Chapter 4—Affected Environment

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A wetland on Alamosa Refuge.

The affected environment section describes those parts of the natural and human environment that could be affected by carrying out any of the proposed management alternatives. This chapter describes the characteristics and resources of the Monte Vista, Alamosa, and Baca Refuges, how we manage the refuge complex, and the effects of current and past management and influences on resources. It specifically addresses the physical environment; biological environment; special land designations; wildlife-dependent recreational opportunities; cultural resources and tribal interests, including a history of human use on the site; and the socioeconomic environment. We used Service data, scientific studies, and communication with resource professionals, both published and unpublished, to describe the resources of the refuge complex.

4.1 Topics Not Analyzed Further

Canada lynx, black-footed ferret, wolverine, gray wolf, Gunnison's sage grouse, boreal toad, Rio Grande cutthroat trout, and Uncompahgre fritillary butterfly were dismissed from further consideration because the alternatives addressed in this document would have no effects on these species or any effects would be negligible. (Refer to table 13, section 4.3 below.)

4.2 Physical Environment

The following sections discuss the physical characteristics that could be affected by the implementation of the CCP. Physical characteristics that are covered are topography, climate, climate change, air quality, geology, minerals, soils, water resources, visual resources and night skies, and soundscapes.

Topography

The San Luis Valley is a large, high elevation basin which is more than 7,500 feet above mean sea level.

Implementation of the CCP would have no effect on topography.

Climate

The climate of the San Luis Valley is arid, with cold winters and moderate summers. Winds, which are usually from the south-southwest with speeds of 40 miles per hour, are common in spring and early summer. There is wide seasonal and annual variation in precipitation. In some years, snow cover can be sparse or totally lacking in the San Luis Valley (BLM 1991). The San Luis Valley lies in the rain shadow of the San Juan Mountains and receives about 7 inches of precipitation per year. Great Sand Dunes National Park and Preserve, on the southeast side of the Baca Refuge, receives an average of about 11 inches annually. About 60 percent of this precipitation occurs as rain in July and August. This summer moisture comes from the Gulf of Mexico and the Gulf of California and is a result of monsoonal flow that moves north through Arizona and New Mexico into the San Luis Valley (Heitmeyer and Aloia 2013a,b,c).

Long-term precipitation data from Saguache, Del Norte, and Manassa, Colorado, suggest that alternating low and high precipitation periods recur on roughly a 30-year cycle (figures 29, 30, and 31). Dry periods occurred in the 1890s, the 1930s, the early 1950s, the early 1970s, the late 1980s, and the middle of the first decade of this century (Thomas 1963, Striffler 2012, Heitmeyer and Aloia 2013a, b, c). Long-term trends in annual precipitation vary somewhat based on location in the San Luis Valley. The long-term annual precipitation trend for Saguache, Colorado, is generally stable, while trends at Crestone, Colorado show a gradual decline in precipitation (Striffler 2013). Recent studies have analyzed tree-ring data to reconstruct historical streamflow through the Rio Grande Basin (Correa 2007). These data suggest that the frequency and duration of droughts have increased over the last 730 years.

The mean annual temperature is 43 Fahrenheit (°F) at Del Norte, Colorado, and the temperature trend is increasing. Low temperatures of -20 to -30 °F can be expected each year, and average highs are in the 80s. The annual frost-free growing season averages between 90 and 100 days from late May to early September (Emery 1996); however, there is wide variation between years, and July and August

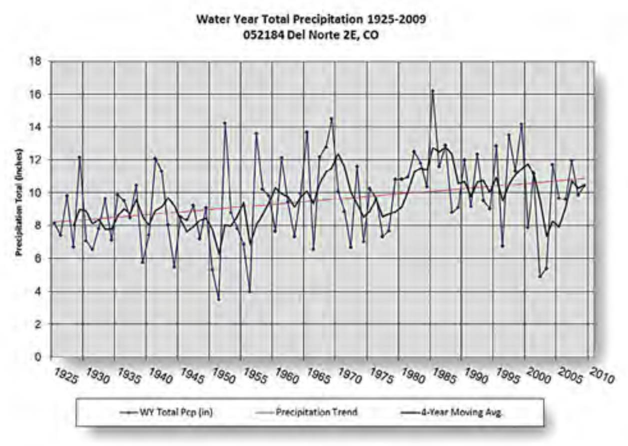

Figure 29. Total water precipitation (inches) for Del Norte, Colorado, 1925-2010.

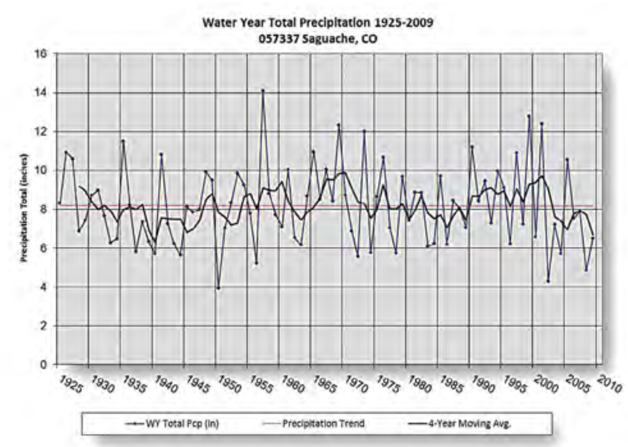

Figure 30. Total water precipitation (inches) for Saguache, Colorado, 1925-2009.

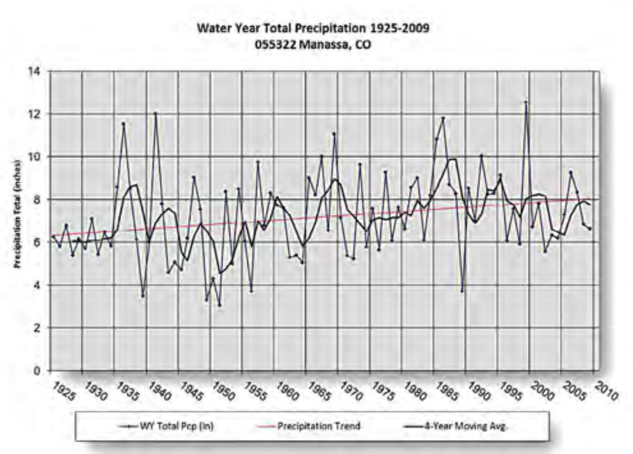

Figure 31. Total water precipitation (inches) for Manassa, Colorado, 1925-2009.

are typically the only frost-free months. Evapotranspiration, which is evaporation from the soil surface plus water use by plants, is typically 45 to 50 inches per year (Leonard and Watts 1989, Ellis et al. 1993). A precipitation deficit (potential evapotranspiration minus precipitation) occurs every month of the year, and deficits are largest in June (Leonard and Watts 1989, Ellis et al. 1993).

The increasing temperature trend is expected to raise average soil temperatures and increase the evapotranspiration rate. The increasing temperature effect outweighs the increasing precipitation trend (BOR 2013b; Striffler 2013, Heitmeyer and Aloia 2013 a, b, c), thereby increasing the precipitation deficit and reducing water resources available throughout the San Luis Valley.

Climate Change

In 2009, the U.S. Global Change Research Program released a comprehensive report (Karl et al. 2009) that synthesized information from a wide variety of scientific assessments and described what is known about the observed and projected consequences of climate change. Average temperatures in the United States have increased by more than 2 °F over the past 50 years. More locally, a report for the Colorado Water Conservation Board shows that temperatures in Colorado increased by about 2 °F between 1977 and 2006 (Ray et al. 2008).

Recently, BOR (2013b) issued a west-wide climate risk assessment that covers the upper Rio Grande, including the San Luis Valley and the San Juan and Sangre de Cristo Mountains. For the entire upper Rio Grande study area, temperatures increased substantially from 1971 through 2012, with average annual temperatures increasing by 2.5 °F. Nighttime low temperatures increased faster than daytime high temperatures (2.7 °F vs. 1.8 °F). Mountain and valley regions responded differently to warming, with average temperatures in the mountains increasing by 2.7 °F, but average temperatures in the valleys increasing by only 1.6 °F over the same period (BOR 2013b).

Overall, climate change is projected to significantly decrease available water supplies in the Upper Rio Grande Basin. Supplies from all native water sources to the Rio Grande are projected to decrease by about one-third. Most flow decreases would occur between June and September, and peak flows, which are now in June, are predicted to shift to May (BOR 2013b).

In all parts of Colorado, no consistent long-term trends in annual precipitation have been detected. Variability between winters is high, which makes detection of trends difficult. Between 1978 and 2004, some data suggest the spring pulse (onset of streamflows from melting snow) in Colorado has shifted earlier by two weeks (Ray et al. 2008), while other reports suggest it is three weeks earlier (Painter et al. 2010). Several studies suggest that shifts in timing and volume of streamflows are related to warming spring temperatures. There are concerns about declines in the spring snowpack because of decreased snow cover on the lower slopes of high mountains, recurring high winds in spring, and ensuing dust events caused in part by increased human activities in the deserts of the southwest (USGS 2010). Other factors include prolonged drought patterns; overall-location of water resources; and increased potential for severe wildfires, invasive species, and other changes.

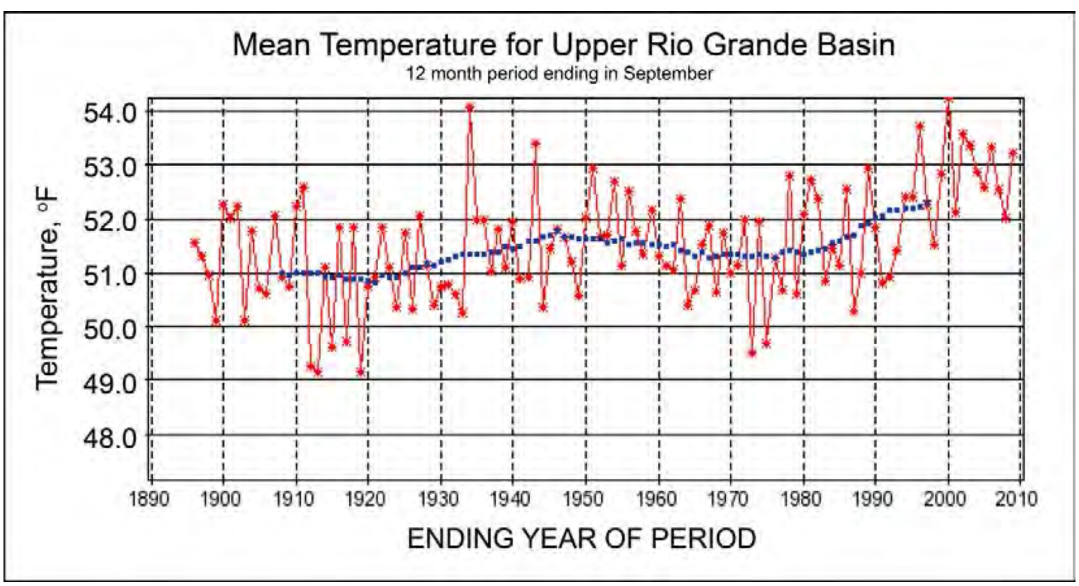

Figure 32. Mean temperature for Upper Rio Grande Basin from the 1890s to 2010.

Source: BOR 2013b

It is difficult to assess how climate change will affect the biological and social resources in the refuge complex because of ongoing drought conditions, over-allocation of water resources in the San Luis Valley, uncertainty about the administration of new State water regulations (see Water Resources below), and limited operational funding to manage the refuges. BOR (2013b) found that potential adaptation and mitigation strategies for the hydrologic response to climate change need to be evaluated in future studies. This will require an analysis of the key thresholds (ecological resilience) associated with both social and ecological systems in the basin. Adaptation could involve transitions into new thresholds for social and ecological systems, rather than simply building resilience into the old social and ecological states (BOR 2013b).

We have been proactively applying the Service's climate change strategy (adaptation, mitigation, and engagement) in the San Luis Valley through landscape conservation planning and strategic habitat conservation (chapter 1, section 1.3), as well as by responding to changes in State water regulations, which affect all users in the San Luis Valley (see Water Resources below).

Air Quality

Air quality in the San Luis Valley is generally good. Except for ozone, existing air pollutant concentrations in the vicinity of the refuge complex are relatively low because there are few air pollution sources in the region. There are limited industrial facilities, and residential emissions are primarily from smaller communities and isolated ranches. Some local, naturally generated particulate matter occurs as windblown dust, in part because of the dry climate. In 2012, air quality data from the EPA (2012b) said that Alamosa County, which is the most populous county in the area, had 332 days of good air quality, 27 days of moderate air quality, 4 days of unhealthy air quality for sensitive groups, and 1 day of unhealthy air quality; the data from earlier years are similar.

All three national wildlife refuges are categorized as Class II air quality areas. Class II areas have less stringent air quality standards than Class I areas and may be allowed slight increases in the concentrations of certain air pollutants over baseline conditions. Great Sand Dunes National Park and Preserve, which is located immediately east of the Baca Refuge, is a Class I air quality area. Designated wilderness is found in the park and preserve as well in the Rio Grande National Forest (Sangre de Cristo Wilderness Area), and under the Clean Air Act of 1977, all 156 National Parks and wilderness areas are designated Class I air quality areas.

Air quality data were collected at the park from 1988 to 1992. Information is available from 1988 to 1991 for ozone concentrations and from 1988 to 1992 for sulfur dioxide (SO2). Data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) for visibility (which involved particle sampling at Morris Gulch and a camera near the landing strip adjacent to the south boundary of the Class I area) are available from 1988 to the present. The IMPROVE monitoring program was established in 1985 to aid in the creation of Federal and State plans for the protection of visibility in Class I areas as stipulated in the 1977 amendments to the Clean Air Act (Colorado State University 2013).

The data presented in table 9 show background air quality conditions near the Baca Refuge and include pollution from sources both inside and outside of the refuge (FWS 2011b). The maximum pollutant concentrations are well below applicable Colorado and National Ambient Air Quality Standards (NAAQS) for most pollutants, although maximum concentrations of ozone (as an 8-hour average) that approach the Federal standard have been observed. Given the episodic nature of observed high ozone levels and limitations in photochemical modeling (which is required to simulate the complex mechanisms that govern ozone formation and fate in the lower atmosphere), the exact cause of this pollution is uncertain, although it appears that regional transport plays a role (Western Regional Air Partnership 2008).

We conform to the interim air quality policy for wildland fire (EPA 1998), which is still the most current air pollution control policy. The policy was prepared in an effort to use wildland fire as a tool for managing natural ecosystems while also protecting public health and welfare by mitigating the negative effects of air pollutant emissions on air quality and visibility. Since 2006, our fire management program on the refuge complex has been guided in part by the Greater Sand Dunes Interagency Fire Management Plan (NPS, FWS, TNC 2006). For all prescribed fires we acquire smoke permits, and fires are conducted under strict smoke and air regulations as established by the State of Colorado's air pollution control division (CDPHE 2013). An airshed coordinator and meteorologist evaluate effects of prescribed fire for each airshed to anticipate cumulative impacts. Smoke concerns are addressed in each individual prescribed burn plan. These plans are thorough and discuss specific smoke issues, measures to reduce negative effects, downwind receptors, and smoke vector maps. On average, the refuge complex averages 2 to 3 prescribed fires annually, with each burn averaging about 600 acres. Accidental wildfire is exempted from Clean Air Act compliance. However, when accidental wildfires do occur on the refuge, we notify the State of Colorado's air pollution control division.

Table 9. Background concentrations, ambient standards, and significant impact levels of regulated air pollutants (FWS 2011b).

Pollutant	*Averaging time*	*Background concentration (µg/m³)*	*NAAQS[1] (µg/m³)*	*CAAQS[2] (µg/m³)*	*PSD class I increment (µg/m³)*	*PSD class II SILs (µg/m³)*	*PSD class I SILs (µg/m³)*
Carbon Monoxide[3]	1-hour	2,060	40,000	40,000	NA	2,000	500
	8-hour	1,831	10,000	10,000	NA	500	NA
Nitrogen Dioxide[3]	Annual	8	100	100	2.5	1	0.1
Ozone[4]	1-hour	151	235	235	NA	NA	NA
	8-hour	138	157	157	NA	NA	NA
	Annual	78	NA	NA	NA	NA	NA
	Max. Season[5]	80	NA	NA	NA	NA	NA
	Avg. Season[5]	78	NA	NA	NA	NA	NA
$PM_{2.5}$[6,4]	24-hour	21	35	35	NA	NA	NA
	Annual	4	15	15	NA	NA	NA
PM_{10}[6]	24-hour	50	150	150	8	5	0.3
	Annual	11	50	50	4	1	0.2
Sulfur Dioxide[7]	3-hour	--	1,300	700	25	25	1
	24-hour	3	365	365	5	5	0.2
	Annual	0.2	80	80	2	1	0.1

[1] National Ambient Air Quality Standards

[2] Colorado Ambient Air Quality Standards

[3] Based on the most recent 3 years of data from EPA AIRS database for data collected near Ignacio, CO (rural location), 2005-2007. http://www.epa.gov/aqspub1/

[4] EPA's current PM2.5 implementation policy was finalized 60 days after publication (Aug. 24, 2010) in the Federal Register

[5] From August through April

[6] Based on the most recent 3-years of data available from the IMPROVE station at Great Sand Dunes NPP, 2002-2004. http://vista.cira.colostate.edu/improve/Data/IMPROVE/AsciiData.aspx

[7] Based on historical data collected at Great Sand Dunes NPP, 1988-1991

µg/m³ = microgram per cubic meter; SIL = Significant Impact Level; NA = Not Applicable

Geology and Geomorphology

The San Luis Valley is the largest of a series of high-altitude intermontane basins in the Southern Rocky Mountains (Jodry and Stanford 1996), and is part of the much larger Rio Grande Rift Zone that extends from southern New Mexico north through the San Luis Valley to its northern terminus near Leadville, Colorado (Chapin 1971, Bachman and Mehnart 1978).

The valley is a compound graben depression that was down-faulted along the base of the Sangre de Cristo Mountains during the Laramide Orogeny. The San Juan Mountains, lying to the west, were created by extensive Tertiary volcanism about 28 to 22 million years ago (McCalpin 1996). The Oligocene volcanic rocks of the San Juan Mountains slope gradually down to the San Luis Valley floor, where they are interbedded with alluvial fill deposits (BLM 1991). This layer extends over the Alamosa Horst, a buried ridge of a normal fault, which separates the San Luis Valley into the Monte Vista Graben to the west and the Baca Graben to the east (Bachman and Mehnart 1978). This normal fault line trends north from the San Luis Hills to the Sangre de Cristo Mountains near Medano Pass. The Baca Graben is about 19,000 feet thick, or almost twice as thick as the Monte Vista Graben, because of its proximity to the Sangre de Cristo fault zone (Zeisloft and Sibbet 1985, Burroughs 1981, Brister and Gries 1994). Alamosa Refuge lies at the boundary between the Baca Graben and the Alamosa Horst (Mackelprang 1983).

From the Pliocene to the middle Pleistocene, a large, high-altitude lake, Lake Alamosa, occupied most of the San Luis Valley (Machette et al. 2007) (figure 33). This ancient lake went through several cycles of drying and flooding, which eroded and deposited sediments within the historic lakebed. These sediments have been designated as the Alamosa Formation (Siebenthal 1910). Pliocene and Miocene formations underlie the Alamosa Formation, and are in turn underlain by Echo Park alluvium and then Precambrian rocks. Lake Alamosa existed for about 3 million years before it overtopped a low wall of Oligocene volcanic rocks near the San Luis Hills and carved a deep gorge that flowed south into the Rio Grande, entering at what is now the mouth of the Red River.

More recent drainages, including La Jara Creek and the Alamosa River, originate from the San Juan Mountains and flow across alluvial fans onto the floor of the San Luis Valley, where they empty into the Rio Grande on the Alamosa Refuge; these tributaries have deposited substantial amounts of alluvial material on what are now refuge lands.

The Rio Grande flows through the Alamosa Refuge and is a dominant feature of the southern San Luis Valley. The Rio Grande enters the valley near Del Norte, Colorado, and flows to the south and east along the southern boundary of the Rio Grande alluvial fan. The area where the Rio Grande enters the valley is bounded by a low-elevation terrace on the south and west sides, which allows the channel to avulse to the northeast of the town of Monte Vista, Colorado, and which has in turn created a floodplain 200 to 300 times the width of the current average river channel (Jones and Harper 1998). The river takes a more southerly direction at the town of Alamosa, Colorado, where a low topographic and hydrologic divide separates the Rio Grande floodplain from the closed basin to the north. After turning south, the Rio Grande is confined to the east by Hansen's Bluff, which is also the eastern boundary of the Alamosa Refuge (Jones and Harper 1998). Hansen's Bluff is an outcrop of the Alamosa Formation and consists of younger Quaternary alluvium with surficial deposits overlaying the formation (Rogers et al. 1992).

The Baca Refuge is in the northeast part of the closed basin of the Baca Graben. The closed basin depression may be a result of subsidence and wind deflation which, over time, prevented external surface drainage to the Rio Grande.

Minerals

The most recent mining activities in the general vicinity of Crestone, Colorado, have been by Battle Mountain Gold Company at its San Luis Mine, which is located more than 50 miles southeast of Crestone in Costilla County and which ceased operations in late 1996; and by Galactic Resources, Inc. at its Summitville Mine, which is located more than 60 miles southwest of Crestone in Rio Grande County and which ceased operations in late 1992. In the immediate vicinity of Crestone, the last recorded mining

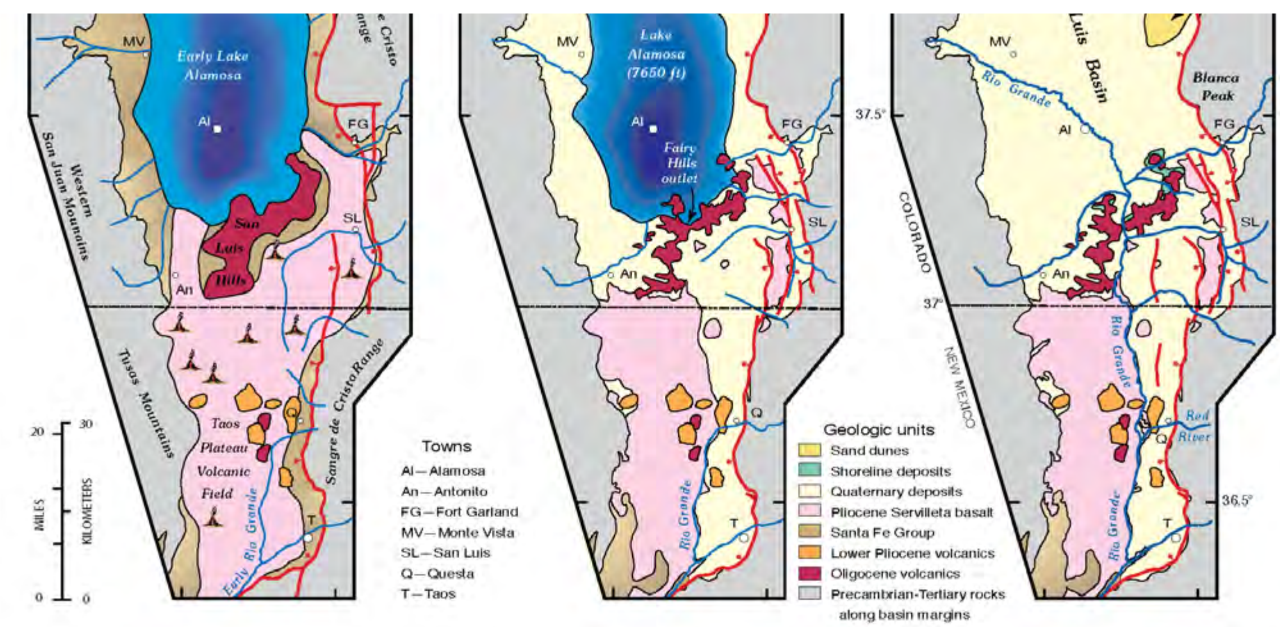

Figure 33. Simplified geological map of the San Luis Basin showing generalized geology and drainage patterns for the time intervals A) 3.5-5 million years before the present (BP); B) 440,000 years BP; and C) current.

Source: Machette et al. 2007

took place in the late 1800s. Prospecting for gold and silver occurred throughout the Sangre de Cristo Mountains, and Crestone itself was founded where there was a small producing ore body. Production here was sufficient to support the construction of a stamp mill at the location; however, the mine soon played out (FWS 2011b).

Sand and gravel are the major mineral commodities that are mined in the valley (Guilinger and Keller 2000). The nearest sand and gravel pits are located a couple of miles north of the refuge complex. Other sand and gravel operations are scattered around the valley and are concentrated around the towns of Alamosa and Del Norte. Other minerals that are mined in the area include gold, silver, peat, and limestone. In 2006, there were no active mine permits issued or pending mine permits in Saguache County (Cappa et al. 2007). Only 46 mining claims were recorded in the county compared with 5,693 for the entire State. No minerals are now being produced from the refuge complex (FWS 2011b).

In 2011, the Service approved an application for exploratory drilling on the Baca Refuge (FWS 2011b) for two wells to explore for oil and gas beneath the surface estate. To date this activity has not taken place.

Soils

More than 30 soil series and land types are present on the Monte Vista Refuge (figure 34), and their distribution reflects three major landforms: the San Juan Range foothills; the large Rio Grande alluvial fan; and Spring, Rock, and Cat Creeks and their associated floodplains. Loamy sands dominate the Rio Grande alluvial fan, which was once vegetated with shrubs (USDA Soil Conservation Service 1980). Some clay loam soils are present on the refuge and indicate former wetland areas (USDA Soil Conservation Service 1980). Cobbly and gravelly loams are present along relict stream courses and terrace edges. (Heitmeyer and Aloia 2013c).

About 29 soil series and land types are present on the Alamosa Refuge (figure 35). There are three major soil associations on the refuge: the Alamosa-Vastine-Alluvial association, which is on floodplains; the Hapney-Hooper-Corlett association, which is in hilly or dune areas; and the Costilla-Space City association, which is on Hansen's Bluff. Soil distribution across the refuge generally reflects the movement of the Rio Grande across its floodplain as well as the deposition and movement of sediments where creeks joined the Rio Grande (USDA Soil Conservation Service 1973).

The Alamosa-Vastine-Alluvial association, which formed on the floodplains of the Rio Grande and its tributaries, covers most of the Alamosa Refuge. These soils and land types cover the largest amount of area on the refuge and are usually associated with seasonal wet meadows in floodplain margins. This association is characterized by deep, dark soils that are commonly flooded in the spring and that have a high water table that creates somewhat saline conditions. The typical surface texture in these soils is loam, but sandy or clayey areas may also be found. Alluvial land is material that has been recently deposited, and it is characterized by stratified layers with little or no soil development. Loamy alluvial land occurs in the central and southern areas of the refuge, and makes up 16.5 percent of the total refuge area. Sandy alluvial land is restricted to natural levees along the active channel of the Rio Grande and covers only 2.2 percent of the area. Vastine soils cover 12.1 percent of the refuge and Alamosa soils cover 9.8 percent of the refuge. Marsh soils are also within the Alamosa-Vastine-Alluvial association and occupy a small area along the toe of Hansen's Bluff and in a few areas throughout the floodplain (Heitmeyer 2013a).

