery 1999). In north-central Colorado, grasshopper sparrows were found on prairie heavily grazed in the winter, but not on prairie heavily grazed in the summer (Wiens 1970 from Chapman et al. 2006). Grazing should be delayed until the end of July and areas should remain undisturbed long enough for grass and forb cover to become dense and for thick layers of ground litter to build up before succession is set back. Mowing should also be delayed until July or after the end of the nesting season. Grasshopper sparrows are sensitive to fire prior to nesting (Nicholoff 2003) and studies have found they tend to avoid burned areas for 2 or more years post-fire (Bock and Webb 1984, Madden 1996, Vickery 1999). Overall, disturbances should be every 3-5 years (Nicholoff 2003).

Associated Species

Upland sandpiper (*Bartramia longicauda*), vesper sparrow, Western meadowlark (Beidleman 2000)

Black-tailed prairie dog (*Cynomys ludovicianus*)

Range

The historic range extends throughout Canada, Mexico and 11 western United States. Currently, the black-tailed prairie dog is found in south-central Canada, northeastern Mexico, and 10 states including Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, South Dakota, Oklahoma, Texas, and Wyoming. In 1998, the Service estimated the Colorado population covered 98,000 acres (USFWS 2008).

Population status

The black-tailed prairie dog occupies an estimated 2% of its former pre-settlement range (U.S. Fish and Wildlife Service 2002a). On July 30, 1998, the National Wildlife Federation petitioned the Service to list the species under the Endangered Species Act as threatened throughout its entire range. The Service concluded that such a listing was "warranted" but "precluded" due to administrative and fiscal constraints. Populations have been increasing or remaining stable (Gober 2009). Most recent data from 2010 show prairie dogs occupy approximately 3,863 acres of RMANWR lands.

Phenology and demographics

Black-tailed prairie dogs do not migrate, although colonies expand and contract temporally and individuals disperse to other colonies. They live in a close-knit group called a coterie, with young emerging in May and becoming sexually active in their second year. The pups emerge about 41 days after birth and will stay in the coterie for two years. Young males will often disperse to the outer portion of the existing colony or move to another colony (Van Pelt 1999).

Habitat requirements

Prairie dogs primarily occur at elevations between 2,300 and 5,500 feet in areas of short- and mixed-grass prairies, sagebrush steppe, and desert grasslands (Clippinger 1989, Hoogland 1996, Ulev 2007). Sites characterized by 2-5% slopes and vegetation ranging from 3-5 inches in height are optimal for colony development because of enhanced predator detection and communication capabilities (Ulev 2007). Rocky soils are not ideal burrow locations (U.S. Fish and Wildlife Service 2002a) and overgrazed land is not ideal due to inadequate nutritional quality of plants and soil erosion (Ulev 2007). Prairie dogs are opportunistic foragers. Grasses such as western wheatgrass, blue grama, and buffalograss are the most common species reported in spring and summer diets (Koford 1958). Their diet increases more to forbs by late summer and fall and prickly pear cactus in winter.

Associated Species

Burrowing owl, prairie rattlesnake (*Crotalus viridis*), American bison (U.S. Fish and Wildlife Service 2002a)

American bison (*Bison bison*)

Range

The historic range of bison includes most of the interior of North America. Prehistoric distribution occurred primarily on the central grasslands and northern parklands of North America, but habitats used ranged from semidesert to boreal forest where suitable grazing was available (McDonald 1981 from Meagher 1986). They currently exist on less than one percent of their former range.

Population status

An estimated 30 million bison inhabited North America until nearly extirpated through overhunting. Through the establishment of public preserves and privately-owned herds, bison numbered an estimated 75,000 in 1983 (Meagher 1986), approximately 150,000 in 1999 (Knapp et al. 1999), and currently number closer to 1 million animals, although cattle gene introgression is a problem in many public and private herds.

Phenology and demographics

Bison are gregarious and form mixed groups of cows, calves, yearlings, and sub-adults. Mature bulls are usually solitary or form small groups of their own, joining the cow herds during the rut, which occurs July through September. Cows usually give birth in isolation from April to July, with the peak being in May. Mature evenly matched bulls will fight for dominance with the winner being able to breed more cows. Cows and bulls reach sexual maturity by age three, however, bulls usually do not breed until they are seven or eight because they are prevented from doing so by mature dominant bulls (Meagher 1986).

Habitat Requirements

Bison require large tracts of grassland and may consume on average 16 pounds of dry forage daily (Hawley et al. 1981) or 5,298 pounds of dry forage annually (Irby et al. 2002). Other estimates show that bison consume between 19 and 31 pounds per day (irrespective of age and sex) and the Colorado State University Extension Range Specialists recommend using a rate of 25.8 pounds per day. Regardless, utilization rates (i.e., the amount of forage consumed relative to forage availability) may be most important to understanding requirements. Utilization rates vary from 40-75%, but Holechek (1988) considers a utilization rate of 40-50% for shortgrass prairie in climates and conditions similar to the RMANWR. Additional information on bison forage requirements can be found in Appendix H.

Bison are grazers at all seasons, taking mostly grasses and sedges. Use of warm season grasses predominated in shortgrass prairie and cool season grasses including some sedges compose 79 to 96% of the diet of herds on mixed prairie (Meagher 1986). Bison are more selective for grasses than are other herbivores and up to 90% of their diet is graminoids (Plumb and Dodd 1993). As bison tend to avoid forbs and woody species, which usually constitute the remaining 10% of their diet, forbs are often conspicuously left ungrazed and are surrounded by grazed grasses (Knapp et al. 1999). Bison show strong preference to grazing in previously burned areas (Pearson et al. 1995, Knapp et al. 1999). When bison coexist with other ungulates, interspecific competition is minimized through differences in habitat use and food habits. Bison and pronghorn showed spatial overlap, but quite different food habits (McCullough 1980; Wydeven and Dahloren 1985 from Meagher 1986).

The RMANWR has limited space, and of that limited space bison would not be allowed on a considerable portion of it, therefore fencing will be required. There is currently an eight-foot perimeter fence that is adequate to keep bison on the refuge.

Associated species

Black-tailed prairie dog, burrowing owl, ferruginous hawk

Potential Refuge Contributions to the Habitat Needs of Resources of Concern

Contributing to the conservation of migratory grassland-dependent birds, many of which are of national or regional concern, is one of the greatest potential values of lands comprising RMANWR. In addition, RMANWR supports a major population of burrowing owls (Klute et al. 2003) and is one of the most important breeding areas along the Front Range of Colorado. Although many factors have contributed to observed population declines of these species, primary factors include habitat loss and fragmentation, as well as degradation of remaining native habitats (Helzer and Jelinski 1999, Nicholoff 2003). This is particularly relevant on the Front Range of Colorado, where urban expansion has resulted in extensive loss of native prairies and remaining tracts are relatively small and isolated. Given that additional urban sprawl is projected in the future, the importance of refuge prairies likely will increase in the future. Several tracts of native prairie >125 acres will be present on the refuge when restoration efforts are complete and should support some breeding of area-sensitive species such as Cassin's sparrow, grasshopper sparrow, and lark bunting. However, the urban environment that surrounds the refuge undoubtedly will limit the ability to produce significant numbers of these species (Jones and Bock 2002).

In addition to grassland-dependent birds, restoration of native prairie will contribute to maintaining a healthy population of black-tailed prairie dogs. Although current populations are hindering restoration of native prairie, the species is an integral component of the shortgrass ecosystem and will be maintained in certain areas of the refuge to maintain prairie plant community composition and structure required by grassland-dependent migratory birds and burrowing owl. Bison, another native herbivore, has already been reintroduced on refuge lands. Although not considered a resource of concern, the population will be managed to help sustain prairies and contribute to the genetic diversity of the Service herd.

Savannah and wetlands in the Educational Zone will continue to support Swainson's hawk, bald eagle, and several species of waterfowl, shorebirds, wading birds, and neotropical migrants such as woodpeckers, jays, tanagers, grosbeaks, towhees and orioles in the Educational Zone. Although not a dominant component of the pre-settlement vegetation community, savannah and wetlands currently provide important habitat (breeding, wintering, foraging) for Swainson's hawk and bald eagle, which are trust resources of the Service. Waterbirds and neotropical migrants were not considered resources of concern because the contribution of the refuge to sustaining populations of these species likely is minimal. However, wetlands and savannah will provide some stopover habitat for these species, much of which has been lost in the Denver Metropolitan area.

Management of habitats to support the identified resources of concern will also provide unique education and interpretive opportunities, an important purpose of the refuge. For example, the public will have the opportunity to learn about environmental damage and the values of habitat restoration. In addition, refuge lands also will support recreational activities that are compatible with wildlife, which will contribute to exposing the public to the importance of conservation activities.

Reconciling Conflicting Habitat Needs for Resources of Concern

A primary purpose of this HMP is to develop natural resource goals for RMANWR that contribute to the mission of the Service and other partners, as well as establish scientifically based objectives that will help ensure these goals are met. To accomplish this task, Service staff incorporated more than 500 applicable scientific studies and reports, including data and reports specific to the refuge, during the development of this HMP. Based on this information and professional experience, the following were identified as potential conflicts between habitat needs of species identified as resources of concern during the 15-year life of this plan.

Visitor Services and Natural Resource Management

In addition to providing suitable wildlife habitat, RMANWR is the nation's premier urban national wildlife refuge and will play a significant role in natural resource education. Imprudent development of the infrastructure required to provide quality visitor services may result in further loss and fragmentation of remaining habitat that may negatively impact some wildlife species.

Prairie Restoration and Long-term Refuge Resources

Past land uses significantly altered several aspects of the landscape, including topography, chemical and physical soil properties, water quality, and plant community composition and structure. In addition, remediation activities to mitigate these damages, although necessary, have further altered the environment. Thousands of cubic yards of soil have been moved to clean up chemical weapons waste and pesticide residue, including excavation of soil to bury waste and construction of caps and covers. Section 36, for example, has been excavated deeper than 20 feet in many places, all existing vegetation was removed and the entire section re-contoured.

Collectively, these past activities complicate Service efforts to restore native vegetation. Protocols developed for preparation and initial seeding of restoration sites, including seed mixes for specific soil types, have resulted in successful restoration of sites, but intensive management is required. One of the most costly and time-consuming management activities is the control of noxious species. The Colorado State Noxious weed list includes 77 weed species, many of which occur or have occurred on the refuge (Table 2), including leafy spurge (*Euphorbia esula*), diffuse knapweed (*Centaurea diffusa*), Russian knapweed (*Acroptilon repens*), houndstongue (*Cynoglossum officinale*), toadflax (*Linaria* sp.), common St. Johnswort (*Hypericum perforatum*), and salt cedar (*Tamarix* sp.) (Colorado Department of Agriculture 2013). For example, between 5,000 and 7,000 acres of invasive species were treated annually from 2007 to 2009. Management to combat these species is conducted via an integrated pest management (IPM) approach that incorporates an early detection and rapid response program for species with a high potential for spread. Methods of control include mechanical, chemical, biological, and cultural treatments that often must be repeated for several years. However, regardless of treatment method, the weed seed bank will likely take decades to deplete because many noxious species can survive more than 50 years in the seedbank. Therefore, personnel and fiscal resources must be available to maintain the integrity of the plant community or the resurgence of the weed seed bank will likely negate millions of dollars and years of effort.

Prairie Restoration and Herbivory

Reseeding of sites designated for restoration will not be completed until 2014 or later and, after native plants have established, many additional years of management will be required before stands can tolerate disturbances, including prescribed fire and herbivory by prairie dogs and bison. Currently, bare or newly seeded restoration sites border virtually every occupied black-tailed prairie dog colony at RMANWR and colonies have been expanding since the last plague event in 2001, increasing from 1,814 acres in 2007 to nearly 3,100 acres in 2009. Recently, colonies have expanded into borrow areas, cap and structures, and newly seeded sites. The maturity of newly seeded restoration sites are not yet sufficient to withstand the prolonged effects of the foraging, clipping, and burrowing activities of these animals. In addition, the bison herd, which currently consists of 70 animals, is expected to increase through natural reproduction and could compromise restoration efforts if these species utilize restoration sites intensively or too early.

Resolving conflicts between restoration efforts and herbivory will require active management of animal populations. Unfortunately, repeated efforts to control the expansion of prairie dogs using non-lethal methods (e.g., live trapping, physical barriers) have not been successful; therefore, refuge staff will develop an EA seeking authority to use lethal control of prairie dogs as another strategy that will help ensure sites restored to native grasses remain in compliance with HRP requirements. Grazing intensity will be managed to minimize degradation of restored prairie sites by adjusting herd size as restored sites mature and sustainable forage production increases (Appendix H).

Grassland Birds and Herbivory

Although bison, prairie dogs, and grassland birds endemic to the shortgrass steppe co-evolved, the beneficial relationship among these species occurred on a large, unfragmented landscape. In comparison, RMANWR is a very small, isolated tract that has been extensively disturbed by human activities. Consequently, habitat to support these species is limited and some form of population management likely will be required to maintain healthy herbivore populations and ensure suitable habitat is available for grassland birds, particularly area-sensitive species.

Refuge staff considered various methods to resolve or minimize conflicts during the HMP development process. To the extent possible, fragmentation of prairie habitats will be minimized by locating visitor services facilities on the refuge perimeter in areas that already are disturbed. In addition, intensive management will be required to ensure the area, composition, and structure of grasslands will provide the life requisites of target grassland bird species. This will include, but is not limited to, designating acceptable boundaries for prairie dog expansion and development of an appropriate rest-rotational grazing system.

Chapter 4 – Goals & Objectives

The intent of the goals stated in the 1996 CMP (U.S. Fish and Wildlife Service 1996a) are retained in this HMP and include 1) the use of indigenous/native species, where possible, 2) development of stable vegetative communities, 3) preservation and management of black-tailed prairie dog colonies, 4) provision of suitable habitat for grassland birds, 5) maintenance of existing Southern Management Zone habitat values, 6) improvement of the First Creek corridor for wildlife, and 7) reintroduction of native species. However, subsequent information developed since completion of the CMP has altered the following decisions:

- Feasibility studies conducted in 2005 resulted in the determination to curtail reintroduction of greater prairie-chicken and plains sharp-tailed grouse as originally planned. The decision also was made that reintroduction of pronghorn, although possible, should not occur in the near future.

- In 2006-2007, disturbance footprints of all completed remediation projects and applied the appropriate mitigation acreage ratios were recalculated and defined in the HRP (U.S. Fish and Wildlife Service 1999). This evaluation resulted in the determination that 10,737 acres were required for mitigation of habitat losses versus the original estimate of 8,300 acres. The restoration goals in the refuge CMP and HRP are not reflective of this new target.

- The original CMP objective of maintaining active black-tailed prairie dog colonies on 3,500 to 5,000 acres of refuge land has been revised to a smaller area for the following reasons. First, prairie dogs that were present in parts of the Central Remediation Area (Sections 1, 2, 25, 26, 35, and 36) had to be permanently removed to protect caps and covers in accordance with agreements with regulatory entities. Second, the original proposed prairie dog area was based partially on the importance of prairie dogs as a prey base for wintering raptors, including bald eagles, that were using the refuge in the late 1980's. Since completion of the CMP, the emphasis on wintering raptors has shifted to breeding birds and the primary role of prairie dogs as identified in the HMP planning process is to sustain the level of burrowing owl nesting that has historically occurred on the refuge. Finally, during the HMP planning process, three grassland bird species were identified as resources of concern and breeding habitat requirements of these species do not occur in prairie dog colonies.

- The Service restored a portion of First Creek (approximately 0.3 miles) to its original channel in 2004 based on recommendations in the First Creek restoration plan (McLaughlin Water Engineers Ltd. 1994). Planting appropriate woody riparian vegetation (cottonwood, willows, understory shrubs) is recommended by the First Creek Redesign Plan and CMP for habitat enhancement along the First Creek corridor.

Habitat Goals and Objectives

Prairie Zone

The Prairie Zone encompasses approximately 12,361 acres or about 77% of RMANWR. The primary focus of management during the next 15 years will be the restoration and maintenance of more than 10,000 acres of short- and mixed-grass prairie to provide breeding habitat for grassland birds while also supporting an expanding bison herd. The Prairie Zone will also support the majority of prairie dog colonies, the primary area in which burrowing owl nesting will occur. In general, management will strive to create vegetative mosaics at different seral stages.

Goal 1 – Native Prairie Goal

Restore a diverse, native prairie comprised of vegetative mosaics that differ in composition, height, and density to accomplish remediation as specified in the HRP and provide habitat for resources of concern.

Rationale

Shortgrass steppe evolved under the influence of bison and prairie dog herbivory and climate. The disturbance patterns created by the random grazing of bison, prairie dog clipping and herbivory, periodic drought, and infrequent wildfires produced a continuum of vegetative mosaics ranging from bare ground to relatively undisturbed short- and mixed-grass prairie. These various seral stages provided foraging and nesting habitat for a unique suite of grassland birds, which as a group have exhibited steeper, more consistent, and more geographically widespread declines than any other group of North American species (Knopf 1994, Samson and Knopf 1996, Beidleman 2000). Based on BBS data, only 10% of all grassland bird species show positive population trends (Line 1997).

The most significant causes of grassland bird population declines include the loss, degradation, and fragmentation of habitat (Helzer and Jelinski 1999, Natural Resource Conservation Service 1999, Nicholoff 2003). For example, fragmentation creates more edge habitat, which results in increased rates of nest parasitism and competition, exposure to larger populations of predators, and reduced pairing and nesting success (Marzluff and Ewing 2001, Nicholoff 2003). Of particular concern at RMANWR is the potential affects of urbanization. A study of grassland birds in Boulder, Colorado stated burrowing owls and lark buntings were common in 1906 but were not reported at all in 1996 and observed declines were attributed to extensive habitat loss associated with urbanization (Jones and Bock 2002). Refuge lands can contribute to the conservation of declining grassland birds by providing high-quality breeding habitat characterized by large native grassland patches of varying seral stages.

The black-tailed prairie dog, a keystone species and surrogate for short- and mixed-grass prairie communities, has undergone significant reductions to its historic range (U.S. Fish and Wildlife Service 2002a). The burrowing owl, a prairie dog obligate, remains a concern for the Service. BBS data remains inconclusive, but as a whole indicate generally declining populations in the northern half of the Great Plains (Klute et al. 2003). Restoration of native prairie on Refuge lands can also provide habitat for prairie dogs and all associated species.

Seeding of the last restoration sites is currently scheduled for completion in 2014, but based on past monitoring, an average minimum of 7-10 years post-seeding likely will be required to meet the following vegetative success criteria that serve as the standard for determining when the U.S. Army has met mitigation requirements and restored land can be transferred to the Service (U.S. Fish and Wildlife Service 1999):

- A minimum of 30% relative live cover of desirable plant species (seeded species and/or native non-seeded species) 5 years post-seeding.

- A minimum of 70% total ground cover, including live vegetation, standing dead vegetation, litter, cryptogams, and rock.

- A minimum of 50% of the seeded grass species present on the site.

- No single species contributes more than 45% of the live vegetation cover, except in areas where a single species or dominance by a few species provides suitable habitat appropriate for long-term wildlife management (e.g., western wheatgrass stands for prairie dog colonies) (U.S. Fish and Wildlife Service 1999).

Although achieving these criteria helps ensure perpetuation of restored plant communities, it is likely that additional time will be required for restored lands to provide the breeding habitat requirements of some grassland birds. Thus, some lands that have yet to be restored likely will not provide suitable habitat for some resources of concern during the timeframe of this HMP. Regardless, the refuge staff incorporated these lands into the following objectives that specify plant community targets that will provide the needs of the grassland species identified as resources of concern.

Objective 1.1 (shortgrass prairie)

By 2028, restore 4,500 acres to native shortgrass prairie patches that are >250 acres and consist of 60-90% grass cover, 10-30% shrubs or mixed-grass species taller than the dominant shortgrass stratum, and 8-13% bare ground to provide nesting habitat for lark bunting and associated species, and foraging habitat for Swainson’s hawk.

Rationale

The lark bunting is thought to be area sensitive and requires relatively large tracts of undisturbed grassland for breeding. Preferred patch size is 250 acres or more, and generally is no smaller than 120 acres (Jones and Vickery 1997, Nicholoff 2003). The larger the grassland area provided, the greater the number of area-sensitive species that can successfully nest in the area (Wyoming Partners in Flight 2002). Therefore, managing for a patch size of at least 250 acres for lark buntings is reasonable. Patch sizes will be defined according to restoration project boundaries which have, or will, occur within the Satanta and Weld soil types in the Prairie Zone.

The Habitat Suitability Index (HSI) model for lark bunting suggests the species prefers nesting in 60-90% cover of grasses (Finch and Anderson 1987), but studies in Colorado documented lark bunting nesting in 81% grass cover with 65.5% cover of shortgrass species (Wiens 1970). A 60-90% range of grass cover is therefore a reasonable assumption. In addition, the HSI model considers vegetation 3-8 inches in height as preferred for nesting. Finally, bunting densities in grazed areas were highest on plots ranging from 8-13% bare ground (Kantrud and Kologiski 1982), whereas bare ground ranging from 3-8% or 12-25% supported only moderate to low densities of lark buntings (Finch and Anderson 1987). The species uses highly variable vegetation associations (prairie grasslands and shrublands) (Nicholoff 2003), but require open grasslands with a mix of short and tall grass and scattered shrubs. Gillihan (1999) indicates a 10-30% cover of shrubs, or tall grasses are preferable for breeding .A high percentage of the seed mixes to be used on the Nunn clay and Weld loam soils consist of shortgrass species such as blue grama and buffalograss and mixed-grass species such as western wheatgrass and sideoats grama (Appendix E). Collectively, areas seeded with these species should result in sufficient grass cover and plant height to support identified resources of concern.

Objective 1.2 (mixed-grass prairie with shrubs)

By 2028, establish 8,000 acres of mixed-grass prairie in parcels greater than 120 acres that are characterized by 50-90% grass cover with a minimum of 30% mixed-grass species >12" in height, 0-15% shrubs and <20% bare ground to provide nesting habitat for Cassin's sparrow, grasshopper sparrow, and associated species, and foraging habitat for Swainson's hawk.

Rationale

Cassin's and grasshopper sparrow nest in similar habitats generally is no smaller than 120 acres (Jones and Vickery 1997), which are characterized as mixed-grass prairies at least 12" high with native grass cover ranging from 50%-90%, and a shrub component that ranges from 0-10% cover (Ruth 2000). However, the amount of shrub cover at nests is not conclusive for either species. Cassin's sparrow seems to favor shrub cover from about 5% to 10%, but in BCR 18 nesting typically occurred in areas with more than 10% shrub cover (Bock and Webb 1984, Gillihan 1999, Ruth 2000). Similarly, grasshopper sparrow used habitat containing about 5% shrub cover in Arizona (Bock and Webb 1984), but in BCR 18 optimal nesting occurred in areas with <1% shrub cover. Nests are typically on the ground under a dome of overhanging grasses (Vickery 1999), so shrub cover may not be required for nesting as long as tall overhanging grasses are present. Therefore, it is reasonable to assume a maximum shrub cover for Cassin's at 15%.

Both species of sparrow require large amounts of bare ground for foraging: 18-26% for Cassin's sparrow (Bock and Webb 1984, Gillihan 1999, Ruth 2000) and 23-35% for grasshopper sparrow (Bock and Webb 1984, Nicholoff 2003). However, past experience at RMANWR suggests bare ground in excess of 20% results in rapid colonization of invasive plant species from the seed bank. Therefore, 20% bare ground has been set as an absolute maximum.

The Service currently utilizes seed mixes which are representative of the vegetative community found to occur naturally on the Ascalon and Bresser soil series (Sandy Plains Range Site, Appendix E). Species in this mix should provide the range of structural objectives specified in this objective, but many of these areas have yet to be restored and it is impossible to predict the plant community that will eventually establish. In all probability, there will be areas where shrubs will establish more densely than in other areas, potentially favoring Cassin's sparrow nesting. Likewise, there will likely be areas where shrub establishment will be minimal or potentially non-existent, which will favor nesting grasshopper sparrows.

Objective 1.3 (native prairie tolerant of intense prairie dog activity)

By 2028, restore 2,585 acres of designated prairie dog zones to a native vegetative community (e.g. buffalograss, blue grama, bottlebrush squirreltail, purple three-awn, scarlet globemallow, western wheatgrass, western wallflower (*Erysimum capitatum*) and other species) tolerant of prairie dog clipping, grazing, and disturbance activities to provide burrowing owl nesting habitat and prairie dog foraging habitat. The desired vegetative composition will consist of 40-60% grass cover, 10-20% forb cover, and <20% bare ground.

Rationale

The current habitat conditions in prairie dog towns at RMANWR reflect the long-term consequences that occur when ecosystem processes are significantly altered or destroyed. The majority of these areas currently occupied by prairie dogs are in poor habitat condition, containing large populations of invasive, exotic species as defined by the Federal Noxious Weed Act of 1974 (Public Law 93-629). Allowing these areas to remain in their current degraded condition would conflict with the statutory purposes of the refuge, the Service Biological Integrity, Diversity and Environmental Health policy, and violate the mandates of the FNWA. Conversely, prairie dogs, which are considered a resource of concern, survive and may seem to thrive in these weedy areas. However, prairie dogs have been described as selective opportunists (Clippinger 1989) and the existing vegetation is not required to support the species and likely is not preferred. For example, native species such as western wheatgrass, blue grama, and buffalograss have been reported as the most common species consumed by black-tailed prairie dogs (Clippinger 1989), yet in most colonies at RMANWR these species are absent or only infrequently present.

Therefore, refuge staff determined specific areas should be designated as prairie dog zones and the distribution and number of animals would be actively managed. Further, designated zones should be restored to native grasslands using seed mixes that combine species adapted to browsing and clipping and species considered undesirable by prairie dogs to fulfill the BIDEH policy and also provide important habitat for prairie dogs and burrowing owls.

In the case of RMANWR, refuge lands are isolated by urbanization and the area of contiguous grassland habitat will be limited to that available on the refuge. Therefore, active management of herbivore populations will be required to achieve a balance that provides the resources necessary for all grassland-dependent species identified as resources of concern. For example, although bison and prairie dogs were critical to the maintenance of healthy, diverse grasslands, reproduction of many grassland bird species require large grassland patches that have not been recently disturbed. Further, until restoration sites meet success criteria stated in the HRP, they must be protected from damage by prairie dog burrowing, clipping, and foraging activities. Most meristematic tissue of grasses is located belowground and is not accessible to grazers; however, prairie dogs can dig and eat this tissue causing lowered productivity and mortality (Winter et al. 2002). Unless every effort is made to keep grasslands intact and healthy for this extended period, which will be more difficult in the future with limited resources, tens of millions of dollars of restoration effort and many years of work will be placed in jeopardy. In addition to wildlife, active management to control prairie dogs is required to prevent damage to the caps and covers administered by the U.S. Army. The caps and covers were constructed to provide a physical barrier to prevent exposure of contaminated wastes to people and the environment. The layer of native grasses on the surface of these areas prevents surface erosion and also functions to remove moisture from the root zone, which prevents water from percolating into the waste materials buried underneath. Therefore, it is necessary to exclude prairie dogs because herbivory may degrade vegetation structure resulting in erosion and the deep, extensive burrow systems created by prairie dogs could create pathways for water to infiltrate through the root zone and percolate into hazardous waste. Prairie dogs may also attract predators such as badgers that dig even larger holes.

Although it is natural for prairie dogs to move across landscapes, confining the species to a specific management zone appears feasible based on existing information. For example, some black-tailed prairie dog colonies at the Conata Basin in South Dakota have been in the same locations for more than 50 years (Scott Larson, USFWS, personal communication 2008), researchers have consistently used the same prairie dog colony locations for studies at Wind Cave National Park for more than 25 years (Detling and Whicker 1987), and colonies existing outside the current distribution of plague can remain in the same approximate location for several decades to several centuries (Augustine et al. 2008). Further, an existing colony at RMANWR (Section 19) is present in 1937 aerial imagery and existing colonies in the northeast corner of Section 8 and southeast corner of Section 5 have been present at these locations for at least 15 years.

Estimates of historical occupancy by black-tailed prairie dogs vary depending on locale and spatial area considered, but range from 2-20% (Flath and Clark 1986, Whicker and Detling 1988, Knowles et al. 2002, Hoogland 2006). The Service, after conducting its 12-month administrative finding for the potential listing of the black-tailed prairie dog in 2000, agreed with Detling and Whicker (1988) that approximately "20% of all potential habitat was inhabited by the species at any given time." Therefore, a goal of managing for a 20% maximum occupancy rate by black-tailed prairie dogs in potentially suitable grassland habitat on RMANWR was considered reasonable (Donald R. Gober, USFWS, personal communication 2005; Scott Larson, USFWS, personal communication 2005) as it represents a pre-settlement condition as mandated by the Service BIDEH policy (U.S. Fish and Wildlife Service 2001) and also should support other grassland species identified as resources of concern. Potentially suitable habitat on RMANWR was determined to be 12,773 acres based on subtracting woodlands (168 acres), shrublands (1,372 acres), aquatic habitats (673 acres), and U.S. Army lands (1,097 acres) from the total refuge area (16,083 acres). Of this area, prairie dogs would be allowed to occupy up to 2,554 acres (20%), which should be adequate to support resources of concern on RMANWR. Stone and Seery (2005) recommended that 1,500 to 2,000 acres of prairie dog colonies were necessary to provide sufficient nesting habitat to maintain the level of burrowing owl nesting at RMANWR and provide a prey base for raptors. Refuge data support this recommendation (Table 4). In addition, David Seery, a former USFWS Prairie Dog Biologist at RMANWR, considered a minimum threshold of 1,500 acres to be adequate for sustaining a viable prairie dog population (David Seery, USFS, personal communication 2007).

Table 4: Active acres of black-tailed prairie dog (BTPD) colonies and number of burrowing owl nests at the Rocky Mountain Arsenal NWR (**bold** years denote occurrence of syvalitc plague)

Year	***Active BTPD Colonies (acres)***	***Burrowing owl nests (#)***
1988	4573	No Data
1989	247	No Data
1990	576	27
1991	1373	46
1992	1502	41
1993	1796	43
1994	381	29
1995	180	31
1996	22	24
1997	89	32
1998	345	68
1999	884	50
2000	1319	40
2001	1645	47
2002	619	44
2003	314	28
2004	660	41
2005	1064	85
2006	1006	55
2007	1482	35
2008	2689	52
2009	3045	36
2010	3863	24
2011	no data	22
2012	no data	20

The location of suitable prairie dog zones was determined by refuge staff in cooperation with the URS Corporation Geographic Information System (GIS) personnel. This group considered existing legal mandates and evaluated several GIS coverages to select the most appropriate areas for maintaining prairie dog colonies. Specific considerations include:

- Legal requirements to protect the caps and covers, North Boundary Containment Well System, sewage lagoons, and other remediation structures from actions that could facilitate exposure of buried contaminants to the surface environment.