The northeastern part of the Alamosa Refuge contains soils of the Hapney-Hooper-Corlett association, which is characterized by moderately fine- to coarse-textured alkali soils that are moderately well to somewhat excessively drained and are on nearly level to hilly sites. The dominant soil series in this association are calcareous and strongly alkaline. Sandy dunes are present in scattered locations throughout this association.

The eastern part of the Alamosa Refuge along Hansen's Bluff has the Costilla-Space City association, which occurs on gently sloping topography and which has coarse-textured soils that are well drained.

About 37 soil series and land types are found on the Baca Refuge (Heitmeyer and Aloia 2013b) (figure 36). Generally, soil distribution across the Baca Refuge reflects the movement, deposition, and scouring of sediments carried by ephemeral creeks that originate in the Sangre de Cristo Mountains; avulsion movements of San Luis Creek; and wind deflation (USDA Soil Conservation Service 1981). Wind deflation of basin sediments has brought the ground water close to the surface through removal of particles. Salts are brought to the surface through capillary action, which alters the salinity of surface water and subsequent particles that are transported by wind. Wind deflation of the sabkha and eolian sand sheet has created playa lakes throughout the western and southern parts of the refuge (as can be seen in the partial 1941 aerial photo, figure 12) and in the dune fields. The wind deflation of the sump area has also created dunes nearby (Madole et al. 2008).

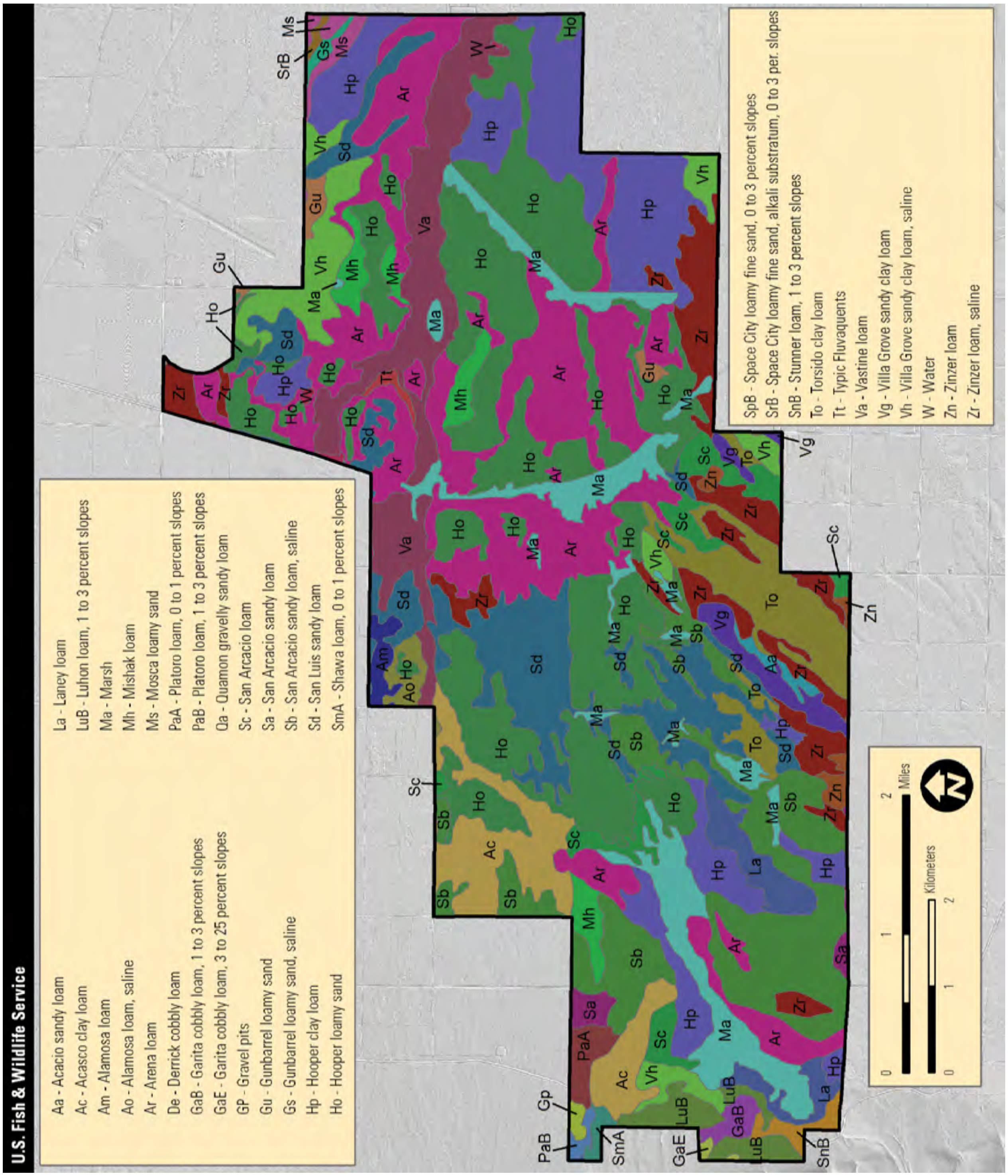

Figure 34. Soils map for Monte Vista National Wildlife Refuge, Colorado.

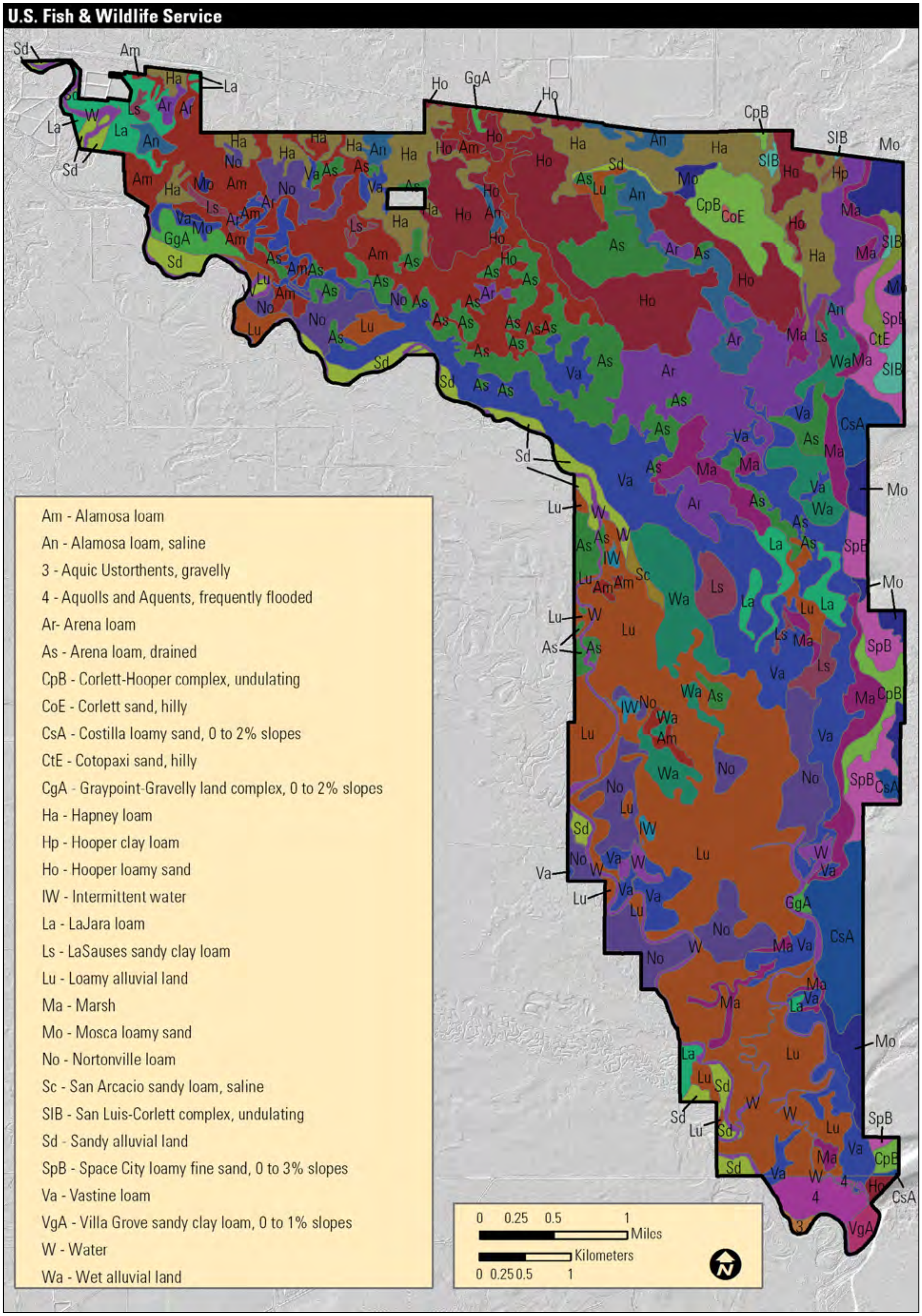

Figure 35. Soils map for Alamosa National Wildlife Refuge, Colorado.

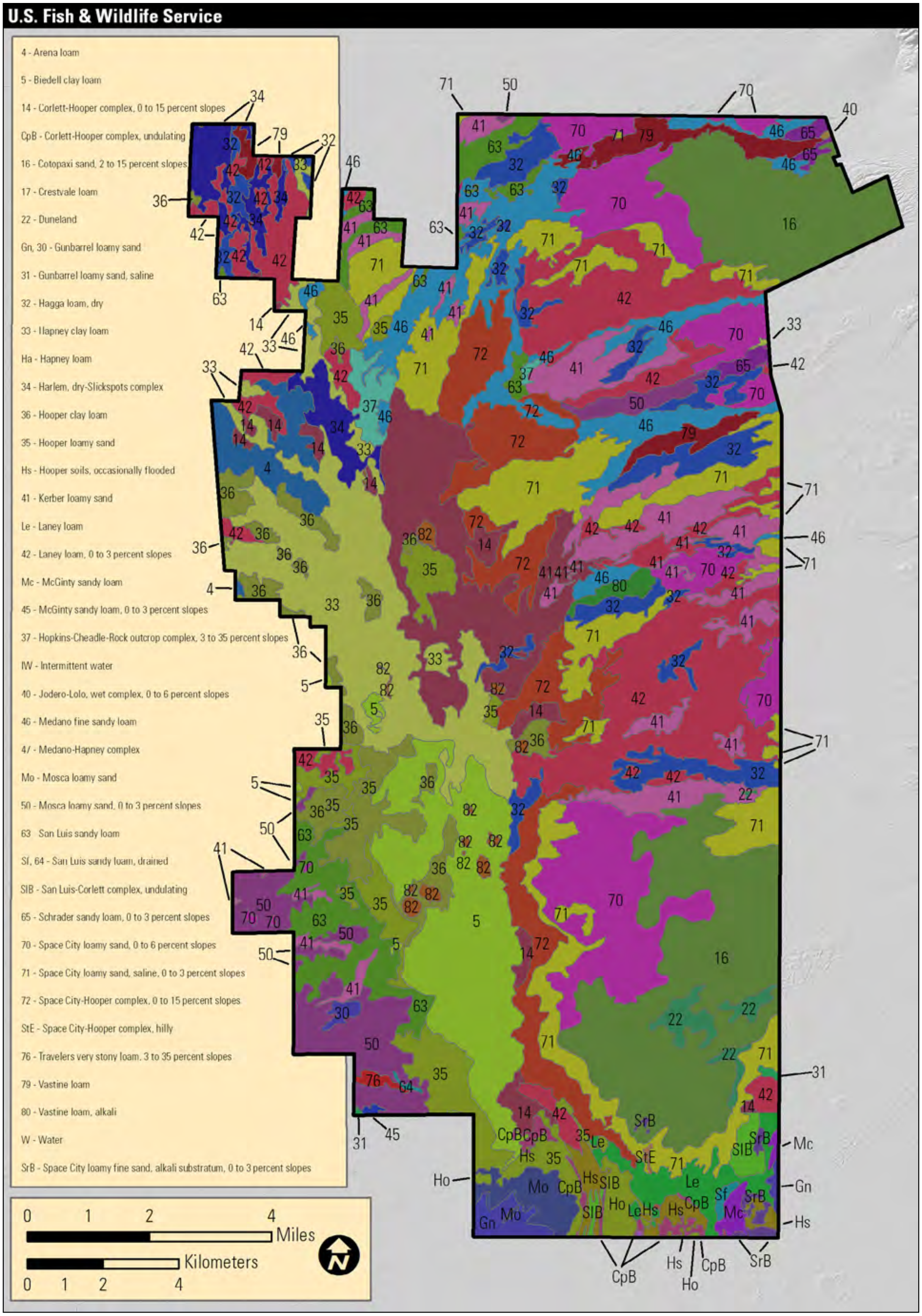

Figure 36. Soils map for Baca National Wildlife Refuge, Colorado.

The Baca Refuge is dominated by three soil associations: Space City-Cotopaxi, which is in the eastern and southern parts; Big Blue-Gerrard, which contains the floodplain of San Luis Creek and most of Cottonwood Creek; and Hooper-Hagna-Hapney, which is west and east of the Big Blue-Gerrard association (USDA Soil Conservation Service 1981).

The Space City-Cotopaxi association is characterized by deep soils that occur on level to moderately sloping land in dune-like topography that is intersected by intermittent streams. Soils in this association have a texture of loamy sand or sand and are underlain by calcareous loamy sand or sand, and they are somewhat excessively drained. Dominant soil series include Space City, Cotopaxi, and Laney. Space City soils occur on 0-15 percent slopes and cover about 22 percent of the Baca Refuge. Cotopaxi sand is on 2-15 percent slopes on dune-like hills and covers 11.5 percent of the refuge. Laney loam is on 0-3 percent slopes on floodplains and fans, formed in calcareous alluvium with saline-alkali characteristics, and covers about 12 percent of the refuge. Grasses and shrubs are typical vegetation found on Space City-Cotopaxi soils (USDA Soil Conservation Service 1973).

The Big Blue-Gerrard association occurs on floodplains along streams on the Baca Refuge and consists of clay loam or loamy surfaces underlain by clay loam and gravelly sandy clay loam. These soils have seasonal high water tables and may be flooded for short periods (USDA Soil Conservation Service 1981). This soil association occurs within the Upper Sump area, which is where most of the playa lakes occur and where ephemeral creeks empty onto the San Luis Creek floodplain.

The Hooper-Hagna-Hapney association on the Baca Refuge includes deep, typically saline-sodic soils on nearly level surfaces of floodplains and terraces. The two major soils of this association, Hooper and Hapney clay loam, each cover about 7 percent of the Baca Refuge (Fig. 13). The water table in these areas is generally high during the spring and summer and historically supported salt desert shrub and salt-tolerant grassland communities; some of these areas are in relict lake basins (USDA Soil Conservation Service 1973). Laney loam, mentioned above, also can occur within the Hooper-Hagna-Hapney areas.

Water Resources

Water is vital for life in the San Luis Valley. Irrigation water converts arid desert ecosystems into productive farmland and hay fields that support livestock, and it is essential for the farming and ranching communities that have defined the character of the area for over 150 years. Water also supports a vibrant resident wildlife population. It is the driving force that forms many unique natural features, including the sand dunes at Great Sand Dunes National Park and Preserve, the playa wetlands and lakes, and the riparian zones along the creeks and rivers.

Water resources include both surface and ground water. Surface water is the result of snow melt in the Sangre de Cristo and San Juan Mountains, intense summer rainstorms, and irrigation return flow from agriculture fields. Ground water comes from a complex aquifer system that has confined and unconfined portions, with artesian flows common. Topographically, the Rio Grande river system dominates the landscape, entering the San Luis Valley from the west and exiting to New Mexico at the south. The valley north of the Rio Grande contains a closed basin. Without a natural surface water outlet, the closed basin acts as a catchment basin, collecting meltwater and rain in a shallow unconfined aquifer. Surface water rarely persists except as playa wetlands, where clay soils impede infiltration. Figures 37, 38, and 39 show how various flow paths for water cross the three refuges.

Hydrology

The Rio Grande is the fifth longest river in North America and the largest river in the San Luis Valley. It starts in the San Juan Mountains above Creede, Colorado, and flows southeast through the towns of South Fork, Del Norte, Monte Vista, and Alamosa, Colorado, and then south to the Colorado State line and into New Mexico (figure 6). Tributaries to the Rio Grande include the Conejos River, Rock Creek, La Jara Creek, and Trinchera Creek. The Rio Grande has an extensive network of storage dams and diversions for irrigation, flood control, and regulation of river flow along its entire length. Rio Grande flow has been regulated by Beaver Creek Reservoir since 1910, Santa Maria Reservoir since 1912, Rio Grande Reservoir since 1912, and Continental Reservoir since 1925, as well as by several smaller reservoirs. The combined capacity of these reservoirs is more than 126,000 acre-feet. These storage reservoirs and other diversions of and changes to the Rio Grande have reduced flooding, but they have also depressed flows during the spring and early summer and led to more prolonged flows throughout the remainder of the year.

The headwaters of the Rio Grande are above the town of Del Norte, Colorado, in the nearby San Juan Mountains. Near the point where it passes Del Norte, the Rio Grande receives surface and subsurface drainage from about 1,320 square miles. There is an extensive history of mining in the upper watershed,

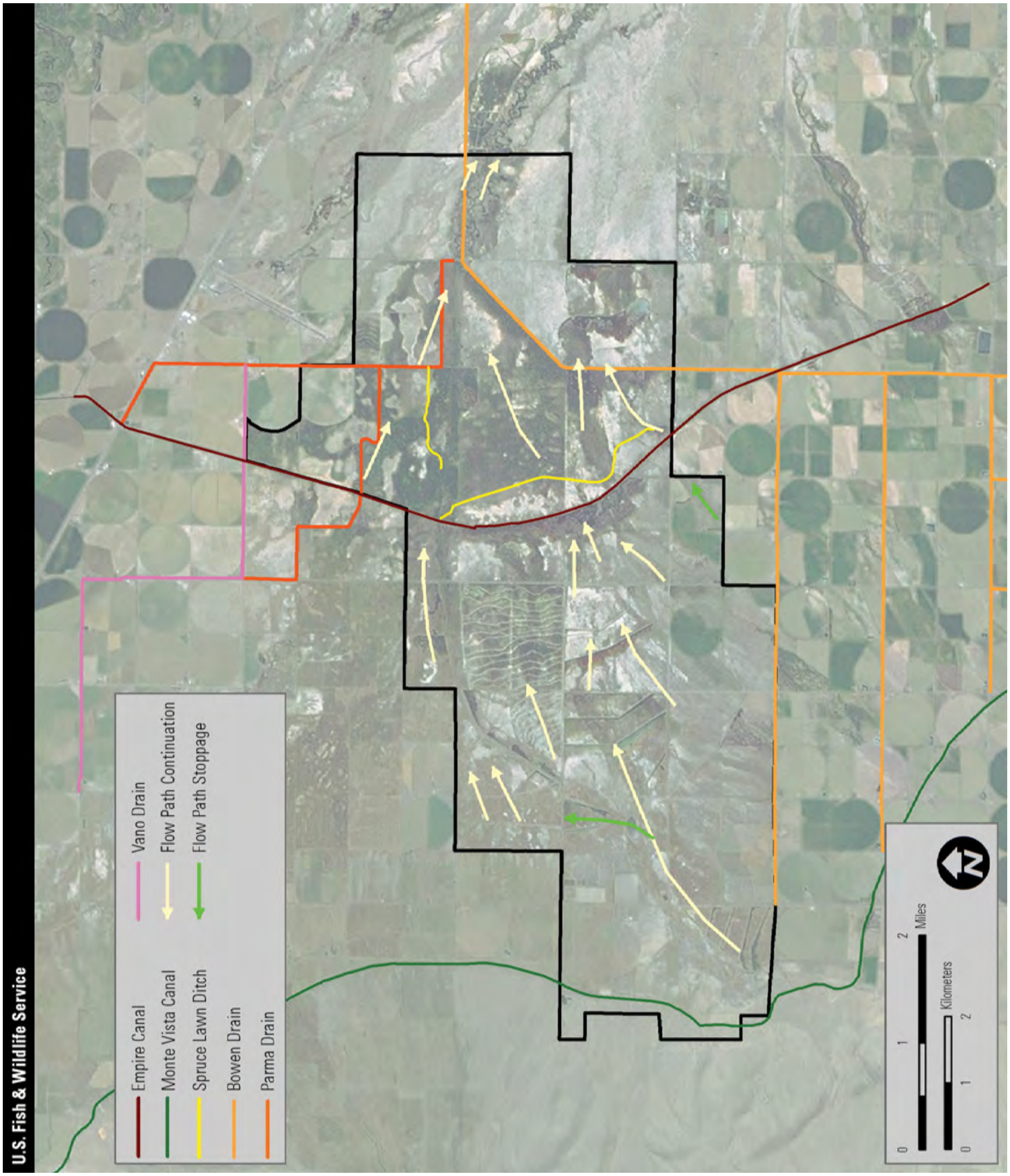

Figure 37. General water flow paths for Monte Vista National Wildlife Refuge, Colorado.

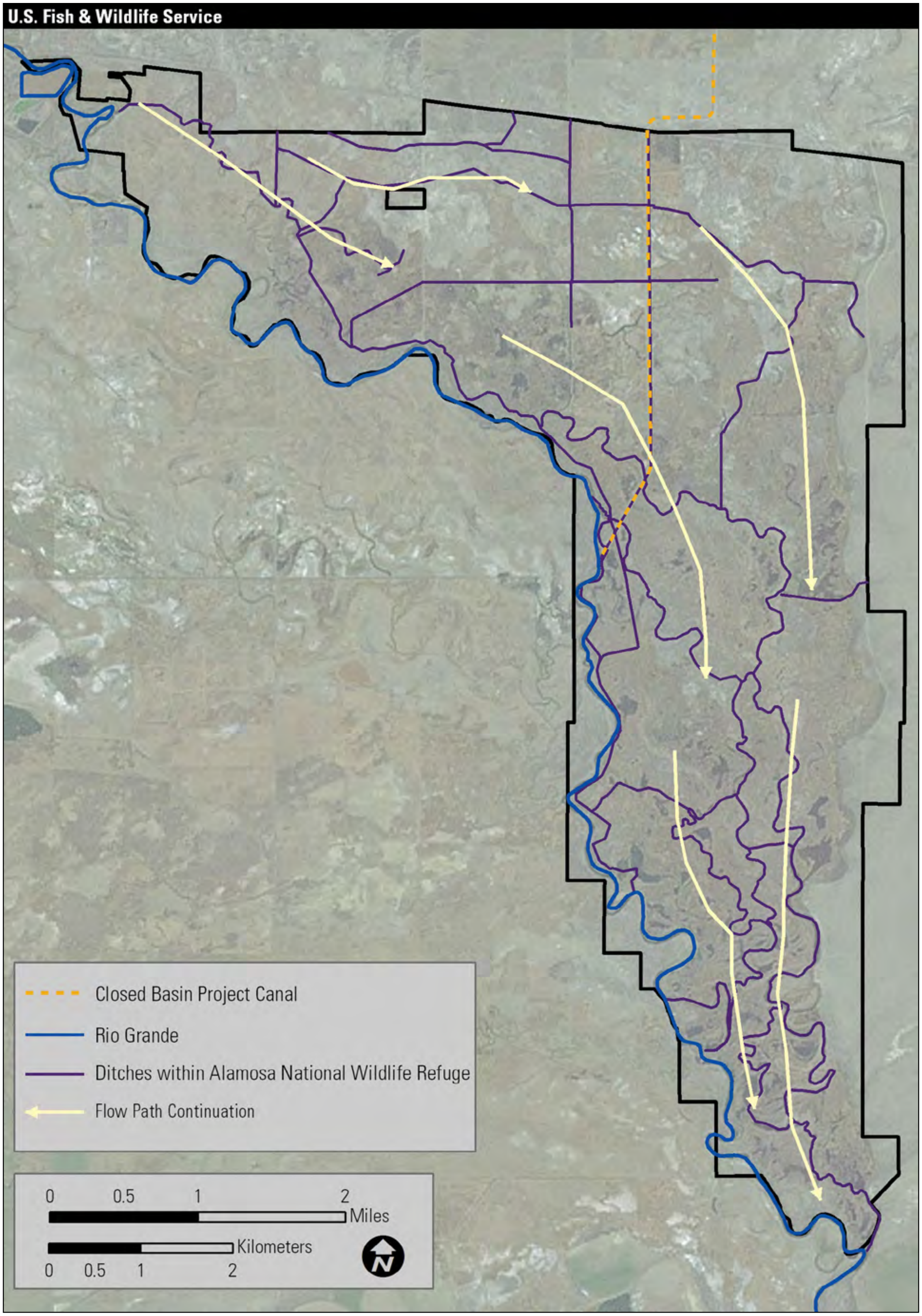

Figure 38. General water flow paths for Alamosa National Wildlife Refuge, Colorado.

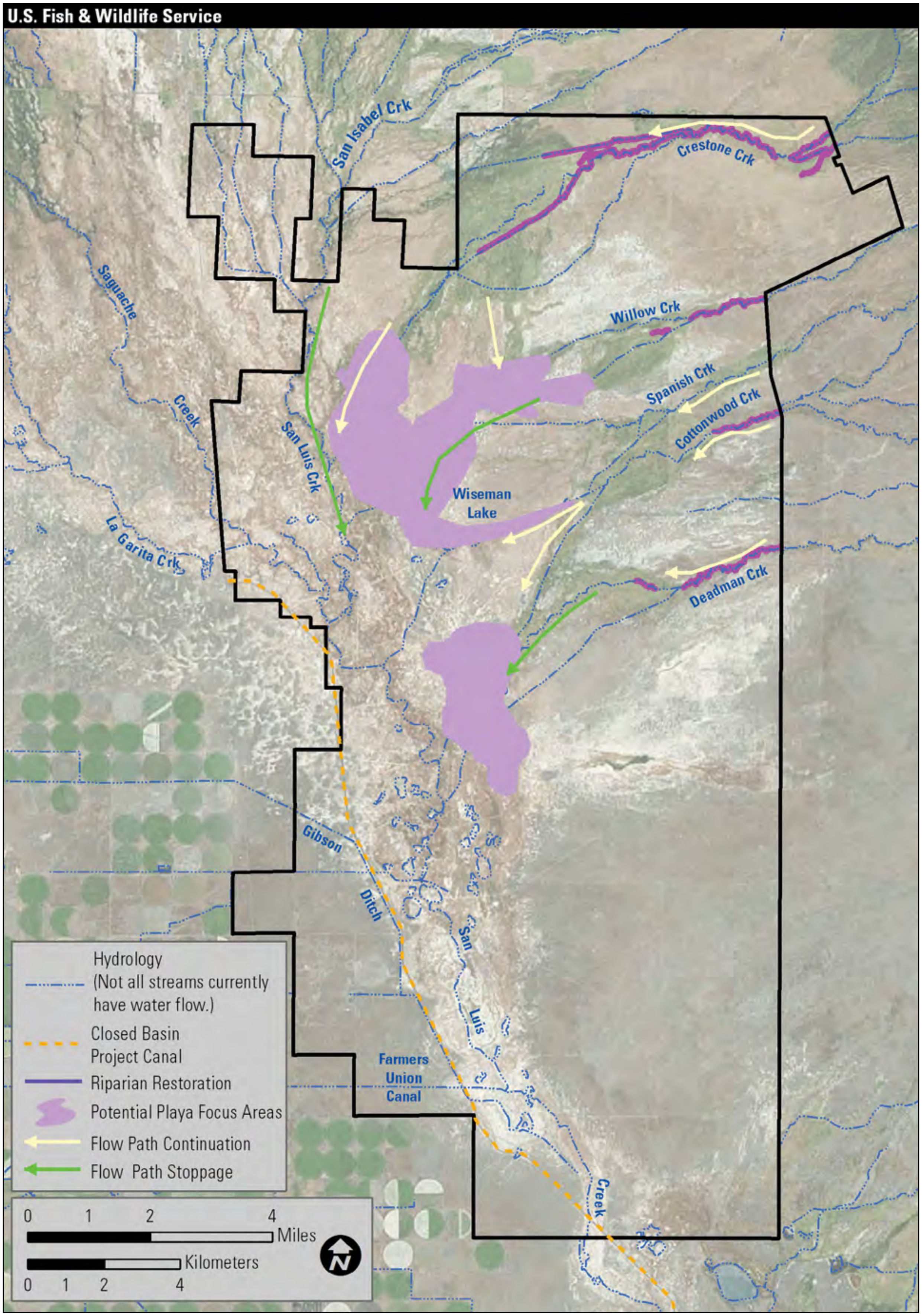

Figure 39. General water flow paths for Baca National Wildlife Refuge, Colorado.

which may still affect water quality in the Rio Grande. From Del Norte, the river passes through predominantly irrigated agricultural land, with the possibility of return flow and associated agricultural chemicals entering the river.

By the time the Rio Grande reaches Monte Vista, the drainage area has increased to 1,590 square miles, and at Alamosa, it has increased to 1,710 square miles. Besides agricultural return flow, water is returned to the river from municipal water treatment facilities and urban runoff, including a golf course in Alamosa. The Empire Canal drains into Rock Creek, but Rock Creek rarely has significant flow by the time it reaches the Rio Grande because the water is diverted for irrigation. La Jara Creek channel joins the Rio Grande at the southern end of the Alamosa Refuge.

The Rio Grande and its tributaries support riparian vegetation along much of their courses, though the cottonwood galleries along the rivers have been in decline for decades. Riparian vegetation is significant for its ability to conserve soil, and for its influence on habitat diversity and aquatic ecosystems. Riparian zones are instrumental in the denitrification of agricultural return flows, and improve water quality by reducing sedimentation and controlling stream temperatures. The water that supports the riparian vegetation comes from seepage and overbank flows as well as return-flow from irrigation ditches and drains. Some discontiguous attempts to restore riparian function have been made by restricting grazing; planting and protecting riparian vegetation; and engineering streambank protection.

The thick basin-fill deposits in the San Luis Valley consist of inter-bedded clay, silt, sand, gravel, and volcanic rock. These form many separate aquifer systems, which are generally grouped into the two major aquifers: a shallow unconfined aquifer and a deep confined aquifer. Combined, these two aquifer systems are contained in deposits that can be as much as 30,000 feet thick (Brendle 2002). The confined aquifer is separated but not totally disconnected from the unconfined aquifer by clay layers and lava flows. The unconfined aquifer is recharged through infiltration of precipitation, irrigation water, runoff, and upward seepage of ground water from the confining bed. Discharge from the unconfined aquifer is from ground water withdrawals, ground water flow to the south, discharge to streams or drains, and evapotranspiration. Water levels in the unconfined aquifer respond to localized rain events.

Wells drilled into the deep confined aquifer are frequently artesian and are buffered from short-term weather conditions. The confined aquifer is recharged from precipitation and snowmelt in the high San Juan and Sangre de Cristo Mountains. Discharge from the confined aquifer is from ground water withdrawals, ground water flow to the south, and upward percolation through the confining bed (The Water Information Program 2012). Wells and diversions for each of the three refuges are shown in figures 40, 41, and 42.

Siebenthal (1910) provides a description of geology and water resources in the San Luis Valley. The eastern limit of the “flowing well area” is in a strip 3 miles wide at the north end and about 5 miles wide in the south and is described as passing through the Baca Refuge and including the playa wetlands area along the western boundary. This area is now known to be broader and extend much further north (R. Cotten, personal communication with planning team, April 21, 2014). The occurrence of natural gas in wells is associated with colored water and coincides with the natural sump area in the San Luis Valley. As distinct as the water and gas occurrence is in this trough, Siebenthal presents evidence for the continuity of the gas-bearing aquifers to the regional ground water aquifers boasting high-quality ground water (Siebenthal 1910).

The San Luis Valley Closed Basin

The San Luis Valley closed basin covers about 1,500 square miles. Closed basins are defined by geographical barriers that prevent drainage out of the basin. In the San Luis Valley, the closed basin is bound on the north end by the convergence of the San Juan and Sangre de Cristo Mountain ranges, and on the south by a low topographical divide north of the Rio Grande. Because the main outflow pathways from the closed basin are primarily evapotranspiration and seepage, the closed basin can accumulate contaminants and environmental pollutants.

The BOR Closed Basin Project was authorized by Congress in 1972 through PL 92-514, (92 Congress, S. 520, 1972) and amended through PL 96-375 in 1980, PL 98-570 in 1984, and PL 100-516 in 1988. The Closed Basin Project is part of the greater San Luis Valley Project, which includes Platoro Reservoir in the Conejos River watershed. Platoro Reservoir was built to control floodwater and provide supplemental water for irrigation. The Closed Basin Project reclaims shallow ground water that would normally be lost to evapotranspiration. Powell and Mutz (1958) found that the shallow water table was within 5 feet of the surface in an area of about 120 square miles within the sump area (Powell and Mutz 1958), an area that includes the Baca Refuge (figure 47). This sump area was targeted for salvage pumping by the Closed Basin Project. Salvaged ground water is carried out of the closed basin to the Rio Grande. The Closed Basin Project’s objectives include helping Colorado to meet annual water deliveries under the Rio Grande Compact; preserving the Alamosa Refuge and the Blanca Wildlife Habitat Area; stabilizing the San

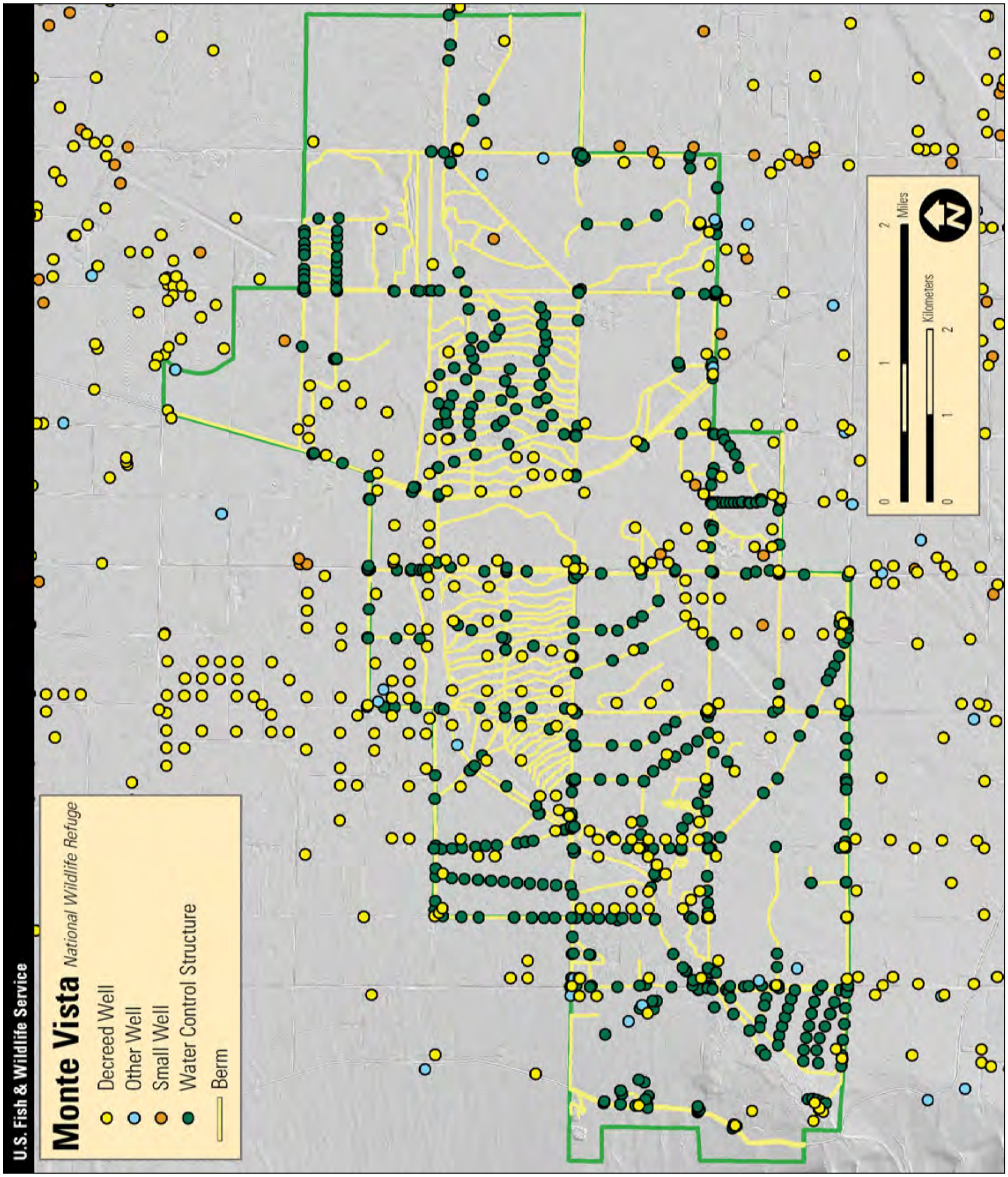

Figure 40. Water wells and diversions for Monte Vista National Wildlife Refuge, Colorado.

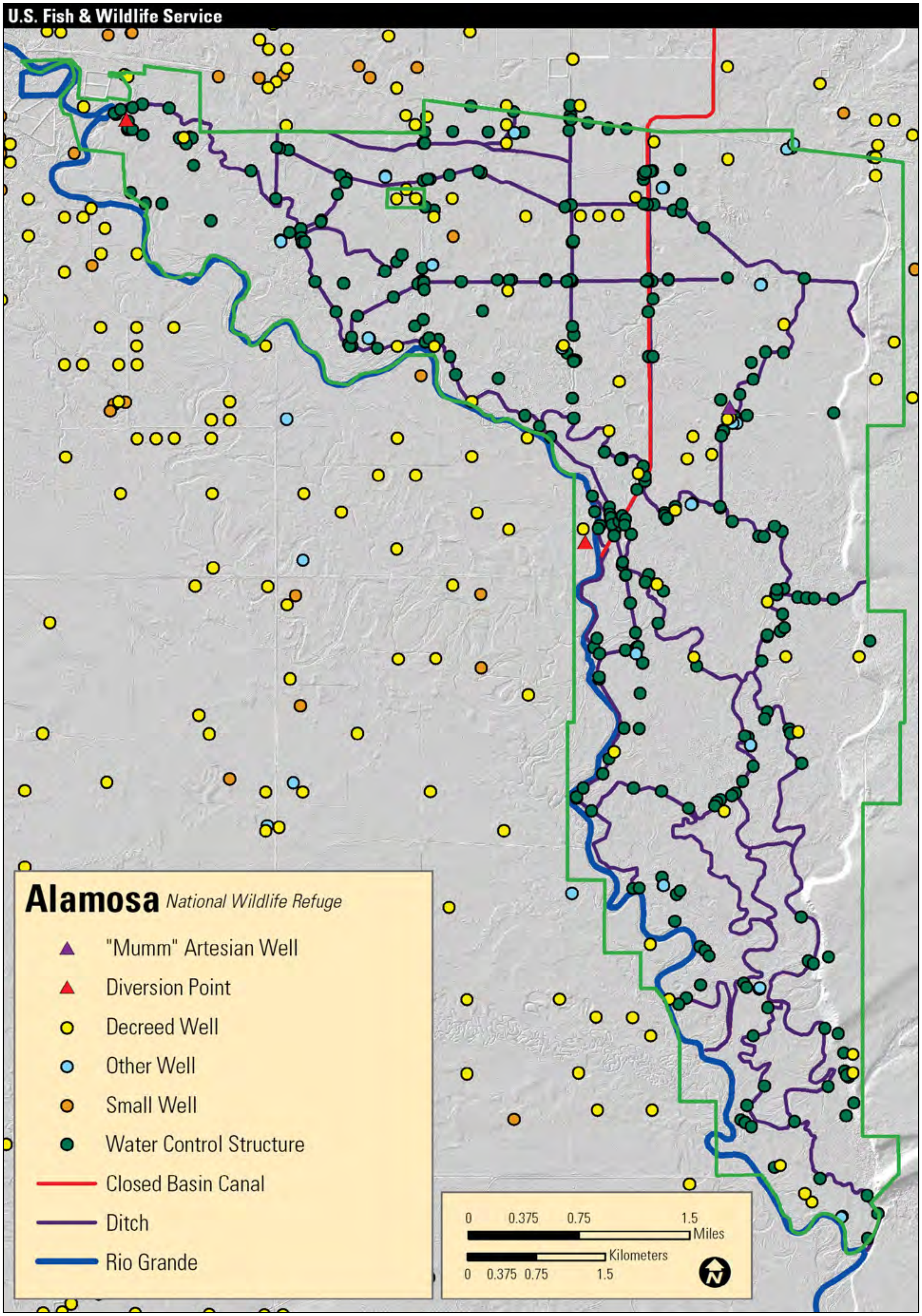

Figure 41. Water wells and diversions for Alamosa National Wildlife Refuge, Colorado.

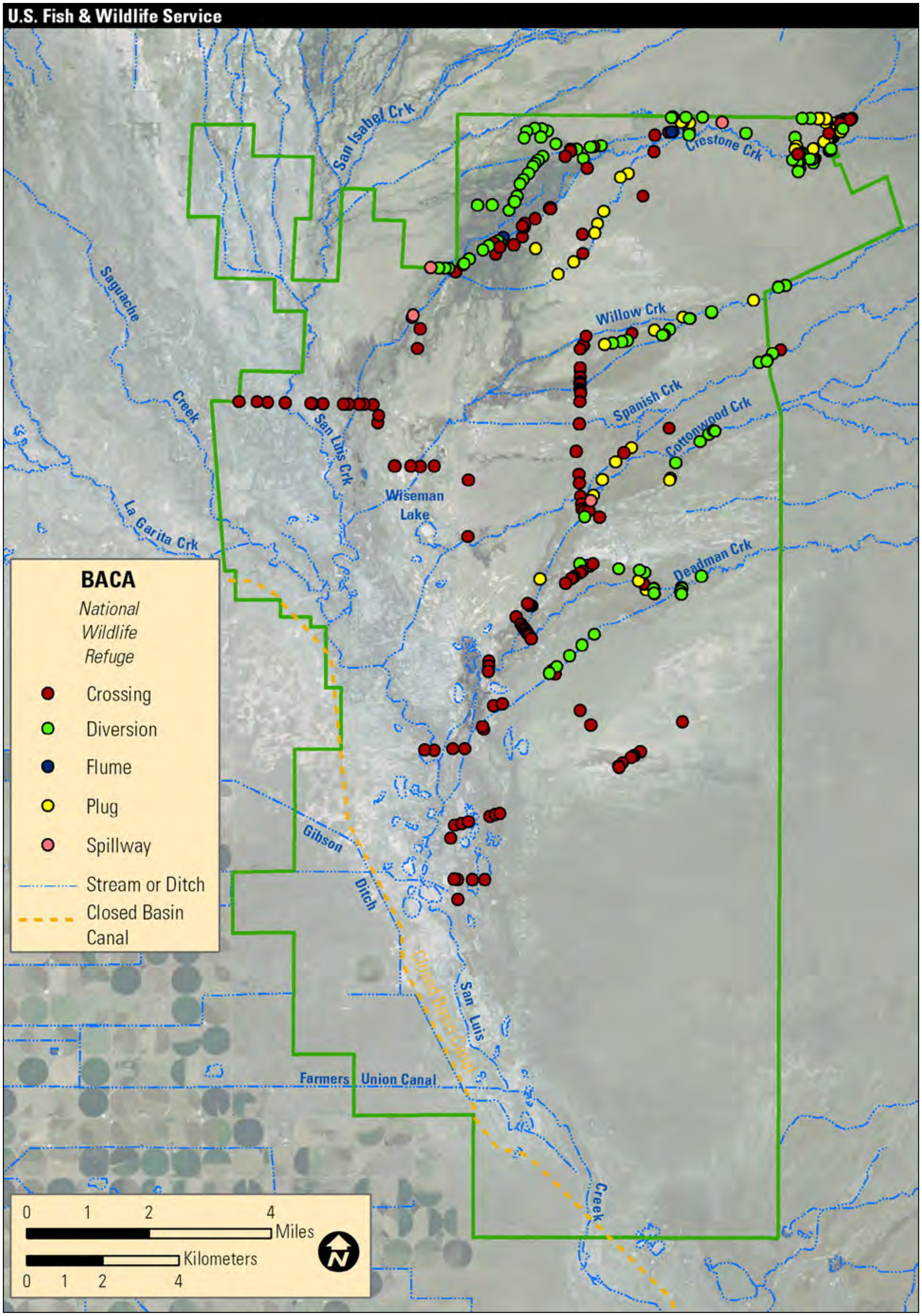

Figure 42. Water wells and diversions for Baca National Wildlife Refuge, Colorado.

Luis Lakes; and providing irrigation water and other beneficial uses.

Congressional authorization of the Closed Basin Project included a stipulation that limits how much Closed Basin Project pumping can lower the area's water table. The Closed Basin Project *"will not cause the water table available for any irrigation or domestic wells in existence outside the project boundary prior to the construction of the project to drop more than two feet."* The project will be operated *"in a manner that will not cause reduction of artesian flows in existence prior to the construction of the project."* The project is required to maintain a system of observation wells, designed to *"provide positive identification of any fluctuations in the water table of the area surrounding the project attributable to operation of the project or any part thereof"* (92 Congress, S. 520 1972).

The Closed Basin Project covers only about 200 square miles of the 1,500 square mile closed basin in the San Luis Valley. The Closed Basin Project consists of 170 salvage wells, 132 monitoring wells, 115 miles of pipeline, and a 42-mile-long polyvinyl chloride (PVC) lined canal. A former manager for the Closed Basin Project (Hildner 2011) said that the Closed Basin Project yields 15,000 to 20,000 acre-feet per year (AFY) of the 117,000 AFY design capacity, which is 15 percent of the design capacity. Of the 170 salvage wells, only about 90 operate at one time, and some wells are not used because of water quality concerns. The Sangre De Cristo runoff, initially projected at around 8,000 AFY, has been closer to 2,000 AFY (Hildner 2011). The water levels in the unconfined aquifer in the closed basin are declining and withdrawals are exceeding recharge (Rio Grande Water Conservation District 2012a). Nearly a third of the Closed Basin Project salvage wells lie in the playa wetlands area along the west side of the Baca Refuge. Figure 48 shows the wells that lie within the Closed Basin Project and the hundreds of wells, miles of canals, and six major creeks found within or adjacent to the Baca Refuge.

The first salvage wells were constructed between 1986 and 1992. Between 1992 and 2000, productivity began to decline because of biofouling of well screens, pumps, and transmission lines caused by iron bacteria and manganese deposits. Beginning around the year 2000, salvage wells for the Closed Basin Project were redrilled in the same locations to regain productivity. Biofouling again affected well productivity, and by 2012 the third round of drilling began. For this third round of drilling,BOR moved the well locations and called for higher capacity wells, with production capacity increasing from 100 gallons per minute (gpm) to 420 gpm. Drilling the new well-field began in 2012 with the wells furthest east drilled first.

Though the new salvage wells for the Closed Basin Project have a higher capacity design, pumping is planned to be intermittent; it is suspected that continuous pumping leads to more biofouling (personal communication, Pete Striffler, February 2013). However, as more wells are being shut down and the productivity of older wells is reduced by bio-fouling across the project, more reliance is focused on wells with the newer design, and continuous pumping of the 2012 wells is providing most of the Closed Basin Project salvage water.

The Closed Basin Project threatens water-dependent wildlife habitat across most of the closed basin. By focusing their salvage pumping on the playa wetlands area, the most extreme ground water level declines attributable to Closed Basin Project pumping occur on the Baca Refuge. Ground water declines have been compounded by insufficient recharge from below average snowpack during dry years in 2011, 2012, and 2013.

Water Rights

The largest reduction in flow in the Rio Grande hydrologic system is from diversions for irrigation. Surface water diversions take water directly out of the river, and ground water diversions cause depletions by lowering local aquifer levels. A complex system of water rights decides who gets to use water first. Interactions between ground water and surface water are complex and poorly understood.

Ground water in Colorado is designated as either tributary or non-tributary. Tributary ground water is water contained in aquifers that have a direct hydraulic connection to surface water. Both the unconfined and confined aquifers in the San Luis Valley are tributary ground water, though the hydraulic connection to the surface water system is poorly understood in the confined aquifer.

Surface and groundwater rights in Colorado are subject to the prior appropriation doctrine: first in time, first in right. The prior appropriation doctrine allows State officials to properly manage and distribute water according to the decreed priority dates. If there is not enough water in a particular stream to satisfy all water right holders, the State may shut off junior right holders as necessary to make sure that senior water right holders receive their full appropriation. The Rio Grande basin is over-appropriated.

The "Rules Governing the Withdrawal of Groundwater in Water Division No. 3" have as their objective "the optimum use of water consistent with the preservation of the priority system of water rights, and protection of Colorado's ability to meet its interstate compact obligations." The use of the confined and unconfined aquifers will be regulated to keep a sustainable water supply, with due regard for the daily, seasonal, and long-term demand for ground water.

The widespread development of ground water-irrigated agriculture in the central valley began in the early 1950s, and water rights associated with the irrigation wells generally carry priority dates from the 1970s. The Rio Grande Decision Support System is a ground water model used to predict the effects of ground water pumping on surface water flows, with specific response functions assigned to each area with similar hydrologic characteristics (response areas). Administration of water rights by the State Engineer's Office will rely on these response functions as a predictive tool for identifying injurious depletions to surface water flows by ground water pumping, and to determine how much depletion is required for a given group of wells. Augmentation plans or any alternatives must also meet aquifer sustainability requirements. The Rules and Regulations allow for the formation of ground water sub-districts within each response area for water users to collaboratively address water use restrictions.

The relationships between the unconfined and confined aquifers and the surface water are not well defined. The purpose of the Rio Grande Decision Support System is to improve the understanding of the aquifer systems and improve estimates of depletions from well users (Colorado Division of Water Resources 2000). The Rio Grande Water Conservation District has gathered well information and water level measurements from their wells, BOR wells, the USGS Groundwater Inventory Database, and the Rio Grande Decision Support System (Davis Engineering Service, Inc.; Principia Mathematica, Inc, 2012). Rio Grande Water Conservation District data allow comparison of water levels through time and examination of well hydrographs. Their data show that there are declining water levels in the unconfined aquifer of the northern San Luis Valley, with aquifer withdrawals exceeding total recharge. The Conservation District emphasizes that the recent water table declines are the result of increased ground water consumption combined with a prolonged drought, and warn that conditions will worsen without reductions in total ground water consumption (Rio Grande Water Conservation District 2012a).

Monte Vista National Wildlife Refuge

Typically, ground water wells that discharge more than 50 gallons per minute (gpm) require metering in the San Luis Valley. On the Monte Vista Refuge, 10 large wells discharge more than 2,000 gpm. Total irrigated acreage permitted from these 10 large capacity wells totals more than 4,700 acres. Thirteen wells discharge between 1,000 gpm and 2,000 gpm, with authorized irrigation on nearly 5,300 acres. Thirty-seven wells discharge at flow rates less than 1,000 gpm. Twenty-two of these wells flow at rates of 50 gpm or less and may not require metering. Eleven wells rated between 75 and 1,000 gpm are inactive and would require maintenance and meters before use. The remaining four wells are active and in use, with meters (figure 40).

Water resources on the Monte Vista Refuge will be affected by the new groundwater rules and regulations that are being developed by the State Engineer's Office. Preliminary estimates of the effects of pumping on the Monte Vista Refuge for wildlife habitat indicate that surface water flow as far away as the Rio Grande and Conejos River systems may be affected. Augmentation of pumping on the Monte Vista Refuge will strain the water resources on the refuge. Joining a ground water sub-district may be necessary to adequately address augmentation needs on the refuge.

Alamosa National Wildlife Refuge

The Chicago ditch and New ditch both get water from the Rio Grande (figure 41). For water rights held by the canal companies, we own all of the water shares in the Chicago ditch. Water available to the refuge from the Chicago ditch is adjudicated for 66.4 cubic feet per second (cfs) through several court proceedings and case numbers:

- October 15, 1934; admin no. 27138
- May 1, 1896; admin no. 11323
- May 1, 1896; admin no. 10788
- The appropriation dates are July 15, 1879, December 31, 1880, and April 20, 1924. Similarly, the Service owns all of the water rights in the New ditch (formerly the Rio Grande ditch) and New ditch enlargement, with 30.43 cfs of water adjudicated through several court proceedings:
- Civil Action 1557; admin no. 19173
- Civil Action 2673; admin no. 32400.31546;
- Case Number April 9,1903; administration numbers 17713 and 16923; multiple appropriation dates June 30, 1890, June 30, 1898, June 30, 1902, and May 15, 1936

The Stewart ditch, the New ditch, and the New ditch enlargement are all segments of the same ditch.

The Shepard ditch has a permanent decree for 1 cfs (case number September 13, 1916; admin no. 23640). It carries seepage from the Costilla ditch, which has a priority date of September 22, 1914, but

USFWS

An example of riparian habitat considered to be in good condition on Baca Refuge. Challenger Peak rises up to over 14,000 from the valley floor.

is not listed in the decrees. The Shepard ditch also carries water from the Closed Basin canal that is diverted from the pumping plant.

The Costilla ditch and San Luis Valley Canal carry water from the Rio Grande. Shares owned by the Service are adjudicated through case numbers and appropriation dates. Water is permitted for use on overlapping areas in the northern parts of the refuge.

The Closed Basin canal brings a valuable water resource to the Alamosa Refuge for wildlife and habitat management outside of irrigation season constraints. Delivery of Closed Basin Project water in the Closed Basin canal is dependent on the production from salvage wells in the closed basin. Availability of the water to the Alamosa Refuge is determined based on the amount of water produced by the Closed Basin Project in a given year. Although it is not a water right, closed basin water is provided to the Alamosa Refuge as mitigation for loss of habitat from Closed Basin Project construction. Water is delivered to the Alamosa Refuge without constraints to place-of-use. The refuge takes water out of the Closed Basin canal from two constant-head orifices and a pumping plant. Water in the Closed Basin Canal that bypasses Alamosa Refuge use is delivered into the Rio Grande near the middle of the refuge. Subdistrict 1, through their approved augmentation plan, provides additional Closed Basin Water to the refuge to make up for out of priority depletions to the Chicago ditch. The volume of water depends on the volume of out of priority depletions.

High capacity ground water wells on the Alamosa Refuge consist of the following:

- 4 Lillpop wells; case number W-2573
  - well #1: 400 gpm; December 31, 1910
  - well #2: 800 gpm; December 31, 1938
  - well #3: 800 gpm; December 31, 1938
  - well #4: 80 gpm; December 31, 1890

- 4 Service wells
  - FWS-25-4A; 100 gpm; December 31, 1906;
  - FWS 28-6A; 100 gpm; December 21, 1947
  - FWS-26-4A; 50 gpm; December 20, 1948;
  - FWS-29-4A; 50 gpm; December 12, 1949), and

- The Mumm well (FWS-23-20A; 2,865 gpm; September 18, 1958).