- Protection of unique plant communities on Henderson Hill and Rattlesnake Hill.

- Protection of previously restored sites. The newer the seeding, the greater the risk of permanent damage from prairie dog grazing. Past experience at RMANWR indicates that restoration sites can be destroyed within one year of seeding by prairie dogs because seedlings.

- Locations of historic prairie dog colonies on RMANWR in relation to soil type (Figure 9). This evaluation clearly indicated prairie dogs prefer heavier textured soils, which is supported by previous research that indicates black-tailed prairie dogs have a marked preference for burrowing in silts, silty clays, and silty clay loams (Clippinger 1989).

- Locations of documented burrowing owl nesting sites to ensure that current populations are not disrupted. Nest locations in 2008 and 2009 were the primary data evaluated because prairie dog burrows generally begin deteriorating after two years and lose value as nesting habitat.

- Locations that would facilitate the use of existing man-made and natural features to help control prairie dog expansion. Use of these areas would minimize the time and resources needed to control prairie dog expansion and minimize the use of barrier materials or T-posts that might interfere with the movement of bison.

- Location of unique remnant/relic native vegetation communities. A 100-foot buffer width was incorporated between prairie dog zone boundaries and these unique vegetative communities.

Based on this information, the refuge staff designated 14 prairie dog zones encompassing 2,585 acres (Figure 10). As of 2010, data indicate the area occupied by prairie dog colonies is about 3,800 acres, approximately 1,300 acres above the maximum proposed. Removal of prairie dogs outside designated zones will be prioritized according to 1) human health and safety issues, 2) restoration areas that have not had sufficient time to mature, and 3) restoration sites that have been site-prepped and undergoing weed control for eventual restoration.

Plant communities within designated prairie dog zones will be restored to native vegetation opportunistically. Species selected for seeding will include a combination of the following: (1) native grass and forb species that prairie dogs prefer to graze that provide the appropriate dietary needs, (2) native grass (e.g., purple three-awn) and forb (Rocky Mountain beeplant, fetid marigold (*Dyssodia papposa*)) species that may be avoided by prairie dogs (Clippinger 1989) and will help maintain suitable vegetative cover to prevent site erosion and compete with exotic species, and (3) species (e.g., plains prickly pear) that will provide refugia for highly desirable species and protect them from being completely eliminated from the site. Based on these criteria, specific species to be seeded will include buffalograss, blue grama, bottlebrush squirreltail, purple three-awn, scarlet globemallow, western wheatgrass, western wallflower, Rocky Mountain beeplant (*Cleome serrulata*), fetid marigold (*Dyssodia papposa*), fringed sage, hairy golden aster (*Heterotheca villosa*), stemless evening primrose (*Oenothera caespitosa*), and blazing star (*Mentzelia nuda*) among others. Grasses, sedges, and forbs comprise up to 60% of prairie dog diets (Clippinger 1989) and species such as western wheatgrass, blue grama, buffalograss, and sand dropseed are preferred in spring and summer. Forbs are consumed throughout the year, but consumption increases during fall with plains prickly pear and scarlet globemallow comprising nearly 60% and 20-24% of the winter diet, respectively (Clippinger 1989).

Klatt and Hein (1978) found perennial grasses comprised 68.5% cover on an active prairie dog town in shortgrass prairie and Clippinger (1989) suggests the optimal percentage of herbaceous cover be at least 15% to facilitate continuous habitation by prairie dogs. Although many studies have documented up to 60% bare ground at prime burrowing owl nesting sites, data on RMANWR indicate the species frequently nests in prairie dog colonies with <20% bare ground (Mia Hannan, USFWS, personal communication). Further, refuge staff does not think a native community consisting of more than 20% bare ground can be sustained due to the potential for germination of invasive species from the seed bank. Therefore, a target of 40-60% native grass cover, 20% forb cover, and a maximum of 20% bare ground is assumed to be reasonable for sustaining native vegetation and supporting prairie dogs and burrowing owls.

Objective 1.4 (riparian)

By 2027, provide a gallery forest at least one mile in length that has a canopy closure of 20-50% and is dominated (>75%) by cottonwoods a minimum of 60 feet in height to provide habitat for bald eagle.

Rationale

Riparian habitats consist primarily of cottonwood/willow galleries in the First Creek riparian zone and refuge lakes. Bald eagles have established an active nest (Table 5) in a stand of mature cottonwoods along First Creek (Section 5) and also roost in cottonwood galleries surrounding Lake Ladora and Derby Lake during winter. Although de-listed, bald eagles are still protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. This species was designated as a species of special management consideration in the refuge CMP and as a resource of concern in this HMP.

Bald eagles prefer to nest in tall (>60 feet), mature cottonwood trees with open canopies and large branches that provide easy access. Scant quantitative information is available on nesting habitat conditions of bald eagles in eastern Colorado, but data from California and the Pacific Northwest indicate average canopy closure varies between 20 and 50% (Petersen 1986). In addition, the bald eagle HSI model indicates the smallest body of water occupied by one pair of nesting bald eagles is 3 acres (Petersen 1986). The current bald eagle nest along First Creek conforms to this description as it is located in a cottonwood gallery that extends approximately one-half mile on either side of the nest and is less than 5 miles from Lake Ladora (58 acres) and Lower Derby (74 acres) (Tom Jackson, USFWS, personal communication 2010). Therefore, these metrics were incorporated into the gallery forest objective.

Table 5. Summary information for the bald eagle nest on Rocky Mountain Arsenal NWR

Year	***Nest Attention***	***Incubation Observed***	***Hatch Date***	***Hatch Total***	***Fledge Date***	***Fledge Total***
2002	Unknown	February 23	April 6	1	June 24-July 11	1
2003	Unknown	March 3	April 7	2	July 2-7	1
2004	February 9-23	February 23	March 30	2	June 22	2
2005	January 25-Unknown	February 19	March 27	1	June 20-27	1
2006	November 25-February 13	February 15	March 20	2	June 15-26	2
2007	February 9-14	February 20	March 27	2	June 18	1
2008	Unknown-February 19	February 21	March 28	1	June 12	1
2009	January 15-February 18	February 19	March 30	2	June 24	1
2010	Unknown	February 22	March 29	2	Unknown	2
2011	February 7-25	March 3	April 7	1	June 30	1
2012	January 31-February 17	February 21	March 28	2	June 16	2
2013	December 8-February 7	February 28	April 6	TBD	TBD	TBD

Goal 2 – Shrubland Goal

Maintain, and restore where appropriate, optimum structure and composition of shrublands to provide suitable nesting habitat for Cassin's sparrow, that will subsequently provide forage and shelter for associated small mammals, and deer.

Rationale

Shrublands, as defined at RMANWR, are a minimum of five acres and have a live shrub cover greater than 25%. Shrubs such as sand sagebrush, rubber rabbitbrush, four-winged saltbush, and sub-shrubs such as yucca occur throughout RMANWR as small islands in shortgrass and mixed-grass stands, but also as individual stands up to 100 acres. These areas provide important habitat for numerous wildlife species, including grassland birds and mammals. The remnant shrub communities in Sections 8, 19, 27, and 28 have historically supported breeding Cassin's sparrow, which show a marked preference for breeding in sand sage shrublands (Lynn 2006). However, at RMANWR, Cassin's sparrow is most abundant in plots dominated by yucca. Yucca and sand sagebrush stands also are some of most productive rodent habitats on the refuge. The Deer mouse and the western harvest mouse (*Reithrodontomys megalotis*) - prairie vole (*Microtus ochrogaster*) communities are two of the most common rodent communities (Boone and Preston 1994). In addition, a lagomorph study frequently documented radio-collared cottontail rabbits in stands of rubber rabbitbrush (Jones et al. 1994). Flinders and Hansen (1972) reported that rubber rabbitbrush was one of seven species that accounted for 65% of the dry weight of plants eaten by jackrabbit (*Lepus* sp.) in northeastern Colorado. A RMANWR study found that small rodents constituted about 60% of a coyote diet, with rabbit constituting an additional 9% (Ronan 2006). Refuge shrublands also provide good escape cover, loafing cover, and fawning habitat for refuge deer populations.

Objective 2.1 (shrubland)

Within 10 years of HMP approval, develop a baseline inventory of plant community composition and structure. Use this inventory as the basis to identify and eliminate 90% of invasive plant species present in shrublands and improve other aspects of plant composition and structure as necessary to support Cassin's sparrow (Native Prairie Objective 1.2) and small mammals.

Rationale

Invasive herbaceous species have replaced the native grass understory in many shrublands and impacted shrub overstory canopies. The probable cause of invasion has been a long-term lack of disturbance (e.g., fire) for many years. For example, the relict sand sagebrush community in the northeast quarter of Section 8 has had no recorded management of any kind since 1942. As a result, shrubs have become decadent with dead centers crowded together, and the stand, while still possessing some small healthy areas of prairie sandreed, blue grama, and bush morning glory, has substantial areas of cheatgrass, mullein (*Verbascum* sp.), Scotch thistle (*Onoporfum* sp.) and Canada thistle, and smooth brome. Similarly, stands of yucca in Sections 27 and 28 appear to be dying or decreasing in abundance and the understory has been invaded by cheatgrass, kochia (*Bassia prostrata*), mullein, and Scotch thistle. Suitability of these areas for nesting Cassin's sparrow and small mammals are likely decreasing due to changes in the composition and structure of vegetation.

Educational Zone

The Educational Zone encompasses approximately 3,299 acres, or slightly more than 20% of the refuge. Lands in this zone continue to reflect past land use activities prior to refuge establishment, including patches of native and non-native grasslands that established following abandonment of agriculture, historic homesteads and U.S. Army infrastructure surrounded by both native and non-native trees that fragment existing grasslands, and lakes and ditches that were created as part of an irrigation infrastructure developed to support agriculture in a water-limited environment. Although severely modified by humans, this zone supports a diverse community of wildlife species, including identified resources of concern (e.g., Swainson's hawks, bald eagles) as well as waterfowl, shorebirds, neotropical migrants, and deer.

The urban setting of RMANWR provides a unique opportunity for the Service to inform a large, diverse human population of the Service mission. Therefore, management of this zone will focus on providing suitable habitat for resources of concern and other wildlife within the context of a historic cultural landscape. Although many features (e.g., lakes, homestead trees) and the wildlife they support are not native to the region, retaining a portion of this severely modified landscape on the refuge will provide an opportunity to educate and inform the public of natural resource values and the importance of habitat management, as well as provide wildlife-related recreational activities.

Goal 3 – Educational Zone Goal

Maintain healthy wildlife communities consistent with the historic cultural landscape of the refuge that includes New Mexico locust thickets, old farmstead windbreaks and other planted trees, cottonwood galleries, created wetlands and lakes, and restored grasslands.

Rationale

Habitats in the Educational Zone are the result of extensive modification by past land-use activities and include many artificial features (e.g., lakes, homesteads). Based on the Service BIDEH policy, refuge staff evaluated the potential for restoring these lands to pre-settlement conditions and determined that retention of artificial features was warranted because the habitats (wind breaks, open water, emergent vegetation) associated with many of these features provide habitat for migratory birds (Appendix G), some of which are identified as resources of concern (e.g., burrowing owls, Swainson's hawks) and, perhaps more important, many features are designated as cultural sites or are of significant historical value. An extensive archeological survey conducted in the mid-1990's identified 235 cultural resources, including 23 prehistoric sites, 80 historic sites, 4 historic irrigation features, 14 multi-component sites (prehistoric and historic), 26 prehistoric isolated finds, 87 historic isolated finds, and an isolated find with both prehistoric and historic materials (SWCA Environmental Consultants 1997). The Highline Canal (Lateral A), Sand Creek Lateral, and the Egli house also are eligible for or already on the National Register of Historic Places, and a World War II bunker was saved as a cultural resource during remediation. Many of these features provide important educational and interpretive opportunities that are vital to the refuge environmental and interpretive program.

From an interpretive standpoint, features in the Educational Zone reflect historical activities important to our nation's history from the late 1800's until cleanup was essentially completed. The final environmental impact statement for RMANWR (1996b) states that the refuge "contains, or has the potential to contain, the physical remains of several themes important to the history of the United States", including: 1) pre-history sites from the Archaic Period (7,800 to 1,500 years before present; (Hastings et al. 2007)) the period of European settlement from the late 1800's until the start of World War II (i.e., early homestead life, farming, ranching and irrigation), and 3) the role Rocky Mountain Arsenal played in our national security during World War II, the Korean Conflict, the Viet Nam War, and the Cold War. In 1994, the National Parks Service prepared *A Plan for the Interpretation of the Rocky Mountain Arsenal National Wildlife Refuge*, which identified the following themes: 1) wildlife habitat and refuge surrounded by urban development; 2) former chemical and weapons manufacturing facility that aided the nation during times of conflict; and 3) Superfund site that used environmental technology to restore a contaminated landscape. Based on this information, the June 1996 Refuge Public Use Plan identified five major interpretive themes integral to refuge management. Theme A is the interpretation of the history of the refuge as it pertains to the historical interaction between land, people, and technology. The following three primary messages were designed address this theme: 1) pre-history/Native American message: closeness to the land, generally minimal changes to the land, the application of fire to the landscape, 2) settlement message: how the existing landscape was changed by the application of agricultural practices, and an 3) industrial message: how the Arsenal was established to support the nation in times of war and conflict by the production of chemical munitions, the effects on wildlife and the environment when the Arsenal facilities were leased to Shell Oil Company for the production of pesticides, and the results of environmental cleanup.

Due to the significant cultural resource values and environmental educational potential of features in the Educational Zone, refuge staff decided that maintaining the current spatial distribution and structure of created habitats associated with this cultural landscape should be the highest priority of management. The contrast in plant and wildlife communities between the Southern and Prairie Zone will provide a powerful visual theme for public and environmental education at RMANWR.

Objective 3.1 (woodlands)

Restore native species composition and maintain the current spatial distribution (Figure 2) and structure of savannah [grasslands interspersed with patches of New Mexico locust, upland cottonwood, and other trees and sub-trees (e.g., *Prunus* spp) associated with homesteads] to provide nesting sites and foraging areas for Swainson's hawks and migratory habitat for other neotropical migrants by quantifying area occupied by cottonwood stands, protecting existing cottonwood, locust, and prunus stands, and planting [where appropriate] and protecting cottonwood and sub-tree species.

Rationale

Although not a true savannah, past planting of trees have created a mosaic of herbaceous and woody plant communities that resemble the structural components of a savannah (e.g. scattered trees of variable density, herbaceous understory). The current condition of New Mexico locust thickets range from healthy to decadent based on the number of dead stems that have been observed. Decadent stands have suffered from repeated locust borer (*Megacyllene robiniae*) outbreaks and contain significant quantities of dead standing and down material (Galford 1984). Though normally a serious pest of black locust (*Robinia pseudoacacia*), locust borers are also pests of New Mexico locust; larvae burrow under the bark and into stems and boles, creating weak points in the stem that cause branches to break off. Other trees in the area include a variety of both exotic (e.g., Siberian elm, white poplar) and native (plains cottonwood) species. Most of these were planted by homesteaders and are part of the cultural landscape. They also provide features that are heavily used by visitors, such as trails for hiking and birdwatching. The amount of dead/down debris in some of the more affected thickets poses a fire hazard, and if ignited by wildfire, may produce levels of heat significant enough to kill living plant tissue. In a few locations the accumulation of dead/down material also blocks refuge hiking trails. Grasslands in this area vary from numerous well restored sand prairie areas to some site still dominating by weedy species such as cheatgrass, crested wheatgrass, and common mullein.

The patches of restored prairie in the savannah type are not large enough to support breeding of area-sensitive grassland birds identified as resources of concern due to the interspersion of woody habitat, but this unique ‘upland savannah’ provides resources (e.g., foods, nest sites) for several neotropical migrants, including Swainson’s hawks (Appendix G). RMANWR is becoming increasingly important for breeding and migrating neotropical species due to the extensive loss and fragmentation of suitable habitat in the vicinity of the refuge. The refuge hosts 1 nesting pair of bald eagles that has fledged 14 bald eagles over the past 10 years (Table 5). The refuge currently supports 11-15 nesting pairs of Swainson’s hawks annually (Mindy Hetrick, USFWS, personal communication 2010). Although nests occur throughout the refuge, most are in Siberian elms planted as homestead windbreaks that are part of the savannah type. Nests also occur in or near smaller cottonwoods, trees at the periphery of planted tree groves, and New Mexico locust thickets. A nesting study at Pinon Canyon Maneuver in southeastern Colorado documented Swainson’s nests primarily in junipers (76%) and cottonwoods (15%), but also in Siberian elm that were part of windbreaks (9%) (Anderson 1995). The preference for Siberian elm on RMANWR may be related to the occurrence of individual trees in grassland patches, which is a characteristic reported in other studies (Burns and Honkala 1990). In contrast, green ash seems to be avoided as nest sites at RMANWR. Populations of this species may have benefitted from human settlement of the Great Plains as trees planted in windbreaks and around homesteads provide nesting substrate and Partners in Flight recommends preserving trees in shelterbelts, windbreaks, and around homesteads, especially trees that already contain nests (Beidleman 2000).

Refuge savannah also provides migratory stop-over habitat, which provide essential resources between breeding and non-breeding locations, including food, cover, and protective areas where migrants can safely molt during migration (Katie Koch, USFWS, personal communication 2010). Species of wood-warblers, thrushes, flycatchers, vireos, grosbeaks, and orioles forage in the locust thickets and homesteads during spring migration. Yellow warbler (*Dendroica petechial*) , American robin (*Turdus migratouis*), Say’s phoebe (*Sayornis saya*), warbling vireo (*Vireo gilvus*), blue grosbeak (*Passerina caerulea*), and Bulluck’s oriole (*Icterus bullockii*) are examples from those neotropical migrants that remain to breed in the patchy habitats present in the Educational Zone.

Bald eagles utilize the savannah zones found in the Educational Zone for hunting perches.

Objective 3.2 (lacustrine)

Achieve and maintain a water quality standard in all lakes (pH = 6.5-9.0[3], maximum water temperature of 86^0 F, and minimum dissolved oxygen concentration of 3.0 mg/L) (Colorado Department of Public Health and Environment 2012) and provide a quality sport fishery for individual lakes as defined in the RMANWR Aquatic Management Step-down Plan (U.S. Fish and Wildlife Service 2006) as follows:

- Lake Mary - maintain a balanced population of largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) as defined by a Proportional Stock Density (PSD) of 40-70 for large-mouth bass, 20-60 for bluegill, and 100 for channel catfish; *and provide a quality sportfishing experience by providing an overall minimum angler satisfaction of 80% and a minimum average catch rate of 0.5 fish per hour.*

- Lake Ladora - maintain a balanced population of northern pike (*Esox lucius*), largemouth bass, and bluegill as defined by a PSD for northern pike of 30-60, 40-70 for largemouth bass, and 20-60 for bluegill; *and provide a quality sportfishing experience by providing an overall minimum angler satisfaction of 80% and a minimum average catch rate of 0.5 fish per hour.*

- Lower Derby - maintain bluegill and largemouth bass populations that can be used to supplement the forage requirements of predacious fish and provide a source of additional sportfish, respectively, in Lakes Mary and Ladora.

Rationale

Although the lakes were originally created as part of the irrigation infrastructure to facilitate agricultural production, the lakes were stocked with various species of fish when the U.S. Army took ownership of the land to provide recreational opportunity for personnel stationed at the Arsenal. In 1960 the monitoring of contaminant uptake in fish was transferred to the Fish and Wildlife Service Assistance Office and in 1990 fisheries management was transferred to the Service. Currently, two lakes (Mary and Ladora) are part of the refuge sport fishery program. Lake Mary also has been used extensively for environmental education purposes. Lower Derby can be used as a source of irrigation water for prairie restoration and to grow forage fish and largemouth bass for stocking in Lake Mary and Lake Ladora. Havana Pond has no fishery. All lakes, depending on hydrology, also provide ancillary benefits to wetland-dependent wildlife. For example, Lower Derby provides a winter roost for bald eagle and migratory habitat (roosting and foraging) for waterfowl and shorebirds. Although important, the extent of use by migratory birds is limited based on refuge data; thus, refuge staff determined that continued management of lakes primarily as a fishery would best meet the refuge purposes with the recognition that this would also provide some roosting and foraging habitat for bald eagles, waterfowl, and shorebirds, as well as breeding and winter habitat for some amphibians. This approach is consistent with purpose three of the RMANWR Act, which is “to provide maximum fish and wildlife-oriented public uses at levels compatible with the conservation and enhancement of wildlife and wildlife habitat.” In addition, the Improvement Act designates hunting and fishing, wildlife observation and photography, and environmental education and interpretation as six priority wildlife-dependent public uses of the NWRS.

Currently, Lake Mary and Lake Ladora support a catch-and-release public fishing program that extends from mid-April through mid-October. The program is supported by the collection of daily user fees from participating fisherman, which are used to offset the costs of maintenance and fish stocking. The fishery program is utilized extensively by children and individuals with physical and emotional disabilities. For example, patients from Craig Rehabilitation Hospital and Children’s Hospital have taken part in the program on a regular basis through the years, the “Fishing Frenzy” program developed in partnership with Commerce City provides children with an outdoor experience and teaches them the ethics of fishing, and the

[3] In 2009, the lakes on the Rocky Mountain Arsenal NWR were incorrectly classified as water supply. This designation was presumptively applied and conflicts with restrictions found in Section 44.2(b) of the Federal Facilities Agreement. Among other things, this change reduces the standard for dissolved oxygen concentrations to a minimum of 3.0 mg/L to the epilmnion and metalimnion strata of the lakes. The Service is currently working to remedy this incorrect classification.

“One-on-One” program provides mentally challenged children the opportunity to fish and experience the lakes.

Water quality sampling is conducted on all lakes, and a complete stocking record and various annual surveys are conducted to determine population size, age structure, and health of the fishery in Lake Mary and Lake Ladora. In 2006, this information was used to develop an Aquatic Management Plan (U.S. Fish and Wildlife Service 2006) that included both water quality and fisheries goals that are adopted in the HMP. PSD, a ratio (expressed as percentage) of the number of quality-sized or larger individuals divided by stock-sized individuals of a species, was selected as the metric on which to evaluate quality of the fishery and creel surveys was selected to assess angler satisfaction.

Aquatic invertebrates are an integral component to the aquatic food web and are sensitive to changes in pH. Chronic pH problems will reduce lake productivity and subsequently reduce the amount of forage available to sport fish populations. Most pH problems can be remedied, but should be viewed as an indicator that the system is out of balance and negatively affecting water quality. Dissolved oxygen (DO) is the most basic measure used in fisheries management. Low DO levels can cause an immediate stress reaction from fish which can lead to poor immune responses and ultimately fish kills. Low DO is a primary cause of fish kills. Low DO can be a normal function of aquatic management in drought years, but chronic low DO levels should be remedied through aeration or other means (Judson Spicer, personal communication 2013).

Based on 2005 data, the fisheries objectives currently are not being achieved. Reproduction and recruitment of largemouth bass and bluegill in Lake Mary was good, and the PSD for bluegill was 39, which is within the desired range. However, the PSD of 30 for bass was below the minimum threshold of 40, indicating growth of larger bass was stunted and the PSD for channel catfish was 100, indicating an unbalanced population of larger fish. In Lake Ladora, the PSD of bluegill was 22, which is near the lower threshold of the objective, indicating a preponderance of small fish. In contrast, the PSD value of 100 for both northern pike and bass was well above the desired ranges of 30-60 and 40-70, respectively, indicating populations of these species were dominated by larger fish. In contrast, creel surveys indicate that objectives for angler satisfaction were achieved in both Lake Mary (85% with an average of 1.32 fish caught per hour) and Lake Ladora (88% with an average of 0.8 fish caught per hour).

Objective 3.3 (wetlands)

Manage wetland plant communities to promote native emergent species and provide opportunistic benefits to wetland-dependent wildlife and maintaining spawning grounds for forage fish and treatment of cattail when 80%+ of shorelines are covered within 30 feet of shoreline.

Rationale

Wetlands on the refuge have been artificially created to provide stormwater retention, wildlife habitat, and public viewing, or are the result of topographic changes associated with remedy activities. In the past, hydrology of these wetlands was determined by a combination of on-site precipitation and management of inputs from various sources, including stormwater runoff from surrounding urban and residential areas, pumping of tributary groundwater from wells in Section 4 and 12[4], and temporary lease of nonpotable water from Denver. However, some wetlands were constructed in sandy soils and only retain surface water for brief periods or not at all (e.g., Wetland 5 in Section 7). In addition, changes in sources of water and associated leases, as well as changes in management infrastructure on the refuge have significantly reduced or eliminated the ability to manage hydroperiods in many wetlands. For example, the wetlands in Sections 7 and 8 no longer can be flooded due to the decommissioning of the Highline Canal. Collectively, these factors limit the capability to manage the hydrology of many wetlands, and concomitantly, the composition and distribution of vegetation. A notable exception is the Rod and Gun Club wetland that receives water from the Uvalda ditch and groundwater discharge. Plant community composition is varied, but dominant species in many wetlands include cattail, cottonwood saplings, and noxious weeds. Although these plant

[4] Per the 1996 Record of Decision for the site, an evaluation of risk may be required prior to use of a new well or wells on Section 12.

communities provide foods and cover for wildlife, refuge records suggest wildlife use has generally declined since the mid-1990's. Although changes in hydrology and shifts in plant community composition are likely responsible for this change, another factor potentially influencing wildlife use is the urban setting and the construction of infrastructure to enhance public viewing opportunities, which is a purpose of the refuge. For example recent residential development to the south of Wetland 1 in Section 8 may be limiting waterfowl use (Mindy Hetrick, personal communication 2011) and construction of public hiking trails may be contributing to declines in use and breeding success of wetland birds in Wetlands 3, 4, and 5 in Section 7.

RMANWR does not have the financial resources to develop a new water management infrastructure to control the timing, duration, and extent of flooding and drawdown. Therefore, refuge staff determined that the best management option is to promote native emergent vegetation that provide the greatest food and cover resources to wetland-dependent wildlife. In most cases, management will focus on strategies to eliminate exotic species (e.g., Canada thistle) and control the expansion of robust emergent species (e.g., cattail) because hydroperiods cannot be managed to stimulate germination of desirable species. Wildlife use of the plant communities will depend on the unmanaged timing and duration of flooding, as well as the type and timing of various public use activities.

Wildlife Goals and Objectives

The habitat goals and objectives are designed to provide for the needs of designated resources of concern. However, RMANWR is located in a metropolitan area that limits the dispersal capability of many mammalian species that currently occupy refuge lands, including bison, deer, and prairie dogs. In addition, natural predators of these species currently are lacking. As a result, populations of these species are likely to increase over time. Therefore, population goals were established for herbivore populations currently occupying the refuge to help achieve the quantity and quality of prairie and shrub habitat necessary to support all resources of concern.

The Theodore Roosevelt National Park developed a forage allocation model in the early 1990s to evaluate to establish ungulate population objectives that would maintain a healthy native plant community and provide sufficient forage for the major ungulates including elk, mule deer, bison, and feral horses (National Park Service 2010). This model is quite simple and is based on the average intake per individual for each species for a specific time interval. Annual production estimates (dry weight) for the vegetation categories are summed across all units to determine "optimal" population goals for each species. Irby et al. (2002) evaluated this model and found it represents a good tool for resource managers, but does have some shortcomings. The model's design to provide "near optimal" population goals does not predict for overuse of highly attractive areas and the model is not sensitive to low precipitation years or unpredictable events described as wildfire, multi-year droughts, or increases in prairie dog towns.

The following goals apply this methodology for herbivore populations on the RMANWR.

Goal 4 – Forage Allocation Goal

Manage herbivore populations as necessary to ensure the long-term sustainability of restored prairie and shrubland, contribute to the Service bison metapopulation goals, and provide suitable habitat for resources of concern.

Rationale

Bison, deer, and prairie dogs depend on prairie and shrub communities for forage. Allowing unregulated population growth of these species would jeopardize the long-term sustainability of native prairie and shrublands and contribute to poorer body condition of individuals, which could result in increased incidence of disease. In fact, prairie dog populations already threaten the success of some prairie restoration sites and chronic wasting disease has been documented in the refuge deer population. Given these considerations, population goals were established for herbivore populations currently occupying the refuge to help achieve the quantity and quality of prairie and shrub habitat necessary to support all resources of concern.

Objective 4.1 (bison)

Manage bison populations, in support of the Department of the Interior's Bison Conservation Initiative, at or below the carrying capacity for the refuge. At present, bison populations would range between 25-40 animals and should not exceed 42 animals. Once additional grazing units and opportunities are fully in place, long-term bison populations would range between 110-180 animals and should not exceed 209 animals.

Rationale

RMANWR is currently one of six Service sites that contribute to the Department of the Interior's Bison Conservation Initiative (U.S. Department of the Interior 2008). In 2007, the Service developed a policy to manage bison as one metapopulation (as opposed to many smaller groups) to help prevent a loss of genetic material and maintain populations at natural densities and levels of variation at the landscape scale (Roffe and Jones 2007). Therefore, one goal of the refuge bison herd will be to serve as a genetic reservoir to lessen the chance of inbreeding depression and reduce the risks of disease and genetic drift. In March of 2007, 16 bison from the National Bison Range NWR in Montana were translocated to RMANWR and two yearling bulls from Sully's Hill NWR in North Dakota were added to the herd a year later. In September 2009, six additional cows and four bulls were added from the National Bison Range NWR. As of February 2013, RMANWR's herd numbered 70 animals and exceed carry capacity for current pastures.

Table 6. Bison population of the Rocky Mountain Arsenal NWR

	Bulls	***Cows***	***Unknown***	***Calves***	***Import/Death***	***Total***
2007	3	13	0	3	16/0	19
2008	7	14	0	7	2/0	30
2009	17	20	2	7	10/1	46
2010	19	20	2	8	1/7	49
2011	18	20	9	11	3/1	59
2012	16	20	21	15	0/2	72
2013	14	20	36	TBD	0/2	70

In 2007, 16 bison were imported bison from the National Bison Range; 2008, 2 bison were imported from Sullys Hill NGP; 2009, 10 bison were imported from the National Bison Range; 2010, 1 bison was imported from the American Prairie Foundation; 2011, 3 bison were imported from Wichita Mountains National Wildlife Refuge.