All of the other wells on the refuge are low-capacity domestic and stock use wells with localized places of use. Only the Mumm well is now being used by the refuge. The refuge may have sufficient surface water rights to provide augmentation water for ground water used from the Mumm well depending on what streams or rivers are determined to be affected based on the response functions. Though the full effects of pumping will not be known until release of the response functions, ground water pumping from the Mumm well may influence both the Rio Grande and the Trinchera Creek hydrologic systems.

Baca National Wildlife Refuge

The Baca Refuge relies heavily on surface water from small creeks that flow out of the Sangre de Cristo Mountains. Water rights were appurtenant to lands acquired with the Baca Refuge property and carry senior priority dates ranging from June 1, 1869, to May 1, 1949. Total adjudicated flow for all water rights on surface water is more than 620 cfs, but most of that is available only seasonally. Because some of these creeks may not flow during dry years, the refuge usually does not get its full water right.

The water rights database maintained by the Service in Region 6, Division of Water Resources, lists 134 wells on the Baca Refuge (figure 42). Fifteen wells are permitted for irrigation use only, 22 wells are for observation or monitoring, 82 wells are livestock wells, and 7 wells are permitted for domestic or municipal use. Twelve wells have multi-use permits, including stock and irrigation or irrigation and domestic uses. Eighty wells are described as confined aquifer wells, 24 are described as unconfined aquifer wells, and 30 do not have an aquifer associated with them in the record.

Some of the water rights are subject to a preexisting lease agreement with the Baca Grande Water and

Sanitation District. This agreement requires that the refuge lease to the District up to 4,000 acre-feet of water annually, primarily for irrigation; fire; and domestic, municipal and recreational uses if the District demonstrates the need. Legislation establishing the Baca Refuge provides for the sale of water rights in order to terminate the lease agreement. Two of the wells are drilled in the unconfined aquifer, one is an alternate point of diversion for one of these two wells, and the Golf Course Well is an alternate point of diversion for Baca Grant ditch 7. Under the lease agreement, we do not own and are not responsible for maintaining the infrastructure enabling water delivery, but could be required to provide replacement water for the wells drilled in the unconfined aquifer under an augmentation plan. Options to relieve this burden on Service resources are being negotiated with the Baca Grande Water and Sanitation District.

We may own sufficient surface water rights for augmentation water to replace ground water pumping, depending on what the response functions show. The legislation establishing the Refuge prohibits the use of Baca surface water for anything other than the historic use, and this may affect the Refuge's ability to use surface water for augmentation. It currently appears unlikely that there will be a Subdistrict developed that would cover the Baca refuge.

Water Quality Monitoring

Water quality in the Rio Grande system is driven by the chemical conditions in the drainage basin. Sub-surface mining was a historically important industry in the high San Juan Mountains, and some mining continues today. Some water quality concerns may be attributable to mine drainage. Water chemistry in the Rio Grande at Del Norte is predominantly calcium bicarbonate (Ca(HCO3)2) type with the silica concentration of secondary importance (USGS 2011a). Soluble calcium bicarbonate is formed when excess carbon dioxide in rainwater reacts with limestone, a process that increases on mine tailings. The EPA assessment data for the Rio Grande headwaters watershed in 2008 list impaired conditions on the mainstem of the Rio Grande below Willow Creek (EPA 2008) for cadmium and zinc, and the probable source is listed as abandoned mine lands. Because of runoff from abandoned mine lands, the EPA has listed the Rio Grande from Del Norte to Monte Vista as impaired due to copper. The designated use group for the impairments is for fish, shellfish, and wildlife protection and propagation. No Total Maximum Daily Loads (TMDLs) apply to this water-body. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards.

Three EPA Clean Water Act facilities exist along the Rio Grande between Del Norte, Colorado, and the Alamosa Refuge: the Town of Del Norte; the City of Monte Vista Henderson Lagoon Facility in Monte Vista, Colorado; and the Regional Waste Water Treatment Facility in Alamosa, Colorado. These are all sewage systems operating under National Pollutant Discharge Elimination System permits. Recent inspection reports are available from the EPA (EPA 2012a). Violations of the Clean Water Act at the Del Norte Facility (EPA, 2012) are limited to pH limit violations in January 2009 (pH=9.36) and again in April 2011 (pH=9.06), and violations of biological oxygen demand limits in monthly gross effluent outfall samples. Biological oxygen demand is used to gauge the effectiveness of wastewater treatment plants and is a surrogate of the degree of organic pollution in water (EPA 2012a).

Similarly, violations were reported for the Monte Vista Henderson Lagoon Facility for pH (10.8, April 2010, and 10.7, May 2010) and biological oxygen demand concentration (57 mg/l, April 2011) (EPA 2012a). The Regional Waste Water Treatment Facility in Alamosa, Colorado, reported violations of biological oxygen demand concentration (93 mg/l, April 2011), and biological oxygen demand percent removal (below 85 percent, April 2011) (EPA 2012a). Additional violations were reported that related to reportable noncompliance, cadmium concentration, copper concentration, and lead concentration.

The environmental assessment for proposed oil and gas exploration (FWS 2011b) compares USGS water quality data from 1967-1968 with more recent data from 2008 and concludes that water quality conditions have not changed appreciably over the past 40 years. The pH values are fairly neutral, the major cation is calcium, and the major anion is bicarbonate. Additional sampling as part of a baseline sampling program did not detect gas or diesel in any of the samples, found methane in all of the Spanish Creek samples, and found volatile organic compounds in two samples from Willow Creek.

Crestone and South Crestone Creeks receive sewage effluent from the Aspen Institute Waste Water Treatment Facility. A recent study of fathead minnows collected from Crestone and South Crestone Creeks found that pharmaceutical and personal care products are being found at low concentrations; however, some products have the potential to be potent. Pharmaceuticals found include antiepileptics, antidiabetics, antibiotics, and antidepressants (Sanchez et al. 2012).

Head Lake, Soda Lake, and the San Luis Lakes, which are in the sump area of the closed basin, vary seasonally, with dissolved solids ranging from 223 to 17,100 milligrams per liter (mg/l), total hardness ranging from 126 to 578 mg/l, and sodium ranging from 30 to 97 mg/l (Powell and Mutz 1958), and relatively high (630 mg/l) concentrations of bicarbonate in Soda Lake and fluoride concentrations in San Luis Lake as high as 3.2 mg/l. These conditions are natural for the area and cannot be attributed to anthropogenic contamination. Total dissolved solids (a measure of the combined content of all inorganic and organic substances contained in water) values of less than 500 mg/l are generally found on the Baca Refuge (FWS 2011b) except in wells deeper than about 2,500 feet, where total dissolved solids can be higher than 3,000 mg/l. The Groundwater Atlas of the United States (Robson and Banta 1995) says that Total Dissolved Solids are less than 500 mg/l along the fringes of the basin but more than 3,000 mg/l in the center of the basin. Mayo reports total dissolved solids as high as 35,000 mg/l in the unconfined aquifer south of the sump as a result of mineral dissolution, ion exchange, and methanogenesis (formation of methane) from organic and evaporate lake sediments (Mayo 2006).

The ground water in the San Luis Valley has bacteria, toxic metals, and nitrate (FWS 2011b). USGS, in an agricultural land use study, found 11 of 35 wells contained nitrate concentrations ranging from 0.1 to 58 mg/l, which is above EPA maximum contamination levels (Levings et al. 1998). Elevated nitrite and nitrate are a result of leaching of fertilizers from the land surface (Anderholm 1993). Trace amounts of pesticides were found in nearly 15 percent of the samples, but in concentrations below EPA health advisories.

Water quality concerns on the Baca Refuge include iron bacteria and manganese deposits that clog well infrastructure, including well-screens, discharge lines, and pumps. Some areas of the unconfined aquifer yield water with naturally high salinity. Ground water that reaches the Baca Refuge from septic leach fields in the Grants section of the Baca Grande subdivision is a concern.

Siebenthal catalogued an area in which gas is mingled with water in the deeper wells, described as a trough of the valley stretching from a point 4 miles northeast of Alamosa, Colorado, within 3 miles of Moffat, Colorado, with a length of 30 miles and an average width of 8 miles that includes parts of the Baca Refuge (Siebenthal 1910). Ground water from these wells is deeply tainted, containing from 42 to 134 parts per million (ppm) organic matter. Streams flowing away from these wells are bordered by alkali incrustation, and reports of the harmful effects of these waters for irrigation vary widely. Moderate use is likely to cause the formation of a hard crust on the soil surface, and its continued use in subirrigation will impregnate the soil with alkali. As distinct as the water and gas occurrence is in this trough, Siebenthal presents evidence for the continuity of the gas-bearing aquifers to the regional ground water aquifers boasting high quality ground water (Siebenthal 1910). During baseline sampling in 2008 for the Baca Refuge's environmental assessment for proposed oil and gas exploration, analysis of ground water samples detected methane in 17 of 20 wells and ethane in 10 of 20 wells (FWS 2011b), verifying the gas-bearing aquifers in the Siebenthal study.

The environmental assessment for the Baca Grande Water and Sanitation District (Brown and Caldwell 2009) found elevated nitrates in the Motel well, which is used as a water source for the Casita Park area of the subdivision near the Baca Refuge. The source of the nitrates is speculated to be either the Casita Park Waste Water Treatment Facility or the White Eagle Inn individual sewage disposal system.

Anderholm concludes that on the basis of areal distribution and range of trace element concentrations, human activities have not caused widespread contamination of the ground water. The main factors affecting trace element concentrations in the ground water are the solubility equilibrium, variation in the distribution of minerals in the aquifer, formation of organic complexes, formation of carbonate complexes, and the oxidation-reduction state of the aquifer. Relatively few synthetic organic compounds were detected, further indicating that human activities have not resulted in widespread contamination of the shallow aquifer system (Anderholm 1993).

Visual Resources and Night Skies

The National Environmental Policy Act requires that measures be taken to "assure for all Americans… aesthetically pleasing surroundings." Visual resources are those qualities of the resource that often inspire people and contribute to their overall experience or quality of life.

The Baca Refuge, which is located at an elevation of about 7,600 feet, has a moderate to high scenic quality, although areas near the Closed Basin Project are less scenic than the wet meadows and shrublands on the eastern side of the refuge. Expansive wet meadows, playas, sand sheets, and greasewood and shrubland communities are juxtaposed against dramatic views of the Great Sand Dunes as well as of the Sangre de Cristo Range, including Challenger Point, Kit Carson Peak, Crestone Peak, and Crestone Needle, which are 14,000-foot-high peaks. Abundant wildlife on the refuge contributes to the scenic qualities of the area.

The Alamosa and Monte Vista Refuges are adjacent to the towns of Alamosa and Monte Vista, but still have a rural atmosphere. As with the Baca Refuge, the scenic qualities of these refuges are high. Blanca Peak, Little Bear Peak, Ellingwood Point, and Culebra Peak, which are 14,000-foot-high peaks of the Sangre de Cristo Range, provide a spectacular backdrop for the wetlands and the shrublands of the Alamosa Refuge. The Rio Grande meanders along the western edge of the refuge, and the Bluff Overlook provides an excellent view of the refuge. Toward the western side of the San Luis Valley, the Monte Vista Refuge lies closer to the San Juan Range, where Bennett Peak rises to more than 13,000 feet and reigns over the refuge's wetlands and shrublands.

Visitor and operational facilities, roads, and smoke from wildfires or prescribed fires are some of the factors that may affect the scenic qualities of the refuges.

Another important part of visual quality is ambient light and its effect on the night sky (NPS 2007). The Baca Grande subdivision next to the Baca Refuge has developed guidelines to reduce light pollution by use of motion-activated lights as well as shielded or hooded exterior lighting that is limited to entry walks, porches, and exterior patios (Baca Grande Properties Owners Association 2012). With the limited commercial development in the area; the predominantly agricultural landscape; the clean, dry mountain air; and the large swath of public land immediately adjacent to the refuge boundary and the national park, the night skies in and around the Baca Refuge are largely dark, which provides outstanding opportunities to see the stars, moon, planets, and other celestial objects on clear nights. Preserving the view of the night sky is important for local residents.

Soundscapes (Acoustical Environment)

Except for small areas next to the refuges, the baseline soundscape is expected to be natural sounds. Localized exceptions include noises located along roads, the railroad track near the Alamosa Refuge, and trails. Noise sources include on-road and off-road vehicles, equipment, airplanes, and rail traffic. Other noise sources in the adjacent area include agricultural activity, State highways, and small airports in Alamosa and Monte Vista.

Noise

Noise is typically defined as disruptive or unwanted sound. Noise has the potential to interrupt ongoing activities and result in community annoyance, especially in residential areas. Most noticeably, annoyance occurs when noise interferes significantly with activities such as sleeping, talking, and listening to the television, radio, or music. Noise can also disrupt wildlife by changing or intruding on the natural soundscape and masking natural sounds.

Environmental noise is typically a collection of distant noise sources that result in a low-level background noise from which no individual noise source is prevalent or identifiable. The background, or ambient, noise remains relatively constant from moment to moment; however, if the area is inhabited, it may vary from hour to hour as changes in human activity patterns occur. Loud, relatively brief noise from identifiable sources such as aircraft flyovers, screeching of brakes, and other short-term events will cause the noise level to fluctuate distinctively from moment to moment.

Brief definitions of noise terminology used in this analysis are listed below (FWS 2011b).

- The receiver is the location at which the sound level is being measured or where the sound would be heard.
- A sensitive receptor is a location where people are subject to sleep or concentration disturbance.
- A decibel (dB) is the expression for sound that describes its energy level.
- A-weighted decibel (dBA) is a weighted sound level that represents how the human ear responds to normal sounds.
- Equivalent energy noise level (Leq) is the equivalent continuous noise level, usually measured over 1 hour.
- The day-night level (Ldn) is a 24-hour average Leq with a 10 dBA "penalty" added to noise during the hours of 10:00 p.m. to 7:00 a.m. to account for the greater sensitivity to noise that people have at night.
- Community noise equivalent level (CNEL) is a 24-hour average with a 5 dBA penalty added to noise during the evening from 7:00 p.m. to 10:00 p.m. and a 10 dBA penalty added during the nighttime from 10:00 p.m. to 7:00 a.m. The CNEL is similar to the Ldn, with the CNEL about 0.2 to 1 decibel greater than the Ldn.

- Sound exposure limit (SEL) is the cumulative noise exposure at a receiver from a single noise event.

Community noise environments are typically represented by noise levels measured throughout the day and night, or over a 24-hour period (CNEL); the 1-hour period is especially useful for characterizing noise caused by short-term events such as operation of construction equipment or concert noise (with Leq).

Community noise levels are generally perceived as quiet when the CNEL is below 45 dBA, moderate when it is between 45 to 60 dBA, and loud when it is above 60 dBA. Noisy urban residential areas are usually around 70 dBA CNEL. Along major thoroughfares, roadside noise levels are typically between 65 and 75 dBA CNEL. Noise levels above 45 dBA at night can disrupt sleep, and levels greater than 85 dBA can cause temporary or permanent hearing loss. When evaluating changes in 24-hour community noise levels, a difference of 3 dBA is a barely perceptible increase to most people, a 5 dBA increase is readily noticeable, while a difference of 10 dBA would be perceived as a doubling of loudness. Table 10 lists dBA noise levels for common events in the environment and industry (FWS 2011b).

Table 10. Typical A-weighted sound levels.

Sound source	*dBA reading*
Air raid siren at 50 feet (threshold of pain)	120
On platform by passing subway train	100
On sidewalk by passing heavy truck or bus	90
On sidewalk by typical highway	80
On sidewalk by passing automobiles with mufflers	70
Typical urban area background/busy office	60
Typical suburban area background	50
Quiet suburban area at night	40
Typical rural area at night	30
Broadcasting studio	20
Threshold of hearing without damage	0

Source: Cowan 1994

Noise levels diminish as the distance from the source to the receptor increases; this is referred to as "attenuation." Other factors such as the weather, reflecting, or shielding can intensify or reduce noise levels at any given location. Noise levels may also be reduced by interrupting the "pathway" between the source and receptor. For example, a single row of buildings between the receptor and the noise source reduces the noise level by about 5 dBA. Generally, the most effective way to reduce noise is through the use of a physical separation, or buffer, between the source and receptor.

Vibration

Ground-borne vibration is a back-and-forth motion that can be described in terms of the displacement, velocity, or acceleration of the motion. Activities such as construction (especially blasting and pile-driving), buses on rough roads, and trains can result in ground-borne vibration. Annoyance from vibration can occur when the vibration is only slightly noticeable and is well below the damage threshold for normal buildings. To avoid confusion with sound decibels, the abbreviation VdB is used for vibration decibels.

Typical background vibration levels in residential areas are usually less than 50 VdB, well below the threshold of perception for most humans, which is 65 VdB. Internal sources of perceptible vibration levels inside homes are attributed to the operation of heating and air conditioning systems, door slams, and foot traffic. Construction activities, train operations, and street traffic are some of the most common external sources of vibration that can be perceptible inside homes. Although perceptible at 65 VdB, typically vibration is not considered significant until it exceeds 70 VdB. Construction activities generate vibration levels between 50 and 81 VdB at a distance of 50 feet from the source. Large bulldozers can generate vibration levels at 87 VdB at 25 feet from the source. Table 11 shows the typical human response to different levels of ground-borne vibration (FWS 2011b).

Table 11. Human response to different levels of ground-borne vibration.

Vibration velocity Level (VdB)	*Response*
65	Approximate threshold of perception for many humans.
75	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find transit vibration at this level annoying.
85	Vibration acceptable only if there are an infrequent number of events per day.

Source: U.S. Department of Transportation. Federal Transit Administration 2006; FWS 2011b

Existing Noise and Vibration Sources

A noise survey has not been conducted for the refuge complex (FWS 2011b). Except for localized areas, the baseline soundscape is expected to be natural sounds. Localized exceptions to the baseline soundscape include linear noise sources located along roads, railroad tracks, and trails. These include on-road and off-road vehicles, construction equipment, planes, and rail traffic. Other existing noise sources in the San Luis Valley include agricultural activity, State highways, a local commercial airport, and freight railroads.

Existing vibration sources consist primarily of vehicular traffic, rail traffic, and intermittent construction activities. When vehicular traffic does cause perceptible vibration, the source can usually be traced to potholes, wide expansion joints, or other "bumps" in the roadway surface. Vibration from rail transit systems is usually one to two orders of magnitude below the most restrictive thresholds for preventing building damage.

Sensitive Receptors

The noise sensitivity associated with land uses determines the noise exposure goals for these various land use types. Places where people may be subject to sleep or concentration disturbance, such as homes, hospitals, guest lodging, schools, places of worship, and libraries, are more sensitive to noise than manufacturing or commercial areas. Therefore, noise exposure targets for these land use types are more stringent.

The refuges are located in a setting that can be characterized as rural, where ambient noise levels can range from 15 to 45 dBA. Noise sensitive receptors near the refuges include rural houses, low-density residential clusters, schools, places of worship, and libraries. The wilderness areas in the San Luis Valley, while not specifically considered sensitive receptors, are naturally quiet environments that are set aside for the preservation of nature and wildlife. An acoustic monitoring system deployed at Great Sand Dunes National Park and Preserve's Alpine Camp in 2009 recorded a daytime natural ambient sound level of 17.0 dBA and a nighttime natural ambient sound level of 8.7 dBA (Turina 2010). These are some of the quietest sound levels ever recorded in the National Park System.

Animal response to noise depends on many variables, including characteristics of the noise, duration of the noise, life history characteristics of the species, habitat type, season, current activity of the animal, sex, age, and earlier exposure. Loud noises do have the potential to influence wildlife activity patterns. Wildlife may temporarily avoid otherwise suitable habitat in response to noise or have reduced breeding success if a species relies on sound to secure a mate.

4.3 Biological Resources

The following section describes the biological resources that may be affected by implementation of the various alternatives. Biological characteristics include vegetation communities (typically referred to as habitats) and wildlife, including birds, large mammals, small mammals, fish, amphibians, reptiles, and threatened and endangered species as well as species of concern.

Habitat is the specific environment or ecological conditions where a species or population lives, and which provides food, cover, and other resources necessary for survival. It consists of biotic variables such as vegetation as well as abiotic variables such as soil and water.

Habitat and Wildlife

Across the refuge complex, the diversity of vegetation, soils, and hydrologic conditions provide numerous habitat types for a wide array of wildlife species. Some species are generalists, while others need a specific combination of resources. In this section, a discussion of the refuge complex's habitats is organized into three broad categories of vegetation classes: riparian areas, wetlands, and uplands (figures 43, 44, and 45).

Riparian Habitat

Riparian habitats are plant communities that are contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent rivers, streams, or drainage ways. Although riparian habitat occupies less than 1 percent of the land area in the western United States, it is disproportionately important for wildlife in general and birds in particular (Pase and Layser 1977; Thomas et al. 1979; Szaro 1980; Krueper 1993; Ohmart 1994). Vegetation associated with streams has been referred to as the "aorta of an ecosystem" (Wilson 1979) because of its significance to water, fish, wildlife, rangeland, and forest resources, and it is believed by many that the riparian ecosystem is the single most productive type of wildlife habitat and supports the greatest number of species (Ames 1977, Hubbard 1977, Patton 1977).

In the Southwest, riparian habitats support a higher diversity of breeding birds than all other western habitats combined (Anderson and Ohmart 1977; Johnson et al. 1977; Johnson and Haight 1985; Rosenberg et al. 1991; Skagen et al. 1998). For example, 82 percent of all species that breed in northern Colorado occur in riparian vegetation (Knopf 1985).

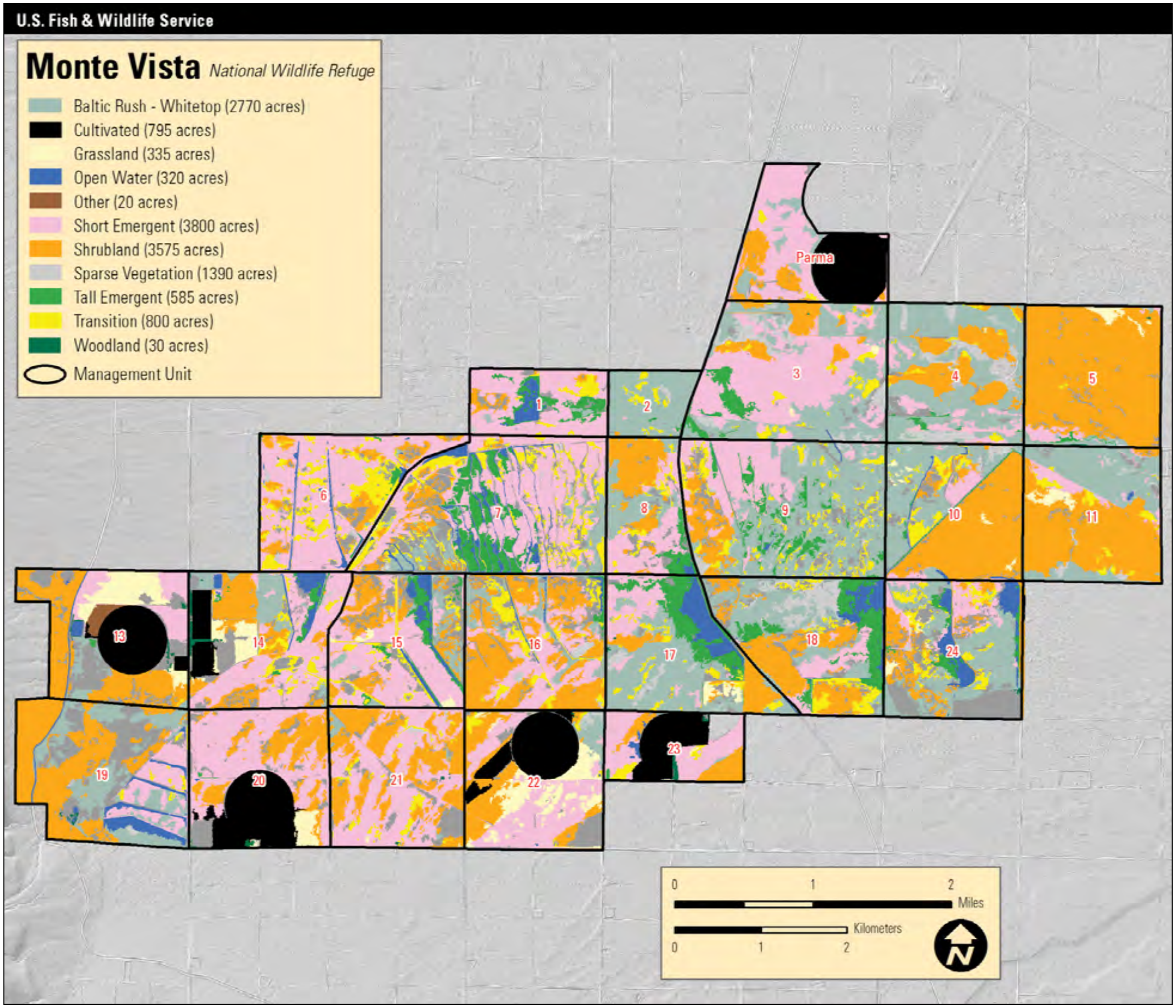

Figure 43. Vegetation classes for Monte Vista National Wildlife Refuge, Colorado.