Bison currently range on approximately 2,370 acres of the RMANWR in two pasture units. An additional pasture unit will be developed in 2013 and as more infrastructure is constructed approximately 12,165 acres will eventually be available for bison grazing. Installation of approximately 47,920 linear feet of tall fence and 63,500 linear feet of "buffer" fence will be required to complete fencing of all bison pastures. The Service has developed a preliminary methodology to assist in determining available forage for bison (Appendix H). This method likely over-represents the amount of available forage due to the status of ongoing restoration, large populations of prairie dogs, and general variability of conditions across the RMANWR. However, the method does assist in predicting carrying capacity and desired population size.

Objective 4.2 (white-tailed and mule deer)

Manage deer populations at or below the carrying capacity for the refuge to maintain a healthy deer herd and minimize adverse affects to vegetation and habitat that support other species. Long-term deer population goals would range from 325 to

550 animals.

Rationale

Maintaining a healthy population of deer is important to refuge visitors and provides a consistent opportunity for wildlife observation. There are no active management prescriptions for deer, but the Service will monitor populations. Certain deer population management techniques may be unpopular with segments of the public, but necessary for the long-term health of the herd. Both chronic wasting disease (CWD) and epizootic hemorrhagic disease (EHD) have been documented on the RMANWR. Ensuring appropriate herd size will limit risk and the Service will euthanize animals exhibiting characteristics of CWD or EHD to provide tissue samples to the Colorado Division of Parks and Wildlife to assist with surveillance efforts (Peterson et al. 2002).

Objective 4.3 (prairie dogs)

Maintain prairie dogs in designated zones at densities of 6-10 animals/acre to promote long-term sustainability of native vegetation and provide sufficient prey and burrow sites for resources of concern.

Rationale

Following native prairie restoration within designated zones, managing the density of prairie dogs to prevent overutilization (e.g., herbivory, clipping) likely will be critical to ensuring the long-term sustainability of native vegetation. However, a sufficient density of animals also should be maintained to ensure that adequate habitat (e.g., burrows) and a sufficient prey base is available for resources of concern. Based on these considerations, refuge staff determined an appropriate density based on a review of historic densities catalogued by researchers and by estimating the density of prairie dogs that could be sustained based on forage consumption relative to forage production on representative range sites at RMANWR.

Black-tailed prairie dog density varies depending on the season, area, and climate, but typically range from 2-18/acres with an average of 10/acre (Gober 2004). Koford (1958) found that most plains habitats supported at least 5/acre and a study of prairie dog density at Wind Cave National Park in midgrass prairie documented an average density of 8.8/acre (King 1955). Prairie dogs will not survive in small groups of less than 4/acre and a viable population requires at least two coteries, each with a minimum density of 6/acre (Clippinger 1989). From 1991 to 1996, prairie dog densities at RMANWR ranged from 4/acre to more than 45/acres (Seery 1998).

To estimate forage consumption of prairie dogs, we used guidelines provided by the Society of Range Management, which defines an Animal Unit (AU) as a mature, 1,000 pound cow, *or the equivalent*, based on an average consumption rate of 26 pounds of forage dry matter per day. To scale this value to prairie dogs, we estimated the average weight of a prairie dog (both sexes combined) based on weights reported in the literature. Hansen and Cavender (1973) estimated the average weight of a male prairie dog at 2.1 pounds and a female prairie dog at 1.8 pounds, which equates to an average weight of 1.95 pounds. This figure represented the lower spectrum of prairie dog weight; therefore, we also estimated an average weight based on information from the University of Michigan, Museum of Zoology, which estimated male black-tailed prairie dogs weighed between 1.9-3.7 pounds and females weighed 1.9-2.3 pounds. Averaging the maximum values for each sex resulted in a weight of 3 pounds. The average of these two values (1.95 pounds and 3 pounds) is 2.5 pounds. Based on these values, we estimated average daily forage consumption of a prairie dog as follows:

1 AU = 1,000 pound animal / 2.5 pound avg. prairie dog weight = 400 prairie dogs

26 pounds of forage per day / 400 prairie dogs = 0.065 pounds of forage per prairie dog per day.

The designated prairie dog zones on RMANWR are dominated by the Loamy Plains Range Site. According to the Adams County Colorado Soil Survey (Sampson et al. 1974), this range site produces a total of 500 pounds of air-dry herbage per acre during drought years. Using the rule of thumb “take half/leave half” (to prevent long-term damage to plants), a conservative estimate of useable forage would be 250 pounds/acre. Given these assumptions, an acre of habitat in designated prairie dog zones could support 3,846 prairie dog days annually (250 pounds of forage / 0.65 pounds of forage consumed daily), which equates to a prairie dog density of 10.5/acre (3,846 prairie dog days / 365 days). This estimate is based on numerous assumptions and does not account forage lost by clipping activities conducted by prairie dogs for defense against predators, but it suggests that a desired management threshold of 10 prairie dogs/acre is a reasonable to prevent long-term damage to plants.

Chapter 5 – Management Strategies

A list of potential management strategies that could be used to accomplish habitat objectives were identified by reviewing the scientific literature and consulting with experts. Each of these strategies was evaluated for possible inclusion in the HMP based on compliance with Service policies, mandates, and legal agreements pertaining to remediation, as well as feasibility relative to refuge-specific management constraints (e.g., urban location). Those strategies that met both of these criteria were considered feasible and an analysis was conducted of potential positive and negative impacts of these strategies on resources of concern and nontarget resources. Based on this analysis, a final set of strategies were selected that would contribute to accomplishing habitat objectives with the fewest short- and long-term negative impacts on all refuge resource (Table 7).

Table 7. Potential strategies to accomplish habitat management plan objectives

		Seeding	*Herbicide(s)*	*Prairie dog control*	*Irrigation*	*Water management*	*Soil disturbance*	*Prescribed fire*	*Vegetation management*
Native Prairie Goal: Restore a diverse, native prairie comprised of vegetative mosaics that differ in composition, height, and density to accomplish remediation as specified in the HRP and provide habitat for resources of concern.									
Objective 1.1	By 2028, restore 4,500 acres to native shortgrass prairie patches that are >250 acres and consist of 60-90% grass cover, 10-30% shrubs or mixed-grass species taller than the dominant shortgrass stratum, and 8-13% bare ground to provide nesting habitat for lark bunting and associated species, and foraging habitat for	X	X	X	X		X	X	X

	Swainson's hawk.								
Objective 1.2	By 2028, establish 8,000 acres of mixed-grass prairie in parcels greater than 120 acres that are characterized by 50-90% grass cover with a minimum of 30% mixed-grass species >12" in height, 0-15% shrubs and <20% bare ground to provide nesting habitat for Cassin's sparrow, grasshopper sparrow, and associated species, and foraging habitat for Swainson's hawk.	X	X	X	X		X	X	X
Objective 1.3	By 2028, restore 2,585 acres of designated prairie dog zones to a native vegetative community tolerant of prairie dog clipping, grazing, and disturbance activities to provide burrowing owl nesting habitat and prairie dog foraging habitat. The desired vegetative composition will consist of 40-60% grass cover, 10-20% forb cover, and <20% bare ground.	X	X		X		X	X	X
Objective 1.4	By 2027, provide a gallery forest at least one mile in length that has a canopy closure of 20-50% and is dominated (>75%) by cottonwoods a minimum of 60 feet in height to provide habitat for bald eagle.	X	X					X	

Shrubland Goal: Maintain, and restore where appropriate, optimum structure and composition of shrublands to provide suitable nesting habitat for Cassin's sparrow, that will subsequently provide forage and shelter for associated small mammals, and deer.

Objective 2.1	Within 10 years of HMP approval, develop a baseline inventory of plant community composition and structure. Use this inventory as the basis to identify and eliminate 90% of invasive plant species present in shrublands and improve other aspects of plant composition and structure as necessary to support Cassin's sparrow and small mammals.	X	X		X			X	X

Educational Zone Goal: Maintain healthy wildlife communities consistent with the historic cultural landscape of the refuge that includes New Mexico locust thickets, old farmstead windbreaks and other planted trees, cottonwood galleries, created wetlands and lakes, and restored grasslands.

Objective 3.1	Restore native species composition and maintain the current spatial distribution (Figure 2) and structure of savannah [grasslands interspersed with patches of New Mexico locust, upland cottonwood, and other trees and sub-trees (e.g., prunus spp) associated with homesteads] to provide nesting sites and foraging areas for Swainson's hawks and migratory habitat for other neotropical migrants by quantifying area occupied by cottonwood stands, protecting existing cottonwood, locust, and prunus stands, and planting [where appropriate] and protecting cottonwood and sub-tree species.	X	X	X				X	
Objective 3.2	Achieve and maintain a water quality standard in all lakes (pH = 6.5-9.0, maximum water temperature of 860 F, and minimum dissolved oxygen concentration of 3.0 mg/L) and provide a quality sport fishery for individual lakes as defined in the RMANWR Aquatic Management Step-down Plan. • Lake Mary - maintain a balanced population of largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) as defined by a Proportional Stock Density (PSD) of 40-70 for large-mouth bass, 20-60 for bluegill, and 100 for channel catfish; • Lake Ladora - maintain a balanced population of northern pike (*Esox lucius*), largemouth bass, and bluegill as defined by a PSD for northern pike of 30-60, 40-70 for largemouth bass, and 20-60 for bluegill; • Lower Derby - maintain bluegill and largemouth bass populations that can be used to supplement the forage requirements of predacious fish and provide a source of additional sportfish, respectively, in Lakes Mary and Ladora.		X			X	X	X	X
Objective 3.3	Manage wetland plant communities to promote native emergent species and provide opportunistic benefits to wetland-dependent wildlife and maintaining spawning grounds for forage fish and treatment of cattail when 80%+ of shorelines within 30 feet of shoreline.		X			X		X	X

Native Prairie

Restoration and management of native prairie is a primary goal of the refuge during the next 15 years. Although much restoration work has already been accomplished, approximately 1,000 acres are yet to be seeded and recently restored prairie will require active management to maintain vegetation composition and structure suitable for wildlife resources of concern. Given that much work remains to be accomplished, restoration and management activities must be prioritized to efficiently and effectively achieve the long-term goals of RMANWR.

Restoration

Strategy A: **Prioritization of sites**

Restoration will continue to proceed according to the following priorities[5]:

- Restore sites outside of established prairie dog zones that currently are NOT occupied by prairie dogs, including remnant prairie fragments.

- Restore sites currently outside of established prairie dog zones that currently ARE occupied by prairie dogs. In some cases these sites were considered restored based on the criteria established in the HRP, but subsequent clipping, grazing, and burrowing activities of prairie dogs have caused plant community changes that now require additional restoration activities to meet compliance thresholds. The extent of rehabilitation required for these areas varies from implementing integrated pest management (IPM) techniques (prairie dog removal, mowing, spraying) to favor native species to complete restoration.

- Restore 1,100 acres of native prairie inside established prairie dog zones to meet the Service/Army habitat mitigation goal of 10,737 acres. It is a high priority that these acres be initiated for restoration before Army restoration funding has been exhausted . Although a low priority, restoration of these sites should become a priority if a plague event occurs that significantly reduces the number of prairie dogs on a given site. To facilitate this shift in priority, sites that are in the early stages of restoration (seedbed preparation) should be planted to sorghum rather than seeded to natives. Sorghum stubble can protect the seedbed from erosion, help conserve soil moisture, and can be treated with a glyphosate herbicide to control weeds for several years. Taking these steps will allow the Service to allocate available resources to restore native prairie in prairie dog zones without completely compromising efforts already expended at other sites.

Strategy B.1: **Seedbed preparation and weed control (seedbed preparation not applicable to remnant prairie fragments)**

One of the most critical factors affecting the success of native prairie restoration efforts on refuge lands is the ability to simultaneously create a suitable seedbed for native species while controlling the extensive weed seedbank, particularly prior to seeding and during the establishment phase. General guidelines for accomplishing these tasks have been developed based on published information and modified as refuge staff gains site-specific experience in the implementation of techniques (Appendix F). However, given the diversity of noxious species in the seedbank, a multi-faceted integrated pest management (IPM) approach of weed control offers the greatest versatility in combating weed problems. IPM is defined in the Federal Insecticide, Fungicide, and Rodenticide Act of 1947(Public Law 80-104) as “a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental

[5] There will also be some restoration required in areas surrounding buildings and parking lots that have been or will be removed in the future.

risks." At RMANWR, the following strategies will be implemented alone, or in combination, to control noxious weeds and prepare seedbeds:

Biological. Used primarily when site access is limited and weeds occur as small infestations. Most biological control efforts were implemented prior to 2002 and results were mixed. For example, a variety of biological agents such as leaf beetles, flea beetles, flower weevils, root weevils, stem weevils, moths, and gall mites have been applied to smaller patches of St. Johnswort, leafy spurge, mullein, Russian and spotted knapweed, and Canada thistle. More recently (spring of 2009), a nursery was established for field bindweed mites (*Aceria malherbae*) on the west side of the intersection at 7th and C Street.

Mechanical. Tillage is used primarily for weed control on new seedbeds. During initial site preparation, the moldboard plow buries weed seed on the surface to a 12" depth, which reduced seed germination. Disking and chiseling are used after the site has been plowed to create a more favorable seedbed for natives prior to seeding and kill weed seed that has germinated since plowing. However, past experience suggests that disking of cheatgrass and field bindweed should be avoided because it is rarely effective at killing these species (particularly cheatgrass that is 3-5 inches in height) and can stimulate establishment of additional plants. Mowing is utilized primarily after initial germination of native species to reduce shading by broadleaf weeds or to prevent seed formation and dispersal of noxious weeds and undesirable annual grasses. Rotary bat-wing mowers can leave significant amounts of mowed thatch on the seedbed which can unintentionally shade out small seedlings; thus, a flail shredder is preferred when windrows or large pieces of thatch on the soil surface are not preferred (e.g., during the first growing season).

Prescribed fire. Prescribed fire can be used to eliminate unwanted standing weedy residue and kill surficial weed seed if fuel loads are adequate and continuous. For example, experience at RMANWR suggests that prescribed fire can be effective in reducing the amount of cheatgrass in mixed-grass communities when fuels are continuous and flame lengths are at least 10-12 feet, particularly when sites are treated with Imazipic (Plateau) herbicide the fall immediately following the burn to prevent re-occurrence. In contrast, inconsistent or low fuel loads typically result in fires that do not consume entire patches or do not produce sufficient heat to effectively kill seeds or newly germinated plants. Prescribed fire also can serve as an effective method to reduce the density or height of surface residue that prevents the use of mechanical or chemical control.

Physical. Involves primarily hand pulling of species that occur in limited numbers or are in areas that are difficult to access. Species such as musk thistle (*Carduus nutans*), mullein, toadflax, and houndstongue are difficult to access. Physical control is limited to small areas ranging from several stems to patches that are a couple acres. Removal locations are documented with GIS technology to allow inspection of the area the following year to determine if control was obtained.

Chemical. Herbicides are utilized at RMANWR when the area of infestation is too large for removal by hand. Herbicides are typically applied using hand sprayers or tank sprayers mounted on UTVs, but aerial application from a helicopter is used when the area to be treated is a total collective acreage of at least 1,000 acres. From 2007 to 2010, between 2,000 and 3,000 acres have aerially treated annually. Herbicides, regardless of application method, follow all approved federal and state requirements and label rates. Safety precautions, including the appropriate personal protective gear, are always followed and no restricted-use herbicides are used. The Service strategy at RMANWR is to use herbicides that provide the greatest effectiveness with the lowest risk (Table 8).

Conservation tillage. Conservation tillage is commonly defined as any tillage and planting system that covers, after planting, at least 30% or more of the soil surface with residue (Natural Resource Conservation Service 2012). One form of conservation tillage, known as "no-till," entails seeding into undisturbed soil with organic residue (usually crop stubble from the previous year) where weed control is accomplished primarily through carefully timed herbicide applications. This strategy primarily is used to conserve soil moisture and limit weed establishment on sites that will not receive irrigation treatments (Appendix F).

Table 8. Pesticides used at the Rocky Mountain Arsenal NWR and their environmental effects

Chemical Name	***Trade Name***	***Target Species***	***Environmental Effects***
Aminopyralid	Milestone	thistles	Slightly toxic to mammals, practically non-toxic to birds, fish, and aquatic invertebrates
Dicamba	Banvel	broadleafed weeds, primarily kochia and Russian thistle	Practically non-toxic to mammals and birds; slightly toxic to fish and aquatic invertebrates
Glyphosate	Roundup	weedy forbs and grasses	No restriction on ground use for invasive species control
Imazapic	Plateau	cheatgrass, field bindweed	Slight acute fish and mammalian toxicity, and practically no acute avian toxicity. Risk quotients for birds, fish and mammals are well below EPA levels of concern for endangered species indicating negligible risk to those taxa resulting from direct exposure.
Metsulfuron	Escort	common mullein	Practically non-toxic to mammals, birds, fish and aquatic invertebrates
Triclopyr	Garlon	Russian olive	Practically non-toxic to birds, mammals, fish, and aquatic invertebrates
2,4-D amine	many	kochia, Russian thistle, broadleafed weeds	Slightly toxic to fish and aquatic invertebrates, moderately toxic to birds, and practically non-toxic to mammals.

Data taken from March 25, 2010 memorandum to all Refuge Project Leaders in Region 6, Delegation of Pesticide Use Proposal Authority and Integrated Pest Management and Pesticide Usage Compliance and Safety

Specific combinations of strategies are determined based on factors such as type of restoration (new establishment or remnant prairie), age of restoration, weed species, extent of weed cover, soil type, and plant physiology. In general, however, the primary IPM techniques used during the first growing season after seeding include mowing, hand-pulling, and biocontrol agents if available and appropriate (e.g., bindweed mites to control field bindweed). These techniques are preferable because of low mortality risk to newly established plants; however, multiple mowing or hand-pulling treatments may be required in a single growing season to prevent shading of native seedlings. Mowing should always be conducted slightly above the height of native seedlings and occur at a frequency that prevents the mowed material from forming thatch. In some cases (e.g., remnant prairie fragments) herbicide applications are used to spot-spray dense, monotypic stands of noxious weeds.

During the second and third growing seasons following seeding, use of mowing, hand pulling, and biocontrol methods to control weeds will continue but the broad application of chemical methods typically increases because native species can tolerate both pre-emergent and post-emergent herbicides. Beyond the third growing season, IPM will primarily consist of chemical application and mowing of targeted areas with higher densities of weeds. When root development is adequate, prescribed fire can be used to maintain plant vigor.

***Strategy B.2:* Seed mix determination**

Following seedbed preparation, sites will be seeded with native grass and forb species that are adapted to specific soil types (Appendix E). Currently, the Service uses five seed mixes: (1) Ascalon/Bresser Mixed-grass (also referred to as “sand prairie” in this HMP) developed for sandy loam soils, (2) Nunn Clay Shortgrass for clay soils, (3) Santana Weld Shortgrass for loam soils, (4) Petrocalcic Mixed-grass for coarse loamy soils, and (5) Haplustoll Mixed-grass for poorly-drained fine loam soils usually found in riparian areas. These seed mixes were originally formulated in the late 1980’s and early 1990’s prior to the initiation of large-scale restoration (Bruce Hastings, USFWS, personal communication 2010; Carl Mackey, URS Corporation, personal communication 2010) and were based on plant species composition in remnant communities on the refuge, USDA Soil Conservation Service range site descriptions for Adams County, Colorado, and commercial availability. In addition, less common species were added to each mix based on species composition in similar, but less disturbed range sites in the vicinity of the refuge, such as the Pawnee National Grasslands (Bruce Hastings, USFWS, personal communication 1999). Original formulations have been modified as experience, new research, and seed availability dictates. For example, in 1996-1997, the Ascalon and Bresser sandy loam types did not include needle-and-thread grass, prairie junegrass (*Koeleria macrantha*), green needlegrass (*Nasella viridula*), little bluestem (*Schizachyrium scoparium*), buffalograss, or sand dropseed. However, these species have been added over the years. Species whose seed is not readily available from commercial sources, such as bush morning glory , are collected on-site and added to the appropriate mixes when harvestable seed crops occur. Other species, such as blue grama, needle-and-thread grass, narrowleaf penstemon (*Penstemon angustifolius*), silver lupine (*Lupinus argentea*), and gayfeather are collected from refuge grasslands and added to seed mixes in whatever quantities are available. Currently, all mixes with the exception of the Haplustoll mix, consist of approximately 90% grass species, 5% forb species, and 5% shrub species. The Service believes these percentages are representative of the composition in naturally occurring short- and mixed-grass prairie (USFWS 1999; Bruce Hastings, USFWS, personal communication 2010; Carl Mackey, URS Corporation, personal communication 2010).

In addition to these five mixes, refuge staff has developed a separate mix for use in restoring sites within designated prairie dog zones (Appendix E). A separate mix was deemed necessary because prairie dogs will be confined to certain areas of the refuge. Consequently, the plant community must be capable of tolerating sustained clipping and herbivory. Species in this mix are also in other mixes, but this formulation was developed with the specific intent to include grasses and forbs that will provide the dietary needs of prairie dogs, as well as species that may be avoided by prairie dogs (Clippinger 1989) or protect preferred forage species from being completely eliminated from the site (e.g., prickly pear).

Strategy B.3: **Seeding method and timing**

Most seeding done by the Service at RMANWR is completed using a seed drill designed to mechanically press seeds into the seedbed to a predetermined depth at specifically calibrated rates. Native seed drills with agitators and ‘picker’ wheels are particularly suited to plant “fluffy” seed, such as sand bluestem or blue grama. Seed is typically planted ½ to ¾” deep, although planting depth is slightly deeper in sandy soils to ensure contact with moisture. The seed rate is normally calibrated at 40 pure live seeds (PLS)/square foot, but can vary between 25 and 40 PLS/square foot depending upon specific seedbed conditions (e.g., the rougher the seedbed, the higher the PLS seeding rate).

When soils are rocky, seedbed conditions are exceptionally rough, or slopes are too steep to safely use a seed drill, broadcast seeding is used. This technique is also advantageous when interseeding native prairie remnants or planting extremely small seeds that may be buried too deeply by a seed drill. Typically, broadcast seeding rates are 1-½ to 2 times greater than the rate of drill seeding because not all seeds will be placed at the right depth and losses occur due to wind erosion (unless mulched at 1.5 tons of weed free grass or straw hay per acre) and consumption by wildlife. Effectiveness of broadcast seeding is greatly improved if a drag harrow is used to cover seed with a thin layer of soil.

The germination rate and survival of seeded species during the establishment phase depends on numerous factors, including time of seeding; soil moisture and temperature during the growing season, soil texture, plant competition, and seed quality (i.e., adapted varieties, germination and purity). These factors interact to make each planting season unique. In general, however, seeding is implemented during both spring (early March through mid-May) and fall (late October through March) on refuge lands. Spring seedings are designed to take advantage of peak annual precipitation, which historically occurs in May and June. Many species of warm-season grasses do not germinate until the soil temperature reaches 50 degrees F; thus, spring seeding of these species typically is best. In contrast, fall (dormant) seedings are designed to favor the establishment of cool-season grasses and forbs because the seed is naturally “cold stratified” over the winter months, which helps improve germination rates of many species. Fall seedings are initiated when there is no chance that seeds will germinate prior to the onset of freezing temperatures as this would kill plants that do not have adequate root systems. They are typically initiated in late October/early November at RMANWR; however, seeding can occur anytime between November and March as long as weather conditions allow for tractors and seed drills to operate properly and the soil is not frozen. Collectively, using both spring and fall seeding provides a logistical benefit because more acres can be seeded annually.

Strategy B.4: **Irrigation (not applicable to remnant prairie fragments)**

The use of irrigation at RMANWR was developed mainly to aid in the establishment of seeded species during the first growing season by promoting germination and early root development. Although irrigation water also can be used in subsequent growing seasons, establishment of seeded natives only increases marginally and may not be cost-effective (Carl Mackey, URS Corporation, personal communication 2010).

The use of this strategy has reduced the time required to achieve HRP criteria for prairie and improved success rates, particularly on soils with higher clay content (i.e., heavier textures). The irrigation method (Figure 11) used is determined by size and configuration of the site, slope, and staff time required for operation and maintenance. A general summary of each method follows:

Linear move. A 1,260-foot disattached pivot irrigation boom suited for irrigating areas generally larger than 100 acres with no obstacles to impede movement. This system distributes water more uniformly than the other irrigation methods and requires the least amount of labor/staff to operate (from 1-2 persons) due to its automated features. This system also is towable, which allows more rapid movement among sites.

Sideroll. Generally referred to as “wheel lines”, the sideroll consists of sprinklers connected to an irrigation pipe that runs through the center of spoked wheels. The mainline valves are at 60-foot intervals, and system lengths range from 600 to 1,400 feet, with one prime mover for roughly each 500 feet of wheel line. Sideroll irrigation is excellent for irrigating flat terrain in smaller areas not always suitable for the linear move, but is moderately labor intensive because the lines need to be manually moved among gates while irrigating. It is commonly used for irrigating crops and alfalfa.

Solid set. Resembles a standard, aboveground sprinkler system with individual sprinkler heads attached to three-foot risers. Water is transported to each sprinkler via irrigation pipe. Although this system is very flexible and facilitates irrigation of irregularly shaped areas, it is also the most labor intensive to set up, test, and maintain. A 50-acre parcel may require as many as 3,000 sections of pipe to be installed and each connection must be checked for leaks.

The Service currently owns enough irrigation materials (linear move, prime movers, piping, nozzles, fittings, lines, etc.) to irrigate a maximum of 400-500 acres annually depending on available water and the distance water must moved through pipes. The Service historically utilizes between 100-150 acre feet of water to irrigate 200-300 acres of habitat. The Service maintains a 1956 water right granted to the U.S. Army for 456 acre feet for its wells located in Section 4. A petition was filed by the U.S. Army to increase this right to 700 acre feet is currently being adjudicated as well as a petition to adjust its source to a well located in Section 12. In addition, the Service is finalizing plans to obtain municipal water from Denver Water needed for augmentation as well as a potential new source. The number of irrigation treatments, timing, and amount of water applied during each treatment varies depending objectives and the irrigation equipment (Appendix F). In general, irrigation schedules are designed to provide a total of six inches of supplemental water over the months of June, July, and August during the first growing season after seeding. However, in 2009, approximately 22 inches of water (irrigation and precipitation) were used to establish native vegetation on the caps and cover to satisfy regulatory requirements. This same strategy could also be applied, if necessary, to expedite maximum establishment of native species during restoration of designated prairie dog zones.

Strategy C: **Removal of prairie dogs (applicable to prairie outside designated zones and as necessary to restore grasslands within designated zones)**

Two types of population control will be used on refuge lands: non-lethal and lethal. Non-lethal methods include textile and vegetation barriers, live trapping, burrow flushing, and translocation. Lethal control methods include shooting, chemical asphyxiation, and burrow fumigants, all of which are approved methods of euthanasia by the American Veterinary Medical Association (American Veterinary Medical Association 2013). Shooting was initiated on a limited basis to protect certain cleanup infrastructure from prairie dog burrowing beginning in 2012, but other methods have yet to be implemented. In addition, the potential exists to release black-footed ferrets, a natural predator of prairie dogs, on refuge lands in the future. The Service has developed a separate plan for reducing prairie dog populations at the RMANWR in support of this HMP (U.S. Fish and Wildlife Service 2013c). The following provides a brief description of strategies included in this plan with any limitations on use based on past experience at RMANWR:

Visual barriers. Both vegetative (shrubs and tall grasses) and textile barriers have been installed as measure to discourage prairie dogs from entering restoration sites. The intent is to keep prairie dogs out of areas long enough to allow native vegetation the opportunity to establish and meet their vegetative success criteria, and provide the intended habitat for prairie dogs, grassland birds, and other wildlife species. This can average 7.8 years and is dependent on soils, slope, moisture, temperature and the cultural maintenance techniques (U.S. Fish and Wildlife Service 2013c). The textile barrier is placed surrounding restoration sites with the bottom of the barrier buried in the soil roughly 4-6 inches. It is maintained using patches, or replaced by sections if the damaged area is large enough, usually torn by high winds. Barriers are checked on a regular basis as employees go to different areas of the refuge to their assigned duties. A map is maintained by refuge staff of areas with barrier fence and areas in need of repair. The visual textile barrier has not proven to be effective as the prairie dogs will either jump over the barrier, burrow under it, or more often chew through it (Chris DiMarco, USFWS, personal communication 2010).

Vegetative barriers are planted using tractors and seeders and are usually shrub species such as four-winged saltbush (*Atriplex canescens*) or rubber rabbitbrush (*Chrysothamnus nauseous*). There have been instances where tall grasses have been used as a barrier as well. Areas planted are 100-200 feet wide with the hope that the prairie dogs will not investigate areas they cannot see. This method is problematic as it takes years for the shrubs to reach a point where they are effective and even then, prairie dogs have been found on the other side of the vegetative barrier in the areas that are being restored. It also results in the establishment of shrubland vegetation in areas that historically supported grassland.

Trapping and relocation. On-site trapping generally occurs when there is a conflict between prairie dog presence and use of an area, such as construction activities, concern for integrity of utilities and structures, and dispersal into remediated or seeded restoration areas. On-refuge trapping is conducted year-round, with the exception of the breeding season, which usually extends from late February through April. One of the first signs of the breeding season is the increased competition and conflicts observed between male prairie dogs.

The area to be trapped is first examined to determine the approximate minimum number of prairie dogs in that area to determine the number of traps required. This is accomplished by conducting two or three visual counts of prairie dogs on the target restoration site from mid- to late-morning (depending on the season; earlier during warm weather) on a sunny day (not temperature dependent). Hav-a-hart© traps are currently used by the refuge. Each uses a hinged door/treadle design that requires a bait to lure the animal into the trap. The traps are checked for smooth operation, and the closing mechanism adjusted if necessary, prior to taking the traps out to the trap site. Following deployment of traps at active burrow entrances, the target area is pre-baited for 2 days with the traps held open to acclimatize the prairie dogs to the traps. The area is not disturbed except for the baiting. Traps are then set with the bait placed in and near the trap door. Traps are checked every 2-3 hours with non-target species released immediately. Captured prairie dogs are taken to the release location where the burrow entrances are examined to find an abandoned burrow, where the prairie dog is released. If more than one prairie dog is caught from the same burrow, they are released to the same spot. The density of prairie dogs in the relocation area is monitored to avoid stressing animals and prevent damage to vegetation. After all prairie dogs are believed to have been trapped from a burrow, the entrance is filled in with soil and checked the next day to assure the burrow has not been reopened.

This method is not considered effective at adequately reducing prairie dog densities necessary for establishment of restoration sites. Trap success declines with time, allowing native vegetation to be damaged by increased herbivory from prairie dogs, allowing noxious weeds to re-establish on site.

Burrow Flushing. The "burrow flush" method is used at ambient temperatures above 70° F to remove remaining prairie dogs from their burrows and *to complement* live-trapping removal efforts. A water truck or water tender is filled with water and soap. The truck is parked near the prairie dog town and a hose is brought to the burrow entrance. The soapy water is slowly added to the burrow to allow the prairie dogs time to evacuate the burrow and prevent drowning. As prairie dogs emerge from the burrow they are grabbed by hand or a cage positioned in such a way in which they have no choice but to enter it.

After towel drying, individuals are placed into pet carriers or traps. As many members of a coterie (family group) as possible are placed into a single carrier, with the exception to not place two or more adult males into the same carrier, and not usually exceeding three dogs in one carrier if possible. The prairie dogs are then transported to the relocation site on the refuge. Selection of suitable relocation sites is based primarily on former occupation of the site by prairie dogs and existence of open burrow systems. Refuge staff will identify open burrows that are wide enough to allow passage of prairie dogs and deep enough to provide immediate protection from predators. This is tested by placing a gloved hand down the burrow as far as possible.

Under ideal conditions the relocation site should be of comparable size to the trap site to maximize retention of prairie dogs. This will give new residents a “buffer” zone that may help to ease tensions at the new site. Family groups are released together at the release site, with females, pups and yearlings going into the same burrow systems (3-4 or more per burrow). Adult females with pups are released into the same burrow. Adult males go into nearby burrows by themselves. This helps reduce fighting immediately after the release.

This method is not effective at reducing prairie dog densities, either alone or in combination with live-trapping, to levels necessary for successful grassland restoration. It is also weather dependent and is costly. Lastly, another habitat area may be stressed to a greater degree by rapidly increasing prairie dog density at the release site.

Use by the National Black-footed Ferret Conservation Center. Beginning in 2012, the Service began trapping and transporting live black-tailed prairie dogs to the Service’s National Black-footed Ferret Conservation Center. The State of Colorado allows for the capture, transport, and relocation of black-tailed prairie dogs to the Conservation Center (Colorado Parks and Wildlife 2012b). This method not only assists in population control on the RMANWR, but also aids in the recovery efforts of one of the country’s most endangered species. A relocation permit from the CPW along with a letter of “non-objection” from the USDA is required annually (Colorado Parks and Wildlife 2012b). Following authorization, animals are live-trapped[6] and directly relocated to the Conservation Center. This method results in no negative impacts to non-target species as well as no negative secondary environmental toxicity effects. Prairie dogs can only be accepted May to November (Paul Marinari, Black-footed Ferret Center, personal communication 2008). Black-footed ferrets appear to be highly susceptible to plague. In 1995, 30 captive ferrets were accidentally fed pieces of prairie dog meat infected with *Y. pestis* or meat that had come into contact with infected pieces (Godbey et al. 2006). In the future, prairie dogs used for this purpose may be required to come from sites “dusted” with deltamethrin to control fleas, the primary vector of disease transmission (Seery et al. 2003).

Shooting. The AVMA recognizes the use of shooting for wildlife control as an acceptable method of euthanasia. Death occurs rapidly as the direct disruption of brain activity immediately renders the animal unconscious (American Veterinary Medical Association 2013). Also, direct handling of the animal is not necessary and thereby eliminates the possibility of human-contact related distress prior to euthanasia.

[6] Prairie dogs are euthanized at the National Black-footed Ferret Conservation Center before feeding to ferrets. Beginning in 2013, the RMANWR will explore euthanizing prairie dogs prior to transporting to the Conservation Center.

Shooting will be implemented during the months of July through March, especially February and March as previous research has indicated success rates are highest during this period. The reproductive activities taking place during this time of year will be disrupted and remove animals before mating can occur. Shooting will not occur between the months of April through June, which will eliminate the chance of pup starvation due to the loss of a parent as pups are not fully weaned until 5 to 7 weeks following birth. The slight increase of noise levels associated with shooting may result in some prairie dogs not emerging from burrows. Until habituation to the noise is developed, oats may be used as bait to encourage more aboveground activity (Andelt and Hopper 2003).

Only Service personnel, who have received firearms training specifically for this purpose, will be permitted to shoot prairie dogs. Recreational shooting will not be allowed. Experience in safe and proper firearm use, accuracy, and compliance with firearm laws and regulations will be implemented to ensure the efficacy of the project and the safety of all staff involved (American Veterinary Medical Association 2013). Concerns regarding lead-poisoning of non-target wildlife (due to consumption) are considered feasible and warranted (Pauli and Buskirk 2007). As such, actions will be taken to reduce the likelihood of lead toxicity. Non-lead ammunition (such as tungsten-tin) is becoming more widely available and in a greater variety of calibers (Kemsley 2007). RMANWR will explore the various options currently available and implement the appropriate non-lead alternative when choosing ammunition.

Chemical asphyxiation. Chemical asphyxiation by carbon monoxide is listed as one of the acceptable methods/agents of euthanasia for rodents and other small mammals by the AVMA Guidelines for Euthanasia (2013). The inhalation of high concentrations of carbon monoxide has a rapid anesthetic effect and when administered correctly, results in swift loss of consciousness before death (Mason and Littlin 2003). Only gas cartridges approved by the Environmental Protection Agency (EPA) will be used. One gas cartridge will be introduced into each active burrow followed by closing the burrow entrance with soil to ensure a lethal concentration of carbon monoxide is released. The carbon monoxide does not accumulate in the tissues and can therefore be safely consumed by other wildlife eliminating any risk of secondary toxicity (American Veterinary Medical Association 2013). Direct handling of the animal is not necessary and thereby eliminates the possibility of human-contact related distress prior to euthanasia.

The use of carbon monoxide cartridges to cause asphyxiation will address the physiologic coping mechanism of the burrowing habits of black-tailed prairie dogs. Prairie dogs have adapted to increased levels of carbon dioxide and other inert gases and can withstand a greater concentration of these gases than non-burrowing species (U.S. Humane Society 2009). This makes the use of cartridges an effective and humane means of lethal control. The gas cartridges are approved by the EPA and do not require a certified pesticide applicator license.

This option will only be conducted after burrowing owls have migrated out of the refuge (November through March) or in towns where burrowing owls are known to not nest. The refuge biologist monitors burrowing owl nesting behavior on a regular basis, marking areas where nesting is taking place with flags located directly south of where the nests are located.

Burrow fumigants. Burrow fumigants (Aluminum phosphide) contain sodium nitrate and charcoal and release carbon monoxide gas when ignited (Witmer and Fagerstone 2003). The rapid loss of oxygen within the sealed burrow quickly renders the target unconscious, and death occurs by hypoxia making this an AVMA acceptable method of euthanasia. Reported efficacy ratings have been as high as 95% (Hygnstrom 1994) where efficacy ratings positively correlate to adequate soil moisture (Witmer and Fagerstone 2003). A burrow with moist soil conditions creates a better seal that results in a higher concentration of carbon monoxide; therefore, this method will only be utilized when ground conditions are conducive to success and there is enough moisture to properly seal the burrow.

Secondary toxicity is a non-issue as bio-accumulation does not occur (Witmer and Fagerstone 2003). Carbon is a naturally-occurring substance; nitrate acts as a source of plant nutrients within the soil; the charcoal is degraded by microorganisms and is immobile (U.S. Environmental Protection Agency 1991, Witmer and Fagerstone 2003). Additionally, dissipation of carbon monoxide occurs relatively rapidly. Application will only occur within burrows known to be occupied by prairie dogs and therefore does not present a threat to avian or aquatic species (U.S. Environmental Protection Agency 1991). This method will only be initiated by refuge staff.

Considerations regarding the use of burrow fumigants will address non-target species. Fumigants are not species-specific and will kill any wildlife within the burrows (Andelt and Hopper 2003). Therefore, fumigants will only be used on observed, active prairie dog burrows and where burrowing owls are not found in the vicinity. Risk to burrowing owls will be minimized by conducting surveys at regularly scheduled intervals to detect activity. Surveys will be conducted by trained professionals (e.g., refuge biologist) at regularly scheduled intervals. Flags will be placed near the burrows indicating that the area has an active burrowing owl nest. As with the use of chemical asphyxiation, applications will be avoided during the burrowing owl nesting season. The potential exists that other non-target species such as tiger salamanders, snakes, and rabbits will be negatively affected by burrow fumigants, but will not have a significant adverse impact on the population as a whole.

Oral Toxicant. Zinc phosphide is an acute rodenticide (not an anti-coagulant) that is usually placed on oats and placed near or in the burrows of prairie dogs. The area to be treated is pre-baited with non-toxic oats to facilitate prairie dog consumption of this food type. There will be a minimum of one pre-baiting session before oats treated with zinc phosphide are placed in the same location. Zinc phosphide is registered for use through the EPA (1998) for the control of prairie dogs and all label instructions will be followed, including application by a certified pesticide applicator.

An essential component for use of this method is pre- and post-monitoring of the area. Before an area is to be treated, surveys will be conducted at various times of the day (morning, afternoon, dusk) using an ATV or by walking the area to be treated. This will enable refuge staff to document what the species present in towns to be treated and assess the risks for secondary toxicity to non-target species. If this method is used, pre-baiting, proper timing to avoid mortality risk of non-target organisms and removal of all prairie dogs that die on the surface will be actions used to minimize risks. Post-treatment surveys to collect and dispose of prairie dogs that have died above ground will be conducted immediately after application and every day for a week following deployment of treated oats as most mortality occurs during this time (Shane Koyle-USDA, personal comm. 2011). Surveys will be conducted by either riding an ATV or walking, depending on the size of the area. It was estimated that following an application of 2% zinc phosphide treated oats in Montana, 12% of the estimated prairie dogs in the town died above ground (Knowles 1986).

A primary concern of using this method is the danger of secondary toxicity. Matschke and Andrews (1990 unpublished report) analyzed the carcasses of black-tailed prairie dogs using zinc phosphide treated bait, and found that 8.9% of the zinc phosphide consumed was outside of the gastrointestinal (GI) tract. Raptors seem to avoid eating the GI tract, reducing the likelihood of secondary poisoning (Johnson and Fagerstone 1994). Glahn and Lamper (1983) concluded that when zinc phosphide applications are used at the recommended rates, they have a minimal impact when alternative food sources are available. Maintaining communication among staff about areas to be treated and non-target species use along with post treatment surveys will help minimize the likelihood of coyotes or any other non-target species consuming prairie dogs that have died as a result of the treatment.

Reintroduction of black-footed ferrets. Black-tailed prairie dogs at the RMANWR are preyed upon by a variety of species including coyotes, bald eagles, and several other raptor species. However, despite the presence of natural predators, prairie dogs have exhibited steady, and oftentimes increasing, population rates (U.S. Fish and Wildlife Service 2013c). The addition of another natural predator, the black-footed ferret, is not seen as a detriment to the future survival of prairie dogs at RMANWR. Instead, it can be viewed not only as an opportunity to aid in the recovery efforts of an endangered species, but also as a chance to reintroduce a component of the grassland ecosystem and to learn more about this endangered predator.

It should be noted that reintroduction of an endangered species raised in captivity has a high risk of failure when it comes to creating a self-sustaining population. This is due to persistent environmental factors that result in population declines, the effects of inbreeding in small populations, and various other behavioral and physiological consequences of their captive up-bringing (Grenier et al. 2007). Reintroduction of black-footed ferrets will be explored in the revision of the RMANWR comprehensive conservation plan and any release would occur when appropriate thereafter.

Strategy D: **Monitor vegetation composition of restoration sites**

Vegetation at restoration sites will be monitored using protocols previously established to assess progress in meeting criteria established in the HRP (U.S. Fish and Wildlife Service 1999). This method consists of random 50-meter fixed-point line transects established at a density one transect per six acres of restoration site (maximum of 20 transects). Along each transect, data is collected at 1-meter intervals using an Optical Sighting Device (OSD) placed directly overhead and perpendicular to the line. Baseline data will be collected the year prior to revegetation work to establish a baseline and during the growing season of the third, fifth, and every fifth year thereafter until the site achieves the HRP criteria. In addition, this data will be used to assess the composition, density, and diversity of seeded sites over time to determine range trend and condition.

Maintenance

Based on past results at RMANWR, restoration of sites dominated by weeds to native prairie that meet the criteria specified in the HRP requires five to seven years. During the first few years, management is intensive and strategies are designed to promote germination and survival of native species. Following this period, additional management is required following this phase to ensure that native species composition is maintained and structural conditions (e.g., height, density) necessary to support resources of concern are available. Many of the same strategies employed during restoration continue to be used during the maintenance phase, but the timing, frequency, and intensity of implementation often differs. For example, prairie dog and weed control strategies are utilized to prevent species composition reversion to weedy species but the frequency and intensity of control typically is lower. Mowing and prescribed fire also are used during maintenance, but implementation schedules are designed to manipulate vegetation structure and emulate various seral stages to benefit wildlife in addition to weed control. In addition, additional strategies are used to manipulate vegetation structure, including herbivory. The strategy implemented will vary depending on the current composition and structure of individual native prairie stands relative to desirable conditions specified in the native prairie habitat objectives and various abiotic factors such as climate and soil type. The following are additional strategies that will be used to accomplish native prairie habitat objectives.

Strategy E: **Bison herbivory**

In addition to contributing to the Service metapopulation goals, bison at RMANWR will be used to manage the composition and structure of native prairie to benefit other resources of concern. The Great Plains prairie ecosystem evolved under the grazing pressure of bison and, in combination with climate, influenced the composition and distribution of native flora and fauna. Bison crop vegetation closer than domestic livestock and create patchier mosaics of heterogeneous vegetation that provide diverse habitats desired by some grassland birds (Vickery and Herkert 1995, Askins et al. 2007). Knopf (1996) noted how an increase in grazing intensities resulted in an increase of species characteristic of the shortgrass. In addition, herbivory decreases competition for available soil nutrients by individual plants (Truett et al. 2001) and increases the nitrogen content and digestibility of plants used as forage.

Traditional grazing schemes employ the concept of uniform utilization. However, this method is incompatible with restoration of biological diversity as it provides limited structural diversity (Truett et al. 2001). Therefore, a rest-rotation system of bison grazing will be used on RMANWR because Fuhlendorf and Engle (2001) determined slow rotations of herbivory and long rest periods (lasting more than one growing season) yield greater structural heterogeneity of vegetation compared to rapid rotational grazing systems. An adaptive grazing system must be developed that will determine the location and frequency of bison herbivory incorporating age of the restoration sites and structural conditions of the vegetation. In general, sites restored less than 7 years will be avoided to allow stands sufficient time to establish root systems that can tolerate herbivory, whereas sites older than 7 years will be grazed at an intensity that contributes to achieving the patch size, species composition, and structural conditions that will contribute to supporting grasslands birds identified as resources of concern (Coffin and Lauenroth 1988, Fuhlendorf and Engle 2001). The grazing system will also be adjusted annually to account for herd dynamics (e.g., time of rut, time of calving, social groups, etc.) to facilitate herd movement and avoid disruptions that may cause a cessation in breeding, fetal abortions, or other behavioral anomalies (Miller 2002).

***Strategy F:* Prescribed fire**

Fire is an essential ecological process in short (Brockway et al. 2002) and mixed-grass prairie ecosystems (Bell 2005). The primary purposes of prescribed burns on RMANWR will be to maintain plant vigor, improve floristic quality, and manipulate vegetation structure to benefit nesting grassland birds and provide quality forage for bison and other herbivores (Pearson et al. 1995, Griebel et al. 1998, Knapp et al. 1999). The frequency, timing, and intensity of fires will vary depending on prairie type, and current vegetation conditions can be found in the RMANWR fire management plan (U.S. Fish and Wildlife Service 2013b); however, the following general criteria will be used when developing fire prescriptions:

Frequency. There is no historical documentation on the actual extent or condition of native grasslands or the frequency of fire before 1850. However, the presumed return cycle for short- and mixed-grass prairie is 3-5 years (Bell 2005). A presumed fire return cycle of 5-10 years was estimated for the southern mixed grass prairie (Joern and Keeler 1995). Most of the dominant grass species were fire-tolerant, although they may require two to three years to recover (Nagel 1980, Launchbaugh 2006). Fires were most frequent where litter accumulation was the greatest. Most grasses tolerate fire during years of normal to above normal precipitation, but are adversely affected during dry years (Wright 1974). Longer term drought is not uncommon in the region. However, past experience at RMANWR strongly suggest maintaining the vigor of shortgrass species in modified systems may require a fire return interval of 10-15 years. However, the interval between fires will be highly dependent on the extent of bison herbivory. For example, an appropriate grazing regime for bison may prove just as effective in maintaining the native composition and structure of restored shortgrass prairie as prescribed fire. Therefore, prescribed fire may be most applicable as a selective management strategy in areas not impacted by bison or as a technique to attract bison into an area (Wright and Bailey 1982). In contrast, past results of prescribed fire in mixed-grass stands suggests a 5-7 year fire return interval may be most beneficial to remove thatch accumulations and stimulate vigor of native plant species. This interval is based on observations that after 5-7 years thatch accumulations of 2-5 inches are common and this condition causes certain grass species (e.g., switchgrass and sand bluestem) to become decadent or significantly die back. However, fire frequency should be based on vigor of plant growth rather than a strict rotational schedule because the rate of thatch accumulation depends on soil type and precipitation.

Timing. In both shortgrass and mixed-grass, burning just prior to leaf emergence is ideal for maintaining existing stand composition. At RMANWR, this equates to late March/early April in stands dominated by cool-season grasses and late April/early May in stands dominated by warm-season grasses. For a stand containing significant components of both cool and warm-season grasses, mid-April may be the best time to initiate burning to minimize mortality of both plant types. Ford (1999) indicated that dormant season fires may help restore vigor to shortgrass steppe where fire has been excluded for a prolonged period. However, if dormant season burning is implemented, it is recommended that burning be postponed until a normal precipitation year if precipitation during the past two or more growing seasons has been below normal (Ford 2003) because fires during dry years may harm many species (Wright and Bailey 1980).

***Strategy G:* Monitor breeding grassland birds**

Breeding grassland birds will be monitored using the *Landbird Monitoring Protocol for the U.S. Fish and Wildlife Service, Midwest and Northeast Regions, Version 1.0* (Knutson et al. 2008). Although originally developed for regions 3 and 5 of the Service, this protocol is appropriate for monitoring the abundance, density, occupancy, and species richness of landbirds in all regions. It incorporates standardized protocols for surveys, data management, analysis, and reporting. These protocols will be further developed in the refuge's inventory and monitoring plans. In general, field data is collected via point count surveys and is uploaded to a central database that incorporates data from multiple sites that can be used to conduct meta-analyses to address large-scale trends in bird populations as well as bird-habitat relationships at various spatial scales (Knutson et al. 2008). The contribution of our field data along with the acquisition of large-scale meta-analyses will allow staff to determine trends in grassland bird populations on RMANWR as well as assess refuge contributions to continental populations.

Strategy H: **Monitor prairie dog density**

Biggins et al. (2006b) describe a process for determining the abundance of prairie dogs. Colony size is the number of prairie dogs that live in a colony. Biologists sometimes use the term for the number of adults and yearlings within a colony (Hoogland 1996), but colony size for this chapter includes juveniles as well. Colony density is the number of adults, yearlings, and juveniles per acre. If colony density were constant, then accurate mapping of colony boundaries instantly would tell us colony size. But densities of prairie dogs vary over space and time with natural factors such as precipitation, vegetation, age of colony, and predation (King 1955), and with unnatural factors such as plague and lethal control (Hoogland 1996). Methods for estimating colony size and colony density include visual counts, capture-mark-recapture (CMR), and inferences from number and density of burrow-entrances. The RMANWR will continue to map active prairie dog colonies and estimate density by counting unmarked prairie dogs (Biggins et al. 2006b).

Strategy I: **Annually map occupied prairie dog areas and burrowing owl nest sites**

As discussed, RMANWR will annually map prairie dog colony distribution after pups have dispersed from natal territories, whereas active burrowing owl nests will be mapped during the nesting period. The presence of burrowing owls is difficult to detect. Beginning with known historic locations, visual scans will collect numbers and age and sex where possible (Wilkerson and Siegel 2010;2011). Data will be incorporated into refuge GIS systems and used to assess several factors, including trends and long-term distribution of burrowing owls nests, as well as the current acreage and distribution of prairie dog colonies.

Before, and during cleanup and restoration, the searching effort and access to burrowing owl nesting habitat varied. When the subject of specific research, (i.e., site fidelity, diet and occupancy: 1990-1993) and banding projects (i.e., survivorship, feather isotopes and West Nile virus: 2005-2007), owl locations on the site and reproductive success were intensely monitored. In other years, to avoid destruction of nest burrows during cleanup, areas targeted for earth work were searched for breeding pairs. A third objective of finding and marking nests was to examine where visitor services could allow non-disruptive viewing of refuge raptors along the tour route and during nature programs. Throughout all of these, a Breeding Bird Survey route has been run annually in June (1991-2012). Burrowing owls have been detected every year with a high of 21 in 2005 and a low of 2 in 2010 and average of 7.9 (n=22).

The standard Breeding Bird Survey run on the refuge will be continued to indicate occupancy rates of the refuge by burrowing owls since the route passes through both preferred and non-preferred owl habitat. However, to map owl nests, a second survey specifically routed through prairie dog towns will be conducted three times annually from April through August. Points on the survey must be one half mile apart and viewed for six minutes (Conway and Simon 2003). The technique is specified in *Recommended Survey Protocol and Actions to Protect Nesting Burrowing Owls* (Colorado Division of Wildlife 2008).

Strategy J: **Develop suitable integrated pest management techniques to control noxious weeds**

Most of the shrublands at RMANWR have understories comprised of multiple weedy invasives, including crested wheatgrass, cheatgrass, mullein, musk thistle, and field bindweed among others. Management to eradicate or control these species has been limited and the efficacy of potential IPM methods is largely unknown. However, the Service has developed a separate integrated pest management plan (U.S. Fish and Wildlife Service 2013d) for the RMANWR in support of this HMP. Some potential IPM strategies included in the plan for shrubland weed control include:

Biological Control. Biological control is used primarily when site access is limited and weeds occur as small infestations (less than 5 acres). Most biological control took place prior to 2002. A variety of biological agents such as leaf beetles, flea beetles, flower weevils, root weevils, stem weevils, moths, and gall mites have been applied to smaller weed patches of St. Johnswort, leafy spurge, common mullein, Russian and spotted knapweed, and Canada thistle with mixed results.

Mowing. Mowing is utilized for two primary purposes: 1) minimize competition for light by preventing new grasses from getting overtopped and shaded by competitive broadleafed weeds, and 2) eliminate or delay the formation of seedheads of noxious weeds and undesired grasses. Mowing to reduce competition is always done during the early life of the newly seeded stand, usually two or three times during each of the first three growing seasons. This can be important as the nitrogen and carbon content are affected by mowing (Dyer et al. 1991). When weedy cover is exceptionally dense, the use of tractor-operated flail shredders is preferred over standard batwing rotary mowers. The swinging blades on shredders pulverize material to be removed and prevent the formation of windrows on the ground, which can shade out and/or smother new grass seedlings. Height of the clipping is determined by the height of the grasses, but as plants develop toward the end of the first growing season the final mowing is not less than 12” in height. Mowing also serves to prevent the formation of weed seed heads. “Spot” mowing may be required for several years to delay or prevent the spread of many weed species. However, mowing cheatgrass to prevent seedhead formation has little effect as plants will simply produce new seedheads on much shorter stems. Spot treating patches of noxious weeds in restoration sites is often most successful when mowing and chemical application are used in combination with each other.

Mechanical Tillage. Mechanical tillage has two purposes where it is used primarily for weed control on new seedbeds to incorporate the weeds and organic residues into the soil, and to influence the soil structure for seedbed preparation (Balesdent et al. 2000). Initial plowing of the site using moldboard plows is helpful in burying the top layer of weed seed to a 12” depth where it cannot germinate. Disking and/or chiseling are used after the site has been plowed to smooth the site and eliminate subsequent weedy flushes prior to seeding. Disking of cheatgrass and field bindweed is most effective when the weeds are very short (under 1”). If they are taller, then disking either “chops” up viable stems and stimulates establishment of additional plants or, when cheatgrass reaches a 3-5” height, disking merely rolls strips of the plant over into the dirt and does not kill them. The use of herbicides on these species provides much more effective control. The tilling of soil is believed to have influence in the changing of soil climate, the mixing of soil organic matter into the soil and the temporary disruption of soil structure (Balesdent et al. 2000). This can be important as soil climate has an effect on microbial activity in the soil which can affect vegetative growth. With currently used tilling techniques, plowing will mix organic residues to a depth of 11” while disking and chiseling will mix it to 4” with untilled residue remaining at the surface (Reicosky et al. 1995).

Herbicides. Evaluate the ability to control noxious weeds without harming shrubs using herbicides applied at various rates. For example, apply Plateau (imazipine) at a rate of 5 ounces/acre in decadent sand sage (e.g., Section 8) and fourwing saltbush shrublands to control cheatgrass less than 2 inches in height and field bindweed during mid to late October. Imazipine may not affect sand sagebrush because the rate is reduced and active growth of shrubs has ceased. Similarly, although rubber rabbitbrush is considered tolerant of Plateau at rates up to 12 ounces/acre, evaluate the effectiveness of a 6 ounces/acre rate in fall (mid-October) to control cheatgrass.

Prescribed Fire. Depending on fuel load and continuity, prescribed fire can be used to eliminate standing weed seed, unwanted standing weedy residue, and surficial weed seed. If amounts of surface residue are too high or too dense to facilitate mechanical or chemical control, prescribed fire can serve as an effective tool to remediate this. Dense, continuous fuels can produce the heat necessary to destroy surficial seed and weedy plant parts. Experience at the refuge has shown that prescribed fire can reduce the amount of cheatgrass in mixed grass communities, but only when fuels are continuous. By contrast, fuels which are not consistently continuous will cause a fire to “mosaic” across the landscape, leaving islands of standing biomass that in many cases will allow patches of weeds and weed seeds to survive. In addition, lack of continuous fuels will generally not produce the heat required to damage or destroy surficial seed or newly germinating weedy plants. Under these conditions, prescribed fire is not used as a tool for weed control, as it may in fact promote a quick establishment of weedy species after burning.

Physical Control. This type of control on the RMANWR involves the physical pulling, cutting or sawing of weedy or woody species in areas that are difficult to access with machinery. Physical control is limited to small areas ranging from several stems to patches that are a couple acres in size. This also includes treatments involving chainsaws or saws to cut down trees such as Russian olives and apply herbicide to the stump. The use of backpack or hand sprayers is also utilized to contain small areas of weeds. Removal locations are documented with GIS technology to allow inspection of the area the following year to determine if control was obtained.

Chemical Control. Herbicides are utilized on the Arsenal when the area of infestation is too large for removal by hand and is seen as the most cost-effective means. Herbicides are typically applied by ground spray rigs (either a spray coupe or truck); however contiguous areas greater than ten acres comprising a total collective acreage of at least 1,000 acres have received aerial application using a contracted helicopter. From 2007 to 2012, the area that has been treated by aerial application has typically been from 1,000 to 5,000 acres annually. In addition to the use of conventional ground-application spray rigs and aerial application, smaller areas of invasives are treated using UTV's with mounted tanks or by crews using backpack or hand sprayers. Herbicide usage is reported and documented according to all required federal and state requirements, including limiting applications to periods when wind speeds are less than ten miles per hour (in order to minimize drift) and when temperatures are below 85° F (in order to minimize volatilization of the herbicide, which can reduce its effectiveness and increase the chance of non-target species damage). Label rates and safety precautions, including the appropriate personal protective gear, are always followed and no restricted-use herbicides are used at this time. The Service strategy at the RMANWR has been to use herbicides that provide the greatest effectiveness with the lowest risk (U.S. Fish and Wildlife Service 2013d) and GIS technology is used to identify locations treated to determine if additional treatment is needed the following year. All herbicides used on the refuge have pesticide use proposals (PUPs) associated with them. There are currently 19 pesticides approved for use on the Complex. The most commonly used are listed in Table 8.

Combinations of treatments. Depending on site conditions, a combination of the above treatments at the appropriate time may be more effective than a single treatment. For example, after burning in the fall to remove the shrub canopy, consider an application of Plateau herbicide to control cheatgrass. When shrubs initiate regrowth, spot spray with appropriate herbicides to control noxious weeds and overseed with native species adapted to the soil types on the site. If burning is not possible, consider mowing shrubs in fall (early September) with a flail mower, followed by a late-September/early-October application of Plateau herbicide to control noxious weeds such as cheatgrass. Mowing the shrub canopies will reduce surface area and stimulate growth of cheatgrass, which should increase herbicide contact with cheatgrass. Applying herbicide during the dormant season of shrubs may also minimize shrub damage because translocation of herbicide that does contact shrubs should be minimized.

Riparian

Strategy K: **Conduct a baseline inventory of the condition of cottonwoods**

The winter roost area at RMANWR east of Lower Derby Lake and extending north to the Integrated Cover System is approximately 100 acres in size. Although used heavily by roosting bald eagles during the autumn and winter, virtually nothing is known about the age and condition of the cottonwoods that comprise this site. Cottonwoods are also used for nesting by bald eagles along First Creek. Additional raptors and other avian species use cottonwoods near First Creek and elsewhere on the refuge in both the Prairie and Education Zones.

The Service will develop a baseline inventory of cottonwoods throughout the refuge to determine age and condition of these stands and to prioritize replacement such that the refuge will always have adequate cottonwood stands, especially for roosting and nest by bald eagles. The Service will initially use aerial photographs from 1937 until the present to estimate ages of stands. Then these estimates will be 'ground-truthed' by visiting stands and collecting core samples of representative trees. Cottonwood stands will be divided into four age classes based on the majority of trees being 0 – 20 years old, 21 – 40 y. o., 41 – 60 y. o., and > 60 y. o. On-site evaluations will also determine whether most of the trees within a stand are healthy, decadent, or dead. Proximity to water will also be evaluated. Priority for planting new cottonwood trees will be given to sites near older stands that have a preponderance of dead or decadent trees and are close to a water sources.