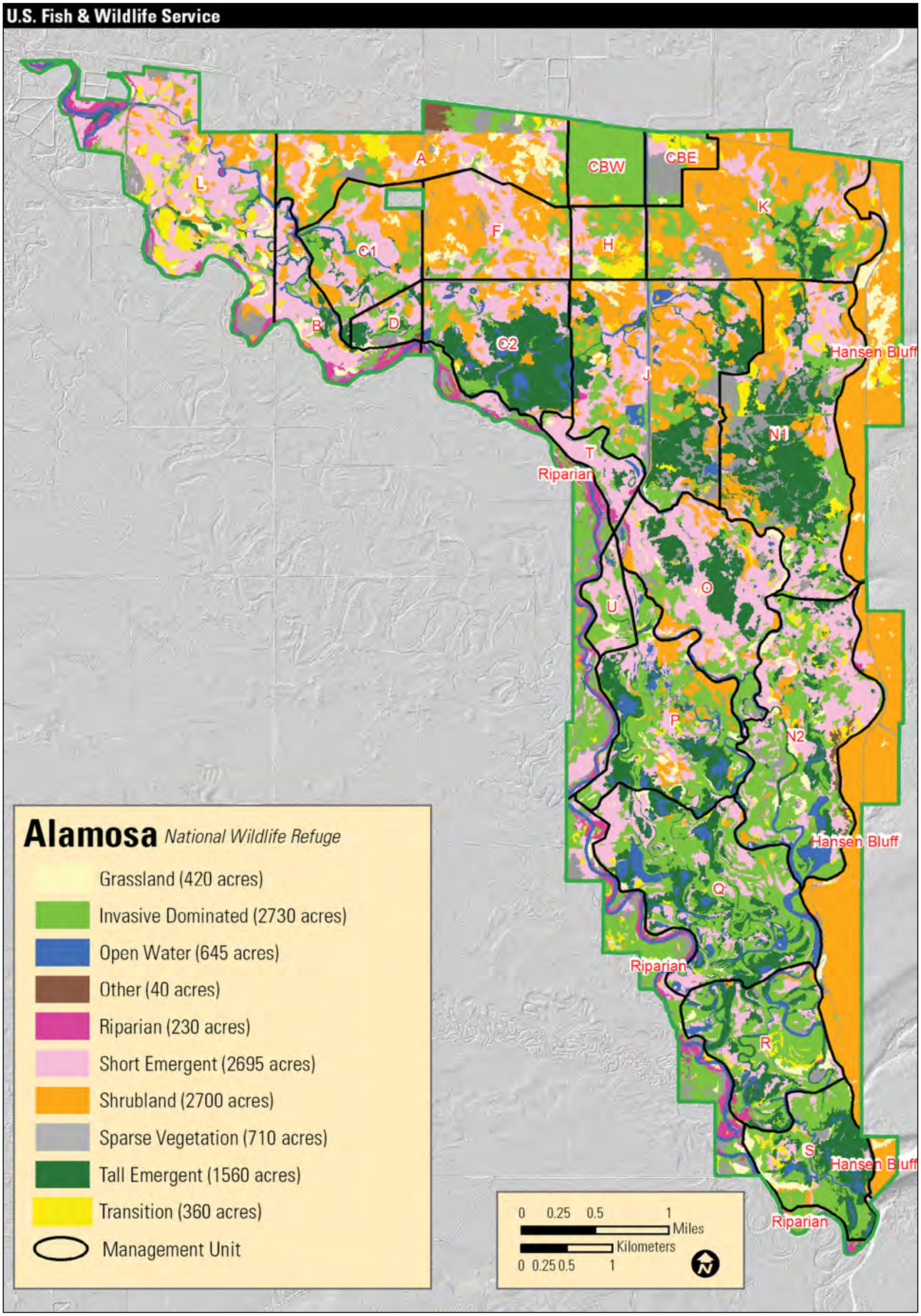

Figure 44. Vegetation classes for Alamosa National Wildlife Refuge, Colorado.

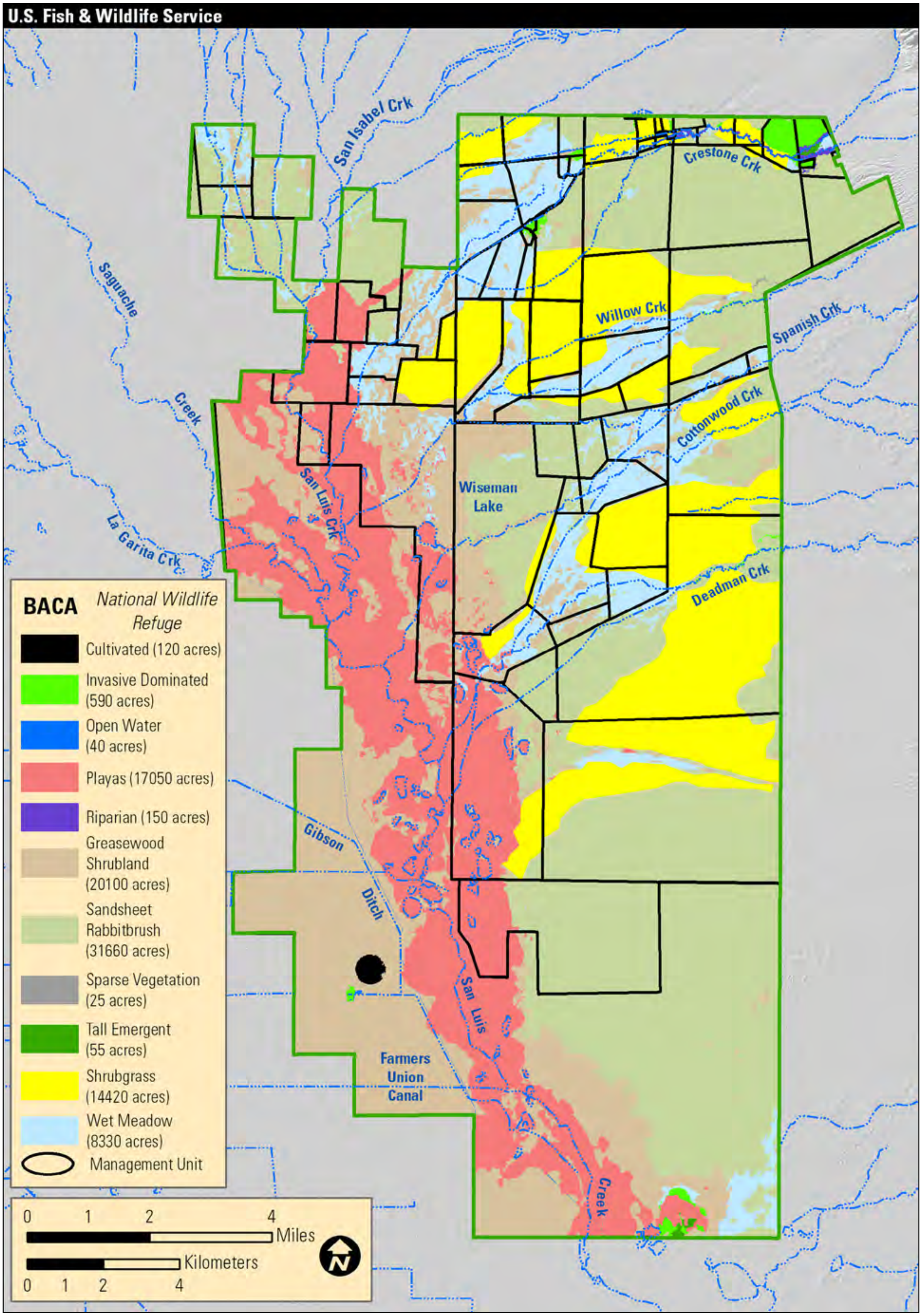

Figure 45. Vegetation classes for Baca National Wildlife Refuge, Colorado.

Johnson et al. (1977) reported that more than 75 percent of southwestern bird species nest primarily in riparian habitats, and 60 percent of them are neotropical migrants. Not only is there a high diversity of breeding bird species, but the highest non-colonial avian breeding bird densities in North America have been reported from southwestern riparian habitats (Carothers and Johnson 1975; Krueper 1993).

Healthy riparian habitats are not only crucial for breeding birds, but they attract a large number and variety of bird species during migration. More than 60 percent of all neotropical migratory birds use riparian habitat in the Southwest during migration, and these habitats have recorded up to 10 times the number of migrants per hectare than adjacent non-riparian habitats (Stevens et al. 1977, Hehnke and Stone 1979). Because of their high rates of metabolism, birds are extremely dependent on the habitats in which they find themselves during the migratory period, and must use seasonally abundant resources when available (Sprunt 1975). Southwestern riparian systems provide rich food resources during the crucial migratory period because plant growth rates and resultant vegetative biomass are high, which allows for greater insect production. In the San Luis Valley, the Rio Grande may be especially important for migrating songbirds. Because of its north-south orientation and the availability of food, water, and cover, this major arid land river may influence the survival and guide the migration of landbirds (Ligon 1961, Stevens et al. 1977, Wauer 1977, Finch 1991, Yong and Finch 2002).

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Riparian vegetation on Baca Refuge.

The disproportionately high value of riparian vegetation extends beyond birds to other vertebrates such as amphibians, reptiles, fish, and small mammals (Brode and Bury 1984, Cross 1985, Bury 1988).

Riparian plant communities are integral to stream function and aquatic productivity (National Research Council 2002). For example, in low-order streams, riparian vegetation strongly influences stream temperature, channel form, and habitats of aquatic invertebrates (Sullivan et al. 2004). Riparian plant communities are also the predominant sources of nutrients and carbon to the aquatic ecosystem through allocthonous inputs (Cummins 1974). Vegetation protects streambank soils through root strength, deflection, and dissipation of stream flow energy. Acting as a roughness element, vegetation enhances sediment, debris, and nutrient retention, and hence, channel and floodplain formation (Meehan et al. 1977; Elmore and Beschta 1987; Gregory et al. 1991). Riparian vegetation also increases channel diversity and aquatic habitats through creation of overhanging banks and coarse wood inputs (Montgomery et al. 1996; Abbe and Montgomery 1996).

There is riparian habitat on the Baca and Alamosa Refuges. There is no riparian habitat on the Monte Vista Refuge so it is not discussed in this section.

Riparian Habitat on the Baca Refuge

There are several factors, both historical and ongoing, that have inhibited the growth and regeneration of riparian vegetation on the Baca Refuge: cattle grazing that has damaged streambeds, haying that has artificially restricted the natural spread of riparian vegetation, changes in hydrology that have reduced streamflows, and elk browsing that now prevents the riparian trees and shrubs from reaching their full size.

Before the establishment of the Baca Refuge in 2004, the property was a private cattle ranch with more than 100 years of livestock grazing. It is believed that this history of grazing by domestic cattle played a significant role in the current poor condition of the riparian habitats. It has been well documented that livestock grazing can have negative effects on woody vegetative structure, composition, and vigor (Ames 1977; Evans and Kerbs 1977; Ryder 1980; Knopf and Cannon 1982; Taylor 1986). It is well documented throughout the West that poorly managed cattle grazing can negatively affect water quality, seasonal quantity, stream channel morphology, hydrology, riparian zone soils, instream and streambank vegetation, and aquatic and riparian wildlife (Belsky et al. 1999). Livestock grazing can also lead to changes in stream channel morphology and function, sediment inputs, channel incision, and streambank instability (Gunderson 1968, Behnke and

Raleigh 1978). As a result of a decline in habitat quality, declines in diversity and abundance of birds typically occurs (Mosconi and Hutto 1982, Taylor 1986, Bock et al. 1993).

Prior haying practices have also prevented the expansion and regeneration of the riparian plant community on the Baca Refuge. Many decades of large-scale haying practices have limited the distribution of various willow species because of the annual cutting of new sprouts that have encroached into the hay meadows. Since haying practices have prevented regeneration and restricted the distribution of willows, they have also likely contributed to the decline of riparian plant communities on the Baca Refuge.

Changes in hydrology that have occurred in the San Luis Valley have also affected the health of the riparian systems on the Baca Refuge. The inconsistent and irregular patterns of water availability during drought years have also lowered water tables. Willow and cottonwood trees can become stressed and die during drought years when water availability is limited. Multiple years of inconsistent water availability for these plants can be detrimental to their survival.

Since the establishment of the Baca Refuge, although livestock grazing within the riparian habitats has ceased and a minimum 20-foot buffer from haying has been enforced, riparian vegetation has not recovered as we expected. Vegetation surveys show that willow and cottonwood seedlings are abundant on many reaches of the creeks, but other sections of the creeks are not regenerating. Willow and cottonwood surveys show that virtually 100 percent of seedlings are being intensively browsed, thereby preventing the trees from reaching full height and stature. Cattle are excluded from riparian habitats, so based on observations of elk distribution and abundance as well as information from existing large mammal exclosures, elk must be responsible for this overbrowsing.

Elk populations on the Baca Refuge have increased significantly over the last three decades. Before the mid-1980s, elk were rarely observed in that part of the San Luis Valley. There are 1,000 to 3,500 elk on the refuge during the winter and 500 to 1,000 on the refuge during the summer, and they spend a considerable amount of time in riparian habitats. It has been shown that overbrowsing of riparian vegetation by native ungulates, as with domestic cattle, can damage willow and cottonwood plant structure, reproductive output, regeneration and establishment, and plant vigor and survival (Kay and Chadde 1992; Kay 1994; Singer et al. 1994; Case and Kauffman 1997; Peinetti et al. 2001; Zeigenfuss et al. 2002; Ripple and Beschta 2004a,b). Elk browsing of willow and cottonwood seedlings has been found to be the primary factor now preventing the recovery of the riparian habitat on the Baca Refuge (Keigley et al. 2009).

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Elk exclosure put up along one of the riparian creeks to limit elk damage.

Current Conditions

There are six creeks, North and South Crestone, Willow, Spanish, Cottonwood, and Deadman, that flow onto the Baca Refuge. (Refer to figures 39 and 45.) Riparian vegetation along these creeks consists primarily of two species of willow: coyote willow *(Salix exigua)* and peach-leaf willow *(Salix amygdaloides)*. Other tree species include greenleaf *(Salix lasiandra)* and strapleaf willow *(Salix ligulifolia)* and narrowleaf cottonwood *(Populus angustifolia)*. Other shrub species include Wood's rose *(Rosa woodsii)* and golden currant *(Ribes aureum)*. The herbaceous understory consists of various grasses, sedges, Baltic rush *(Juncus balticus)*, and forbs. The current overall condition of riparian habitats on the Baca Refuge is poor, particularly the structure and distribution of woody riparian vegetation. The Crestone Creek system has some fairly healthy patches of riparian vegetation; however, these areas are limited in extent (<0.5 mile of creek) and located next to buildings. Most of the remaining Crestone Creek system, as well as the other creeks on the refuge, have scattered mature willows and cottonwoods with some patches of small (<2 feet tall) young plants. Many reaches of these creeks are incised because of the disappearance of woody vegetation and the subsequent instability of the creek bed and banks. As a result, the width of the riparian zone and active floodplain is now limited in many areas.

Characteristic Wildlife

To date, a thorough inventory of wildlife species that use riparian habitats on the Baca Refuge has not been completed. Except for the isolated patches of willows and cottonwoods on Crestone Creek, which are a small part of the creek system on the refuge, observations by refuge staff show that riparian birds are absent on most reaches of the creeks. Documented birds include yellow warbler, common yellowthroat, American robin, and song sparrow.

As with birds, a detailed inventory of small mammals has not been completed but observations from refuge staff have shown that deer mouse, western harvest mouse, Ord's kangaroo rat, least chipmunk, and meadow vole are present, and we suspect that species such as masked shrew and montane shrew also use these habitats. Porcupines and raccoons also occur. Elk use the riparian habitats throughout the year but are most abundant during the winter months. Amphibians include chorus frog and leopard frog, and reptiles include western terrestrial garter snake and smooth green snake.

In Crestone Creek, a unique native fish community is present in areas of perennial water. This creek is host to four of the six native fish species that occur in the San Luis Valley: Rio Grande sucker (Colorado State endangered), Rio Grande chub (petitioned for listing under the Endangered Species Act in 2013), fathead minnow, and longnose dace. Of particular importance is that no non-native fish species have been found in Crestone Creek, and it is one of only two remaining aboriginal populations of Rio Grande sucker in Colorado.

Riparian Habitat on the Alamosa Refuge

Aerial photographs from 1941 of the Alamosa Refuge show that there has been little change in the extent of cottonwood and willow habitats since then (Heitmeyer and Aloia 2013a). Little information exists before this time period. Though the natural extent of the riparian habitat along the Rio Grande through the Alamosa Refuge is unknown, the distribution of sandy, seasonally hydrated soils suited for cottonwood and willow survival and growth (Cooper et al. 1999, Scott et al.1999) show that this habitat was probably once much more extensive along the Rio Grande on the Alamosa Refuge. Cottonwood (which is "alamo" in Spanish) was once prevalent in the town of Alamosa (just upstream from the Alamosa Refuge); however, the historical distribution of cottonwood galleries on the Alamosa Refuge itself was not well documented.

Before the establishment of the Alamosa Refuge in 1963, the property was privately owned and managed as a working cattle ranch. Similar to other areas along the Rio Grande in the San Luis Valley, we assume that the riparian area on the Alamosa Refuge was actively grazed by domestic livestock and that damage to woody vegetation occurred. After the refuge was established, the riparian habitat continued to be grazed by cattle, though information on stocking densities is unknown. This was done in an attempt to restrict cottonwood and willow encroachment into adjacent wetland areas in an effort to preserve the integrity of waterfowl nesting habitat. It wasn't until about 1990 when all domestic livestock grazing in the riparian corridor ceased.

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The Rio Grande meanders through the San Luis Valley.

A small herd of elk became established on the Alamosa Refuge in the late 1990s, which grew over the next decade to approximately 400 head. In 2009, data showed that elk were damaging willow growth on the Alamosa Refuge (Keigley et al. 2009). This damage, though apparently localized, is restricting willows from reaching their full height and stature.

Although past grazing by domestic livestock and current browsing by elk have damaged cottonwood and willow growth and distribution, it appears that changes to hydrology and river morphology are causing the most damage to the regeneration, growth, and survival of cottonwoods and willows (Keigley et al. 2009). Since Euro-American settlement in the San Luis Valley, many rivers including the Rio Grande as well as the unconfined and confined aquifers have been drastically altered (Siebenthal 1910; Natural Resources Committee Report 1938; Emery et al. 1973; San Luis Valley Water Conservancy District 2001). Some of the changes to the Rio Grande and its tributaries upstream of the Alamosa Refuge include straightening of reaches of the river (the most significant of which was east of the town of Monte Vista during the late 1940s and early 1950s by the U.S. Army Corps of Engineers), construction of numerous reservoirs designed to catch and store early spring runoff from snowmelt, and the construction of a minimum of 48 irrigation diversions designed to divert Rio Grande water for irrigation (San Luis Valley Water Conservancy District 2001).

Because of these changes, the hydrology and morphology of the Rio Grande through the Alamosa Refuge have been severely altered. A study of the Rio Grande found that the reach through the Alamosa Refuge is deprived of sediment from upstream because of such factors as low flows and trapping and diversion of sediment at diversion structures (San Luis Valley Water Conservancy District 2001). As a result, the reach through the Alamosa Refuge is entrenched, has poor point bar formation, and has excessively eroding banks. Because the system is sediment deficient in this reach, the river has tended to lengthen and lengthening occurs as the river seeks to increase sediment supply by eroding the channel banks (San Luis Valley Water Conservancy District 2001). This is evident by the high, steep banks that are present today.

Current Conditions

Riparian habitat on the Alamosa Refuge is mostly restricted to approximately 229 acres in a fairly narrow section along the Rio Grande. Riparian vegetation consists primarily of coyote willow, peach-leaf willow, and Goodding willow *(Salix gooddingii)* as well as narrowleaf cottonwood. Other shrub species include Wood's rose and golden currant. The herbaceous understory consists of various grasses, sedges, Baltic rush, and forbs.

Although there are small patches of less than 2 acres that appear fairly healthy, most of the riparian habitat on the Alamosa Refuge is considered marginal at best. Narrowleaf cottonwoods are a small component of the woody vegetative community, with only a few patches containing this overstory species. Goodding willow, another overstory species, has individual plants scattered throughout the riparian corridor and is the least abundant species of woody vegetation. Peach-leaf willow, while abundant in a handful of patches, is primarily represented by scattered individuals or small groups of plants throughout the riparian corridor. The most abundant and widespread species of woody vegetation is coyote willow, which can be found in varying densities throughout the riparian corridor. In many parts of the riparian corridor, coyote willow is restricted to narrow (<3 meter) patches immediately adjacent to the waterline of the Rio Grande. In general, the width of the riparian habitat on the Alamosa Refuge is less than 20 meters and is considered in moderate to poor health because of various factors such as hydrology and browsing.

Characteristic Wildlife

Observations by refuge staff and sporadic surveys have documented more than 80 bird species using riparian habitats on the Alamosa Refuge for foraging, migration, or nesting. Primary nesting birds include red-tailed hawk, Swainson's hawk, American kestrel, northern flicker, western kingbird, western wood-pewee, American robin, yellow warbler, common yellowthroat, song sparrow, American goldfinch, Brewer's blackbird, and Bullock's oriole. Although numbers have declined in recent years, the federally endangered southwestern willow flycatcher nests in the willow habitat on the Alamosa Refuge. Small and medium-sized mammals using riparian habitats include deer mouse, meadow vole, long-tailed vole, masked shrew, western harvest mouse, least chipmunk, beaver, porcupine, and raccoon. Bat species such as Yuma myotis and little brown bat are also regularly found in riparian habitats. Large mammals include mule deer and elk. Amphibians using riparian habitats include chorus frog, leopard frog, and tiger salamander, and reptiles include the western terrestrial garter snake. Fish species found in the Rio Grande through the Alamosa Refuge include nonnative species such as common carp, white sucker, and northern pike. Native fish known to inhabit the refuge include black bullhead, fathead minnow, flathead chub, green sunfish, longnose dace, and red shiner.

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Porcupines often strip bark off willows or cottonwood trees, which can be of concern when restoring riparian areas on Alamosa Refuge.

Wetland Habitat

Wetlands are some of the most important habitats in the world, and countless animal and plant species depend on wetlands and the resources they provide. More than one-third of the United States' threatened and endangered species live only in wetlands, and nearly half use wetlands at some point in their lives.

Wetlands provide breeding and foraging habitat for birds and amphibians, permanent homes for fish, and a water source for many other species. Wetlands intercept and filter sediment, nutrients, and toxic chemicals from surface water runoff before it reaches open water areas or ground water.

Land use practices in the San Luis Valley have significantly changed the landscape and ecosystem. Hydrologic conditions have changed, and the dominant land uses are ranching and growing potatoes, small grains, and alfalfa. Natural flow regimes in creeks and rivers have been significantly altered and, in some cases, depleted entirely.

For example, Spring Creek, which originates from a natural spring on the western part of the Monte Vista Refuge, ceased flowing in the early 1970s as the spring dried up and has not flowed since. Rock Creek, which is fed by mountain snowmelt, once created the largest natural wetland complex on the refuge. Rock Creek has had its water diverted for irrigation of agricultural lands at upper reaches, has been obstructed by roads and canals, and has had its channel completely obliterated west of the refuge. As a consequence, there are no natural flows onto the refuge from Rock Creek (figure 46).

The Baca Refuge has experienced similar events. Much of the water that had historically created the roughly 17,049 acres of playa and associated 8,329 acres of short-emergent habitat and that had contributed substantially to ground water levels entered from the west side of the refuge from snowmelt-fed streams, including Saguache, La Garita, and San Luis Creek with all its tributaries north of the refuge (figure 39). As with many other stream systems in the San Luis Valley, during most years all the water in these creeks is diverted for agricultural purposes. Ground water pumping of the unconfined aquifer within the closed basin of the San Luis Valley has resulted in a lowered water table, which dramatically influences surface flows. The result is that surface flows have not reached the refuge boundary from the west since the late 1980s.

On the Alamosa Refuge, hydrologic conditions have also changed. Even though the Rio Grande still flows along the western boundary of the refuge, flows have been severely altered to the extent that at times the lowest annual flows through this reach occur during the periods when the highest annual flows used to occur. Even during the years when annual high flows do occur during the typical period of peak snowmelt runoff (late spring to mid-summer), that peak has substantially diminished due, in large part, to the diversion of water upstream for the irrigation of agricultural lands. (Refer to water resources, section 4.2 above.)

Historical Water Use on the Refuges

Before the establishment of the refuges, all three were privately owned cattle ranches focused on livestock grazing and hay production.

Because hydrologic changes have drastically reduced or eliminated natural stream flows entering the refuges, surface hydrologic inputs are dependent on diverted surface irrigation water from the Rio Grande (Monte Vista and Alamosa Refuges) and smaller creeks originating in the Sangre de Cristo Mountains (Baca Refuge) as well as from pumped ground water. Water management infrastructure, including irrigation ditches and canals, levees, and water diversion and control structures, has precipitated changes in land use and vegetation type (figures 43, 44, and 45). Water diversion and irrigation in the valley have resulted in a drastic change in habitat types in many areas. For example, by controlling the timing and depth of water, native shrub habitats have been converted to and managed as semipermanent or permanent wetlands.

Current Conditions

The refuge complex supports a diversity of wetland types (figures 43, 44, and 45), including temporary or ephemeral wetlands interspersed with native shrublands, semipermanent wetlands such as oxbows along the Rio Grande, and created wetlands. Collectively, these wetland areas support a range of primary habitats, including open water; bare mudflats; short-emergent; tall-emergent; transition (dominated by saltgrass), and other vegetative communities associated with the primary wetland habitat types described earlier.

Short-emergent habitat is the most abundant wetland type on the refuge complex, with an area of about 20,753 acres, of which 5,426 acres are on the Alamosa Refuge, 6,998 acres are on the Monte Vista Refuge, and 8,329 acres are on the Baca Refuge. This habitat type, also referred to as wet meadow, is characterized by grasses and grass-like plants and is seasonally and shallowly flooded. The dominant species in this habitat are cool-season plants that require water early in the growing season. Most of the short-emergent habitat on these refuges is dominated by a dense growth of Baltic rush, although other species are also abundant, such as spike rush, alkali muhly, curly dock, *Calamagrostis*, foxtail barley, short-awn foxtail, awned sedge, woolly sedge, short-beaked sedge, and beaked sedge. Invasive weeds such as

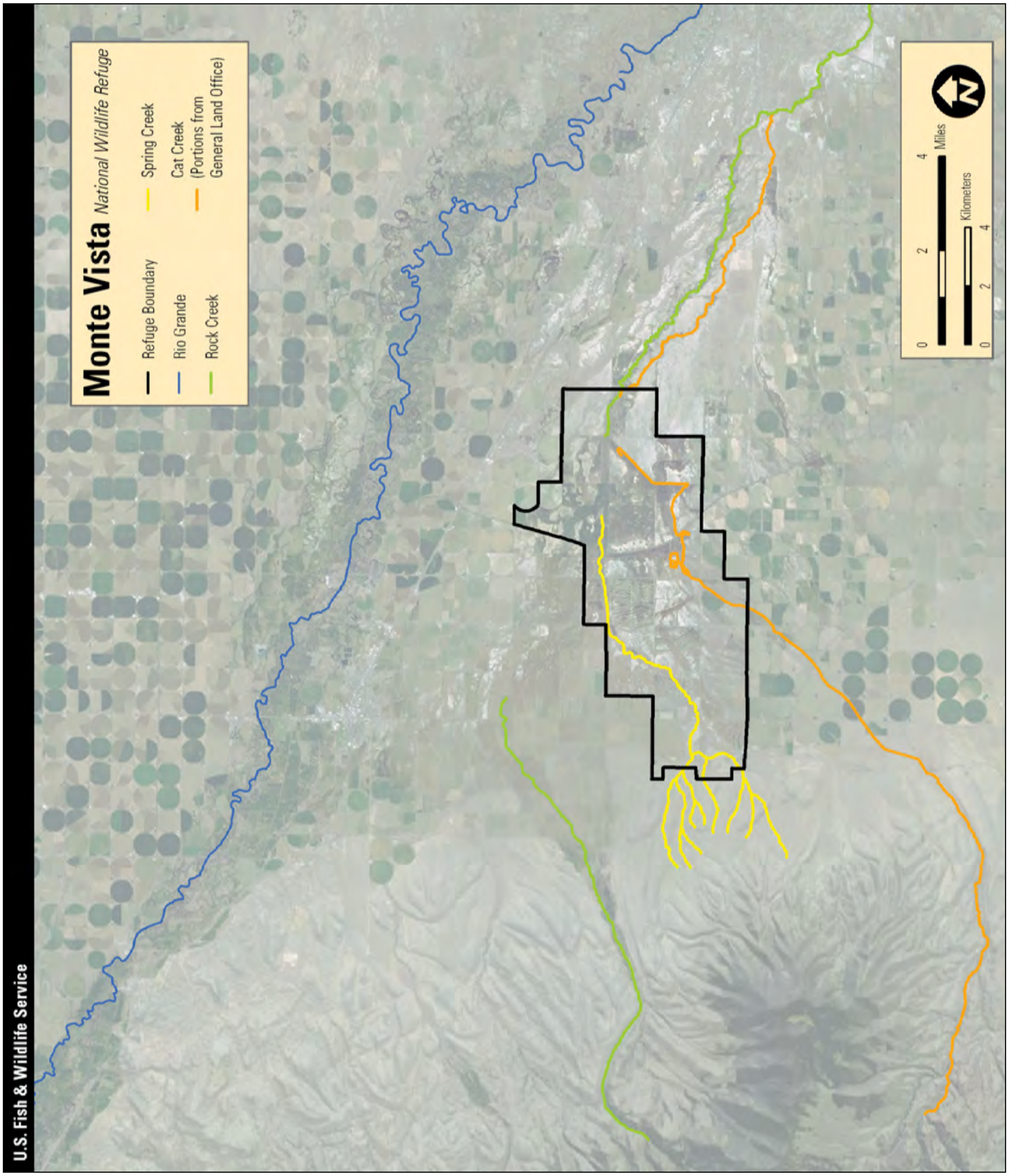

Figure 46. Location of historical creeks flowing into and through Monte Vista National Wildlife Refuge, Colorado.