Planting methods will be determined by both the resources available and the specific replanting site. The Service can employ three main types of tree stock: commercial ball & burlap, poles, and transplanted material originating from elsewhere on the refuge. The most frequently used materials and techniques may involve planting poles in holes augured into the water table. Both poles and transplanted material could be taken from even age stands elsewhere on the refuge. Any commercial sources should be from genetic stock from the general area (approx. a 50-mile radius).

All of the materials above will be protected with appropriate mesh cages or wire fences to protect the plants from damage by deer over-browsing or scraping antlers. Fencing will likely be conducted by refuge staff, but may include a variety of volunteer or youth corps groups.

In addition, the Service will investigate the feasibility of simulating natural seeding of cottonwoods that would occur during flood events. If deemed appropriate, the Service will search for appropriate sites adjacent to First Creek to scrape such that the areas will be similar enough to flood-produced sandbars that they can be successfully planted with cottonwood seeds.

Strategy L: **Implement cottonwood planting along First Creek and thereafter in areas based upon condition**

The current cottonwood galleries adjacent to First Creek likely established following the 1933 flood event and are more than 75 years old. These trees, which currently are used by nesting and roosting bald eagles, will likely begin to die within 20-25 years and new cottonwoods are not surviving to replace these trees. This is likely due to a combination of factors, including channelization of the creek in the 1940's and 1950's that produced steep cut-banks and construction of upstream stormwater retention basins to minimize large water inflows. Collectively, these alterations have eliminated flood events that are necessary to create bare mineral substrate necessary for germination of cottonwood seedlings. Although urbanization surrounding RMANWR is expected to increase flows in First Creek, most of the increased runoff created during significant rain events will be trapped and caught upstream. Consequently, the increased flow will probably result only in a temporary rise of the groundwater table near streams like First Creek for short periods (Joseph Capesius, USGS, personal communication 2003) rather than larger peak stream flows or "pulses" necessary to create the scouring conditions at the proper time for natural cottonwood regeneration. Therefore, maintaining a suitable mile-long gallery of old-growth cottonwood forest to perpetuate bald eagle nesting along First Creek will require systematic planting of replacement cottonwoods. Under favorable conditions, young plains cottonwood trees can grow 6-12 feet in height per year (Burns and Honkala 1990) and it is possible that trees would attain an height and girth necessary for use by nesting and roosting bald eagles in 20-25 years.

Potential sites for planting woody riparian and associated understory vegetation along the First Creek corridor are provided in the *Conceptual Plan for First Creek at the Rocky Mountain Arsenal, Title I Services Report* (McLaughlin Water Engineers Ltd. 1994*)* and *Contract Documents for Construction of Habitat Restoration, Plan 35, Redesign of First Creek, Phase 2* (Sellards & Grigg Inc. Aquatic and Wetland Company 1997). These documents also provide recommendations for biotechnical slope protection of eroding banks along various reaches of the Creek.

In general, a systematic cottonwood replacement effort can be accomplished at a reasonable cost. Areas to plant can be selected a year prior to the actual planting and herbicide applied to control weeds (some areas may require two seasons of weed control, depending upon types of invasives present). Six-foot plains cottonwood b&b (balled and burlapped) stock are easily obtainable at most nurseries and are relatively inexpensive. If saplings are planted at 25’ x 25’ spacing, approximately 70 trees would be needed to restore 1750 feet of linear cottonwood gallery and it estimated that one mile could be completed in three years. Not every tree will survive, and some replanting will need to be done, but a relatively small planting effort of 70 six-foot cottonwood saplings per year over 10 years would replace existing cottonwoods along First Creek.

Planting of saplings will be accomplished by volunteer groups working with a small number of RMANWR staff. Planting will be done in spring (mid to late May) unless the location is near the current bald eagle nest. In this case planting will be delayed until fall (mid-September to mid-October). Volunteers will also be used to assist in the construction of fences to protect saplings from deer damage. RMANWR has excess polyvinyl water tanks, several hundred gallons in size, which were used for similar shrub planting efforts on the refuge in the mid-1990’s. These tanks will be staged in planting areas as necessary to provide water to the newly planted saplings. RMANWR also has the necessary plastic line needed for small areas of drip irrigation which could be re-used over time.

Strategy M: **Minimize unnatural erosion occurring along First Creek**

Bank sloughing along reaches of First Creek has occurred as a result of channelization by farmers and the U.S. Army. This unnatural erosion has led to considerable headcutting, which in turn has undercut mature cottonwood trees in several places, and may threaten the one tree currently used by a nesting pair of bald eagles. The Service will conduct a visual assessment of the entire 5.1 miles of First Creek, with particular emphasis on problems within Section 5. If serious erosion problems exist, the Service will initially follow the appropriate recommendations provided within the Conceptual Plan for First Creek at the Rocky Mountain Arsenal, Title I Services Report, (McLaughlin Water Engineers Ltd. 1994) and Contract Documents for Construction of Habitat Restoration Plan 35, Redesign of First Creek Phase 2 (Sellards & Grigg Inc. Aquatic and Wetland Company 1997). However, the Service will remain open to new approaches because new issues may be discovered that were not a problem when these documents were written.

Reaches affected by erosion will be stabilized and rehabilitated using bioengineering tactics that incorporate biological, mechanical and ecological concepts. Specific actions will include the use of vegetation and natural construction materials (Allen and Leech 1997) and include bank sloping and reinforcement by coir fabric, facines, or root wads, as well as redirecting flows using log barbs. Bank rehabilitation techniques will include planting of saplings or mature plants that will help stabilize banks and also provide habitat for wildlife. Implementation of these techniques will follow the recommendations provided in the aforementioned plans and results will be visually monitored to facilitate adaptive management.

Shrubland

Strategy N: **Conduct baseline inventory to determine current species composition and structure**

The current composition and structure of shrublands is uncertain and an inventory is necessary prior to implementing management actions. The Service will initiate a baseline inventory by reviewing existing vegetation maps. Shrub areas will be ground-truthed. Shrubland boundaries and acreages will be determined by using GPS units attached to ATV’s or UTV’s. Seeded areas that are possibly shrublands will be evaluated by estimating shrub density with the following method. Ten locations for 50-meter transects will be selected randomly in shrub areas. Shrubs will then be counted in the 1-meter area on each side of the 50-meter transects yielding a shrub density sample of the number of shrubs per 100 square meters. After ten samples, an average number of shrubs per 100 square meters will be calculated and a sample adequacy calculation will be made. If an adequate number of samples (90% confidence level) has not been acquired, the process will be repeated with 5 more random shrub density samples. A maximum number of 20 samples will be taken to estimate shrub density in the area.

A density of 1 or more shrubs per 45 square feet (on a per acre basis) will determine if the area is defined as a shrubland.

In addition, seeded areas that are possibly shrublands will be evaluated using the same methods as grassland monitoring. Baseline data will be collected the year prior to revegetation work to establish a baseline and during the growing season of the third, fifth, and every fifth year thereafter until the site achieves the HRP criteria. These data will be used to assess the composition, density, and diversity of seeded sites over time to determine range trend and condition.

***Strategy O:* Monitor long-term vegetation composition and structure following compliance with HRP requirements for establishment.**

Initially, success of restoration efforts will be based on meeting mitigation requirements established in the HRP (U.S. Fish and Wildlife Service 1999). These requirements primarily are based on plant composition and the amount of live and bare ground cover. Although important, these attributes do not consider all composition and structural components (e.g., grass /forb cover, plant height, patch size) that the scientific literature suggests are necessary to support grassland birds identified as resources of concern in the HMP.

Therefore, following attainment of HRP requirements, we will monitor progress in achieving native prairie objectives using the belt transect method proposed by Grant et al. (2004). The belt transect method consists of establishing transects that are 0.3 feet in width and 82 feet (25 m) in length in each of the restoration sites. Native prairie sites will be stratified by dominant soil type and transects established randomly within each type at a density sufficient to detect a 20% change in composition or structure with 80% confidence of all attributes. Preliminary data will be collected to facilitate calculating the number of transects required to meet these requirements. Transects will be permanently marked using a global positioning system (GPS) to facilitate comparisons over time and will be established coincident with bird survey points so vegetation data can be used to assess species-habitat relationships (Vickery et al. 1994).

Each transect will surveyed every 3 years at a minimum to assess changes in composition and structure. During each survey, the investigator will walk the middle of each transect and classify the dominant plant group (including bare ground), average plant height, and litter depth at each 0.3-ft x 1.5-ft segment. Dominant plant groups will be determined based on local and regional references and will include categories that define common invasive species, forbs, grasses, and shrubs. Data for each transect will be summarized as percent occurrence of dominant plant groups/bare ground and average plant height and litter depth to facilitate evaluation of vegetation conditions relative to metrics stated in the native prairie objectives.

Current imagery has been used to determine the patch size of restoration sites and is available in a geographic information system (GIS). The area of these sites is unlikely to change dramatically unless management actions result in the removal of woody vegetation or additional infrastructure is installed that fragments restoration sites. In these cases, aerial photography or other suitable imagery will be used to recalculate the area of each patch and this information will incorporated into the GIS.

***Strategy P:* Monitor treatment effects of fire and herbicides on vegetation composition and structure**

Monitoring vegetation on restoration sites is a mandated part of the Mitigation Program (a subset of the overall Habitat Restoration Program). Monitoring vegetative responses to prescribed burns and herbicide treatments is not mandatory because the use of burning or application of herbicides is already based on extensive research and is expensive in terms of staff time. However, such monitoring is always encouraged and is especially appropriate when 1) the vegetative response may be in question and 2) adequate resources are available from staff or funding exists for formal research.

If the future vegetative response to larger (100 + acres) fires or herbicide treatments is questionable and staff time is available, a normal vegetation monitoring protocol will be implemented. Vegetation at treated sites will be monitored using protocols previously established to assess progress in meeting success criteria (U.S. Fish and Wildlife Service 1999). This method consists of random 50-meter fixed-point line transects established at a density one transect per six acres of restoration site (maximum of 20 transects). Along each transect, data are collected at 1-meter intervals using an OSD placed 1 meter to the right and left of the center point (yielding a total of 100 data points). Baseline data will be collected the year prior to treatments to establish a baseline and during the third and fifth growing seasons to determine the efficacy of the treatments to achieve the grassland or shrubland criteria. The composition, density, and diversity of the sites will help to determine range trend and condition over time.

Woodlands

Strategy Q: **Removal of Russian olive and dead and downed debris**

Russian olive is a "List B" species in the Colorado Noxious Weed Act and the species is to be eradicated, contained, or suppressed. Trees will be cut during spring (April-June) using saws and debris will be chipped or stacked in piles and burned. If material is chipped, it will be scattered on the ground in a thin layer to facilitate decay. Stumps will be treated with full-strength glyphosate (Roundup) immediately after cutting or with Garlon herbicide at other times during the season. Treated stumps will be inspected the following year and treated with the appropriate herbicide if resprouting has occurred. Replacement of Russian olive with native trees (e.g., cottonwoods) helps suppress reestablishment.

In addition, cottonwoods, Siberian elm, and white poplar mortality and loss of branches due to strong winds, heavy snow, and disease results in the accumulation of fuels that, if ignited, may generate sufficient heat to kill living trees. Removal of this decadent woody vegetation will help protect habitat for Swainson's hawk, bald eagle, and neotropical migrants by reducing the probability of a catastrophic fire. Volunteer groups, community groups, and Mile High Youth Corps crews will be used to pile debris for burning or, in the case of smaller branches, to use a chipper. It is a popular activity with such groups and relatively easy to organize and supervise. In some cases, a two-member refuge sawyer-qualified team may be required to cut larger materials. Based on past experience, groups of 15 individual working 2-3 days each year should be sufficient to remove debris in areas where snags and downfall are not considered a safety risk.

At least every 5 years, refuge staff will identify and prioritize sites for treatment. Dense areas of Russian olive and areas with the greatest fuels will be the highest priority. Dimensions of each pile will be about 20 feet in diameter and about 8 feet high. To facilitate burning, piles will be constructed in open areas away with minimal ground cover and away from forest canopies. Currently there are over 300 debris piles on the RMANWR in need of burning.

Strategy R: **Investigate strategies to minimize damage from future locust borer outbreaks in New Mexico locust thickets**

Some New Mexico locust thickets are clogged with dead debris that has been caused by past locust borer outbreaks. Females deposit eggs under the bark from August through October. The eggs hatch in about a week and new larvae bore into the inner bark where they overwinter. The following spring, larvae will bore deeper into the woody part of the tree. Although specific information regarding New Mexico locust is lacking, only vigorous and fast-growing black locust trees at least 10 years of age are able to withstand attack (Galford 1984). Therefore, given the life span of New Mexico locust is considered short, it is reasonable to assume that existing thickets on RMANWR are old and more susceptible to borer attacks.

Dead material in the thickets serves as brood areas for the locust borer (Red Planet Inc. 2012) and should be removed to prevent further outbreaks. However, the most appropriate strategies to interrupt the life cycle of the borer and stimulate sprouting New Mexico locust will require evaluation. Therefore, the Colorado State Forest Service will be consulted to help develop a feasible technique to remove decadent trees and develop a monitoring protocol that can be used to track the distribution and extent of locust borer infestations. Because borer larvae live under the bark, one potential alternative is to use prescribed fire in decadent thickets. New Mexico locust has relatively thin bark and larva may be susceptible to heat, but root crowns survive only low to moderate intensity fires (Pavek 1993) and stems can be killed. Burning when locust tress are dormant could minimize tree damage, but this should be evaluated prior to implementing on a large scale.

Strategy S: **Prevent overbrowsing of native shrubs (e.g., Prunus spp) by deer [volunteer projects]**

Many shrub species are preferred forage of white-tailed and mule deer, particularly plum and chokecherry. Numerous shrub thickets have been overbrowsed in the past and some have been destroyed or severely damaged. To prevent further browse damage and promote regrowth, the perimeter of remaining thickets will be fenced to protect stems. Deer will still be able to browse on the plant material that grows through the fence, but a core area of “mother” plant material will be protected. This protection method has been implemented at RMANWR in the past and has functioned well for over 20 years.

Approximately 25 shrub thickets still exist that should be fenced. Fencing materials will be selected based on the type and size of a shrub thicket, but most will be surrounded by woven wire fencing. Fences will be wired to T-posts, which will be spaced about 10 feet apart. Fencing will mostly be conducted using small groups of volunteers on regular intervals (e.g., 1 time per week), large groups of volunteers on one specific date, youth corps groups as available, and/or scout projects.

Strategy T: **Establish additional plum and chokecherry in suitable locations [volunteer projects]**

In the past, Mule Deer Foundation volunteers have planted plum and chokecherry thickets in the cottonwood understory around Upper Derby Lake (the portion of Upper Derby Lake east of E Street) as well as in isolated spots along First Creek in Section 30. Additional thickets of native shrubs (including plum, chokecherry, buffaloberry, and golden currant) will be established in strategic locations in and adjacent to existing woody vegetation to improve stop-over habitat for neotropical migrants and other wildlife, as well as provide additional winter browse for deer. Planting and protection methods will follow guidelines established in the Habitat Restoration Plan (U.S. Fish and Wildlife Service 1999). Planting and protection will mostly be conducted using small groups of volunteers on regular intervals (e.g., 1 time per week), large groups of volunteers on one specific date, youth corps groups as available, and/or scout projects.

Strategy U: **Annually monitor Swainson’s hawk nest trees and ensure adequate nesting sites are available**

Annual surveys of Swainson’s hawk nest sites will be conducted by refuge staff to document locations and evaluate the condition of nest trees. Nest trees in need of replacement will be replaced with a new tree that is planted during the fall to avoid disturbance to spring-nesting Swainson’s. If the original nest tree was an exotic species, such as Siberian elm, it will be replaced with a suitable native species such as cottonwood, boxelder, or New Mexico locust. The species selected will be determined based on soil type and moisture condition at each site.

Breeding Bird Surveys conducted on the site from 1991 through 2012 have recorded Swainson’s hawks every year with a high of 10 in 1991 and a low of 2 in 1992, 1996, and 2004 with a mean of 5.22 (n=22). Annual nest numbers have ranged from 2 to 16 with an average of 10.6 (n=23).

Swainson’s hawks are typically the last raptor on the refuge to start nesting due to their long spring migration from southern South America. Like most raptors, Swainson’s show site fidelity to nests where they successfully have fledged young. Hence, documenting their breeding cycle begins with locating last year’s nests and determining if those nests are available for reuse. This is best done prior to leaf-out, which is before the hawks arrive in April. Frequently, the nests have succumbed to the Colorado winds, or are occupied by earlier nesters, i.e. great horned owl, red-tailed hawk and black-billed magpie. Thus Bechard et al (2010) found more than 50% of nests were freshly built. After leaf- out, bird presence will be detected by roadside surveys through August. Since these hawks have historically chosen nest sites along well-travelled roads and their young frequent road surfaces and shoulders to feed, buffer zones may have to be erected to avoid vehicle collisions including mowers and visitor transport.

Lacustrine

***Strategy V:* Stocking of forage fish when necessary to maintain a quality sport fishery on refuge lakes by annually monitoring fish populations and conducting annual water quality monitoring.**

All three lakes are monitored annually to track population trends, fish health, and management actions that are needed. Based on the data collected, calculated Proportional Stock Density (PSD), fish health, weight, etc., fish are stocked in the lakes with the goal of providing ample forage fish, a balanced fish population, and a quality sportfishing experience. Annual monitoring occurs in June after all fish have completed their spawning activities and have returned to their normal habitat/niches within the lake. Regular locations have been established in each lake for various sampling gears so trends can be monitored. Gill nets, Fyke nets, and minnow traps are used at these set locations over a 2-4 day sampling period. Electrofishing activities occur over 2-3 nights at regular established transects in each lake. Fish are then stocked based on the collected data in mid-late summer. Assistance for this monitoring comes from the Service's Fish and Wildlife Conservation Office for net and trap surveys and Colorado Division of Parks and Wildlife for electrofishing surveys to track population trends and management actions needed.

Water quality in lakes is within the Colorado guidelines for Class 1 and Class 2 parameters for warm water biota most of the time. A wide range of conditions in lakes affect the water quality including temperature, vegetation growth, lake water levels, drought conditions, water supply, and other issues causing short term deviations outside the standards. These short term deviations do not have long lasting effects to the fishery and can be tolerated by the fishery, but need to be monitored so that they don't become a chronic issue that can have devastating effects. Water quality sampling can be accomplished while performing the net sampling activities using a portable DO/pH/Temp probe and a Secchi disk. Water temperature, DO, pH, and Secchi depths will be conducted in June at standardized locations in each lake. Additional periodic sampling, every 3-5 years, of invertebrate taxa presence, lake nutrients in the water column (phosphorus and nitrogen), and chlorine can give a good indication of water quality based on the presence or lack of presence of sensitive invertebrate taxa and algae. This is highly recommended, but not a requirement.

***Strategy W:* Conduct cattail control as needed and to the extent practicable, based on available resources.**

Cattails (*Typha spp.*) are widely distributed and are the dominant plants of many shorelines of refuge lakes and wetlands. At optimal interspersion levels, cattails are important to marsh wildlife, however, continuous unbroken stands provide for little or no wildlife use or production (Murkin and Ward 1980). Water level manipulation is an effective means of cattail control, but is not always possible on refuge lakes and wetlands. Herbicides, cutting, and crushing have been used to control cattail with varying degrees of success (Murkin and Ward 1980).

Burning alone is not considered effective in suppressing cattails. Burning should not be used as the sole means of cattail control; however, burning will remain an effective treatment to prepare a site (e.g., remove litter) before additional management is implemented (Kostecke et al. 2004). Cutting and discing of cattails in early spring can provide good results assuming water levels will be raised to submerge stalks (Murkin and Ward 1980). Glysophate herbicides (Rodeo®) can be effective at suppressing cattails for up to 2 years. Herbicide should be applied to cattails during peak growth in mid- to late summer and according to label directions. Application to wetlands in the drawdown phase is not recommended unless the wetland can be reflooded soon after treatment (Solberg and Higgins 1993). Therefore, in areas of large cattail encroachment (>80% of shorelines covered within 30 feet of shoreline), refuge staff will utilize prescribed fire, discing, mowing, and herbicide to reduce large stands.

Wetlands

There are no formal HMP Objectives or Strategies for wetlands. Refer to discussion in *Riparian, Lacustrine and Wetlands Habitats,* page 57. However, we do expect that the Rod and Gun wetland and emergent wetlands along the northern portions of First Creek will become greater priorities during the revision of the CMP due to their significant value to environmental education programs.

Forage Allocation

Bison, deer, and prairie dogs depend on prairie and shrub communities for forage. Allowing unregulated population growth of these species would jeopardize the long-term sustainability of native prairie and shrublands and contribute to poorer body condition of individuals, which could result in increased incidence of disease. As described throughout this HMP, restoration of prairie habitat is the paramount objective. The goal of this HMP is to design habitat conditions that will allow for long-term ecosystem health capable of supporting bison, grassland birds, raptors, prairie dogs, and other prairie species. Given these considerations, population goals were established for herbivore populations currently occupying the refuge to help achieve the quantity and quality of prairie and shrub habitat necessary to support all resources of concern.

Table 9. Potential strategies to accomplish habitat management plan objectives

Forage Allocation Goal: Manage herbivore populations as necessary to ensure the long-term sustainability of restored prairie and shrubland, contribute to the Service bison metapopulation goals, and provide suitable habitat for resources of concern.

Objective 4.1	Manage bison populations, in support of the Department of the Interior’s Bison Conservation Initiative, at or below the carrying capacity for the refuge. At present, bison populations would range between 25-40 animals and should not exceed 42 animals. Once additional grazing units and opportunities are fully in place, long-term bison populations would range between 110-180 animals and should not exceed 209 animals.
Objective 4.2	Manage deer populations at or below the carrying capacity for the refuge to maintain a healthy deer herd and minimize adverse affects to vegetation and habitat that support other species. Long-term deer population goals would range from 325 to 550 animals.
Objective 4.3	Maintain prairie dogs in designated zones at densities of 6-10 animals/acre to promote long-term sustainability of native vegetation and provide sufficient prey and burrow sites for resources of concern.

Strategy X: **Develop a forage allocation methodology**

A forage allocation methodology (Appendix H) will be used to inform management decisions to attain sustainable populations of bison, white-tailed deer, mule deer, and prairie dogs on refuge lands. This method focuses on bison, the largest consumer, and will be refined into a more robust model over time and adjusted when restoration activities are completed. The current method, and its assumptions, will provide desired populations of bison based on estimates of average annual plant (forage) productivity, daily bison consumption rates, and bison forage utilization rates to inform management in setting the size of the refuge’s herd(s).

Strategy Y: **Monitor populations of herbivores**

The quantification of available forage is essential to understanding the competing interests in the highly managed RMANWR system. Once carrying capacity is determined, refuge staff must ensure appropriate populations of each herbivore are at or below carrying capacity.

Bison. The Service typically monitors its bison populations by conducting annual "round-ups," where all animals are herded so that each animal can be individually handled for identification and testing purposes. Round-ups typically occur in the late fall or early winter and are scheduled to avoid conflicts with other Service bison round-ups. During round-ups, all animals are placed in corrals. For the safety of refuge staff and bison, extremely uncooperative animals may be excluded from a particular roundup. All animals are uniquely identified using microchips, which are generally implanted during the first year of age. At most national wildlife refuges, excess bison are either sold or relocated to other lands during round-ups. At present, bison on the RMANWR cannot be sold or relocated.

Deer. Annually, refuge staff will complete a deer census using the following methods. A combination of census techniques along and between paved and dirt roads, including Mobile Line, Hahn Line, and Mobile Hahn Line transects to monitor populations of herbivores (deer in particular). Each method is completed at least twice. Observers count groups of deer, classifying the groups into MD/WT or mixed groups, then further classifying the sex and age composition of each group by individual species. Traditional Hahn Line data analysis methods are applied to acquired data per number of acres utilized by deer: approximately 14,481 acres (excluding 142 lake surface acres and 1,460 acres within bison pilot area enclosure where zero deer were observed during each census). Future census methods may change to accommodate expansion of the bison enclosures. In October 2012, the combined population density estimate of mule deer and white-tailed deer was estimated at 368 deer (Table 10).

Table 10. Deer census results at the Rocky Mountain Arsenal NWR (October 2012)

Area Utilized by Deer (acres)	***Area Observed (acres)***	***Ratio (acres:deer)***	***Estimated Deer Population Density***
14,481	16,026	37.17	368

Groups Observed, Species Totals, Sex/Age Distribution

Groups Observed				**Species Totals**				**Sex/Age Totals**			
Mule deer	***White-tailed deer***	***Unknown***	***Total***	***Mule deer***	***White-tailed deer***	***Unknown***	***Total***	***Buck***	***Doe***	***Fawn***	***Unknown***
36	37	-1	72	191.5	114.5	1.5	307	130.00	134.50	35.00	8.00
49.65%	51.75%	-1.40%	-	62.28%	37.24%	0.49%	-	42.28%	43.74%	11.38%	2.60%

[*]Negative number(s) in Unknown Groups manifest when groups contain both species of deer.

Buck:Doe:Fawn Ratios by Species

Mule deer				**White-tailed deer**			
Buck	***Doe***	***Fawn***	***Unknown***	***Buck***	***Doe***	***Fawn***	***Unknown***
79.00	55.50	17.00	40.00	38.50	51.50	8.50	16.00
41.25%	28.98%	8.88%	20.89%	33.62%	44.98%	7.42%	13.97%

Prairie dogs. Prairie dogs will be managed within the 14 designated black-tailed prairie dog zones. The location of active prairie-dog colonies and density of prairie dogs will be monitored as described in Strategies C and H.

***Strategy Z:* As determined by the forage allocation methodology, manage populations of herbivores**

The HMP outlines the strategies necessary to meet the goals and objectives essential to meeting the purposes of the refuge. The combination of goals, objectives, and strategies in this plan clearly display the challenges in maintaining an appropriate balance throughout the RMANWR. The forage allocation methodology shows that periodic human interventions will be necessary to reduce herbivore populations to ensure the long-term ecological health and viability of the refuge. As needed, black-tailed prairie dog populations will be managed according to an adaptive combination of lethal and non-lethal control measures (U.S. Fish and Wildlife Service 2013c). Currently, predation by coyotes (Whittaker and Lindzey 1999) and periodic harsh winters are keeping deer populations within the desired population range. As needed, refuge staff has and will continue to cull deer to maintain appropriate age and sex ratios and monitor for disease.

Management of bison populations is an emerging challenge for the refuge. The Service is currently prohibited by restrictions found in the Federal Facilities Agreement from removing bison from the RMANWR (either for sale or for use at another location). Bison populations already exceed desired numbers for areas currently available for grazing. Restoration of prairie habitat is the paramount objective of this HMP which will allow for long-term ecosystem health capable of supporting bison, grassland birds, raptors, prairie dogs, and other prairie species. Until the Federal Facilities Agreement is amended, over the next 3-5 years, refuge staff will focus efforts on ensuring success of restoration sites by increasing forage within existing bison grazing units (e.g., irrigation, supplemental feeding of long-hay). As discussed, utilization rates will allow the refuge to manage for ecosystem health. In the interim, the refuge may increase utilization to support excess bison, but if populations are having too negative of impacts on long-term grassland health, the Service may be forced to cull bison. Any culling of bison will be coordinated with the Service's Wildlife Health Office to ensure consistency with metapopulation goals and maintain appropriate age and sex ratios within the herd.

Management Strategy Constraints

Funding

Since cleanup activities were initiated in the mid 1990's, millions of dollars have been spent to restore plant communities on the refuge. Cooperation between the U.S. Army, Shell Oil Company, and the Service in this extensive restoration effort has proven to be an outstanding national model of interagency cooperation. In 2012, the U.S. Army provided one-time funding to the Service to complete the final establishment of the remaining acres of mitigation sites. This funding is expected to last until at least 2014. When these funds are expended, the financial cost of habitat management will become the sole responsibility of the Service. Ensuring the long-term sustainability of these sites will be costly because intensive management will continue to be a necessity and funds likely will be limited.

Federal Facilities Agreement

Pursuant to §120 of CERCLA, some aspects of current management of the RMANWR are included in the Federal Facilities Agreement. This 1989 agreement was designed to govern the cleanup and remediation activities occurring on the Rocky Mountain Arsenal. Section 44.2 of this agreement includes certain restrictions on ownership and use that the Service must currently follow (until amended) including:

- Residential development on the Arsenal shall be prohibited.
- The use of groundwater located under, or surface water located on, the Arsenal as a source of potable water shall be prohibited.
- Consumption of all fish and game taken on the Arsenal shall be prohibited, although hunting and fishing on the Arsenal for non-consumptive use may occur if subject to appropriate restrictions.

- Agricultural, including all farming activities such as the raising of livestock, crops, or vegetables, shall be prohibited. Agricultural practices used in Response Action or used for erosion control, however, shall be permitted.
- Wildlife habitat(s) shall be preserved and managed as necessary to protect endangered species of wildlife to the extent required by the Endangered Species Act, 16 U.S.C. §§ 1531 et seq., migratory birds to the extent required by the Migratory Bird Treaty Act, 16 U.S.C. §§ 703 et seq., and bald eagles to the extent required by the Bald Eagle Protection Act, 16 U.S.C. §§ 668 et seq.
- Other than as many be necessary in connection with a Response Action or as necessary to construct or operate a Response Action Structure, no major alteration shall be permitted in the geophysical characteristics of the Arsenal if such alteration may likely have an adverse effect on the natural drainage of the Arsenal for floodplain management, recharge of groundwater, operation and maintenance of Response Action Structures, or protection of wildlife habitat(s).

Restrictions that do not allow consumption of fish and game and restrictions preventing the raising of livestock present challenges to the Service in long-term management of the refuge. The removal of excess bison, which may be considered game or livestock, is an emerging issue that must be addressed soon. In addition, the Service would like to explore additional opportunities for wildlife-dependent recreation at the refuge including an archery hunt to reduce excess deer (versus culling by refuge staff). The Service believes that both of these restrictions can be adjusted or removed by coordinating with the EPA and Colorado Department of Public Health and Environment.

Prescribed Fire

Another potential constraint to achieving HMP goals and objectives is the inability to apply prescribed fire as a disturbance at the appropriate time and intensity. The effect of smoke dispersal on residential neighborhoods and busy roadways is an obvious concern that must be considered when preparing burn plans. In addition, the initiation of prescribed burns is dependent on Denver-metro air quality. It is acceptable for burns to be conducted on “blue” days, but burns cannot be conducted on “red” days due to air quality considerations. The red/blue air quality category is based on a combination of particulates, carbon dioxide, and ozone, and is determined by the Air Pollution Control Division of the Colorado Department of Health. A “red” day is characterized by little atmospheric movement that would result in the concentration of particulates, such as those that would be generated from a prescribed fire that could pose potential health issues to persons with respiratory problems. Blue days occur when air movement is sufficient to disperse smoke and particulates into the atmosphere. It is anticipated that burn “windows” will become narrower in the future due to increasing residential development around RMANWR, which in turn will also affect future air quality. The increasing complexity of prescribed fire planning, the increased training and qualifications required for firefighters, and the logistical complexities of completing burns using interagency assistance will also continue to limit the amount of prescribed burning that can be implemented.

Aerial Herbicide Application

The use of aerial herbicide application methods must be coordinated with local schools, city governments, and fire departments. Due to the history of contamination, the aerial application of herbicides must be carefully coordinated with outdoor school activities occurring at the new learning center bordering the west edge of the refuge at 72nd and Quebec and with ongoing Visitor Services activities. The development of future retail stores near the northwest boundary of the refuge will also require the same careful coordination. Much of the perceived risk can be mitigated by timing herbicide applications on weekends at very early hours or late in the afternoons when human activity is minimized, and by having Service personnel on the ground to monitor wind speed and direction and direct air operations during herbicide application. The Service is in the process of developing a ‘Fact Sheet’ for the public on the aerial application of herbicides at RMANWR, and plans to post this and additional information on the RMANWR website.

Irrigation

The Service will retain the opportunity to use irrigation for future restoration. However, the cost of irrigation water is high whether purchased directly or pumped on-site with additional water augmentation costs. The scope and acreage of irrigation to complete future restoration sites is tied to climatic conditions and will be directly tied to Service budgets.

The Occurrence of Plague

The timing of plague is unpredictable and can affect habitat management in a variety of ways. The area occupied by prairie dogs at RMANWR in 2012 is estimated to be around 4,000 acres, which is approaching the all-time high prairie dog acreages of the late 1980's. This expansion creates the need to direct more resources to protecting new restoration sites and critical infrastructure (i.e., caps and covers) from occupation. A major plague event will trigger a shift of refuge resources to restoration of native plant communities in prairie dog zones.

Resources Necessary to Successfully Implement HMP

This HMP has made repeated references to the nature and consequences of habitat restoration on a highly disturbed landscape, possibly the most disturbed landscape in the United States. Seeded restoration sites will take decades to stabilize. It is critical that the Service allocate necessary staffing and funding to maintain the health and integrity of restored habitats to protect the large investment of public dollars that has gone into restoration at RMANWR.

Staffing Needed for Implementation of the HMP:

To determine future staffing levels at RMANWR, the following assumptions are necessary to provide stewardship of restored habitats:

1. Current staff is necessary to maintain existing restoration sites and complete restoration of remaining mitigation acreage by 2014 using U.S. Army one-time funding.

2. Following completion of final mitigation seedings, reductions in field staff should be gradual. Restoration stands require a minimum of 5-7 years to reach vegetative success criteria, therefore sufficient staff must be retained to ensure newly seeded sites properly mature.

3. Following completion of initial restoration, there will be areas on the refuge that require additional restoration work, including the potential need to re-seed areas that were originally seeded. In addition, there will always be a need to perform weed control at RMANWR.

Based on these assumptions, a total of three permanent Service positions and a seasonal workforce will be required to implement this plan (Table 11). This does not include current positions not fully dedicated to restoration work that indirectly support this plan (e.g., refuge biologist, maintenance staff, fire personnel, etc.).

Table 11. Staffing resources necessary to implement the Rocky Mountain Arsenal NWR habitat management plan

	Current *(funded by U.S. Army)*		Future *(funded by the Service)*	
Position Title	***Number of Positions***	***Nature of Employment***	***Number of Positions***	***Nature of Employment***
Supervisory Rangeland Management Specialist, GS-12	1	Permanent	1	Phase Out
Rangeland Management Specialist, GS-9	1	Permanent	1	Permanent
Wildlife Refuge Specialist, GS-9	1	Term Appt	1	Permanent

Biological Sciences Tech, GS-7	1	Term Appt	0	Phase Out
Biological Sciences Technician, GS-5	5	Term Appt	1-2	Seasonal
Tractor Operator, WG-7	6	Seasonal	2-4	Seasonal
GIS Specialist, GS-9	1	Term Appt	0	Phase Out

Addendum

Bats are significant components of mammalian diversity and their importance has been of increasing concern to wildlife managers. Everette et al. (2001) completed a study in 1997 and 1998 to determine species richness of bats at the RMANWR. They detected three species foraging at the refuge: big brown bats (*Eptesicus fuscus*), hoary bats (*Lasiurus cinereus*), and silver-haired bats (*Lasionycteris noctivagans*). Big brown bats represented 86% of their captures and two additional species *Myotis* spp. And red bats (*Lasiurus borealis*) were later identified.

With the recent possibility that White Nose Syndrome may spread to Colorado, monitoring of bat species on the RMANWR may be of greater importance. The fungus responsible for White Nose Syndrome (*Geomyces destructans*) has the potential to kill individuals of many of the 18 bat species native to Colorado. Any monitoring would be in accordance with the Colorado's *White-Nose Syndrome Response Plan* (Colorado Division of Parks and Wildlife 2012).

As this emerging issue, the Service has included the following information for future consideration at the RMANWR. Objectives, goals, and strategies for this species will likely focus on baseline inventories and monitoring for disease and may be better discussed and analyzed in the upcoming revision of the CMP.

Big brown bat (*Eptesicus fuscus*)

Range

The big brown bat is distributed from southern Canada through northern South America, including nearly all of the lower 48 United States (Kurta and Baker 1990), up to at least 9000' in elevation (Reid et al. 2006). It is located throughout much of temperate forested North America; it is more restricted to forested highlands in the arid western U.S.

Population Status

In contrast to species such as game animals and breeding birds, bats have suffered from a relative lack of consistent, recurring monitoring, and neither range wide nor regional population estimates are available for the big brown bat. Estimates are further challenged by the species' predisposition to hibernating and rearing young in dispersed colonies in buildings and rock crevices (Lausen and Barclay 2006, Nuebaum et al. 2007), which are often not accounted for in colony counts at larger caves and mines. It is thought that populations of big brown bats may have increased and spread in historical times due to the proliferation of human-built roost structures (Whitaker and Gummer 2000). While big brown bats do suffer mortality when infected with white nose syndrome, the species has shown stable (Ford et al. 2011) or even increasing population trends (Francl et al. 2011) after white nose syndrome infection in the eastern U.S., possibly due to competitive release following population crashes of more susceptible species.

Phenology and demographics

Big brown bats are year-round residents of Colorado. They are obligate hibernators, and typically are in hibernation from October through March or April in this part of their range. Like most hibernating bats, they typically mate in the fall and have delayed fertilization, followed by a 2 month gestation in the spring. Females typically form maternity colonies of 20-300 individuals where they rear young from May to July. Eastern genetic lineages tend to have 2 pups/year, while those west of the Rockies tend to have a single pup. Strongly divergent eastern and western lineages co-occur in the Front Range corridor of Colorado, even within individual colonies (Neubaum et al. 2007). Females tend to be somewhat loyal to these colonies, though genetic evidence argues that there is more dispersal than would be the case under strict philopatry (Vonhof et al. 2008).

Habitat Requirements

During gestation and lactation, female big brown bats prefer roosting in buildings to natural roosts (Lausen and Barclay 2006) and tend to use roosts with warmer temperatures and higher exits from the ground than random buildings (Nuebaum et al. 2007). Males tend to use roosts with lower temperatures (Hamilton and Barclay 1994) and are generally less selective. Bats trapped at RMANWR were tracked to roosts in metro Denver between 9 and 19 km away, much farther than is typical for the species, and no maternity colonies were located on the refuge.

Big brown bats do not show strong habitat associations, so management of individual habitat types is not likely to be critical to the conservation of the species (Agosta 2002). Their foraging activity is negatively associated with impervious surface (Dixon 2012) and has sometimes have lower activity in urban areas (Geggie and Fenton 1985), probably due to lower insect densities in these habitats; however the relationship between land cover and big brown bat activity appears to be related to the landscape context of a given site in the urban matrix (Gehrt and Chelsvig 2004). They are also found more frequently in more open environments (Ford et al. 2005). Big brown bats will consume a variety of prey, though they strongly favor beetles in their diets relative to their availability (Brigham 1990, Agosta 2002, Agosta and Morton 2003, Carter et al. 2003).

Area and Landscape Considerations

In a systematic survey of RMANWR, at least 5 species of bats were observed on the refuge, but 86% of captures were big brown bats (Everette et al. 2001); these trappings results are consistent with a repeat survey in 2004 which found that, of 291 captures, 242 were big brown bats, and 196 of these were adult females (N. Roman unpublished data). This, plus the atypically high commuting distance that radio tagged bats flew from day roosts in Denver to RMANWR to feed, suggests that the refuge is a regionally significant foraging resource for lactating females of that species. Interestingly, because of its history, RMANWR also hosts big brown bats with organochlorine pesticide and other contaminant loads up to an order of magnitude higher than non-contaminated sampling sites (O'Shea et al. 2001), though later sampling shows an apparent decline in these contaminant loads (N. Ronan unpublished data). The fitness consequences of these contaminants, and their relative levels following ongoing remediation, are unknown.

Objective 5.1 (bats)

Maintain a mosaic of wetland and riparian habitat within the grassland matrix of RMANWR to provide foraging habitat for bat populations. Research relationships between vegetation type and height, insect production, and echolocation activity; use findings to define a measurable habitat objective for bats.

Rationale

Research at RMANWR found that the presence of water and tree edge features were significantly associated with echolocation activity, with activity more than 5 times higher along edges than in open prairie. The same study found a disproportionately high ratio of adult female and juvenile big brown and hoary bats, suggesting the importance of the refuge to recruitment in local bat populations (Everette et al. 2001). Unfortunately, data on the necessary area and arrangement of vegetation types to support lactating females and young of the year are not extant, and would need to be developed specifically for RMANWR because of the vastly different caloric expenditures of these high-distance nightly foragers relative to more typical colonies that fly 1-2km per night from day roosts to foraging sites.

Glossary

Adaptive management - the rigorous application of management, research, and monitoring to gain information and experience necessary to assess and modify management activities

Biological diversity - the variety of life and its processes, including the variety of living organisms, the genetic differences among them, and communities and ecosystems in which they occur

Biological integrity - biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities

Environmental health - composition, structure, and functioning of soil, water, air and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment

Fitness - the ability of an organism to survive in its habitat and pass those genes on to subsequent generations

Fragmentation - a state of discontinuity throughout a defined habitat

Goal - descriptive, open-ended, and often broad statement of desires future conditions that conveys a purpose, but does not define measurable units

Habitat island - an area of wildlife habitat delineated by areas of unsuitable wildlife habitat

Historic conditions - composition, structure, and functioning of ecosystems resulting from natural processes that, based on sound professional judgment, were present prior to substantial human related changes to the landscape

Invasive species - any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem; and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Objective - a concise statement that is derived from goals and provides the basis for determining strategies, monitoring refuge accomplishments, and evaluating the success of strategies

Resource of concern - all plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), System mission, or international, national, regional, State, or ecosystem conservation plans or acts

Strategy - a specific action, tool, technique, or combinations of actions, tools and techniques used to meet unit objectives.

Appendix A

Environmental Compliance

Environmental Action Statement

U.S. Fish and Wildlife Service, Region 6
Lakewood, Colorado

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record. I have determined that the action of implementing the "Habitat Management Plan—Rocky Mountain Arsenal National Wildlife Refuge Complex" is found not to have significant environmental effects, as determined by the attached "finding of no significant impact" and the environmental assessment.

____

Project Leader,
Rocky Mountain Arsenal National Wildlife Refuge
U.S. Fish and Wildlife Service
Commerce City, Colorado

____

Refuge Supervisor
U.S. Fish and Wildlife Service
Lakewood, Colorado

____

Assistant Regional Director
National Wildlife Refuge System
U.S. Fish and Wildlife Service
Lakewood, Colorado

Finding of No Significant Impact

U.S. Fish and Wildlife Service, Region 6
Lakewood, Colorado

U.S. Department of the Interior
FISH AND WILDLIFE SERVICE
Region 6, Denver, Colorado

FINDING OF NO SIGNIFICANT IMPACT

Habitat Management Plan – Rocky Mountain Arsenal National Wildlife Refuge
Adams & Denver Counties, Colorado

The U.S. Fish and Wildlife Service (Service) has completed a habitat management plan (HMP) to outline the habitat goals and objectives for the Rocky Mountain Arsenal National Wildlife Refuge (Refuge). This plan describes the goal of native grassland restoration as paramount to meeting the purposes of the Refuge and includes identification of resources of management concern, redesignation of existing habitat management zones, identification of black-tailed prairie dog management zones, and specific strategies to attain these goals. The resulting Environmental Assessment (EA) evaluates two alternatives: Alternative A, a no action alternative; and Alternative B, the preferred alternative, to implement the strategies included in the habitat management plan.

Alternative B, the preferred alternative, was selected for implementation because it best meets the Service's mission to sustain fish and wildlife populations. Restoration of short- and mixed-grass prairie are considered to be of primary importance in achieving the purposes of the Refuge, because these habitats provide the life requisites of numerous migratory bird species, many of which are considered to be species of conservation concern due to population declines. While this plan does include several aspects of intensive management, the goal is to best emulate a functional landscape capable of supporting wildlife populations. The plan identifies all of the components of short- and mixed-grass systems and clearly shows how some species can negatively impact the structure and function of these systems if populations exceed system capacity.

<u>Public Involvement</u>
On April 17, 2013, a press release was issued by the Refuge which announced the release of a draft HMP and associated environmental assessment for 30 days of public comment. An informal public meeting was held on May 1, 2013, at the Refuge visitor center. In addition to comments presented by some of the approximately ___ people who attended this meeting, another ___ written comments were received from individuals, organizations, and agencies. Public comments and responses are included as Section 6 of the EA.

<u>Effects of the Proposed Action</u>
This EA has taken a hard look at the environmental impacts to inform the public and ourselves about the consequences of the proposed action (the Service's preferred alternative).

In determining whether this project is a major action significantly affecting the quality of the human environment, we looked at both the context and intensity of the action (40 CFR § 1508.27, 40 CFR § 1508.14) as required by NEPA. In terms of context, the preferred alternative will occur on the Rocky Mountain Arsenal National Wildlife Refuge, but we have evaluated whether it will have effects on the human environment on a broader scale. Because the human environment and the relationship of people with that environment (40 CFR § 1508.14), in addition to our thorough analysis of physical environmental effects, we carefully considered the manner in which the local people and natural resources relate to the surrounding environment, though economic and social effects are not intended by themselves to require preparation of an environmental impact statement (40 CFR § 1508.14).

The HMP identifies several species as resources of concern. These species act as surrogates for other species and the larger biological environment. HMP goals include restoration of native prairie, which includes designation of habitat for black-tailed prairie dogs, a keystone species and surrogate of the short- and mixed-grass prairie. Native prairie restoration will have beneficial effects to grassland birds, including the lark bunting, grasshopper sparrow, and Cassin's sparrow. The HMP identifies specific treatments necessary to restore short- and mixed-grass prairie and methods to address the threat of invasive plants and noxious weeds. Riparian habitat in the Great Plains is an extremely important resource to wildlife. The HMP outlines goals and strategies to establish baseline conditions and plant replacement cottonwood trees on the RMANWR. These efforts in connection with treatment of invasive plants in woodland will provide beneficial impacts to local bald eagle populations and other associated species. Implementation of the HMP is an essential step in identifying and preparing appropriate lands for reintroduction of the federally endangered black-footed ferret. However, the decision on whether or not to reintroduce ferrets will be ultimately determined during the revision of the CMP, but the ability to do so will is contingent upon the habitat goals outlined in the HMP.

<u>Decision and Finding of No Significant Impact</u>

The analysis indicates that there will not be a significant impact[7], individually or cumulatively, on the quality of the human environment[8] as a result of this proposed action. I agree with this conclusion and therefore find that an EIS need not be prepared. This determination is based on the following factors.

1. Environmental consequences of implementing the strategies included in the habitat management plan, using an adaptive management framework, will result in largely beneficial impacts to fish and wildlife resources. Restoration and long-term monitoring of 4,000 acres of shortgrass and 8,000 acres of mixed-grass prairie will benefit all prairie-dependent species with priority on declining species of grassland birds. Restoration and maintenance of riparian corridors will have beneficial impacts to bald eagles and other associated species. Continued care for wetlands and lacustrine features will have beneficial impacts to a broad variety of wildlife and human users. Based on informal intra-Service section 7 consultation, the proposed action, will not result in the jeopardy of any federally threatened or endangered species, or adversely modify existing designated critical habitat.

2. The proposed action would pose no known risk to public health or safety.

3. The effect on the quality of the human environment is not highly controversial.

4. The proposed action will not affect sites, structures, or objects listed in or eligible for listing in the National Register of Historic Places, nor would it likely cause any loss or destruction of significant scientific, cultural, or historic resources.

5. No significant cumulative effects were identified through this assessment. The EA discussed the cumulative effects on and off the Refuge with those actions proposed by others.

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[7] 40 CFR § 1508.27 "Significantly" as used in NEPA requires considerations of both context and intensity (a) Context. This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), and affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of site-specific action, significance would usually depend upon the effects in the locale rather than in the world *as a* whole. Both short- and long-term effects are relevant; and (b) Intensity. This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action.

[8] 40 CFR § 1508.14 "Human environment" shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment. (See the definition of "effects" (40 CFR § 1508.8).) This means that economic and social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment.

Therefore, in light of the compelling science in support of the plan, and my review of the information contained in the supporting reference, I have determined that implementing the strategies contained in the habitat management plan for the Rocky Mountain Arsenal National Wildlife Refuge is not a major federal action that would significantly affect the quality of the human environment with the meaning of Section 102(2)(C) of NEPA.

The Finding of No Significant Impact (FONSI) and supporting NEPA analysis will be available to the public upon request. Copies of the EA are available for all affected agencies, private groups, and other interested parties. These documents are on file at the Rocky Mountain Arsenal National Wildlife Refuge, 6550 Gateway Road, Building 121, Commerce City, Colorado 80022 (telephone: 303-289-0232).

____

Regional Director, Region 6
U.S. Fish and Wildlife Service
Lakewood, Colorado

Supporting Reference:

U.S. Fish and Wildlife Service. 2013. *Environmental Assessment: Habitat Management Plan : Rocky Mountain Arsenal National Wildlife Refuge*, Commerce City, Colorado.

Intra-Service Section 7 Consultation

Rocky Mountain Arsenal National Wildlife Refuge
Adams & Denver Counties, Colorado

Originating Person: David Lucas Date Submitted: 17 April 2013

Telephone Number: 303-289-0350

I. **Service Program and Geographic Area or Station Name**:
Rocky Mountain Arsenal National Wildlife Refuge

II. **Flexible Funding Program** (e.g. Joint Venture, etc) if applicable:
N/A

III. **Location**: Location of the project including County, State and TSR (township, section & range):
Adams and Denver Counties, Colorado (39.85°N 104.86°W)

IV. **Species/Critical Habitat**: List federally endangered, threatened, proposed, and candidate species or designated or proposed critical habitat that may occur within the action area.

Black-footed ferret (*Mustela nigripes*) - The black-footed ferret is an endangered species where it is located. At this time, no ferrets exist on the Refuge.

Eskimo curlew (*Numenius borealis*) - The Eskimo curlew is a wide ranging bird species that favors open grassy meadows. Habitat fragmentation, loss of prey populations of grasshoppers and commercial hunting are thought to have led to their decline. The endangered Eskimo curlew has never been sighted on the Refuge, and has not been sighted in Colorado since 1965.

Ute ladies'-tresses orchid (*Spiranthes diluvialis*) - The Ute ladies' -tresses orchid is a threatened plant species found along streams, in wetlands, and in other moist habitats along Colorado's Front Range and plains areas in elevations below 6,500 feet. The Refuge contains habitat suitable for the orchid, but surveys of the Refuge have not located any populations of this species.

Platte River species - Several threatened and endangered species, such as whooping crane (*Grus americana*) and piping plover (*Charadrius melodus*) may exist on or near the South Platte River.

V. **Project Description:** Describe proposed project or action or, if referencing other documents, prepare an executive summary (attach additional pages as needed):

Located approximately ten miles from downtown Denver, the Rocky Mountain Arsenal National Wildlife Refuge (RMANWR) encompasses 15,988 contiguous acres. Due to contamination from the production of chemical munitions and pesticides, significant portions of this land underwent environmental cleanup as stipulated in the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) administered by the Environmental Protection Agency (EPA). With the exception of about 1,084 acres that will be retained by the U.S. Army, the balance of land within the boundary was transferred from EPA to U.S. Fish and Wildlife Service (Service) jurisdiction following completion of remediation activities. Although most environmental cleanup was completed by the fall of 2011, native plant restoration activities continue on most lands.

In 2003, the RMANWR began development of its habitat management plan (HMP). The HMP is a step-down management plan of the Comprehensive Conservation Plan (CCP) or, in the case of the RMANWR, the Comprehensive Management Plan (CMP) that was approved in 1996 (U.S. Fish and Wildlife Service 1996a;b). The intent of the HMP is to provide additional details regarding specific strategies and implementation schedules for meeting goals and objectives set forth in the CCP/CMP during a

15-year period. In addition, an HMP provides an opportunity to evaluate the applicability of goals and objectives previously established in the CCP/CMP and determine if changes are required based on available data and other information. HMPs are dynamic documents that are modified using an adaptive management process that is based on monitoring progress toward achieving goals and objectives. In addition, the HMP is evaluated when a refuge considers revisions to the CCP (at least every 15 years) or at 5-year intervals using a peer review process (U.S. Fish and Wildlife Service 2002b). The RMANWR will begin the process of revising its CMP in May 2013.

The proposed action is to implement the HMP for the RMANWR. The scope of this HMP is to:

1. Identify important resources of management concern on RMANWR.
2. Develop goals and objectives that, once achieved, will ensure perpetuation of those resources.
3. Identify management strategies necessary to attain stated goals and objectives.
4. Identify appropriate monitoring strategies to measure progress toward achieving goals and objectives.

Further, using adaptive management techniques, the Service would implement the goals, objectives, and strategies included in this HMP over the next 15 years. This includes restoration of short- and mixed-grass prairie as well as shrubland and woodland communities. The Service would enlarge bison grazing units, designate black-tailed prairie dog management areas, and establish conditions necessary to consider reintroduction of the federally endangered black-footed ferret.

VI. **Determination of Effects:**

(A) Description of Effects: Describe the action(s) that may affect the species and critical habitats listed in item IV. Your rationale for the Section 7 determinations made below (B) should be fully described here.

Black-footed ferret (*Mustela nigripes*)	May Effect (beneficial) – species does not exist on the Refuge at this time, but designation of approximately 2,585 acres for black-tailed prairie dogs will facilitate the stable environment necessary to consider reintroduction of a discrete population of ferrets on the Refuge. The decision on whether or not to reintroduce ferrets will ultimately be determined during the revision of the CMP, but the ability to do so will is contingent upon the habitat goals outlined in this HMP.
Eskimo curlew (*Numenius borealis*)	No Effect – species has not been documented on the Refuge or in the State of Colorado in recent history
Ute ladies'-tresses orchid (*Spiranthes diluvialis*)	No Effect – species has not been documented on the Refuge; proposed action is to burn slash in an upland area behind the maintenance facility
Platte River species	No Effect – species are not present; proposed action will occur between 2 and 6 miles from the South Platte River

(B) Determination: Determine the anticipated effects of the proposed project on species and critical habitats listed in item IV. Check all applicable boxes and list the species (or attach a list) associated with each determination**.**

Determination

No Effect: This determination is appropriate when the proposed project will not directly or indirectly affect (neither negatively nor beneficially) individuals of listed/proposed/candidate species or designated/proposed critical habitat of such species. **No concurrence from ESFO required.** ________

May Affect but Not Likely to Adversely Affect: This determination is appropriate when the proposed project is likely to cause insignificant, discountable, or wholly beneficial effects to individuals of listed species and/or designated critical habitat. **Concurrence from ESFO required.** X

May Affect and Likely to Adversely Affect: This determination is appropriate when the proposed project is likely to adversely impact individuals of listed species and/or designated critical habitat. **Formal consultation with ESFO required.** ________

May affect but Not Likely to Jeopardize candidate or proposed species/critical habitat: This determination is appropriate when the proposed project may affect, but is not expected to jeopardize the continued existence of a species proposed for listing or a candidate species, or adversely modify an area proposed for designation as critical habitat. **Concurrence from ESFO optional.** ________

Likely to Jeopardize candidate or proposed species/critical habitat: This determination is appropriate when the proposed project is reasonably expected to jeopardize the continued existence of a species proposed for listing or a candidate species, or adversely modify an area proposed for designation as critical habitat. **Conferencing with ESFO required.** ________

Signature: **/s/ David Lucas** Date: **April 17, 2013**

Reviewing Ecological Services Office Evaluation (check all that apply):

A. **Concurrence _____** **Nonconcurrence _____**
Explanation for nonconcurrence:

B. Formal consultation required _____
List species or critical habitat unit

C. Conference required _____
List species or critical habitat unit

Name of Reviewing ES Office: ______________________________

Date: ______________

Name of Reviewing ES Office: ______________________________

Date: ______________

Revised 3/2010

1.0 Introduction

This environmental assessment (EA) documents the purpose of and the issues, alternatives, and analysis associated with implementation of a habitat management plan (HMP) for the Rocky Mountain Arsenal National Wildlife Refuge (RMANWR).

The EA provides a comparison of two alternatives: (1) not implementing a habitat management plan for the Refuge (no action) and (2) implementation of the habitat management plan for the Refuge (proposed action). This represents the full range of alternatives and evaluates potential effects on resources protected by the Refuge and associated cultural, socioeconomic, and aesthetic resources that may be affected during implementation of the habitat management plan.

1.1 Rocky Mountain Arsenal National Wildlife Refuge

Located approximately ten miles from downtown Denver, the RMANWR encompasses 15,988 contiguous acres. Due to contamination from the production of chemical munitions and pesticides, significant portions of this land underwent environmental cleanup as stipulated in the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) administered by the Environmental Protection Agency (EPA). With the exception of about 1,084 acres that will be retained and managed by the U.S. Army, the balance of land within the boundary was transferred from EPA to U.S. Fish and Wildlife Service (Service) jurisdiction following completion of remediation activities. Although most environmental cleanup was completed by the fall of 2011, native plant restoration activities continue on most lands.

As the nation’s premier urban national wildlife refuge, the RMANWR is host to a robust environmental education program and a various forms of wildlife-dependent outdoor recreation. The Refuge provides catch-and-release recreational fee fishing, nearly ten miles of trails, a nine mile Wildlife Drive auto tour, wildlife viewing opportunities and site tours for the public.

1.2 Background

The HMP is a step-down management plan of the Comprehensive Conservation Plan (CCP) or, in the case of the RMANWR, the Comprehensive Management Plan (CMP) that was approved in 1996 (U.S. Fish and Wildlife Service 1996a;b). The intent of the HMP is to provide additional details regarding specific strategies and implementation schedules for meeting goals and objectives set forth in the CCP/CMP during a 15-year period. In addition, an HMP provides an opportunity to evaluate the applicability of goals and objectives previously established in the CCP/CMP and determine if changes are required based on available data and other information. HMPs are dynamic documents that are modified using an adaptive management process that is based on monitoring progress toward achieving goals and objectives. In addition, the HMP is evaluated when a refuge considers revisions to the CCP (at least every 15 years) or at 5-year intervals using a peer review process (U.S. Fish and Wildlife Service 2002b). The RMANWR will begin the process of revising its CMP in May 2013.

Section 4(a) and 4(b) of the National Wildlife Refuge System Improvement Act (Improvement Act) directs the Secretary, when administering the National Wildlife Refuge System, to “ensure that the biological integrity, diversity, and health of the System are maintained for the benefit of present and future generations of Americans…” The Improvement Act clearly mandates the use of sound professional judgment when determining the relationships between Refuge purposes and biological integrity, diversity, and environmental health (BIDEH). Further, the BIDEH policy (U.S. Fish and Wildlife Service 2001) clearly emphasizes management that restores historical ecosystem processes and functions as they are directly related to biological integrity and health. Collectively, these mandates instruct Refuge Managers to evaluate the potential to restore BIDEH when critical elements have been lost or severely degraded. The RMANWR HMP plays a key role in this process by defining historical ecosystem functions and to what degree they can be restored and maintained.

1.3 Proposed Action

The Service began development of this HMP in 2003. The proposed action is to implement the HMP for the RMANWR using the principles of adaptive management. The scope of this HMP is to:

1. Identify important resources of management concern on RMANWR.
2. Develop goals and objectives that, once achieved, will ensure perpetuation of those resources.
3. Identify management strategies necessary to attain stated goals and objectives.
4. Identify appropriate monitoring strategies to measure progress toward achieving goals and objectives.

Using adaptive management techniques, the Service would implement the goals, objectives, and strategies included in the HMP over the next 15 years. This includes restoration of short- and mixed-grass prairie as well as shrubland and woodland communities. The Service would enlarge bison grazing units, designate black-tailed prairie dog management areas, and establish conditions necessary to consider reintroduction of the federally endangered black-footed ferret.

1.4 Decisions to Be Made

Based on the analysis provided in this final EA, the Service will make two decisions:

1. Determine whether the Service should implement a habitat management plan for the Rocky Mountain Arsenal National Wildlife Refuge, in accordance with its planning policy.
2. If yes, determine whether the selected alternative will have a significant impact on the quality of the human environment. This decision is required by the National Environmental Policy Act (NEPA). If the quality of the human environment would not be affected, a "finding of no significant impact" will be signed and will be made available to the public. If the preferred alternative would have a significant impact, an environmental impact statement will be prepared to further address those impacts.