Canada thistle *(Cirsium arvense)* and tall whitetop *(Lepidium latifolium)* are present in some areas.

Tall-emergent habitat, which covers 1,561 acres on the Alamosa Refuge, 599 acres on the Monte Vista Refuge, and 54 acres on the Baca Refuge, is associated with water that is usually more than 15 inches deep and is semipermanent to permanent. Cattails, hardstem bulrush, and phragmites (on the Alamosa Refuge) dominate these deeper water areas. This vegetative community is typically found lining edges of ponds, levees, and canals, or as large contiguous patches or islands in areas of open water.

Transition habitat (called shrub–grass on the Baca Refuge) is usually associated with alkali soils in a variety of hydrologic conditions and is dominated by salt-tolerant grass species such as inland saltgrass, alkali sacaton, alkali muhly, and alkali grass. It can contain scattered black greasewood and rabbitbrush plants. When higher soil moisture occurs, large amounts of slender spiderflower appear. Typically, this is a seasonal wetland habitat type flooded only for short durations (< 60 days) in the spring with shallow water (< 3 inches).

Characteristic Wildlife

Wetlands in the San Luis Valley, particularly those found on the refuge complex, are vitally important to birds because they provide foraging, resting, and breeding habitat. More than 100 bird species have been documented using the wetland habitats on the refuge complex. At least 11 species of waterfowl nest on the refuges: Canada goose, mallard, gadwall, blue-winged teal, cinnamon teal, green-winged teal, northern shoveler, northern pintail, redhead, American wigeon, and ruddy duck. Many shorebirds use refuge wetlands, especially short-emergent and transition habitats, for foraging and nesting. American avocet, black-necked stilt, Wilson's phalarope, Wilson's snipe, killdeer, and spotted sandpiper have been documented nesting on the refuge complex. The largest colony of nesting white-faced ibis in Colorado uses some of the tall emergent habitats on the refuge, as do snowy egret and black-crowned night-heron. Species such as American bittern, sora, and Virginia rail also nest and forage in refuge wetland habitats. Common yellowthroat, yellow-headed blackbird, red-winged blackbird, western meadowlark, marsh wren, Savannah sparrow, and vesper sparrow can be found foraging and nesting in the wetland habitats found on the refuges. About 95 percent of the Rocky Mountain population of greater sandhill cranes spends several weeks in the San Luis Valley during spring and fall migration, feeding and roosting in shallow water wetlands, primarily on the Monte Vista Refuge.

Many species of mammals use the refuge wetlands, including elk, deer, coyote, muskrat,weasel, deer mouse, and meadow vole. The San Luis Valley is a cold mountain desert and, as such, supports a limited number of amphibians and reptiles; however, tiger salamander, chorus frog, leopard frog, Woodhouse's toad, Plains spadefoot toad, Great Plains toad, and western terrestrial garter snake are common on the refuges.

Playa Habitat

Playa wetlands are shallow, typically round, ephemeral bodies of water with clay floors that lie in the lowest point of a closed watershed. In the San Luis Valley, playa systems are found in the closed basin and have formed in the terminal reaches of streams that originate in the nearby mountain ranges (Cooper and Severn 1992). Playa formation is also influenced by the complex interactions of surface and ground water (Riley 2001). The playa habitat on the Baca Refuge represents just some of the playa system occurring in the San Luis Valley, which stretches from the northwestern corner of the San Luis Valley to the northern tip of the Alamosa Refuge, with the greatest concentration of playas occurring along the western boundary of the Baca Refuge (figure 45), and extending south to BLM's Blanca Wetland Habitat Area, 5 miles northeast of the Alamosa Refuge. In the San Luis Valley, playas are the rarest and one of the most valuable wetland habitat types for wildlife. The playa area is commonly referred to as the sump of the San Luis Valley (figure 47). Playas are intimately tied to snow-melt runoff patterns and the water table (Cooper 1996). Hydrologic inputs to the playas were historically provided primarily through snowmelt-fed streams during spring to mid-summer, and many playas dried up by late summer. Monsoonal rain events may have caused some playas to refill in late summer; however, these were of secondary importance. Ground water levels most likely also affected the hydrology of the playas (Cooper et al. 2000, Riley 2001). Ground water discharge into the playas may also have occurred in the closed basin during years of high precipitation when the subsurface flow was forced to the surface by the semipermeable clay layer separating the unconfined and confined aquifers. The soils in playas are alkali clays with low rates of water infiltration, which allows rapid evaporation at the water surface and subsequent accumulation of salts. As a result, they support flora and wildlife communities adapted to saline conditions and a dynamic hydrologic regime.

Historical Condition of Playas

For thousands of years, the creeks entering the San Luis Valley from the northwest, north, and east drained into this sump, creating a series of playas. (Heitmeyer and Aloia 2013b, figure 47). Reports and maps created by a U.S. Army surveyor (Wheeler

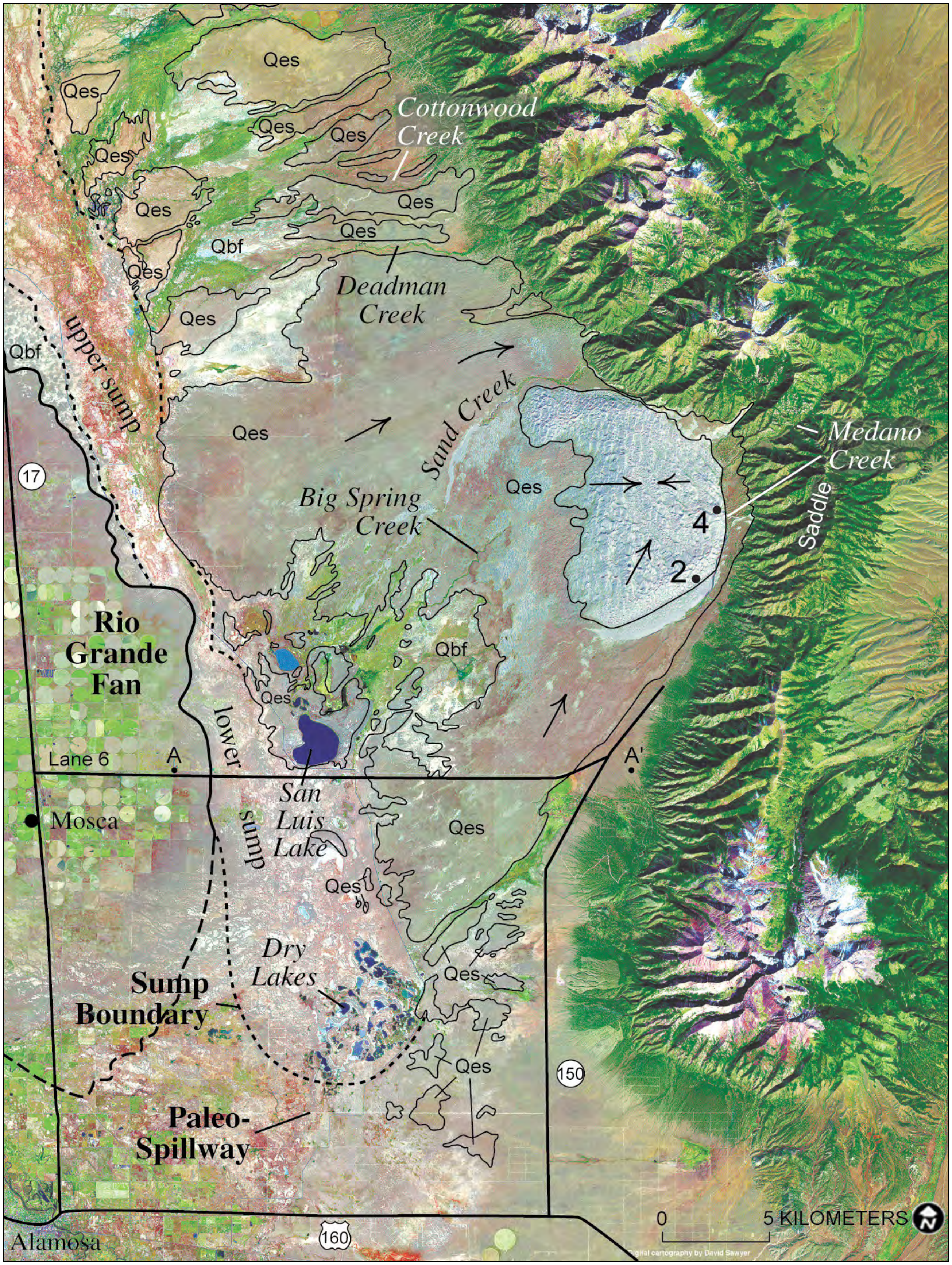

Figure 47. Location of upper and lower sump area on Baca National Wildlife Refuge, Colorado.
Source: Madole et al. 2008

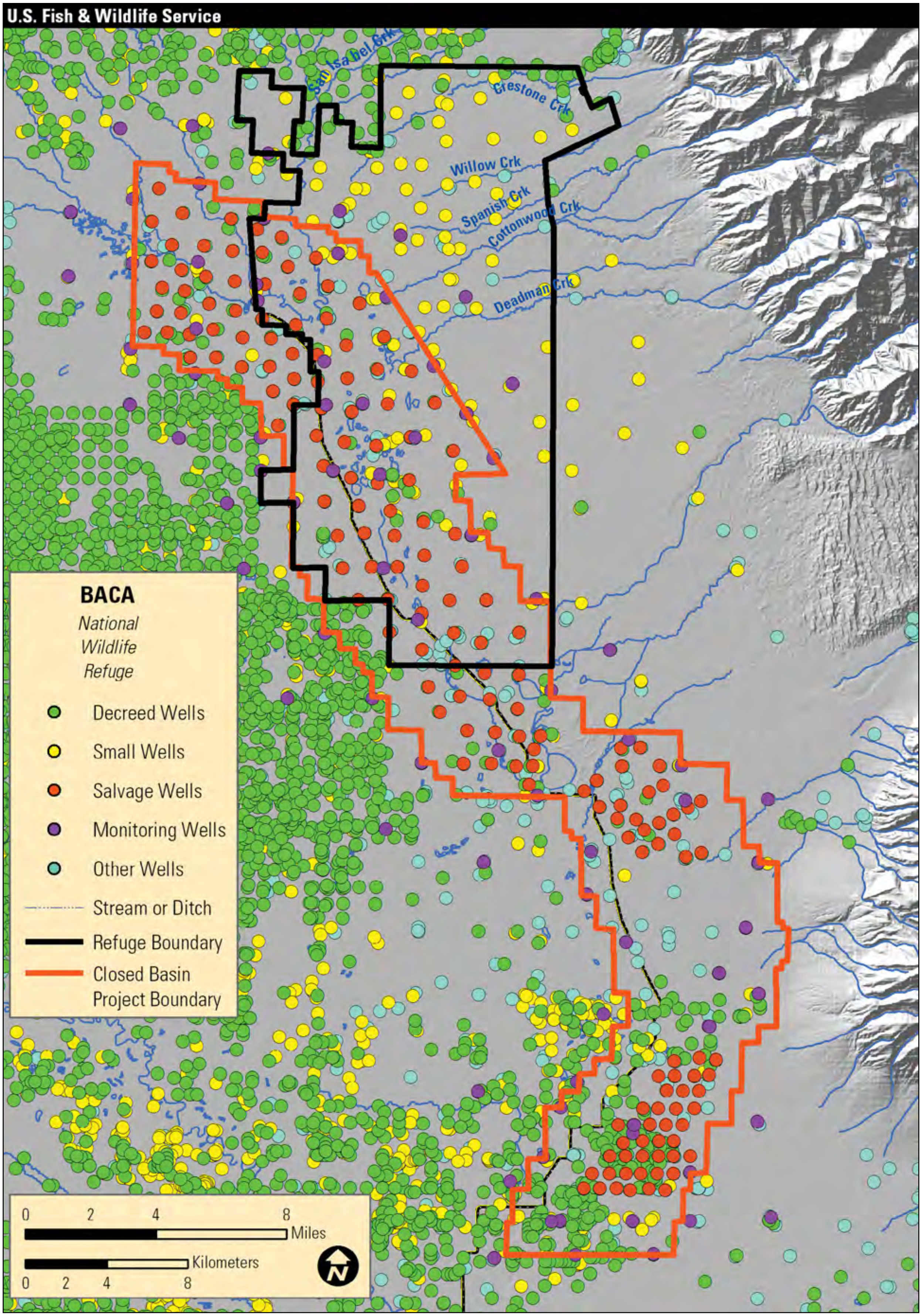

Figure 48. All wells on or adjacent to Baca National Wildlife Refuge, Colorado.

1877) show extensive marshes in the northern San Luis Valley, and Wheeler and Humphreys (1878) describe the "San Luis swamp" extending nearly 100 kilometers down the middle of the valley, including the area that is now the Baca Refuge. The primary surface water inputs to the playa system were from snowmelt-fed creeks from both the San Juan Mountains to the west and the Sangre de Cristo Mountains to the east. Historically, Saguache, La Garita, and Carnero Creeks flowing from the west most likely provided the greatest water inputs to the playa system. From the northeast, Rito Alto and San Luis Creeks as well as Crestone, Willow, Spanish, Cottonwood, and Deadman Creeks from the east provided additional surface flows to the playa system.

Playa habitat in the area has been altered more than all other wetland habitat types, including riparian habitat. The changes to the hydrology of the creeks and the unconfined aquifer have contributed immensely to the decline in the function, extent, and productivity of the playa system.

Significant diversion of water for agriculture from these creeks began toward the end of the 19th century and extended into the 20th century. Aerial photography from the 1940s (Heitmeyer and Aloia 2013b) shows that a lot of water was still reaching the playa habitat, at least during some years. The advent of large-scale ground water pumping in the mid-20th century and the start of the Closed Basin Project in the late 1980s led to the virtual elimination of functional playa habitat on the Baca Refuge and in the rest of the closed basin. Because playas depend on a complex interaction of surface and ground water sources, any land use changes that alter the timing or magnitude of surface and ground water flows are likely to detrimentally affect playas. Even minor changes in the water table depth or duration of inundation can have profound effects on soil salinity, and consequently, wetland vegetation (Cooper and Severn 1992). Although a dynamic hydrologic regime is natural and preserves the unique flora, fauna, and soil chemistry associated with playas, these prolonged, substantial perturbations to the hydrology result in severe damage to the function and productivity of playa habitats.

Current Condition

Because the playa wetlands on the Baca Refuge are usually dry, the current condition of this habitat type could be described as poor.

Mud flats may also be present in areas where soil salts are less abundant. Because most of the playa habitat on the Baca Refuge has not been inundated for approximately 20 years, many of these classic vegetation zones have disappeared and have been replaced by vegetation typical of upland habitats, such as greasewood and rubber rabbitbrush, even into the deepest playa basins. Playa basins are typically surrounded by greasewood and rabbitbrush with an understory of saltgrass. These basins have been dry more often than wet, and the result is mostly barren salt flats. Invasive Russian knapweed *(Acroptilon repens)* may be present on basin floors. Basins are productive when inundated and are capable of producing high amounts of native herbaceous biomass. Common plants in playa basins during wet years consist of saltgrass *(Distichlis stricta)*, native rushes such as Baltic rush *(Juncus balticus)*, and sedges *(Carex* spp.*)*. Patches of tall emergent plants such as bulrush *(Scirpus* spp.*)* and cattails *(Typha* spp.*)* may also be present.

Characteristic Wildlife

When playa wetlands are in good condition, they serve as important reservoirs of biodiversity (Haukos and Smith 1994). Although wildlife species such as waterfowl, passerines, and amphibians rely on functional playa habitats for nesting, brood rearing, and foraging, shorebirds are perhaps the most dependent on these saline wetlands. On the Baca Refuge, the overall poor condition of this habitat type makes it of little value for the bird guilds mentioned above. However, species that have been observed in the dry playas include upland birds such as the mourning dove, sage thrasher, loggerhead shrike, vesper sparrow, and horned lark. In recent years, when surface water from the east has been able to reach and wet some of the playas, Wilson's phalarope, black-necked stilt, American avocet, white-faced ibis, and black tern have been observed in the area. However, in recent years, as well as since refuge establishment in 2004, the playa system generally has received little to no water. Few wetland species have used these habitats for many years. If wetted, this area has the potential to support species such as killdeer, semipalmated plover, Baird's sandpiper, Wilson's snipe, greater and lesser yellowlegs, long-billed dowitcher, long-billed curlew, marbled godwit, red knot, and a variety of other shorebird species.

Functional playa habitats are extremely important for numerous species of waterfowl such as cinnamon teal, mallard, northern pintail, and gadwall. Playa basins and temporary wetlands provide resources for several amphibians to meet their lifecycle needs. Northern leopard frog, chorus frog, Great Plains toad, spadefoot toad, and tiger salamander are all found in these habitats. Lastly, highly diverse and abundant macroinvertebrate populations are found in the playa basins, with many of these surviving in a dormant cyst condition for years in the soil and emerging after a few weeks of available water in the basins.

Upland Habitat

Native upland habitat has been altered or destroyed by conversion to agriculture, livestock grazing, infrastructure development, and altered hydrologic regimes. Many of the songbird species found in the shrubland habitats on the refuges have experienced population declines throughout their ranges (Robbins et al. 1986, Askins 1993, Sauer et al. 1997). For example, according to the breeding bird survey, Brewer's sparrow populations have fallen by more than 50 percent during the past 25 years (Holmes and Johnson 2005). Species such as sage thrasher (Gebauer 2004, Sauer et al. 2004) and loggerhead shrike (Yosef and Lohrer 1995) have also experienced population declines.

Before the refuges were established, many of the management practices on all three refuges were designed to expand the area of wetland vegetation (primarily Baltic rush and other forage grasses) to promote livestock grazing and hay meadows. After the Alamosa and Monte Vista Refuges were established, maximizing waterfowl production became the primary goal. This was accomplished through the construction of water management infrastructure without considering soil type or other abiotic factors. As a consequence, many areas of native upland habitat were inundated, and hydric conditions were created on soil types that would not naturally support wetland plant growth unless substantial amounts of water were applied. In these areas, wetland vegetation can persist in these created wetlands as long as sufficient amounts of water are available.

Also before refuge establishment, areas of native upland habitat were converted to agricultural fields on both the Monte Vista and Alamosa Refuges. Since the refuges were established, many of these former farmland areas have been abandoned or attempts have been made to create artificial wetland habitat.

In areas where irrigation of upland habitats was not possible or attempted, native upland vegetation remained largely intact. Before the refuge was established, these areas provided additional land for livestock grazing. Since the refuge was established, these areas have not been intensively managed.

Current Conditions

Most upland habitats on the refuges are dominated by salt desert shrub communities, including sandsheet rabbitbrush in sandy soils and greasewood shrubland in clay soils. In sandsheet rabbitbrush, the shrub overstory is typically dominated by rubber rabbitbrush *(Ericameria nauseosa)*. Other shrub species are more uncommon but may be present, such as greasewood *(Sacrobatus vermiculatus)*, fourwing saltbush *(Atriplex canescens)*, shadscale *(Atriplex confertifolia)*, and winterfat *(Krascheninnikovia lanata)*. Native bunchgrasses occupy the understory, with the density of ground coverage heavily dependent on precipitation levels. Ground coverage of bunchgrasses can be medium to high in years with a lot of precipitation, and can be sparse to medium in years with little precipitation. Typical understory grasses include Indian ricegrass *(Oryzopsis hymenoides)*, alkali sacaton *(Sporobolus airoides)*, western wheat grass *(Pascopyrum smithii)*, needle and thread *(Hesperostipa comata)*, and blue grama *(Bouteloua gracilis)*. Native forbs are abundant in the understory during years of high precipitation. Large patches of grassland with few or no shrubs may be found within this habitat type, resulting in a grassland-shrubland complex.


USFWS

Western meadowlarks are focal birds found in native grasslands.

In greasewood shrubland, the shrub overstory is dominated by greasewood. Fourwing saltbush is present but less common. Ground cover density in the understory is typically sparser in this plant community than in the sandsheet rabbitbrush habitat type, but is denser during years of high precipitation. Inland saltgrass *(Distichlis stricta)* and other native bunchgrasses such as alkali sacaton and ring muhly *(Muhlenbergia torreyi)* occupy the understory. Sparse herbaceous vegetation and bare soil is common, especially in dry years.

Some areas where upland habitat was converted to wetlands but then was allowed to dry out are dominated by annual and perennial invasive weeds such as kochia *(Kochia scoparia)* and tall whitetop *(Lepidium latifolium)*. Similarly, on former farmland areas, current vegetation consists primarily of annual and perennial invasive weeds such as tall whitetop and Russian knapweed *(Acroptilon repens)*.

Characteristic Wildlife

Bird diversity and densities tend to be relatively low in semi-desert shrubland and other upland habitats because of structural and floristic simplicity (Wiens and Rotenberry 1981). Species common to these upland habitats are mourning dove *(Zenaida macroura)*, western meadowlark *(Sturnella neglecta)*, loggerhead shrike *(Lanius ludovicianus)*, sage thrasher *(Oreoscoptes montanus)*, and Brewer's sparrow *(Spizella breweri)*. Areas where grasses dominate have the potential to support rare grassland dependent species such as vesper sparrow *(Pooecetes gramineus)*.

Numerous mammal species use upland habitats on the refuges, including elk *(Cervus elaphus)*, pronghorn *(Antilocapra americana)*, white-tailed jackrabbit *(Lepus townsendii)*, Wyoming ground squirrel *(Spermophilus elegans)*, northern grasshopper mouse *(Onychomys leucogaster)*, northern pocket gopher *(Thomomys talpoides)*, Ord's kangaroo rat *(Dipodomys ordii)*, plains pocket mouse *(Perognathus flavescens)*, silky pocket mouse *(Perognathus flavus)*, and thirteen-lined ground squirrel *(Spermophilus tridecemlineatus)*.

Shrub-Grass Habitat on the Baca National Wildlife Refuge

This upland habitat type occurs in areas that receive high amounts of subsurface irrigation from the adjacent wet meadows (see cover types map, figure 45). Before refuge establishment, more than a century of irrigation practices resulted in artificially expanded areas of short-emergent vegetation. Meadows were expanded to promote hay production. Since the Baca Refuge was established, these wet meadows are managed to provide valuable habitat for many native species. These large wetlands have also resulted in sizeable expanses of adjacent areas that receive subsurface irrigation. The shrub-grass habitat is associated with these conditions, and vast areas of this habitat occur. Before these extensive irrigation practices, the shrub-grass plant community likely consisted of upland shrubs and grasslands because little subsurface water would have reached these areas (see potential historic vegetation map, Heitmeyer and Aloia 2013b).

Current Conditions

This habitat type is generally located between irrigated wet meadows and dry uplands on sandy and loamy soils. It combines characteristics of both adjacent habitat types. Like the uplands, it is dominated by a shrub overstory; like the wet meadows, it can have patches of dense grass in the understory.

The shrub overstory is dominated by rubber rabbitbrush. Other shrub species such as black greasewood, fourwing saltbush, and shadscale are uncommon. Shrubs in this plant community are typically taller and denser than in the sandsheet rabbitbrush upland habitat. The understory is dominated by native grasses such as alkali sacaton and inland saltgrass as well as rushes such as Baltic rush. In this plant community, the ground cover density of herbaceous vegetation is usually higher than in the adjacent uplands because of subsurface irrigation from the wet meadows. This habitat type may also contain areas with excess alkali in surface soils, and patches of barren salt flats can occur among the shrubs. The globally rare slender spiderflower occurs commonly along the periphery of this habitat. Invasive weeds are uncommon in this habitat type, but include Canada thistle, tall whitetop, and Russian knapweed.

USFWS

White-tailed jackrabbits are seen on the refuge complex.

Characteristic Wildlife

Common birds are Brewer's sparrow, vesper sparrow, western meadowlark, sage thrasher, loggerhead shrike, and mourning dove. Numerous mammals use the shrub-grass habitat, including elk, pronghorn, coyote, badger, white-tailed jackrabbit, Wyoming ground squirrel, northern grasshopper mouse, northern pocket gopher, Ord's kangaroo rat, plains pocket mouse, silky pocket mouse, deer mouse, least chipmunk, and thirteen-lined ground squirrel.

Invasive and Noxious Plant Species

Many invasive and noxious plant species have infected and degraded many of the aquatic and terrestrial habitats in the refuge complex (table 12). Some highly invasive species such as tall whitetop, phragmites, and Russian knapweed can produce monotypic stands that completely displace native and desirable plant communities. Some invasive species are also classified as noxious weeds; they can directly or indirectly injure crops, navigation, other agriculture, fish and wildlife, and public health. For the refuge complex, native communities are essential for supporting high-priority species and species groups on the refuges. Our overall strategy in managing invasive plants is to use an integrated pest management approach, which is a structured and logical approach that uses a combination of cultural, biological, mechanical, and chemical tools. Past efforts have included mapping and treating invasive species. Treatment methods for invasive weeds vary with species, daily weather conditions, plant growth stage, and time of year.

Table 12. High-priority invasive weeds found on the San Luis Valley Refuge Complex.

Common name	*Scientific name*
Canada thistle	*Cirsium arvense*
Tall whitetop or perennial pepperweed	*Lepidium latifolium*
Russian knapweed	*Acroptilon repens*
Hoary cress	*Cardaria draba*
Phragmites	*Phragmites phragmites*
Russian olive	*Elaeagnus angustifolia*
Saltcedar	*Tamarix ramosissima*
Eurasian watermilfoil	*Myriophyllum spicatum*
Swainsonpea	*Swainsona pyrophilia*
Yellow toadflax	*Linaria vulgaris*

Methods used to treat invasive species have included herbicide application, prescribed fire, grazing, biological controls, hand pulling, haying, mowing, and plowing. Along with prescribed fire, grazing, and mechanical treatments, chemical applications of herbicides have significantly aided in efforts to control the spread of invasive plant species. Chemical applications are used on specific species and applied during the optimal plant stage of growth to increase the effectiveness of the application. We only use chemicals that have been approved for use on refuges, and the application of a specific chemical onsite must undergo a pesticide use proposal (also called PUP) evaluation. The refuge complex also has partnerships with county weed districts to exchange knowledge and resources.

Typically, we use a combination of techniques to control invasive plants and achieve desirable habitat conditions. For example, we have used sheep to graze Russian knapweed infestations followed by herbicide application. We use prescribed fire to remove decadent plant material to ensure greater efficacy of chemical application on the targeted species. Mechanical treatments of Russian olive have been followed by chemical application to prevent shoots from sprouting from the stump or root system.

The plants listed in table 12 and described below are of the highest priority for the refuge complex and are part of our invasive species management efforts. Several of these are also classified as noxious weeds by the State of Colorado and are targeted for eradication or other management actions (Colorado Department of Agriculture 2013). These species represent a significant threat to the refuge's capability to meet refuge purposes and habitat management objectives, especially those related to migratory birds.

Tall Whitetop or Perennial Pepperweed

This noxious weed is a perennial forb from southeastern Europe and western Asia. It is competitive and adaptive; as a result, it has become established throughout the western United States and is a serious land management and conservation problem. This species tolerates saline soils and thrives under an array of hydrological conditions. Tall whitetop is well adapted to riparian and wetland areas and threatens native hay and forage production. In riparian zones, it interferes with regeneration of willows and cottonwoods, and in wetland areas, the composition and productivity of herbaceous species is radically changed (Young et al. 1995). This tall weed (3 to 4 feet) grows and reproduces vigorously and is capable of forming dense monocultures. Tall whitetop started becoming established in the early 1950s (Harrington 1954), and now, to varying degrees, occurs in most of the refuge complex's habitat types, but is most prevalent in short-emergent vegetation, where it can be sparse to dominant. It is found along roads, levees, and other disturbed areas. This weed decreases the quality and quantity of wildlife habitat and it is a concern to refuge neighbors and local weed boards. Therefore, control of this weed is a vital issue for habitat management on the refuge complex.

Canada Thistle

This creeping perennial is a noxious weed that reproduces from vegetative buds in its root system and from seed. Because it has an extensive root system with vast nutrient stores, it is difficult to control. It is fairly common in riparian and wet meadow areas as well as disturbed sites. The infestation of this species is similar to that of tall whitetop on the refuge complex except that thistle exists in a slightly more narrow range of hydrological conditions. Few monotypic stands of thistle occur on the complex, but it is a species of concern for refuge managers because of its degradation of habitat and because it is a large concern of the county weed boards and neighbors.

Russian Knapweed

This weed is a nonnative, herbaceous perennial that reproduces from seed and vegetative root buds. This weed forms dense, single-species stands over time because of its allelopathic capabilities and ability to outcompete native species. Russian knapweed is found throughout the west under various conditions, and in Colorado it is found on a variety of soil types. On the refuge complex, this species is found in or near agriculture fields, in disturbed areas, along roads and levees, in playa basins, and in some upland grass habitats. This weed has formed large monotypic stands only in abandoned farm fields on the Monte Vista and Alamosa Refuges and in playa basins on the Baca Refuge. Across the rest of the refuge complex, it occurs as localized patches typically less than one-quarter acre in size.

Hoary Cress

This perennial weed is abundant across the San Luis Valley. Once established in a meadow, it is a highly competitive weed that is unpalatable to most livestock and wild grazers. It has been creeping its way into pastures, fields, croplands, and meadows across most of the United States for many years. Hoary cress is native to western Asia and Eastern Europe and most likely entered the United State via contaminated alfalfa seeds in the early 1900s. The plant emerges in early spring and blooms between May and June, producing many white flowers with four petals with a flat-topped appearance. It typically grows between 0.1 to 0.5 m tall with lance shaped leaves.

Each plant can produce 1,200 to 4,500 seeds annually that can spread by wind, vehicles, and even irrigation systems, quickly saturating their surrounding areas. Buried seeds can remain viable in the soil for up to 3 years even through the harsh, freezing winters that are common in the San Luis Valley. Hoary cress does not rely only on seed dispersal for taking over the landscape. Each plant can establish an extensive lateral root system that can spread out to 30 feet within 2 to 3 years, sending off up to 50 new shoots per year from that single root structure. In general, hoary cress grows better in alkali soils with moderate amounts of moisture. Hoary cress can take over disturbed sites, including areas with extensive grazing or tilling. It is commonly found in fields, meadows, pastures, open grasslands, waste areas, roadsides, gardens, feedlots, watercourses, and riparian habitats, and along irrigation ditches. Hoary cress has the ability to spread quickly and crowd out native plants. Within two to three years of entering an area, it can become a monoculture. Grazing, irrigation, and cultivation, all of which are common practices in the San Luis Valley, can promote the spread of hoary cress. It is an extremely persistent noxious weed on many areas of the refuge complex.

Phragmites

Also known as common reed, it is a large, coarse, perennial grass often found in wetlands. Although scattered clumps of phragmites provide cover for small mammals and birds, it usually forms large, dense stands that provide little value for wildlife. Phragmites reduces the diversity of plant and wildlife species. It is found in wetlands worldwide. It grows in wet areas including fresh or brackish marshes, creeks, the edges of ponds and lakes, and ditches. Dense stands of phragmites usually are associated with areas where soil has been exposed or disturbed. The plants are less competitive when water levels vary by seasons and years. Phragmites has a thick stalk that can reach 13 feet in height. It has a large plume-like inflorescence that persists throughout the winter. Phragmites most often spreads by creeping rhizomes. All stands of phragmites have vertical and horizontal rhizomes, and young stands have long surface runners that help to rapidly expand the colony.

Phragmites occurs on the Alamosa Refuge, where there are extensive and monotypic stands that extend along the eastern side of the refuge from the middle (near the Mumm Well) to the southern end. These stands have replaced approximately 600 acres of marsh and wet meadow vegetation that would otherwise be occupied primarily by cattail, bulrush, Baltic rush, and sedges.

Eurasian Watermilfoil

This species is native to Northern Europe and Asia. Eurasian watermilfoil spreads most commonly by stem fragmentation and runners. The plant roots on the bottom, but survives and is spread as free floating plants waiting to take root. Eurasian watermilfoil also spreads by seeds. The leaves each have 12 to 21 pairs of leaflets and are 1 inch long. The plant is typically submersed with stems to 4 m long, becoming emerged only while flowering or after stream or canal drawdown when moisture is present. The flowers occur from June to September and are pinkish and whorled with emerged bract-like leaves just below each whorl. This species has been found along the Rio Grande and at the terminal end of the Closed Basin canal on the Alamosa Refuge. This noxious plant was discovered in the late 1990s by the Alamosa County Weed Board. Although it can produce a thick vegetative mat that degrades water quality, reduces dissolved oxygen levels, and replaces native plant communities, these effects have not occurred on the Alamosa Refuge. However, populations of this plant continue to be a concern. To date, no control of this species has occurred either on the refuge or elsewhere in the San Luis Valley.

Saltcedar

This is a deciduous tree (or shrub) with long, slender branches and deep pink flowers. It is long-lived (50-100 years) and grows to 6 to 26 feet (2-8m) tall. The branches often form thickets many feet wide. The narrow leaves are small (1.5 cm) and grayish green, often overlapping and crowding on the stems. The leaves have the appearance of a conifer. Saltcedar is a native of Eurasia. Saltcedar typically occupies sites with intermediate moisture, high water tables, and minimal erosion, and mainly occurs along floodplains, riverbanks, stream courses, salt flats, marshes, and irrigation ditches in arid regions of the Southwest. It often forms pure stands in disturbed riparian areas of the Southwest.

Riparian ecosystems have been detrimentally affected by saltcedar throughout the southwestern United States. In many places, monotypic stands of saltcedar aggressively replace willows, cottonwoods, and other native riparian vegetation. Saltcedar can consume enormous amounts of water, and a single large plant can absorb 200 gallons of water a day. This can result in the lowering of the ground water, drying up of springs and marshy areas, and a reduction in the water yield of riparian areas. Saltcedar's dense roots can slow down river flow, increasing deposition and sediments along the riverbank. This can lead to saltcedar colonization further into the floodplain, widening the riparian zone and resulting in severe reduction of streamflow or even rechanneling. On the other hand, saltcedar root systems can also lead to flooding through choking of the watercourse. Although it can provide nesting areas for some species, compared with native vegetation, the density and diversity of birds decreases dramatically when saltcedar is present. Saltcedar communities also tend to have smaller numbers of insects as well. Although saltcedar occurs in the San Luis Valley, most occurrences are isolated plants or small patches on all three refuges. Because the establishment of this species is of great concern, all plants have been detected early and infestations have been controlled by mechanical and chemical methods while the plants were young.

Russian Olive

This is a perennial tree or shrub native to Europe and Asia. The plant has olive-shaped fruits, which are silver at first but then become yellow-red when mature. Russian olive can reproduce by seeds or root suckers. Seeds can remain viable for up to 3 years and are capable of germinating in a broad range of soil types. Spring moisture and slightly alkaline soil tend to favor seedling growth. The plant's extensive root system can sprout root suckers frequently. The stems can reach up to 30 feet in height with branches and trunks that have 1- to 2-inch thorns. Russian olive can grow in a variety of soil and moisture conditions, but prefers open, moist riparian zones. It is shade tolerant and can be found along streams, fields, and open areas. Russian olive can outcompete native vegetation, interfere with natural plant succession and nutrient cycling, and tax water reserves. Because Russian olive is capable of fixing nitrogen in its roots, it can grow on bare mineral substrates and dominate riparian vegetation. Although Russian olive can provide a plentiful source of edible fruits for some birds, ecologists have found that bird species richness is higher in riparian areas dominated by native vegetation.

Similar to saltcedar, few large stands of Russian olive exist in the San Luis Valley, though isolated patches and individual plants are common throughout the San Luis Valley and on all three refuges. Few attempts have been made throughout the years to eradicate this species from the refuges. Our observations are that Russian olive appears to be spreading throughout the refuges, and in recent years we have increased our efforts to eradicate this species. Removal of new plants will continue across the refuge complex.

Yellow Toadflax

This is a perennial weed that is native to south-central Eurasia; it was imported into North America in the late 1600s. Vegetative shoots usually emerge in mid-summer, growing to between 1 and 3 feet tall. Flowering may not start until late July. Once established, toadflax can easily spread into adjacent areas through its quickly developing root system, outcompeting native vegetation for resources. Toadflax is difficult to control, and an integrated management approach is most successful with this species. Yellow toadflax can quickly colonize disturbed areas and expand into undisturbed sites. Yellow toadflax occurs along the upper reaches of riparian habitat along north Crestone Creek in the Baca Refuge. The distribution of this plant appears to be limited to this area, and efforts are in place to eradicate the species through an integrated approach.

Swainsonpea

This is a perennial plant that branches out from the base with a woody taproot and rhizome. Swainsonpea is native to Asia. It is considered a watch list species in the State of Colorado, meaning that it may pose a potential threat to the environment, and information is being collected to make that determination. Flowers are brick red to purple and form into seed pods containing many seeds. Reproduction can occur vegetatively through rhizomes or by seed. Like many invasive plants, new populations can quickly colonize disturbed sites. These plants can grow up to 5 feet tall, but are usually 2-3 feet tall. The seed size is similar to alfalfa, so it can easily be a contaminant of that crop, and its presence in the San Luis Valley is of high concern. Swainsonpea has a patchy distribution at the Baca Refuge, and it appears to be spreading. Efforts are in place to eradicate this species using an integrated approach.

Threatened and Endangered Species (Federal) and Species of Concern

Table 13 shows the potential for occurrence of endangered species, threatened species, and species of concern on or near the refuge complex. Southwestern willow flycatcher is the only endangered species with an established presence on the refuge complex.

Table 13. Threatened, endangered (Federal), and other species of concern that potentially occur on the refuge complex.

Common name / scientific name	*Status*	*Range/habitat needs*	*Potential for occurrence on or near the three refuges*	*Eliminated from detailed analysis*
		Mammals		
Townsend's big-eared bat *(Corynorhinus townsendii)*	SC	**Range:** Occurs throughout the western U.S. **Habitat:** Highly associated with caves and mines. Susceptible to disturbance at roost sites. Periodically moves to alternate roosts and actively forages and drinks throughout the winter. Foraging associations include edge habitats along streams and within a variety of wooded habitats.	Moderate. Suitable foraging habitat exists within the three refuges.	No
Northern pocket gopher *(Thomomys talpoides agrestis)*	SC	**Range:** This subspecies occurs in the San Luis Valley north and east of the Rio Grande. **Habitat:** A wide variety of vegetation communities including semi-desert shrublands, grasslands, forests, and alpine tundra.	High. This species has been documented east of the Baca Refuge on the Baca Grande.	No
New Mexico Meadow Jumping Mouse *(Zapus hudsonius)*	FP	**Range:** Southwestern United States including riparian areas along the Rio Grande. **Habitat:** Prefers riparian habitat and requires permanent free-flowing water.	Low: The presence of this species is unknown in the San Luis Valley Conservation Area. However, protection of riparian corridors of the San Juan and northern Sangre de Cristo Mountains within the proposed San Luis Valley Conservation Area could give the species the adaptive capacity to persist in the likely range contractions in more southerly parts of its range.	No

Table 13. Threatened, endangered (Federal), and other species of concern that potentially occur on the refuge complex.

Common name / scientific name	*Status*	*Range/habitat needs*	*Potential for occurrence on or near the three refuges*	*Eliminated from detailed analysis*
Black-footed ferret *(Mustela nigripes)*	FE, SE	**Range:** Isolated locations in South Dakota, Wyoming, Utah, and Colorado. **Habitat:** Prairie dog colonies. Uses the burrows as living quarters and nurseries.	Low. Suitable habitat occurs within Gunnison's prairie dog colonies on the Baca Refuge. However, the nearest known population is located in northwest Colorado.	Yes
Wolverine *(Gulo gulo)*	FP, SE	**Range:** Throughout boreal forest and tundra regions of North America. Several records exist for Colorado and some recent observations have occurred. **Habitat:** Boreal forests, bogs, lowlands, and tundra. Dens are typically in log jams, under rocks and boulders, or under tree roots.	Low. There is no suitable habitat in the three refuges.	Yes
Canada lynx *(Lynx canadensis)*	FT, SE	**Range:** Found throughout Canada and Alaska as well as the high elevation forests of Colorado, Utah, Wyoming, Montana, and Idaho. **Habitat:** Coniferous forests such as spruce-fir with well-developed understories. Uneven aged stands of spruce-fir with rock outcrops and large boulders are the preferred habitat. Dens are typically under ledges, trees, or deadfalls, but are occasionally in caves.	Low. Found in San Juan and Sangre de Cristo Mountains. The Culebra Range of the Sangre de Cristo Mountains has been identified as a particularly important corridor for the species and within the Sangre de Cristo Conservation Area. Most lynx habitat within the San Luis Valley Conservation Area is already protected. There is no suitable habitat in the three refuges.	Yes
Gray wolf *(Canis lupus)*	FE, SE	**Range:** Found in Wyoming, Montana, Idaho, north central Utah, and other States. Mexican gray wolf (*Canis lupus baileyi*) is found in the Blue Mountains in New Mexico and Arizona. **Habitat:** Ungulates are the typical prey source for wolves, but they will also eat smaller mammals, birds, and fish.	None. In Colorado, the gray wolf is an extirpated species that no longer exists in the wild in its historical habitat. (Refer to chapter 3.)	Yes. (Refer to end of chapter 3.)
		Birds		
Bald eagle *(Haliaeetus leucocephalus)*	SC	**Range:** Throughout Colorado; however, most breeding occurs along the front range and western parts of the State. **Habitat:** Generally nests and roosts in proximity to large water bodies including rivers, lakes, and reservoirs. Nests in large trees such as cottonwood and ponderosa pine. Breeding season is February 15–July 15.	High. Occurrence is limited to migrating and wintering individuals. Most of the bald eagle use is along Crestone Creek and Alamosa Refuge.	No

Table 13. Threatened, endangered (Federal), and other species of concern that potentially occur on the refuge complex.

Common name / scientific name	*Status*	*Range/habitat needs*	*Potential for occurrence on or near the three refuges*	*Eliminated from detailed analysis*
Ferruginous hawk *(Buteo regalis)*	SC	**Range:** Throughout the Great Plains and grassland/shrub-steppe areas of western North America. **Habitat:** Open grassland and shrub-steppe habitats. Nests on the ground, usually on a hill or rock outcrop. Forages over open country. Breeding season is March 15–July 15.	High. This species has been documented foraging around wetlands and marshes within the three refuges.	No
American peregrine falcon *(Falco peregrinus anatum)*	SC	**Range:** Primarily found in western Colorado but breeding pairs also are found along the front range. **Habitat:** Foothill and mountain cliffs surrounded by pinyon-juniper or ponderosa pine woodlands. Nest sites consist of a small depression on a cliff ledge. Breeding season is March 15–July 15.	High. This species has been documented foraging around wetlands and marshes within the project area. However, there is no known nesting habitat near the three refuges.	No
Gunnison sage-grouse *(Centrocercus minimus)*	FC, SC, proposed for listing	**Range:** In Colorado this species is found primarily in Gunnison County with small scattered populations in Montrose, San Miguel, Mesa, and Saguache counties. **Habitat:** Sagebrush grasslands. Leks are located in open areas in proximity to escape cover. Nests are located in sagebrush habitat, typically within 2 miles of the lek. Broods are raised in wet, grassy areas near sagebrush. Winter habitat consists of south and east facing slopes with minimal snow cover. Breeding season is March 15–July 1.	None. Little suitable sagebrush grasslands within the three refuges. A small population is found near Poncha Pass, northwest of the Baca Refuge. This area would be protected as part of the San Luis Valley Conservation Area.	Yes
Greater sandhill crane *(Grus canadensis tabida)*	SC	**Range:** In Colorado this species breeds in the northwest portion of the State and migrates through the San Luis Valley in the fall and spring. **Habitat:** Flooded fields, wetlands, marshes, meadows, and agricultural fields. Breeding season is April 1–July 15.	High. A large number of greater sandhill cranes, part of the Rocky Mountain population, migrate through the San Luis Valley in the fall and spring.	No
Western snowy plover *(Charadrius alexandrinus)*	SC	**Range:** Found along artificial reservoirs in southeast Colorado and alkali-covered playas in the San Luis Valley. **Habitat:** sandy beaches, dry salt flats, river bars, and alkali-covered playas. Breeding season is April 1–July 15.	High. This species has been documented approximately 15 miles south of the Baca Refuge near San Luis Lake.	No

Table 13. Threatened, endangered (Federal), and other species of concern that potentially occur on the refuge complex.

Common name / scientific name	*Status*	*Range/habitat needs*	*Potential for occurrence on or near the three refuges*	*Eliminated from detailed analysis*
Mountain plover *(Charadrius montanus)*	SC	**Range:** Western North America with the largest breeding populations found in Colorado and eastern Montana. **Habitat:** Native short-grass prairie, stunted shrublands, agricultural fields, and overgrazed pastures. Breeding season is April 1–July 15.	High. Only a few records exist for the San Luis Valley, although this species was observed east of the project area on the Baca Grande in 2005. Suitable habitat occurs within the Baca Refuge.	No
Long-billed curlew *(Numenius americanus)*	SC	**Range:** Found primarily in southeastern Colorado with isolated populations in the northeast and northwest Colorado. **Habitat:** Short-grass prairie with scattered playas. Feeds along lake and reservoir edges during migration. Breeding season is April 1–July 15.	High. This species has been documented migrating through all three refuges. Suitable nesting habitat occurs within the project area.	No
Western yellow-billed cuckoo *(Coccyzus americanus)*	FC, SC; proposed for listing	**Range:** In Colorado, this species is primarily found west of the continental divide along riparian areas. **Habitat:** Old growth riparian woodlands with dense understory. Nests are typically located high in trees with closed canopies. Breeding season is April 15–July 15.	Moderate. This species has been documented in dense, old-growth cottonwood forests near McIntire Springs. Suitable habitat occurs near the Alamosa Refuge.	No
Burrowing owl *(Athene cunicularia)*	ST	**Range:** Found primarily in eastern Colorado as a summer resident, although small populations occur in the western Colorado and the San Luis Valley. **Habitat:** Open country from desert scrub to grasslands. Often found in or around prairie dog colonies. Nests in burrows. Breeding season is March 15–August 15.	High. This species has been documented nesting at several locations on the Baca Refuge.	No
Southwestern willow flycatcher *(Empidonax traillii extimus)*	FE, SE	**Range:** Southwestern U.S. and Mexico. In Colorado, this species has been found in the southwest corner of the State and the San Luis Valley. **Habitat:** Riparian areas with lush willows. Breeding season is April 15–July 15.	High. This species has been documented on the Alamosa Refuge and at Rio Grande and Higel State Wildlife Areas.	No

Table 13. Threatened, endangered (Federal), and other species of concern that potentially occur on the refuge complex.

Common name / scientific name	*Status*	*Range/habitat needs*	*Potential for occurrence on or near the three refuges*	*Eliminated from detailed analysis*
		Amphibians		
Boreal toad *(Bufo boreas boreas)*	SE	**Range:** In Colorado, this species is restricted to the Rocky Mountains and is found at elevations between 7,000 and 12,000 feet. **Habitat:** Restricted to areas with suitable breeding habitat in spruce-fir forests and alpine meadows. Breeding habitat is lakes, marshes, ponds, and bogs with sunny exposures and quiet, shallow water. Breeding season is April 15–August 15.	None. There is no suitable habitat within the three refuges.	Yes
Northern leopard frog *(Rana pipiens)*	SC	**Range:** Once the most widespread frog species in North America, this species has been drastically declining in the last 50 years. In Colorado, this species is found statewide except for the southeast and east-central part of the State. **Habitat:** Typical habitats include wet meadows and the banks and shallows of marshes, ponds, glacial kettle ponds, beaver ponds, lakes, reservoirs, streams, and irrigation ditches. Breeding season is April 15–August 15.	High. Suitable habitat exists on all three refuges.	No
		Invertebrates		
Uncompahgre fritillary *(Boloria acrocnema)*	FE	**Range:** This butterfly is endemic to the high alpine meadows of the San Juan Mountains in southwestern Colorado. **Habitat:** This species of butterfly lives in patches of snow willow *(Salix* spp.*)* at high elevations as well as moist tundra with dwarf willows above 13,000 feet.	None. The refuges are outside of the species' range and there is no suitable habitat in the refuge complex.	Yes
		Fish		
Rio Grande sucker *(Catostomus plebeius)*	SE	**Range:** Historically, this species was found throughout the Rio Grande system. In Colorado, this species is now limited to several small tributaries of the Rio Grande. **Habitat:** This species prefers small streams with clear water, pools, and riffles.	High. This species is found on the Baca Refuge along Crestone Creek.	No

Table 13. Threatened, endangered (Federal), and other species of concern that potentially occur on the refuge complex.

Common name / scientific name	*Status*	*Range/habitat needs*	*Potential for occurrence on or near the three refuges*	*Eliminated from detailed analysis*
Rio Grande chub *(Gila pandora)*	Proposed for listing 2013	**Range:** In Colorado this species' range is restricted to the Rio Grande Basin. **Habitat:** This species prefers pools of small to moderate streams near areas of current.	High. This species is found on the Baca Refuge in Crestone Creek and Willow Creek.	No
Rio Grande cutthroat trout *(Oncorhynchus clarki virginalis)*	FC, SC	**Range:** In Colorado this species' range is confined to the headwaters of the Rio Grande surrounding the San Luis Valley. **Habitat:** This species, like other cutthroat trout species, prefers clear, cold streams and lakes.	Moderate. This species is known to occur in the Saguache Creek drainage west of the project area and in the San Luis Creek drainage northwest of the Baca Refuge. This species occurs in perennial streams, but has never been documented in Crestone Creek, the only perennial stream in the project area.	Yes

Abbreviation Status:

FE - Federally Endangered
FT - Federally Threatened
FC - Federal Candidate
FP - Federally Proposed
SE - State Endangered
ST - State Threatened
SC - State Species of Concern

Primary sources: Fish and Wildlife Service endangered species database (FWS 2013c); Colorado Parks and Wildlife threatened and endangered list (CPW 2013c); Final Baca oil and gas environmental assessment (FWS 2011b); Sangre de Cristo Conservation Area land protection plan (FWS 2012b); Final interim elk management plan and environmental assessment for San Luis Valley National Wildlife Refuge Complex (FWS 2013e).

Note: Several other birds of concern found on the refuge complex are discussed in chapter 3 in tables 3, 4, and 5, or in the text.

Southwestern Willow Flycatcher

The southwestern willow flycatcher *(Empidonax traillii extimus)*, one of four subspecies of the willow flycatcher, is a small neotropical migrant that can be fairly abundant along the Rio Grande on the Alamosa Refuge, and in other riparian habitats within the San Luis Valley. In recent years, however, the hydrology of the Rio Grande through Alamosa Refuge appears to be limiting the number found. The subspecies was listed as federally Endangered in 1995 (FWS 1995). Arizona, New Mexico, and California are the core of the southwestern willow flycatcher's historic and current range (Owen and Sogge 1997). Southwestern Colorado may have been used by breeding southwestern willow flycatchers, but nesting records are lacking (FWS 1995). Determining the boundaries of this subspecies' range has been difficult for several reasons, including the limited number of museum specimens from some regions including southwestern Colorado (Paxton 2000), the difficulty in separating breeders from migrants in many areas, and the lack of data on willow flycatchers in south-central Colorado (Owen and Sogge 1997). In general, southwestern willow flycatchers nest in dense stands of mixed willows that are adjacent to or near open water or that are temporarily flooded, at least during nest initiation.

Genetic studies have been conducted to evaluate the genetic composition of willow flycatchers, including those captured in the San Luis Valley. A 1996-1997 study conducted by the Colorado Plateau Field Station (Owen and Sogge 1997) evaluated the number, location, and extent of willow flycatcher breeding sites and analyzed genetic characteristics of willow flycatchers at 20 sites in Arizona, California, New Mexico, and Nevada, as well as at five sites in Colorado, including the Alamosa Refuge and McIntyre Springs (which is managed by the BLM) (Owen and Sogge 1997). The results suggest that considerable genetic diversity exists both within the *extimus* subspecies and within local breeding sites (Busch et al.

2000). Another study examined the molecular genetic structure of willow flycatchers throughout their range, and the results show that the flycatchers sampled on the Alamosa Refuge and at McIntyre Springs belong to the endangered *extimus* subspecies. Southwestern Colorado, however, proved to be the intergrade zone between the *extimus* and the northern neighboring *adatmus* subspecies (Paxton 2000).

The 1995 listing (FWS 1995) identified the entire San Luis Valley as being within the breeding range of *extimus*. In 2013, critical habitat was designated, which included 8,345 acres of the Alamosa Refuge (FWS 2013b), including the entirety of the riparian corridor as well as other areas. Management of the southwestern willow flycatcher will be guided by the *Recovery Plan* approved in December 2002 (FWS 2002).

Management Activities

We manage habitats within the refuge complex through water management (see discussion under physical environment), rest, and prescribed grazing, haying, mowing, and fire.

Rest

Dense stands of wetland vegetation are an important part of migratory bird habitat on all three refuges. This has been documented for ducks on the Monte Vista Refuge (Gilbert et al. 1996), but likely applies to other species nesting in associated habitats, such as American bittern, sora, Virginia rail, northern harrier, and short-eared owl. Production of this dense undisturbed vegetation distinguishes the refuges in the San Luis Valley from almost all lands in agricultural production. Although irrigation practices are fundamentally the same on agricultural lands and lands that are used by nesting water birds, the use of the resulting vegetation is dramatically different. Farmers and ranchers depend on the harvest of vegetation for their livelihoods; however, waterbirds need stands of vegetation that are largely excluded from harvest. Because of this, the refuges provide important islands of nesting cover within the San Luis Valley and the flyway.