1.5 Relation to Statutes, Regulations, and Other Plans

The primary statutory authorities for management of the RMANWR are the Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 (Public Law 102-402) and the National Wildlife Refuge System Administration Act of 1966 (Public Law 89-669), as amended by the National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57). Additional relevant statutes, regulations, and/or plans follow:

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
Pursuant to §120 of CERCLA, some aspects of current management of the RMANWR are included in the Federal Facilities Agreement. The Service currently conducts biomonitoring activities for cleanup parties and must follow certain restrictions on ownership and use including:

- Residential development on the Arsenal shall be prohibited.
- The use of groundwater located under, or surface water located on, the Arsenal as a source of potable water shall be prohibited.
- Consumption of all fish and game taken on the Arsenal shall be prohibited, although hunting and fishing on the Arsenal for non-consumptive use may occur if subject to appropriate restrictions.
- Agricultural, including all farming activities such as the raising of livestock, crops, or vegetables, shall be prohibited. Agricultural practices used in Response Action or used for erosion control, however, shall be permitted.
- Wildlife habitat(s) shall be preserved and managed as necessary to protect endangered species of wildlife to the extent required by the Endangered Species Act, 16 U.S.C. §§ 1531 et seq., migratory birds to the extent required by the Migratory Bird Treaty Act, 16 U.S.C. §§ 703 et seq., and bald eagles to the extent required by the Bald Eagle Protection Act, 16 U.S.C. §§ 668 et seq.
- Other than as many [sic] be necessary in connection with a Response Action or as necessary to construct or operate a Response Action Structure, no major alteration shall be permitted in the geophysical characteristics of the Arsenal if such alteration may likely have an adverse effect on the natural drainage of the Arsenal for floodplain management, recharge of groundwater, operation and maintenance of Response Action Structures, or protection of wildlife habitat(s).

National Environmental Policy Act

NEPA (42 USC 4321-4370f) requires federal agencies to examine the environmental impact of their actions, incorporate environmental information, and utilize public participation, as appropriate, in the planning and implementation of their actions. NEPA compliance is required only when a federal agency takes an action.

- The HMP is a step-down management plan identified in the CMP. An environmental impact statement was completed for the CMP in 1996 (U.S. Fish and Wildlife Service 1996b).
- In addition to the HMP, the Service will release a revised fire management plan, an integrated pest management plan, and an environmental assessment specific to the Service's control of black-tailed prairie dog populations on the RMANWR.
- The RMANWR will begin the process of revising its CMP in May 2013.

National Historic Preservation Act of 1966, as Amended
Section 106 of the National Historic Preservation Act requires federal agencies to assess the effects of an undertaking on historical and cultural resource sites. This is accomplished by inventorying proposed disturbance areas or the area of potential effect (APE), evaluating site importance and eligibility to the NRHP, assessing the effect of the undertaking on National Historic Preservation Act eligible sites, and consulting with appropriate historic preservation agencies. Compliance with Section 106 of National Historic Preservation Act of 1966 was followed for the disturbance activities described in this EA.

Archaeological Resources Protection Act of 1979
The Archaeological Resources Protection Act of 1979 (16 USC 470aa-470mm) and amendments provide for the protection of archaeological resources on public and Native American lands and provide for exchange of information between governmental entities and academic or private archaeological researchers. An archaeological resource under this act is defined as material remains of past human life or activities that are of archaeological interest and includes but is not limited to pottery, basketry, bottles, weapons, tools, structures, rock paintings or carvings, intaglios, graves, and human skeletal materials.

Migratory Bird Treaty Act and Migratory Bird Conservation Act
The Migratory Bird Treaty Act (MBTA) (16 USC 703-712) implements various treaties between the United States and other nations of the MBTA, and provides for the protection of migratory birds and specifies penalties for harming or unlawfully killing migratory birds.

Endangered Species Act
The Endangered Species Act (16 USC 1531-1544) provides for the protection of endangered and threatened species and the habitats upon which they depend. Section 7 of the act requires federal agencies to consult with the Secretary of the Interior or the Secretary of Commerce in cases where the agencies' action may affect a listed species, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of threatened or endangered species or result in the destruction or adverse modification of critical habitat for these species.

2.0 Description of Alternatives

This section describes the two alternatives identified for this project:

- no-action alternative
- proposed action, giving the Service the authority to implement a habitat management plan for the Rocky Mountain Arsenal National Wildlife Refuge

These alternatives were developed according to NEPA §102(2)(E) requirements to "study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternatives uses of available resources." The alternatives consider the effects of planned habitat management activities within the Rocky Mountain Arsenal National Wildlife Refuge boundary.

In addition, alternatives that were eliminated from detailed study are briefly discussed. Effects associated with implementation of other step-down management plans for integrated pest management, fire management, and management of black-tailed prairie dog populations are not included in this analysis.

2.1 Alternative A – (no action)

The Service would continue with its management of the RMANWR in accordance with the goals and objectives outlined in the CMP (U.S. Fish and Wildlife Service 1996a) and HRP (U.S. Fish and Wildlife Service 1999).

2.3 Alternative B – (proposed action)

Using adaptive management techniques, the Service would implement the goals, objectives, and strategies included in the HMP over the next 15 years. This includes restoration of short- and mixed-grass prairie as well as shrubland and woodland communities. The Service would enlarge bison grazing units, designate black-tailed prairie dog management areas, and establish conditions necessary to consider reintroduction of the federally endangered black-footed ferret.

2.4 Alternatives Considered but Eliminated from Further Analysis

The HMP is a step-down management plan. There was little controversy associated with the direction outlined in the CMP and there were no additional alternatives considered in this analysis.

3.0 Affected Environment

Please see a discussion of the resources and affected environment in Chapters 2 and 3 of the HMP in this volume.

4.0 Environmental Consequences

For alternatives A and B described in section 2, the following narrative documents the analysis of any significant environmental effects expected to occur from implementing each of the alternatives. For the purposes of this EA, the Service analyzed the potential effects of implementing each alternative on all resources protected by the Refuge, including the following:

4.1 Effects on the Physical Environment

The estimated effects of each alternative on mineral, soil, and water resources, and on the Service's ability to address climate change, are described below.

Alternative A
The land surface of RMANWR has been shaped largely by erosional and depositional processes associated with the South Platte River and its tributaries. These processes have been stopped by surrounding urban development and will not occur in the future. Under alternative A, the Service would continue with its management of the RMANWR in accordance with the goals and objectives outlined in its CMP and in accordance with its policies and procedures regarding climate change.

Alternative B
Implementation of the HMP includes several steps that are considered beneficial to the soils and water resources of the Refuge. Restoration of native plant communities will have beneficial effects on soils and water quality on the RMANWR. In addition, restored plant communities will be more resilient to potential effects resulting from climate change to the benefit of the RMANWR and the wildlife species it supports.

4.2 Effects on the Biological Environment

This section describes the likely effects of the project on species and their habitats.

Alternative A
During U.S. Army ownership, thousands of acres of abandoned cultivated lands were allowed to revegetate naturally. Problems with weeds and blowing soils, however, resulted in the U.S. Army initiating a grass seeding program that according to some estimates included seeding much as 6,200 acres of crested wheatgrass, an invasive species. Cleanup activities disturbed large areas of the RMANWR with the excavation of soils and creation of temporary improvements. The extent of disturbed prairie was extensive and is estimated at approximately 65%.

As required by CERCLA, restoration of native short- and mixed-grass prairie would continue to the levels required by the Habitat Restoration Plan (U.S. Fish and Wildlife Service 1999). Under alternative A, the Service would continue with its management of the RMANWR in accordance with the goals and objectives outlined in its CMP, but would not maintain or restore further sites. Similar to surrounding lands, the RMANWR contains many invasive plant species and noxious weeds (see Table 2 of the HMP). These invasives alter the heterogeneity of short and mixed-grass prairie with detrimental effects to grassland birds and other prairie species. Under alternative A, the Service will continue to manage weeds, but at lessor levels than identified in the HMP. It is believed that current cottonwood galleries likely established following a 1933 flood event. These trees are currently used by nesting and roosting bald eagles, a species protected by federal statute. Under alternative A, the Service will not attempt to restore cottonwood and associated riparian habitats.

The HMP fully describes the importance of bison to restoring biodiversity of short- and mixed-grass prairie ecosystems. Bison were reintroduced to the RMANWR in 2007. The herd currently numbers 70 animals in two grazing units encompassing approximately 2,370 acres. Under alternative A, the Service would not expand bison grazing to other parts of the Refuge with potentially negative effects to restored lands.

Alternative B
The HMP identifies several species as resources of concern (see Table 3 of the HMP). These species act as surrogates for other species and the larger biological environment. HMP goals include restoration of native prairie, which includes designation of habitat for black-tailed prairie dogs, a keystone species and surrogate of the short- and mixed-grass prairie. Native prairie restoration will have beneficial effects to grassland birds, including the lark bunting, grasshopper sparrow, and Cassin's sparrow. The HMP identifies specific treatments necessary to restore short- and mixed-grass prairie and methods to address the threat of invasive plants and noxious weeds. Riparian habitat in the Great Plains is an extremely important resource to wildlife. The HMP outlines goals and strategies to establish baseline conditions and plant replacement cottonwood trees on the RMANWR. These efforts in connection with treatment of invasive plants in woodland will provide beneficial impacts to local bald eagle populations and other associated species.

Lastly, an intra-Service Section 7 consultation will be completed on the proposed action to ensure there will not be negative impacts to any species listed under the federal Endangered Species Act of 1973. Implementation of the HMP is an essential step in identifying and preparing appropriate lands for reintroduction of the federally endangered black-footed ferret. The decision on whether or not to reintroduce ferrets will be ultimately determined during the revision of the CMP, but the ability to do so will is contingent upon the habitat goals outlined in the HMP.

4.3 Effects on Cultural Resources

The estimated effects of each alternative on cultural resources are described below.

Alternative A
No effect. Under alternative A, the Service would continue with its management of the RMANWR in accordance with the goals and objectives outlined in its CMP and in accordance with the National Historic Preservation Act of 1966 and Archaeological Resources Protection Act of 1979.

Alternative B
No effect. Under alternative B, the Service would implement the HMP in accordance with the goals and objectives outlined in its CMP and in accordance with the National Historic Preservation Act of 1966 and Archaeological Resources Protection Act of 1979. The HMP does not include activities that will impact RMANWR cultural or historic sites.

4.4 Effects on Socioeconomic Environment

This section describes the estimated effects of the alternatives on land use, ecosystem services, land ownership, and the regional economy.

Alternative A
No effect. The population of the Denver-Metro area (Denver, Adams, Jefferson, Douglas, Arapahoe, Boulder, and Broomfield counties) was 2,543,482 people according to the 2010 census (U.S. Census Bureau 2012). Under alternative A, the Service would continue with its management of the RMANWR in accordance with the goals and objectives outlined in its CMP with little to no effect on the local economy.

Alternative B
Implementation of the HMP provides the opportunity to clearly identify habitat management goals and objectives for large segments of the RMANWR. Implementation of alternative B will not only provide increased habitat quality for wildlife, but will enhance opportunities for the public to pursue wildlife-dependent recreation on the RMANWR. These increases are important to neighboring communities, but they are not a significant impact to the regional economy of the greater Denver-Metro area.

4.5 Irreversible and Irretrievable Commitment of Resources

Any commitments of resources that may be irreversible or irretrievable because of carrying out alternatives A or B are described below.

Alternative A
There would be no commitment of resources by the Service if alternative A were selected. The Service could still exercise its existing authority to manage the Refuge in accordance with the 1996 CMP.

Alternative B
Implementation of the HMP would not, of itself, constitute an irreversible or irretrievable commitment of resources. The implementation of habitat management activities and appropriate monitoring of these actions would represent a minor increase in overall Service costs borne by the RMANWR.

4.6 Cumulative Impacts

As defined by NEPA regulations, a cumulative impact on the environment "results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions" (40 CFR 1508.7). The following describes the past, present, and reasonably foreseeable actions related with implementation of a habitat management plan. A discussion follows regarding the cumulative impacts of these actions in combination with the actions of alternatives A and B.

Past, present, and reasonably foreseeable future actions
The Service completed its CMP in 1996 (U.S. Fish and Wildlife Service 1996a). This CMP provided guidance and direction to the management of the RMANWR during the cleanup process. The RMANWR will begin the process of revising its CMP in May 2013. This revision will guide activities for the next 15 years. In addition, the Service will release a revised fire management plan, an integrated pest management plan, and an environmental assessment specific to the Service's control of black-tailed prairie dog populations on the RMANWR

Alternative A
Under alternative A, there would be no cumulative impacts on the environment since the Service would not undertake any of the habitat management activities included in the HMP.

Alternative B
The RMANWR is surrounded by urban development. Management actions occurring on the RMANWR are often incorrectly considered as isolated from larger ecosystems. The goals and strategies outlined in the HMP do have do impact wildlife species at larger scales, but the cumulative impacts of these actions is not considered significant.

5.0 Coordination and Environmental Review

This section describes how the Service coordinated with others and conducted environmental reviews of various aspects of the project proposal and analysis. Additional coordination and review would be needed to carry out the proposed action, if selected.

5.1 Agency Coordination

The Service has discussed the HMP with other Federal (U.S. Army and the EPA), State of Colorado (Colorado Parks and Wildlife, Colorado Department of Public Health and Environment), local county governments, and regional entities (Tri-County Health Department, Stapleton Redevelopment Foundation, Denver Water) through a series of meetings and correspondence. Tribes with an aboriginal interest in the Rocky Mountain Arsenal were invited to participate or formally consult in the planning process (Northern Arapaho Tribe, Northern

Cheyenne Tribe, Southern Ute Tribe, and the Ute Mountain Ute Tribe). The Service's Regional Archaeologist consulted with the State Historic Preservation Officer. A number of nongovernmental organizations are active in the RMANWR and were also consulted, including the Friend's of the Front Range National Wildlife Refuges.

The Service coordinated internally in the development of this EA as well. RMANWR staff conducted the analysis and prepared this document, as well as the HMP. An intra-service Endangered Species Act section 7 consultation was conducted, and resulted in a finding of "May affect but not likely to adversely affect" ESA protected or candidate species (Appendix A). Region 6 biological and water resources staff assisted with the development of resources of concern and specific habitat management activities. The Region 6 regional archeologist has also reviewed this plan (see Appendix B, List of Preparers and Reviewers).

5.2 National Environmental Policy Act

The Service conducted this environmental analysis under the authority of and in compliance with NEPA, which requires an evaluation of reasonable alternatives that will meet stated objectives, and an assessment of the possible effects on the natural and human environment.

5.3 Environmental Assessment

This EA will be the basis for determining whether the implementation of the proposed action would constitute a major federal action significantly affecting the quality of the natural and human environments. NEPA planning for this EA involved other government agencies and the public in the identification of issues and alternatives for the proposed project.

5.4 Distribution and Availability

The Service will make the draft EA (with the associated HMP in the same volume) available to the project mailing list, which includes federal and State legislative delegations; tribes; federal, State, and local agencies; nongovernmental organizations; and interested individuals. Copies may be requested from the RMANWR.

6.0 Public Comments

Appendix B

List of Preparers &Reviewers

List of Preparers

Author's Name	***Position***	***Work Unit***
Mike Artmann	Fish and Wildlife Biologist	Regional Office (Lakewood, Colo.)
Lisa Brashear	Biological Science Technician	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Joel Colvin	Biological Science Technician	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Michael Dixon	Fish and Wildlife Biologist	Regional Office (Lakewood, Colo.)
Brian Fairchild	Biological Science Technician	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Bruce Hastings	Deputy Project Leader	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Mindy Hedrick	Refuge Biologist	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Mark Kalitowski	Refuge GIS Specialist	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Murray Laubhan	Zone Refuge Biologist	Quivira NWR (Stafford, Kans.)
David Lucas	Project Leader	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Scott Quayle	Biological Sciences Technician	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Tom Ronning	Refuge Operations Specialist	Rocky Mountain Arsenal NWR (Commerce City, Colo.)
Terry Wright	Supervisory Rangeland Management Specialist	Rocky Mountain Arsenal NWR (Commerce City, Colo.)

List of Reviewers

Reviewer's Name	***Position***	***Work Unit***
Barbara Boyle	Zone Refuge Supervisor	Regional Office (Lakewood, Colo.)
Meg Estep	Chief, Water Resources	Regional Office (Lakewood, Colo.)
Wayne King	Chief, Biological Resources	Regional Office (Lakewood, Colo.)
Meg Van Ness	Regional Archaeologist	Regional Office (Lakewood, Colo.)

Appendix C

Relationship to other management plans

Table C. Relationship to other plans

Plan	***Mission***	***Objectives relevant to Refuge purposes***	***Affected habitat/ resource of concern***
Multi-state conservation plan for black-tailed prairie dogs (Luce 2003)	Provide long-term conservation of the black-tailed prairie dog and preclude the need for Endangered Species Act listing.	- maintain currently occupied area in the U.S and increase to 1,693,695 acres in the U.S. by 2011 (255,733 acres in Colorado) - maintain at least 10% of total occupied area in colonies or complexes greater than 1,000 acres - maintain distribution over at least 75% of counties in the historic range or at least 75% of the historic geographic distribution - maximize conservation potential among federal and state land management agencies by coordinating through state management plans	black-tailed prairie dog shortgrass prairie
Northern states bald eagle recovery plan (U.S. Fish and Wildlife Service 1983)	Re-establish self-sustaining populations in suitable habitat throughout the Northern States Region.	- tentative goal of 1,200 occupied breeding areas distributed over a minimum of 16 states within the Region by 2000, with average annual productivity of at least 1.0 young per nest - suitable habitat for individual and population growth and normal behavior throughout the annual cycle	bald eagle riparian habitats
Platte/ Kansas Rivers Ecosystem : analysis and conservation focus area development (U.S. Fish and Wildlife Service 2008)	Identify key resource components and threats within the ecosystem and initiate plans and actions to minimize threats to promote landscape level conservation efforts with partners.	- native grasslands remain the predominant habitat and conversion to other uses is minimized - habitat values of existing grasslands are restored - threatened, endangered and endemic species are protected - based decisions on the best available scientific data and adaptive management	bald eagle black-tailed prairie dog shortgrass prairie
Colorado's comprehensive wildlife conservation strategy & wildlife action plans (Colorado Division of Wildlife 2006)	Identify the threats to species of greatest conservation need and habitats upon which they depend and strategies to lesson those threats.	- encourage natural regeneration of old growth riparian habitats - revegetation and control of invasive species in the shortgrass prairie - reduce plague outbreaks and maintain appropriate patch size and habitat mosaic for black-tailed prairie dogs	bald eagle Cassin's sparrow Swainson's hawk burrowing owl lark bunting black-tailed prairie dog bison
Conservation plan for grassland species of Colorado (Colorado Division of Wildlife 2003)	Ensure, at a minimum, the viability of the black-tailed prairie dog and associated species and provide mechanisms to manage for	- raise awareness of grassland conservation needs within the private and public sector - raise awareness of grassland wildlife of high conservation concern, including how to identify species, habitat needs, and management recommendations	black-tailed prairie dog burrowing owl

	populations beyond minimum levels while addressing the interests and rights of private landowners.	- promote long-term conservation and sustainable use of grassland wildlife and their habitats; - CDOW (Colorado Division of Wildlife) will encourage significant contributions from publicly owned lands, particularly the National Grasslands, toward grassland species conservation and work with federal, state, county and municipal partners to support these efforts.	
North American Waterfowl Management Plan (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986, U.S. Fish and Wildlife Service et al. 1994;2012) & Playa Lakes Joint Venture area implementation plan for the shortgrass prairie (Playa Lakes Joint Venture 2008)	Conserve the habitat of some 400 species of shorebirds, waterfowl, waterbirds, and landbirds that utilize playa lakes and associated habitats.	- acquire, maintain, and restore suitable habitat for migratory birds in the Central Flyway	Cassin's sparrow lark bunting short- & mixed-grass prairie
Colorado Partners in Flight bird conservation plan (Beidleman 2000)	Establish objectives for preserving or conserving bird populations and their habitats in Colorado.	- monitor habitats and associated breeding birds - identify core habitat areas for breeding, migration, and breeding - implement site-based conservation, promote best management practices, and incorporate adaptive management into decision-making	Swainson's hawk burrowing owl Cassin's sparrow grasshopper sparrow lark bunting short- & mixed-grass prairie
Central shortgrass prairie ecoregional assessment and partnership initiative (The Nature Conservancy 2006)	Identify a portfolio of sites and strategies to protect the species and natural communities' representative of the ecoregion and thereby conserve species diversity.	- identify species, plant communities, terrestrial and aquatic ecological systems that represent the biodiversity of the ecoregion - develop conservation goals to maintain targets or groups of targets - assess the ecological condition of sites to identify priority areas and conservation strategies - develop management guidance templates for selected species at risk.	burrowing owl Cassin's sparrow bald eagle black-tailed prairie dog bison short- & mixed-grass prairie
Rocky Mountain Arsenal NWR CMP (U.S. Fish and Wildlife Service 1996a)	Enhance and sustain fish, wildlife, and habitats to provide the public with meaningful opportunities to experience nature near an urban area.	- restore, maintain, and enhance terrestrial and aquatic habitats - manage RMANWR for sustainable wildlife communities that meet the purposes of the refuge	burrowing owl bald eagle black-tailed prairie dog bison grassland & riparian habitats

Appendix D

Summary of Habitat Goals and Objectives

Original 1996 CMP Habitat Management Goals

Only one of the six management goals in the 1996 CMP pertains to habitat management:

> "Manage wildlife and habitat to contribute to ecosystem management using strategies that recognize the Refuge's different resource types and the varying purposes specified in the enabling legislation." (U.S. Fish and Wildlife Service 1996a).

From this broad goal, eleven management *principles* were developed which pertained to both the Northern [Prairie] and Southern [Educational] Zones. Not all of these principles relate specifically to habitat management, and they serve more as good ideas than as measurable habitat objectives. Three management principles were developed specifically for the Prairie Zone and four management principles were developed specifically for the Educational Zone.

Management principles for the Prairie Zone:

1. Manage and restore the prairie zone of the Refuge as habitat for indigenous species.
2. Promote the preservation and establishment of native plants and animal species to encourage self-sustainable systems.
3. Preserve, enhance, restore, and augment prairie dog communities.

Management principles for the Educational Zone are:

1. Manage and improve the educational zone of the Refuge to maintain and enhance diverse habitats for wildlife populations at appropriate densities.
2. Preserve, enhance, and augment wetlands for use by waterfowl, fish and shore birds (also applies to First Creek in both zones).
3. Promote the preservation and establishment of native plant species to maintain or enhance habitat values for wildlife.

Management principles for both the Prairie and Educational Zones:

1. Preserve, enhance, and augment grasslands for use by songbirds and other grassland-related species.
2. Reintroduce and manage appropriate indigenous species.
3. Conserve and enhance species listed as threatened or endangered under the Endangered Species Act, species that are candidates for such listing and sensitive or regionally declining species.
4. Manage First Creek as an important riparian corridor and restore degraded portions.

Summary of CMP, HRP, and MWE Management Goals, Objectives

When the goals and objectives of the Refuge CMP, the HRP, and the *Conceptual Plan for First Creek* by MWE are organized according to the CMP objectives under which they apply, a myriad of written objectives and strategies unfolds.

Most fail to meet the *SMART* criteria, so that there is no linkage between wildlife habitat goals and vegetative goals.

The following list is a highlighted compilation of all of the Goal 1 Objectives described in the CMP, in general terms, combined with supporting goals and objectives from the Refuge Habitat Restoration Plan (U.S. Fish and Wildlife Service 1999) and the *Conceptual Plan for First Creek* (McLaughlin Water Engineers Ltd. 1994). They are listed here primarily for reference, to give the reader a sense of what direction the management of the refuge was intended to be. The majority of these concepts will be incorporated into the new HMP management goals and objectives. The difference is the new HMP goals and objectives will tie the habitat needs of the Resources of Concern to specific vegetative/habitat requirements.

A. Habitat Management Objectives for the Prairie Zone:

1. *Restore native plant communities consisting of 70-100% grasses and 0-30% forbs and shallow-rooted shrubs (CMP).*
2. *Restore important components of the native plant communities thought to have existed prior to European settlement (HRP Goal 3)*
3. *Reintroduce a herd of 10-100 bison in the prairie zone within 5 years of cleanup completion (CMP).*
4. *Develop stable vegetation communities for native wildlife species, including small mammals, grassland birds, those species emphasized in the "Goals and Objectives" section of the CMP (BTPD's, deer, bison, pronghorn, prairie grouse) (HRP, Goal 4)*
5. *Ensure that enough grassland (TBD) is available for 10-100 bison within 5 years of the completion of cleanup. (HRP Goal 4, Objective D).*

B. Habitat Management Objectives for the Educational Zone:

1. *On restoration/enhancement areas, restore 1,000 to 1,500 acres to native grasses, and maintain the remaining habitat in areas as identified on the Service's map of restoration priorities. (CMP)*
2. *On undisturbed habitat, maintain 5,000 acres of existing vegetative composition of 70-90 per cent grassland and 10-30 per cent woody vegetation according to priority areas identified by the Service. Woody vegetation will continue to be dominated by cottonwoods, New Mexico locust thickets, white poplar, sumac, and Siberian elm. This maintenance program is on-going and will sustain current habitat values for existing wildlife species through the 15 year planning horizon. (CMP)*
3. *Maintain woodlands by supplementing dead trees with living ones, usually by transplanting with native species whenever appropriate. Dead trees usually will be left in place for nesting and perching value. If habitat value cannot be approximated by replacement with native plant species, then some exotic plants may be used unless the species is considered invasive (e.g., Russian olive) (HRP, Goal 6)*
4. *Develop stable vegetation communities for native wildlife species, including small mammals, grassland birds, and those species emphasized in the "Goals and Objectives" section of the CMP (prairie dogs, deer, bison, pronghorn, prairie grouse.*
5. *Small mammals and grassland birds will benefit within 10 years of seeding. (HRP, Goal 4, Objective A)*

C. Habitat Management Goals for First Creek/Riparian/Wetland

Manage First Creek as an important riparian corridor and restore degraded portions. Restore and improve the First Creek riparian corridor, including upland tree replacement, restoring riparian vegetation, and restoring flow to portions of the old stream channel. The Service will restore and improve First Creek according to the First Creek Restoration Plan (CMP), which includes:

A. *Restore where ever possible alignment and characteristics of First Creek and associated wetlands to pre-*

cultivated condition (MWE plan).

- B. *The important features of First Creek believed to have existed prior to European settlement will be restored within 5 years of cleanup completion. (pg15). Restore stream meandering where appropriate, particularly in reaches within Sections 19, 24, 30, and possibly 5. (HRP Goal 5, Objective 1)*
- C. *Install drop structures to prevent further erosion (CMP). Control increased flows and related erosion by helping to design a potential detention facility in Section 8, constructing one to four grade control structures in Section 5, and installing biotechnical bank protection in potentially all sections (HRP).*
- D. *Enlarge / improve Bald Eagle shallows, if required, by the Urban Drainage and Flood Control District Master Plan (when completed) (CMP).*
- E. *Restore and create wetlands in the First Creek corridor (CMP).*
- F. *Restore functions and values of wetlands by crushing underground tile, guiding borrow activities adjacent to First Creek, and planting appropriate wetland species particularly in Sections 24, 30, and 31. (HRP Goal 5, Objective 4)*
- G. *Restore riparian vegetation and replace upland trees (CMP).*
- H. *Revegetation goals: increase the over story canopy in the open reaches; increase the extent of wetland areas; increase the biodiversity of the existing vegetation communities; increase the understory woody species (MWE plan)*
- I. *Restore riparian vegetation by planting clusters of native woody and grassland communities throughout the stream corridor. (HRP Goal 5, Objective 5)*
- J. *Control 90-100% of the Russian olive plants through both mechanical and chemical means, while leaving many dead mature olive trees in place for perches. (HRP Goal 5, Objective 6)*
- K. *Control other weedy or nuisance species (e.g., 100% of salt cedar, 75-100% of Canada thistle (Cirsium arvense), and 10-15% of cattails (Typha spp.) pg. 16 (HRP Goal 5, Objective 7)*
- L. *Protect known bald eagle habitats, and ensure that proposed improvements are compatible with existing and planned roost protection measures (MWE).*
- M. *Protect known bald eagle habitats, particularly the eagle roost in Section 5, probably with construction of a flood channel to divert flows greater than 300 cfs west of the roost. (HRP Goal 5, Objective 4)*
- N. *Control increased flows associated with upstream development of First Creek and its watershed. Ensure compatibility with the need for future water retention and detention on First Creek. (MWE plan)*
- O. *Refine existing plans for eagle roost bypass to incorporate habitat and aesthetic concerns. (MWE plan)*
- P. *To provide habitat for abundant and diverse terrestrial and aquatic organisms, manage storm water, and provide environmental education opportunities. (CMP).*
- Q. *Preserve, enhance, and augment wetlands for use by waterfowls, fish, and shore birds (also applies to First Creek in both zones- CMP pg. 48).*
- R. *Create new wetlands resulting from cleanup borrow pits. (CMP)*
- S. *Maintain the existing lakes and wetlands water levels (CMP pg52)*

D. Refuge-Wide 1996 CMP Habitat/Wildlife Management Goals

1. *Manage Prairie Dog Communities (from CMP):*
    - A. *The Service will strive to maintain 3,500 to 5,000 acres of prairie dog colonies to serve primarily as a year-round regional prey base for raptors and habitat for other wildlife species.*
    - B. *Control plague and minimize public health risks.*
    - C. *Maintain isolated colonies in selected areas to serve as population reservoirs in the event of plague episodes. These colonies would be 50 acres or less in size (pg. 104, CMP)*
    - D. *Control prairie dog use of capped areas and landfills. (CMP)*
    - E. *Control the introduction / colonization of prairie dogs into selected habitat restoration areas to allow revegetation establishment (CMP pg104)*

F. Relocate prairie dogs in appropriate areas by live trapping (CMP).

G. Establish new grasslands such that a total of 3,500 to 5,000 acres of appropriate native vegetation are available as stable prairie dog habitat within 5 years of cleanup completion. (HRP Goal 4, Objective B) Pg. 15 HRP

2. Deer Management (CMP and HRP)

A. The Service will use a variety of management techniques to control numbers including culling/hunting and contraception.(CMP)

B. Herd should be managed at or below the carrying capacity for the Refuge/325-550 animals. (CMP)

C. Maintain a population free from CWD / healthy herd. (CMP)

D. Prevent population from significantly degrading habitat for other species. (CMP)

E. Sustain the existing habitat diversity caused by the historical modification to the native landscapes. (CMP)

F. Ensure that enough browse (i.e., forbs and shrubs) is available to maintain a pre-determined number of mule and white-tailed deer. (HRP Goal 4, Objective C).

3. Species Reintroductions:

A. Reintroduce a herd of 15-30 pronghorn which would roam Refuge-wide, within 5 years after cleanup completion (CMP).

1. Develop enough (TBD) habitats to sustain a herd of 15-30 pronghorn within 5 years of the completions of cleanup. Herd would be Refuge wide. (CMP pg. 94, HRP Goal 4, Objective E).)

B. Reintroduction of Greater Prairie Chickens, Plains Sharp-tailed Grouse

1. Establish appropriate habitats for a self-sustaining population of either greater prairie chicken or Plains sharp-tailed grouse. (HRP, Goal 4, Objective F)

C. Reintroduction of Bison—"the Service may reintroduce a herd of 10-100 bison in the northern zone within 5 years after cleanup completion." (CMP pg52)

Appendix E

Current Seed Mixes

There are five seed mixes currently used for restoration as well as a seed mix used for black-tailed prairie dog habitat restoration:

1. Haplustoll (Overflow Range Site)
2. Ascalon/Bresser (Sandy Plains Range Site)
3. Nunn Clay (Clayey Plains Range Site)
4. Petrocalcic (Gravel Breaks Range Site)
5. Santana Weld (Loamy Plains Range Site)
6. Black-tailed Prairie Dog Habitat Restoration

The following charts display the breakdown of species composition and percentages. However, it should be noted that the following figures are averages and are subject to change based on the specified needs of each restoration site.

Table E-1. Current seed mix for Haplustoll soils (Overflow Range Site)

Scientific Name	***Common Name***	***Percent of mix***
Grass species (95%)		
Bouteloua curtipendula	Sideoats grama	12.00%
Bouteloua gracilis	Blue grama	12.00%
Elymus canadensis	Canada wildrye	12.00%
Elymus trachycaulus	Slender wheatgrass	12.90%
Koeleria macrantha	Prairie junegrass	5.00%
Nasella viridula	Green needlegrass	2.00%
Panicum virgatum	Switchgrass	12.00%
Pascopyron smithii	Western wheatgrass	15.00%
Sorghastrum avenaceum	Yellow indiangrass	12.00%
Sporobolus cryptandrus	Sand dropseed	0.10%
Forb species (5%)		
Dalea purpurea	Purple prairie-clover	1.00%
Helianthus annuus	Annual sunflower	1.00%
Ratibida columnifera	Prairie coneflower	1.00%
Rosa woodsii	Wood's rose	1.00%
Rudbeckia hirta	Black-eyed susan	1.00%

Table E-2. Current seed mix for Ascalon/Bresser soils (Sandy Plains Range Site)

Scientific Name	***Common Name***	***Percent of mix***

Grass species (90%)		
Andropogon hallii	Sand Bluestem	2.0%
Bouteloua curtipendula	Sideoats Grama	5.0%
Bouteloua gracilis	Blue Grama	15.0%
Bouteloua dactyloides	Buffalo grass	15.0%
Calamovilfa longifolia	Prairie Sandreed	15.0%
Hesperostipa comata	Needleandthread	0.0%
Koeleria macrantha	Prairie Junegrass	4.0%
Nasella viridula	Green Needlegrass	1.0%
Achnatherum hymenoides	Indian Ricegrass	3.0%
Panicum virgatum	Switchgrass	5.0%
Pascopyron smithii	Western Wheatgrass	10.0%
Schizachyrium scoparium	Little bluestem	14.9%
Sporobolus cryptandrus	Sand dropseed	0.1%
Forb species (5%)		
Achillea lanulosa	Yarrow	0.227%
Artemisia frigida	Fringed sage	0.909%
Artemisia ludoviciana	Louisiana sagewort	0.455%
Cleome serrulata	Rocky Mountain Bee plant	0.227%
Coreopsis tinctoria	Plains coreopsis	0.227%
Gaillardia aristata	Blanket flower	0.455%
Helianthus annuus	Annual sunflower	0.227%
Liatris punctata	Dotted gayfeather	0.000%
Linum lewisii	Blue flax	0.455%
Oenothera villosa	Tall evening-primrose	0.455%
Penstemon angustifolius	Narrow-leaf penstemon	0.455%
Sphaeralcea coccinea	Scarlett globemallow	0.909%
Shrub species (5%)		
Atriplex canescens	Fourwing saltbush	1.65%
Ericameria nauseosus	Rubber rabbitbrush	1.65%
Krascheninnikovia lanata	Winterfat	1.65%
Yucca glauca	Yucca	0.05%

Table E-3. Current seed mix for Nunn Clay soils (Clayey Plains Range Site)

Scientific Name	***Common Name***	***Percent of mix***
Grass Species (90%)		
Bouteloua gracilis	Blue grama	25.00%
Bouteloua dactyloides	Buffalo grass	25.00%
Koeleria macrantha	Prairie junegrass	2.40%
Nassella viridula	Green needlegrass	15.00%

Pascopyron smithii	Western wheatgrass	20.00%
Schizachyrium scoparium	Little bluestem	2.50%
Sporobolus cryptandrus	Sand dropseed	0.10%
Forb Species (5%)		
Achillea lanulosa	Yarrow	0.43%
Artemisia frigida	Fringed sage	0.83%
Artemisia ludoviciana	Louisiana sagewort	0.56%
Cleome serrulata	Rocky Mountain bee plant	0.23%
Coreopsis tinctoria	Plains coreopsis	0.28%
Gaillardia aristata	Blanket flower	0.55%
Helianthus annuus	Annual sunflower	0.55%
Linum lewisii	Blue flax	0.46%
Penstemon angustifolia	Narrow-leaf penstemon	0.28%
Sphaeralcea coccinea	Scarlet globemallow	0.83%
Shrub species (5%)		
Atriplex canescens	Fourwing saltbush	2.50%
Ericameria nauseosus	Rubber rabbitbrush	2.50%

Table E-4. Current seed mix for Petrocalcic soils (Gravel Breaks Range Site)

Scientific Name	***Common Name***	***Percent of mix***
Grass species (90%)		
Bouteloua curtipendula	Sideoats grama	20.00%
Bouteloua gracilis	Blue grama	15.00%
Hesperostipa comata	Needleandthread	0.00%
Koeleria macrantha	Prairie junegrass	3.00%
Oryzopsis hymenoides	Indian ricegrass	12.00%
Pascopyron smithii	Western wheatgrass	12.00%
Poa secunda	Sandberg bluegrass	5.00%
Schizachyrium scoparium	Little bluestem	21.00%
Sporobolus cryptandrus	Sand dropseed	2.00%
Forb species (5%)		
Achillea lanulosa	Yarrow	0.63%
Artemisia frigida	Fringed sage	0.63%
Artemisia ludoviciana	Louisiana sagewort	0.63%
Gutierrezia sarothrae	Broom snakeweed	0.63%
Helianthus annuus	Annual sunflower	0.63%
Liatris punctata	Dotted gayfeather	0.00%
Linum lewisii	Blue flax	0.63%
Penstemon angustifolia	Narrow-leaf penstemon	0.63%
Sphaeralcea coccinea	Scarlet globemallow	0.63%

Shrub species (5%)		
Atriplex canescens	Fourwing saltbush	1.25%
Ericameria nauseosus	Rubber rabbitbrush	1.25%
Krascheninnikovia lanata	Winterfat	2.00%
Yucca glauca	Yucca	0.50%

Table E-5. Current seed mix for Santana Weld soils (Loamy Plains Range Site)

Scientific Name	***Common Name***	***Percent of mix***
Grass species (90%)		
Bouteloua curtipendula	Sideoats Grama	10.00%
Bouteloua gracilis	Blue grama	18.00%
Bouteloua dactyloides	Buffalo grass	18.00%
Elymus elymoides	Bottlebrush Squirreltail	5.00%
Koeleria macrantha	Prairie Junegrass	2.00%
Nasella viridula	Green Needlegrass	1.00%
Achnatherum hymenoides	Indian Ricegrass	5.00%
Pascopyron smithii	Western wheatgrass	14.90%
Schizachyrium scoparium	Little bluestem	16.00%
Sporobolus cryptandrus	Sand dropseed	0.10%
Forb species (5%)		
Achillea lanulosa	Yarrow	0.455%
Artemisia frigida	Fringed sage	0.455%
Artemisia ludoviciana	Louisiana sagewort	0.455%
Cleome serrulata	Rocky Mountain Bee plant	0.455%
Coreopsis tinctoria	Plains coreopsis	0.455%
Gaillardia aristata	Blanket flower	0.455%
Helianthus annuus	Annual sunflower	0.450%
Linum lewisii	Blue flax	0.455%
Oenothera villosa	Tall evening-primrose	0.455%
Penstemon angustifolius	Narrow-leaf penstemon	0.455%
Sphaeralcea coccinea	Scarlett globemallow	0.455%
Shrub species (5%)		
Atriplex canescens	Fourwing saltbush	1.66%
Ericameria nauseosus	Rubber rabbitbrush	1.67%
Krascheninnikovia lanata	Winterfat	1.67%

Table E-6. Seed mix for black-tailed prairie dog habitat restoration at the Rocky Mountain Arsenal NWR

Species	***Common Name***	***Life Form****	***Percent of Mix***

Grasses			
Aristida purpurea	Purple threeawn	WSP	10.00%
Bouteloua curtipendula++	Sideoats grama	WSP	5.00%
Bouteloua dactyloides	Buffalograss	WSP	15.00%
Bouteloua gracilis	Blue grama	WSP	13.00%
Elymus elymoides	Bottlebrush squirreltail	CSP	10.00%
Koeleria macrantha	Junegrass	CSP	3.00%
Pascopyrum smithii	Western wheatgrass	CSP	17.00%
Sporobolus cryptandrus	Sand dropseed	WSP	2.00%
Total: 75%			
Forbs			
Achillea millefolium	Western yarrow	P	1.00%
Cleome serrulata	Rocky Mountain beeplant	A	2.00%
Dyssodia papposa	Fetid marigold	A	2.00%**
Heterotheca villosa	Hairy golden aster	P	2.00%
Machaeranthera canescens	Purple aster	P	5.00%**
Mentzelia nuda	Blazing star	P	1.00%
Oenothera villosa	Stemless evening primrose	P	4.00%
Sphaealcea coccinea	Scarlet globemallow	P	5.00%
Total: 22%			
Sub-shrubs and Succulents			
Artemisia frigida	Fringed sage	P	2.00%
Artemisia ludoviciana	Prairie sage	P	1.00%
Total: 3%			
Opuntia polycantha	Plains prickly pear	P	Planted randomly throughout

*WSP = warm season perennial; CSP = cool season perennial; P = perennial; A = annual:
++ Additional recommendations from a study conducted in Boulder County, Colorado and RMANWR (Carl Mackey, URS Washington Group, and Dave Buckner, ESCO Associates, Inc., personal communication 2000); **can be hand-collected

Appendix F

Techniques for Seedbed Preparation and Weed Control

One of the most critical factors affecting the success of native prairie restoration efforts on Refuge lands is the ability to simultaneously create a suitable seedbed for native species while controlling the extensive weed seedbank, particularly prior to seeding and during the establishment phase. The following general guidelines have been developed based on published information and modified as Refuge staff gains site-specific experience in the implementation of these techniques.

Table F-1. Application rates and frequencies of supplemental water for establishing native perennial grasslands at the Rocky Mountain Arsenal NWR

Application Method		*Water Application Regimes*	*Purpose*	*Amount of Supplemental Water Applied*
Linear Move & Sideroll	1.	½" once per week for a total of 4 applications	Provides more water to soil surface to aid in germination	2 inches
	2.	1" every other week for 3 applications	Allows for more water to percolate into soil profile, helping root development	3 inches
	3.	½" every other week for 2 applications	Hardens plants and weans them from supplemental moisture	1 inch
			Total:	6 inches
Solid Set	1.	¼" two times a week for 4 applications	Provides more water to soil surface to aid in germination	1 inch
	2.	½" once per week for 2 applications	/	1 inch
	3.	1" every other week for 3 applications	Allows for more water to percolate into soil profile, helping root development	3 inches
	4.	½" every other week for 2 applications	Hardens plants and weans them from supplemental moisture	1 inch
			Total:	6 inches

Table F-2. Timing and frequency of field practices to prepare seedbeds for seeding to permanent native vegetation at the Rocky Mountain Arsenal NWR

Seedbed Preparation for Permanent Seeding		*Schedule of Field Practices to Employ*
First Phase: Site preparation and summer fallow	1.	If site consists of tall, weedy vegetation, mow first before deep plowing. Initiate any mowing prior to grassland bird nesting in the spring.
	2.	Use glyphosate (Roundup) to kill cheatgrass or crested wheat in early spring, again prior to initiation of grassland bird nesting if possible.
PURPOSE: Eliminate unwanted dead weed stubble and vegetation, weedy invasives, and destroy as much of the weed seed bank as possible	3.	Consider the use of prescribed fire for special situations where it could be used to destroy standing weed crops and surface seed (e.g. burn the fall prior to initiation of seedbed prep or in the early spring prior to initiation of any mechanical tillage).
	4.	Deep plow site to bury weed seed present in the top 3" of soil to a 12" depth to

		prevent germination.
	5.	Wait for first weed flush ("greenup") to occur, then disk to eliminate weeds, level the site, and break up clods. Weed flushes will be dependent upon precipitation received and moisture present in the seedbed.
	6.	Treat subsequent greenups with Roundup herbicide. If the seedbed needs additional leveling or smoothing (e.g. breaking up of clods), utilize a light mechanical tillage operation instead of herbicide application to treat weed flushes. Minimize mechanical tillage to treat flushes as much as possible to preserve moisture in the seedbed and prevent "pulverizing" of soil structure, particularly if soils are lighter-textured.
NOTE: This may take from one to two field seasons (mid-March to mid-November) to accomplish, depending upon the quantity and species of weedy perennials and exotics present. Refer also to Strategy 3.	7.	If difficult to control weedy species such as field bindweed, cheatgrass, Canada thistle, musk thistle, scotch thistle, or mullein are present, complete an additional second-year fallow period using chemical control. Avoid further mechanical disturbance to the seedbed.
Second Phase: Successfully establish a cover crop (sorghum or oats) to serve as a standing mulch (conservation tillage) when seeded to permanent native vegetation.		*IF SORGHUM IS SELECTED AS THE COVER CROP TO ESTABLISH:*
	1.	From April to mid-May apply glyphosate herbicide to kill any remaining germinating weeds on seedbed if necessary.
NOTE: Employ this phase if site will NOT receive irrigation. If irrigation is to be utilized, skip to Third Phase.	2.	Seed either grain sorghum (milo) or forage sorghum into seedbed from mid-May to early June at 8-10 pounds per acre and at a 1" to 2" depth, depending on soils (seed deeper in sandier soils). Use sterile varieties or extremely late-maturing varieties to prevent large quantities of seed formation.
	3.	Use forage sorghum for its greater height to seed in areas surrounded by prairie dogs to act as a vegetative barrier.
	4.	Clip in mid-August to a minimum of 1' in height. The use of a flail shredder helps chop up residue to a much finer degree than the use of conventional rotary mowers and does not result in 'windrowed' material which may be difficult to treat.
	5.	Treat any additional weedy invasives appearing on the seedbed from September through October with glyphosate or other suitable herbicides as opportunities for control may exist. The seedbed is now at a point where it can be fall seeded, or seeding can be delayed until the following spring, allowing the stubble to protect the site and collect additional moisture during the winter. *Additional spraying with glyphosate for control of weedy species germinating after the cover crop is planted has been indicated in recent cover crop plantings. This will kill the cover crop, but not reduce its purpose and reduce the need for mowing.*
Cover crops such as sorghum provide the following benefits: a) stubble collects snowfall, helps preserve moisture in the seedbed; b) helps shade out any newly germinating weeds; c) prevents wind and soil erosion; d) improves soil tilth, especially important in heavier-textured soils; e) helps in the establishment of mycorrhizae in the seedbed*; f) increases organic matter in the soil; g) provides temporary escape and loafing cover for many species of wildlife. This is important at RMANWR where so many acres of highly disturbed lands exist.		*IF OATS ARE SELECTED AS THE COVER CROP TO ESTABLISH:* *(Oats require moist sites and better soils than sorghum and are not as drought tolerant. Do not use oats as a nurse crop—it is too competitive to seed directly.)*
	1.	Seed from March 1 to April 30 at a depth of 1-2" at 30-40 pounds per acre (Crossant and Echols 2003)
	2.	Do not let oats produce viable seed. Spray crop with glyphosate herbicide before seed matures (mid-June), striving for a 1' high stubble height.
	3.	Keep site weed free through October with appropriate herbicide(s) treatments. Do not mechanically till.
	4.	Site is ready for fall seeding. Spring seeding into oats stubble is not generally recommended as it does not weather like sorghum stubble, and structure may be lost over the winter depending upon snowfall received.

Third Phase: Seed the site to a permanent, native seed mix. NOTE: In certain situations, seeding of forbs and shrubs may be postponed for up to 3 growing seasons if certain cultural treatments (e.g. herbicide application) are anticipated for weed control on the site, which may kill or damage newly seeded forbs while grasses are establishing.	1. Calibrate seed drills utilizing seed mixes in Appendix E at a seeding rate of 25-40 pure live seeds per square foot, depending on soils, condition of seedbed, and seed mix to be utilized. (Poorer condition seedbeds may require higher seeding rates.) 2. Seed at a depth of ½" to ¾", depending on soil texture (slightly deeper on sandier soils). Drill seed directly into sorghum stubble. Use a native grass seed drill (such as a Truax) equipped with depth bands, "trash plows" (rippled coulters), double disk furrow openers, and spring-loaded packing wheels that are specifically designed to seed in higher levels of organic surface material. 3. If site is to be irrigated, seed directly into fallowed seedbed without cover crop *providing seedbed is appropriately firmed up (adult footsteps sink in no more than 1").* If seedbed is too fluffy, it will need to be packed with a roller harrow prior to permanent seeding. 4. If fall seeding is selected, seed any time after mid-October to mid-March when there is no chance of seed germination from warm temperatures or moisture. 5. If spring seeding is selected, seed anytime from mid-March to mid-May. If irrigation is being utilized, seeding can occur throughout May and into early June if necessary. 6. To complete postponed forb/shrub seedings, use the same fall seeding window to broadcast seed onto restoration sites. Broadcasting can be initiated over snow-covered ground as well. Utilize as much refuge-collected seed as possible. Initiate the broadcasting of forb seed only when mowing and herbicide treatments are not generally needed anymore in the developing stand (typically 3 growing seasons.) *Forbs and shrubs can be difficult to establish in developed grass stands. Where forbs and shrubs are desired, they should be seeded initially and weed control options should be modified appropriately. Alternatively, forb and shrub plants can be transplanted into established grass stand and maintained appropriately.*

Appendix G

Neotropical Migratory Birds found at the RMANWR

The following information was taken from a combination of the Population Ecology, Habitat requirements, and conservation of neo-tropical migratory birds published by Deborah Finch in Technical Report RM-205 and compared to the bird list of species commonly found on the Rocky Mountain Arsenal NWR. These are only the common species found, not uncommon or rare.

Bald eagle - nesting (Winter)
Swainson's hawk
Mountain bluebird
Swainson's thrush
Hermit thrush
Wilson's warbler
Red-winged blackbird
Western meadowlark
American white pelican
Canada goose
Lark bunting
American tree sparrow
Grasshopper sparrow
Virginia rail
Western and Eastern kingbirds
Cassin's sparrow
Red-tailed hawk
Turkey vulture
American kestrel
Killdeer
Western wood-pewee
American robin
Yellow warbler
Yellow-headed blackbird
Ferruginous hawk
American coot
Violet-green swallow
Barn swallow
Chipping sparrow
Vesper sparrow
Brewer's sparrow
Western tanager
Blue-gray gnatcatcher
****Note- waterfowl are not included in this list (12 species)

Appendix H

A Forage Allocation Methodology for use at the RMANWR

As proposed in the draft Habitat Management Plan (HMP) for the Rocky Mountain Arsenal NWR (RMANWR), a forage allocation methodology will be used to inform management decisions to attain sustainable populations of bison, white-tailed deer, mule deer, and prairie dogs on refuge lands. The forage allocation model developed for Theodore Roosevelt National Park (National Park Service 2010), which includes an optimization routine for all populations combined, is referenced in the HMP. Data used to develop the RMANWR methodology was obtained from the published literature and included estimates of plant productivity and forage consumption.

To estimate the number of bison that potentially could be supported on RMANWR, we calculated annual carrying capacity based on estimates of average annual plant (forage) productivity, daily bison forage consumption rates, and bison forage utilization rates from the published literature. We did not use an optimization routine that included all herbivores because the current distribution of deer does not overlap the area that would be used to support bison and prairie dogs will be excluded from this area by active management.

Methods

Bison Foraging Area

The area available for bison herbivory was defined by the refuge staff. Within this area, roads and the bison holding facility (10 acres) were excluded because they do not provide forage. In addition, we assumed the following:

• Woodland (30 acres) and locust stands (8 acres) provide the same amount of forage as the Ecological Site Description (ESD) in which they occur (i.e., these habitats were not deleted from the area calculated for forage). In addition, areas dominated by shrubs were not excluded or reduced in their contribution of available forage. **Both of these probably results in a slightly greater estimate of bison forage availability.**

• Prairie dog occurrence was restricted to zones designated in the draft HMP. Currently, this is not true and prairie dogs occur on approximately 1,300 acres outside designated zones. **This results in a greater estimate of bison forage availability.**

• The area within designated prairie dog zones does not provide forage for bison. However, bison and prairie dogs co-evolved and some forage likely would be available in these areas. **This results in a slightly lower estimate of bison forage availability in these areas.**

• Bison would be allowed to utilize forage produced on lands retained by the U.S. Army. The U.S. Army, which retains authority for these lands, has expressed willingness to allow bison on these lands; however, authorization has yet to be granted. **If authorization is not granted, exclusion of U.S. Army lands would result in a significant reduction in bison forage availability.**

• The infrastructure (e.g., fences) necessary to allow bison access to the entire bison foraging area currently exists today. **This is not the case, thus most of the available forage calculated within the bison foraging area is currently not available.**

Collectively, these assumptions result in a greater area of forage availability than actually occurs under current conditions. The extent to which this estimate is biased positive would depend primarily on infrastructure developments to provide access to the entire bison foraging area and the inclusion/exclusion of forage on lands retained by the U.S. Army. The remaining assumptions would likely only result in slight changes in area.

Forage Production

We used annual forage production estimates of Historic Climax Plant Community (HCPC) provided for each ESD that was present in the Bison Foraging Area. ESDs incorporate information on abiotic factors (e.g., climate, soils) and native plant communities to estimate plant productivity under different conditions. We used estimates at the low end of the forage production range to reflect forage productivity during drought conditions. Of the forage produced annually, only a portion should be made available for consumption by herbivores to ensure long-term sustainability of the plant community and to provide foods and vegetation structure required for reproduction and survival of other resources of concern (e.g., migratory birds). Based on general range management prescriptions for livestock production, a commonly applied rule is to manage for 50% consumption of annual production (e.g., take 50%/leave 50%). However, this rate of consumption is for rangeland and does not account for plant survival and maturation of restored plant communities that are comprised of seedlings or young plants with limited root biomass. To ensure long-term sustainability of native prairie, refuge staff developed the following rules for application in the Bison Foraging Area:

• Do not allow intentional removal of any annual plant production on restoration fields less than 7 years of age (i.e., forage multiplier [FM] = 0).

• Remove a maximum of 20% annual plant production on restoration fields between 7 and 10 years of age (FM = 0.2).

• Remove a maximum of 50% annual plant production (moderate grazing) on restoration fields greater than 10 years of age and other native prairie (FM = 0.5).

• Remove a maximum of 20% annual plant production in the south half of Section 27 due to poor current condition resulting from prairie dog herbivory (David Lucas & Bruce Hastings, personal communication 2013).

Annual plant productivity varies considerably within and among years depending on numerous factors, many of which cannot be forecasted accurately. As a result, future estimates based on averages are prone to be misleading. Therefore, these estimates should be viewed cautiously. Specific assumptions used in this approach tend to be conservative and include, but are not limited to, the following:

• Estimates of forage production in each ESD are based on drought conditions to help reduce risk associated with increasing herd size beyond long-term carrying capacity. **This results in lower estimated carrying capacity during periods of average and above-average precipitation.**

• Estimates of forage production are bases on HCPC for each ESD. This assumption does not apply to restoration sites that have not fully matured. To offset this bias, rules were developed to lower forage consumption on restoration sites in various age categories. **The validity of these age categories and associated consumption limits are not known. For example, data indicate an average of 7 years is required to meet the HRP requirements for restoration success on refuge lands; however, the potential impacts of herbivory during the first 7 years of growth are unknown. Similarly, no information specific to the refuge is available to support the rule that restorations greater than 10 years of age are capable of supporting moderate grazing pressure without some change in plant composition or vigor.**

• Restoration sites (past and future) do not require reseeding and stand condition improves over time such that the FM would approach the maximum of 0.5 (Take 50% Leave 50% rule). **The validity of this assumption is questionable for some**

restoration sites because the lack of infrastructure has precluded moving bison to prevent extensive removal of plant biomass. As a result, some existing restoration sites may require reseeding.

• Bison can access all sites every year because estimated annual plant productivity is the same. **This assumption is not valid because forage production will not be the same every year. In addition, some areas will require rest for 2-3 years to provide vegetation structure necessary to support other resources of concern.**

Bison Forage Consumption

Based on a limited review of the literature, bison consume between 19 and 31 pounds of dry matter per day (irrespective of age and sex); although CSU Extension Range Specialists recommend using 25.8 lbs./day. However, the utilization rate of forage (i.e., amount of forage consumed relative to forage available) by bison is not 100% because some forage is lost due to insects, trampling, defecation, and herbivory of other species among other factors. Bison utilization rates reported in the literature generally range from 40-75%; however, Holechek (1988) considers a utilization rate of 40-50% for shortgrass prairie in areas with 10-16 inches of precipitation to represent moderate grazing pressure. He adds that “ranges in good condition and/or grazed during the dormant season can withstand the higher utilization level, while those in poor condition or grazed during active growth should receive the lower utilization level.” Others suggest even lower rate to maintain healthy plant communities; Rates above 60% are considered a heavy grazing pressure.

Given the variability in quantitative estimates available in the literature, and the impact that these values exert on final estimates of carrying capacity, the following two scenarios were developed:

Liberal. Assumes daily forage consumption of 19 lbs. dry matter and a utilization rate of 75% (i.e., lower daily consumption and higher efficiency of consumption)

Conservative. Assumes daily forage consumption of 26 lbs. dry matter and a utilization rate of 40% (i.e., values that are more specific to shortgrass prairie ecosystems)

Assumptions in determining bison consumption rates include, but are not limited to, the following:

• Consumption is the same among sex and age classes

• Consumption is the same during different annual cycle events

• Utilization rates are the same for different plant communities

Determination of Annual Carrying Capacity

Annual estimates for the period 2013 to 2018 (see Figures 3-8) were developed using the following formulas in sequence:

• Forage Produced: ESD Forage Production Value for HCPC x Acres of ESD in Bison Foraging Area

• Adjusted Forage: Total Forage Produced x applicable FM (apply rule set after adjusting for time step each year)

• Total Forage Produced: Sum “Adjusted Forage” for all ESDs

• Forage Available: Total Forage Produced x Utilization Rate

• Bison Supported: Forage Available / (Daily forage consumption x 365 days)

Results

The total area of the bison zone was calculated to be approximately 12,165 acres. Prairie dog zones (2,585 acres), road surfaces (112 acres), and the bison holding facility (10 acres) were not considered to provide forage, resulting in a Bison Foraging Area of 9,748 acres. The minimum forage production values based on each ESD are as follows: Clayey Plains (500 lbs./acre), Gravel Breaks (500 lbs./acre), Loamy Plains (600 lbs./acre), Overflow (1,200 lbs./acre), and Sandy Plains (800 lbs./acre) (See Figure H-1). Below are two summary tables: Table H-1 shows the estimated number of animals that can be supported across the entire Bison Area at multiple utilization rates and daily consumption rates. Table H-2 shows the estimated number of animals that can be supported within the current two pasture system.

Table H-1. Number of bison that can be supported on the Rocky Mountain Arsenal NWR

	2013	***2014***	***2015***	***2016***	***2017***	***2018***
Total Dry Forage Available			*(pounds)*			
Outside of Restoration Fields	1,086,811	1,086,811	1,086,811	1,086,811	1,086,811	1,086,811
Restoration Fields	726,679	858,115	1,022,458	1,208,458	1,376,740	1,557,841
Daily Forage Requirement (31 lbs./day)			*(# of bison)*			
75% Utilization Rate	120	129	140	152	163	175
60% Utilization Rate	97	104	112	122	131	141
50% Utilization Rate	80	86	93	101	109	117
40% Utilization Rate	64	68	74	81	87	93
Daily Forage Requirement (26 lbs./day)			*(# of bison)*			
75% Utilization Rate	143	154	167	181	195	<u>209</u>
60% Utilization Rate	103	111	122	133	144	**155**
50% Utilization Rate	95	102	111	121	130	139
40% Utilization Rate	77	82	89	97	104	**112**
Daily Forage Requirement (19 lbs./day)			*(# of bison)*			
75% Utilization Rate	197	211	229	249	267	286
60% Utilization Rate	141	152	166	183	197	213
50% Utilization Rate	130	140	152	165	177	190
40% Utilization Rate	105	112	122	133	142	153

Bold and <u>underline</u> represent figures used to developed management objectives for bison

Table H-2. Number of bison that can be supported on current two pasture system

Total Dry Forage Available	*(pounds)*
Outside of Restoration Fields	175,068
Restoration Fields	353,618
Daily Forage Requirement (31 lbs./day)	*(# of bison)*
75% Utilization Rate	35
60% Utilization Rate	28
50% Utilization Rate	23
40% Utilization Rate	19
Daily Forage Requirement (26 lbs./day)	*(# of bison)*
75% Utilization Rate	<u>42</u>
60% Utilization Rate	**33**
50% Utilization Rate	28
40% Utilization Rate	**22**
Daily Forage Requirement (19 lbs./day)	
75% Utilization Rate	57
60% Utilization Rate	46
50% Utilization Rate	38
40% Utilization Rate	30

Bold and <u>underline</u> represent figures used to developed management objectives for bison

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