Stands of dense vegetation are achieved through careful water manipulation and rest from management practices that result in defoliation, such as grazing, fire, herbicide, haying, and mowing. Although the use of rest has tremendous value for a wide variety of birds, it is not feasible or desirable to constantly keep all of the refuge complex's wetland habitats in a densely vegetated state. In the cool climate of the mountain valley, decomposition occurs slowly and organic matter allowed to accumulate over too many years will shade the soil and suppress the new growth of desired vegetation. Therefore, it is necessary to periodically disturb dense stands of vegetation to accelerate the breakdown of organic matter, hasten mineral cycling, reduce invasive weed densities, and create vegetative structural diversity.

Prescribed Grazing

Prescribed grazing has occurred at varying degrees on all three refuges since they were established. Prescribed grazing is the planned application of livestock grazing in a specified area, season, duration, frequency, and intensity to achieve specific vegetation objectives. The objectives are designed to meet the broader habitat and wildlife goals. Instead of managing the refuges for livestock grazing or other economic uses, livestock grazing is used as a tool to improve wildlife habitat (FWS 2001). On the three refuges, we work with local livestock owners who are issued annual special use permits specifying the location, timing, duration, and intensity of grazing so that habitat management objectives can be met.

The primary use of livestock grazing on the refuges is to enhance desirable plant growth and vigor in wetland habitat and for invasive weed control. Grazing in wetland habitats is used to reduce the accumulation of organic litter at the surface. A large amount of organic litter often favors invasive species such as Canada thistle and tall whitetop. Removal of this litter layer stimulates the growth, spread, and vigor of desirable plants that will help out-compete invasive plant species. Increased plant height and density, especially of Baltic rush, is also beneficial to many nesting waterfowl species during the period these areas are rested (Gilbert et al. 1996). Prescribed grazing, coupled with other treatments such as flooding, prescribed fire, and herbicide application, is used to help with direct control of invasive weeds, especially tall whitetop. For example, grazing has been used early in the growing season when rosettes and young stems are eaten by cattle. Cattle are removed when they no longer consume plants in the later growth stage, and these plants are then treated with herbicide to further control infestations. Sheep grazing has been used to target Russian knapweed infestations. Once the sheep are removed, herbicide is applied. The refuges have experienced significant control in these areas using this combination of treatments. Recently, prescribed grazing (primarily with cattle) has been used to achieve a specific vegetative structure that benefits bird species that require moderate vegetation height for nesting and foraging, such as Wilson's phalarope, Wilson's snipe, and cinnamon teal. Prescribed grazing is used to create heterogeneity in vegetation structure as compared to tools such as haying and mowing or prescribed fire that uniformly affect the height of vegetation.

When prescribed grazing is used to meet habitat, wildlife, and other land management goals, it can be an extremely effective tool. For example, short-duration, high-intensity grazing treatments can be used to control invasive plants. Grazing can also be used to manipulate vegetative structure to meet the nesting or foraging needs of specific wildlife species. After a period of rest, grazing can be used to remove excess plant material to stimulate the establishment, growth, spread, and vigor of desirable plant species.

Natural herbivory by elk and bison once occurred on all three refuges, where large herds grazed for short intervals, moved to other sites when forage resources diminished, and returned when the vegetation had recovered. This strategy allowed plant species to recover without being defoliated to the point where they could not regrow. Consequently, both plant and wildlife species evolved with this disturbance regime and overall habitat health was sustained.

Prescribed Haying and Mowing

Similar to prescribed grazing, prescribed haying and mowing are used to meet specific vegetation objectives. Haying and mowing are used to remove the buildup of residual vegetation in wetland habitats and promote the growth, spread, and vigor of desirable plant species. As with other mechanical activities, guidance and policy are followed to help avoid disturbing ground-nesting birds. Timing and other factors are considered to encourage desired plant species and habitat conditions and to discourage the establishment of invasive weeds.

Prescribed Fire

Prescribed fire is a wildland fire intentionally used to meet specific objectives that are identified in a written, approved prescribed fire plan. As a management tool, we use prescribed fire to achieve fuel reduction, resource protection, community protection, and our habitat management goals.

By using prescribed fire, the refuges are able to reduce and remove dead and decadent vegetation, which allows vegetation to regenerate which promotes increased wildlife use of these habitats. Removal of dead and decadent vegetation with prescribed fire also removes fuel that could create a destructive wildfire. Fire characteristics and the resulting effects are dependent on fuel type, weather, and topographic conditions. After a prescribed fire, light, moisture, and nutrients that would have otherwise been blocked by or tied up in dead and decadent vegetation become available to regenerating plants (FWS 2013f).

Prescribed fire has been used or is planned in all major habitat types on the refuges, except for riparian habitat, although the refuges are investigating the use of prescribed fire to help riparian habitats. Before prescribed fire is used, specific procedures that set priorities for human safety are set. All prescribed fires will be monitored in accordance with Service policies and the specifics of the burn plans. One of the main directives of Federal land management is to let agency directives, the best available science, and ecological principles dictate management (Dombeck et al. 2004). An intensive vegetation and wildlife inventory is a part of successful fire management. Climate change may continue to increase temperatures and fire season duration, creating new complications for management strategies (Stephens et al. 2009). As the climate changes and plant communities change accordingly, it is the responsibility of land managers to be aware of these issues and plan for them in advance. Habitat monitoring will be crucial for determining vegetation trends and how fire should be used to enhance wildlife habitat in the

Prescribed fire is used as a habitat management tool on the refuge complex.

changing environment. Arno et al. (2000) describe the importance of adaptive management and the need to study fires, learn from them, and more importantly, adapt to the new patterns.

We conduct prescribed burns under an approved interagency fire management plan (NPS, FWS, TNC 2006), complying with all regulations and guidelines established by the Colorado Department of Public Health and Environment (Air Pollution and Control Division). The interagency program consists of fire professionals from the USFS, BLM, NPS, and the Service.

Unlike a prescribed fire, a wildfire is a wildland fire originating from an unplanned ignition, usually caused by lightning, unauthorized and accidental human-caused fires, and escaped prescribed fires. Past and current management of the refuges has been to fully suppress all wildfires. Some of the other Federal land management agencies (BLM, USFS, and NPS) have allowed some wildfires to be managed to help achieve benefits.

Bird Species

Providing habitat for migratory birds is a central mission of the refuge complex.

Focal Birds

Focal birds serve as indicator species on the refuge complex. These are species that regularly nest on one or more of the refuges; are species of conservation priority or concern listed in local, State, regional, or national conservation plans; or have been named as target species. The focal birds for the major habitat types on the refuge complex are listed below. (Refer also to tables 3, 4, and 5 in chapter 3.)

- Wetland (tall-emergent/short-emergent/wet meadow/playa): mallard, cinnamon teal, American bittern, white-faced ibis, greater sandhill crane, American avocet, Wilson's phalarope, and Savannah sparrow
- Upland: Brewer's sparrow and western meadowlark
- Riparian: southwestern willow flycatcher and western wood-pewee

Waterfowl

The refuges support several priority waterfowl species that are highlighted in the North American Waterfowl Management Plan (DOI [FWS], SEMARNAP Mexico, Environment Canada 1998). Mallard, northern pintail, and lesser scaup, which are named as high-priority species in the plan, use the refuges for either nesting or migration. Substantial numbers of mallards and smaller numbers of northern pintails nest on the Monte Vista and Alamosa Refuges, while lesser scaup is primarily a spring and fall migrant. Other priority waterfowl species named in the plan that use the refuges include redhead, wood duck, canvasback, American wigeon, and ring-necked duck. Most of these species use the refuges as migration stopovers, but redheads and American wigeon are common breeders.

In general, the Baca Refuge supports few numbers of breeding waterfowl, but the Monte Vista and Alamosa Refuges may support breeding waterfowl in large numbers, depending on habitat conditions. Canada goose, mallard, gadwall, cinnamon teal, blue-winged teal, green-winged teal, northern pintail, northern shoveler, American wigeon, redhead, and ruddy duck commonly nest on the Monte Vista and Alamosa Refuges. During nesting season, the Monte Vista Refuge has one of the highest densities of nesting ducks on the continent (Gilbert et al. 1996). In the mid-1990s, 15,000 ducks were produced on the Monte Vista Refuge annually, which constitutes a major part of the State's population and subsequently the central flyway's population. The Alamosa Refuge also produced 5,000 to 8,000 ducks annually. Drier conditions over the last decade have resulted in few ducks being produced compared to the 1980s and 1990s; the number of ducks currently being produced is unknown. Because water availability on the Baca Refuge can be limited and habitats are not as conducive to meeting the breeding needs of many waterfowl species, waterfowl use of this refuge is much lower than on the Monte Vista and Alamosa Refuges.

Numbers of wintering waterfowl in the San Luis Valley vary depending on weather conditions and, consequently, the availability of unfrozen water and waste grain. In the early part of the 20th century, waterfowl, primarily mallards, wintered on artesian-dependent wetlands that were found throughout the valley. By 1970, the increase in the human population and its demand for water, as well as the change from flood irrigation to center pivot sprinklers on local farms, significantly increased the overall demand for water. Subsequently, ground water levels dropped dramatically and most artesian wells ceased to flow, which decreased the amount of wetlands available to wildlife. From 1980 through 1990, most of the waterfowl wintering in the San Luis Valley (approximately 15,000 ducks) were using the Monte Vista Refuge where open water was still available. As a result of a high number of ducks concentrated into a relatively small area, avian cholera outbreaks became common in the winters after 1980. An average of 6,500 ducks died yearly from the disease between 1985 and 1990.

In 1990, the Service, through the Partners for Fish and Wildlife program and in cooperation with the Colorado Division of Water Resources, started actively securing and increasing wintering habitat on private lands. Local farmers were paid to keep some of their crops standing in the field during the winter in an attempt to disperse waterfowl across the San Luis Valley and reduce the large concentrations on the Monte Vista Refuge. This program was successful in that ducks dispersed to other areas within the valley and cholera mortality was significantly reduced. However, this program was costly and not designed to be a long-term solution. Since 1996, we have not actively provided wintering waterfowl habitat so that ducks will migrate south to the Middle and Lower Rio Grande Valley and into Mexico where better wintering habitats exist.

Canada geese nest on, migrate through, and often winter on the Monte Vista and Alamosa Refuges. Geese build their nests in areas of thick cattails in and along wetland edges and on vegetated levees. At one time, Canada geese were declining in numbers in many areas, so we placed nesting structures in wetlands throughout the two refuges. Canada goose numbers have increased so much that they have become overpopulated in some areas and have become a nuisance, especially in urban areas. Although most of the nesting structures have been removed, this species continues to nest on the refuges.

Lesser Canada geese spend a few days to weeks on the refuges during the spring and fall migrations. Occasionally, some greater white-fronted geese and tundra swans visit the refuges during migration if conditions are suitable.

Other Waterbirds

The refuges, particularly Monte Vista and Alamosa, support several waterbird species named as priority species in the Intermountain West Conservation Plan (Ivey and Herziger 2006), including greater sandhill crane, western grebe, Clark's grebe, eared grebe, pied-billed grebe, American white pelican, Forster's tern, black tern, Franklin's gull, American bittern, black-crowned night-heron, snowy egret, white-faced ibis, sora, and Virginia rail. Many of these species nest on one or more of the refuges. Others use refuge habitats only during migration.

Pied-billed grebes are the most common nesting grebe on the Monte Vista and Alamosa Refuges, while western and eared grebes breed in smaller numbers. Grebes breed in wetlands with deep water, where they build their nests on floating mats of cattail or bulrush.

Black-crowned night-herons, white-faced ibis, and snowy egrets nest on the refuge complex, often on the same bulrush islands. The Monte Vista Refuge supports one of the largest nesting colonies of white-faced ibis and snowy egret in the State. These colonial-nesting waterbirds can change nesting locations each year if habitat conditions vary; however, they have nested consistently on the Monte Vista Refuge for the last 20 years. Foraging ibis use wet meadow and marsh communities during the spring, summer, and fall. Snowy egrets and black-crowned night-herons use open, shallow water as well as wet meadows and marshes for foraging. American bitterns are common on the Monte Vista and Alamosa Refuges and breed and forage in dense cattail stands.

Little is known about habitat use and nesting success of secretive marshbirds such as Virginia rail and sora in the San Luis Valley. Virginia rail and sora nest on the refuge complex and are commonly observed during spring, summer, and fall in wet meadow and marsh communities. The number of rails produced on the refuge complex is unknown; however, these species and their young are regularly documented.

Shorebirds

The refuges provide important habitat for a wide variety of shorebirds. Twenty-three shorebird species have been documented on the refuges during different seasons of the year. Many of these species are migrants and use the refuges during spring and fall. Killdeer, American avocet, black-necked stilt, Wilson's phalarope, Wilson's snipe, and spotted sandpiper are the most common breeders. These species use a variety of nesting habitats from unvegetated flats and levees to flooded short-emergent vegetation and gravel roads.

The potential of the playa habitat on the Baca Refuge for providing nesting and foraging resources is significant. Because of numerous factors (see Playa Habitat), this playa system has received little to no water since the late 1980s. Should sufficient water be available to irrigate the playas, we expect that the diversity of shorebirds using this area would be substantial and that it would become an extremely important nesting area for numerous species.

Sandhill Crane

Three subspecies of sandhill cranes spend several weeks in the San Luis Valley during each spring and fall to rest and feed during migration. The Rocky Mountain population of the greater sandhill crane *(Grus canadensis tabida)* nests primarily in Wyoming and Idaho and winters in the Lower and Middle Rio Grande Valley, primarily at the Bosque del

Apache National Wildlife Refuge in New Mexico. Ninety-five percent of this population (approximately 18,000 to 20,000 cranes) and 5,000 to 6,000 lesser *(Grus canadensis canadensis)* and Canadian *(Grus canadensis rowani)* sandhill cranes migrate through the San Luis Valley. Spring migration occurs from mid-February through late March, with peak numbers in early March. Fall migration is from early September through mid-November, with peak numbers in mid-October.

Most of the crane use in the San Luis Valley is on and around the Monte Vista Refuge, primarily because there are suitable roost sites on the refuge and because there are private agricultural fields nearby where cranes feed extensively on barley and other small grains in the spring and fall. In the fall, local farmers harvest their crops, and cranes feed on the excess grain left in the fields. In recent years, farmers have been tilling or irrigating after harvest. As a consequence, the amount of waste grain on private agricultural fields has been limited during the following spring, when cranes are migrating north to their breeding grounds. The agricultural fields on the Monte Vista Refuge are left standing in the fall when adequate supplies of waste grain are available on neighboring fields. In the spring, refuge barley fields are cut but not harvested, which provides food for cranes when it is limited on private lands.

As well as providing important feeding sites in the spring, the Monte Vista Refuge has the largest roosting site in the San Luis Valley, and up to 15,000 cranes seek protection each night in the refuge's shallow-water wetlands. *Because of* the Monte Vista Refuge's water rights and the ability to pump ground water starting in late winter, suitable roost sites are available by mid-February, when shallow-water wetlands elsewhere in the San Luis Valley are still dry. By providing these important roost sites and high-energy food resources, we continue to support the Pacific and central flyway greater sandhill crane conservation and population goals.

Raptors

The San Luis Valley, including the three refuges, hosts an array of hawks, eagles, owls, and falcons throughout the year.

Red-tailed hawks and Swainson's hawks nest in trees on old homesteads and in large riparian trees. Red-tailed hawks and ferruginous hawks also commonly nest on utility poles in the valley. Northern harriers nest in dense vegetation in wet meadows as well as in tall-emergent wetland vegetation.

Great horned owls nest in deciduous and evergreen trees and on the banks of canals and water delivery ditches. Short-eared owls, like harriers, nest in dense vegetation in wet meadows.

Burrowing owls are declining in Colorado and are a species of management of concern in Region 6, Mountain-Prairie Region, and other western regions. Burrowing owl is a grassland species that often uses abandoned prairie dog tunnels for nesting. This species is rare to uncommon in the San Luis Valley as it is in most of the western valleys and mountain parks of Colorado (Andrews and Righter 1992). Habitat loss is responsible for some of the declines in the State; however, burrowing owls are missing from areas with apparently suitable habitat. Therefore, other factors may be involved (Andrews and Righter 1992).

They are uncommon on the Monte Vista and Alamosa Refuges because of lack of suitable habitat. Burrowing owls are more common on the Baca Refuge because it has more habitat and a few mid-sized prairie dog colonies. On the Baca Refuge, burrowing owls are usually found in unirrigated short-emergent wetlands and greasewood shrubland, with the main prey source being insects, small mammals, and birds. Burrowing owls occupy multiple areas outside of prairie dog colonies on the refuge using burrows dug by other mammals.

Peregrine falcons and prairie falcons hunt for shorebirds and other small waterbirds in the wetlands and wet meadows of the refuge complex during spring and fall migration. Peregrine falcon nesting is suspected in the mountains 5 miles west of the Monte Vista Refuge, and fledglings have been found in the southern valley near Jaroso (Dean Swift, personal communication [date unknown]). Kestrels nest in tree cavities, nest boxes, and other structures throughout the valley.

Red-tailed hawks, ferruginous hawks, rough-legged hawks, northern harriers, short-eared owls, golden eagles, and bald eagles are common winter residents on the refuge complex. The hawks, owls, and golden eagles find rodents, rabbits, and other prey in the uplands and short-emergent wetlands where cover is abundant. Bald eagles spend the winter feeding on waterfowl or on carrion. Most of the bald eagle use is on the Alamosa Refuge, where eagles extensively use the cottonwood trees along the Rio Grande. In February and March, the Alamosa Refuge is an important staging area for spring migrating bald eagles. During winter, golden eagles use the Baca Refuge for hunting small mammals.

Songbirds

The refuge complex provides habitat for a variety of migrating, nesting, and wintering songbirds and other birds. Nesting species include swallows, wrens, blackbirds, sparrows, and flycatchers. Songbirds nest and depend on all habitat types on the refuges, from uplands, which support sage thrasher, Brewer's sparrow, and loggerhead shrike, to dense cattails, which support common yellowthroat and marsh wren, to short-emergent grasslands, which support western meadowlark, Savannah sparrow, and vesper sparrow.

Riparian habitats, particularly on the Alamosa and Baca Refuges, support the greatest diversity of nesting and migrating songbirds, including southwestern willow flycatcher, western wood-pewee, yellow warbler, and Bullock's oriole. These species and many others that nest in riparian habitats are neotropical migrants that winter in Central or South America. All of these songbird species face a multitude of threats, from loss of habitat to the use of pesticides, and many songbird species are experiencing population declines throughout their range.

Other Wildlife Species

Large, medium, and small mammals; amphibians and reptiles; and fish are important parts of the biodiversity of the refuges.

Rocky Mountain Elk, Mule Deer, and Pronghorn

Rocky Mountain elk are native to the San Luis Valley, but the distribution and abundance of this species has changed in recent years. Figure 49 shows the summer and winter elk concentration areas in the San Luis Valley.

Before the mid-1980s, elk were rare on the Baca Refuge. CPW estimated less than 50 elk in 1988. In 1991, a district wildlife manager with CPW observed approximately 80 elk just south of the Baca Refuge, and in 1993, approximately 1,500 elk were observed on the refuge. From the mid-1990s to the present, the elk population on the Baca Refuge and in the surrounding area has continued to increase to a current population of more than 3,500.

On the Alamosa Refuge, there were no documented elk observations before 1997. In 1998, CPW issued private land-only elk hunting licenses to address elk damage to private lands near Fort Garland, Colorado. Pressure from these hunts pushed approximately 300 elk to the southern end of the Alamosa Refuge, although many left the refuge after the hunting season. In 1999, this occurred again, with about 400 elk being pushed to the Alamosa Refuge. Once again, many returned to the Fort Garland area after the hunting season. By 2009, the elk population on the Alamosa Refuge and in the surrounding area increased to more than 400 animals, with approximately 200 elk remaining on the Alamosa Refuge year-round.

On the Monte Vista Refuge, only a few elk were observed before the late 1980s. By 1989, there were approximately 300 elk spending the winter on the refuge, and by 1997 that number had increased to more than 900, of which approximately 70 had become year-round residents. In 1997, efforts were made to reduce elk numbers on the Monte Vista Refuge. Within 4 years, the number of elk wintering on the Monte Vista Refuge declined to less than 100, and the resident population was eliminated. Since 2003,


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Mule deer are found across the refuge complex.

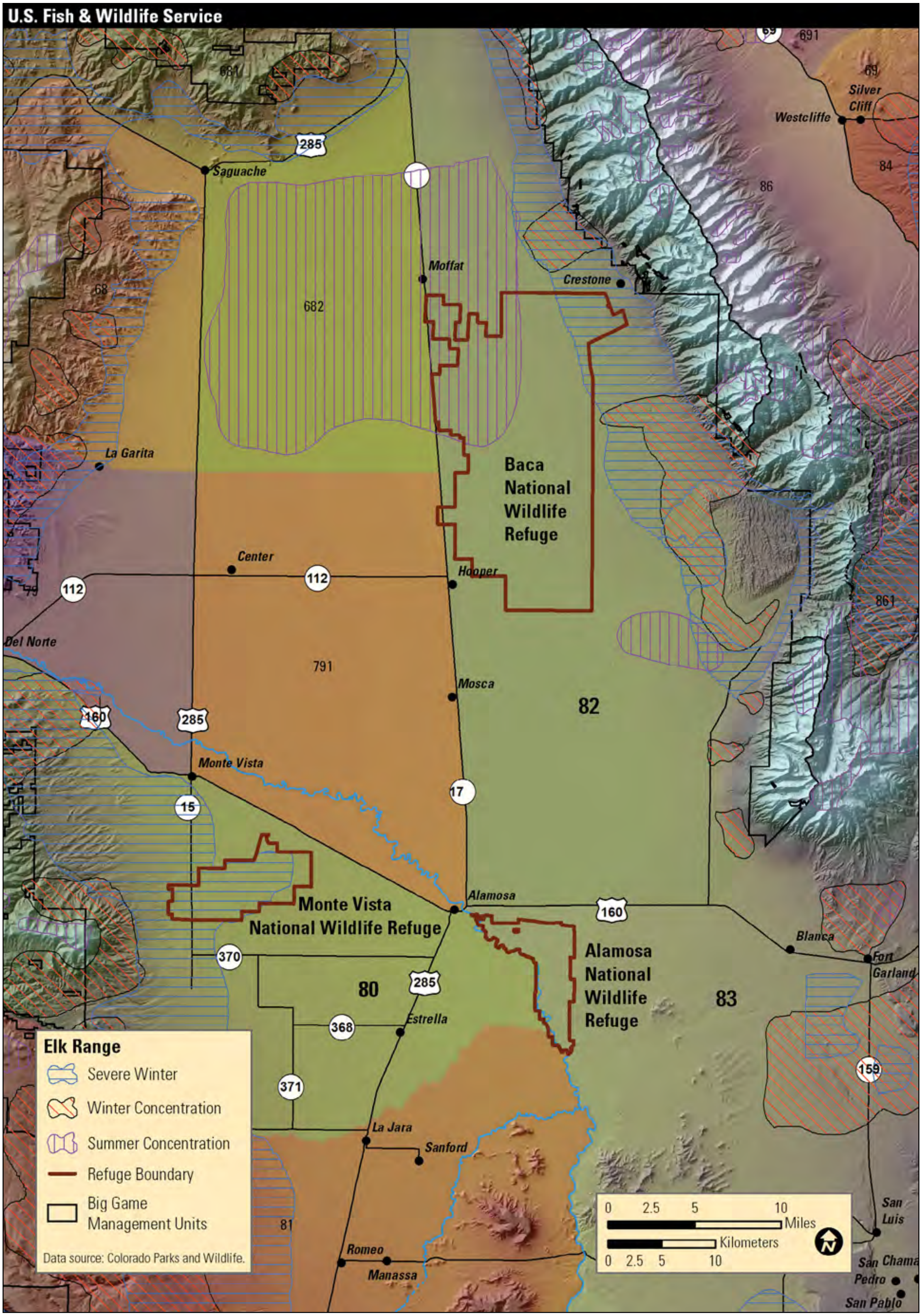

Figure 49. Summer and winter elk concentration areas in the San Luis Valley.

the wintering population has increased, but has remained fairly constant at approximately 250 elk. A year-round population of about 50 animals has become reestablished.

Elk overpopulation has resulted in vegetation damage and degraded habitat quality for many other species (see discussion under Riparian Habitat above). Because CPW is financially liable for damage to privately owned property, such as fences, forage crops, and other agricultural crops such as potatoes, they are extremely concerned about the rapidly growing elk populations on the refuges as well as throughout the San Luis Valley. Large numbers of elk on the refuges have resulted in conflicts with neighboring landowners as well as an increase in collisions with elk on State highways and county roads. The refuge staff coordinates closely with CPW to study populations and make decisions about potential elk population control or dispersal methods.

Mule deer occur on all three refuges. Deer feed and rest in agricultural fields on the Monte Vista Refuge and in other upland and wetland communities on the Monte Vista and Alamosa Refuges. On the Baca Refuge, deer are usually found in upland and riparian habitats in a small part of the refuge. Pronghorn occur on the Baca and Monte Vista Refuges, primarily in upland habitats and on the agricultural fields of the Monte Vista Refuge.

Midsized Mammals

Little is known about population sizes of midsized mammals found on the refuge complex, as few population surveys have been conducted. Coyote, red fox, striped skunk, raccoon, porcupine, beaver, badger, muskrat, mountain cottontail rabbit, white-tailed jackrabbit, long-tailed weasel, and American mink are some of the species that are common to abundant on the refuges. Some of these species, such as red fox, raccoon, striped skunk, and American mink, can be significant predators of ground nesting birds, especially waterfowl. These species can also keep rodent populations in check. Beaver and porcupine can impair riparian vegetation growth and survival, especially in areas where riparian habitat health is poor.

Bison

Historical accounts and archeological evidence prove that bison are native to the San Luis Valley, but their historic role in the ecology of the region is largely unknown. Jodry and Stanford (1996) uncovered an ancient bison kill site in the northern San Luis Valley from the Folsom period. In 1694, the Vargas Expedition reported seeing 500 bison in the San Luis Valley (Espinosa 1939, Simmons 1999). In the early 1800s, Zebulon Pike referenced bison in his accounts of expeditions in the Colorado mountains (Spencer 1975). Meaney and Van Vuren (1993) also documented bison in the valley by collecting and referencing specimens from Colorado museums and private collections. Observations of bison in the valley were rare after the mid-1800s.

In North America, before their extirpation in the late 1800s, bison were an important factor in the ecology of tall grass prairies (Knapp et al. 1999). Bison also contribute to the heterogeneity of various habitats by grazing, rubbing, wallowing, and pounding, and they help shape ways in which fire, water, soil, and energy move across the landscape (Knapp et al. 1999, Sanderson et al. 2008). Historic vegetative communities on the Baca Refuge include upland salt desert shrub, grasslands, shrublands, wet meadow, riparian woodland, and playa wetlands (Heitmeyer and Aloia 2013b). The effects that grazing bison have on these plant communities and other native wildlife species are not well understood.

Small Mammals

Twenty-eight species of small mammals have been documented in the refuge complex, including Wyoming ground squirrel, thirteen-lined ground squirrel, northern pocket gopher, plains pocket mouse, silky pocket mouse, Ord's kangaroo rat, northern grasshopper mouse, meadow vole *(Microtus pennsylvanicus)*, long-tailed vole *(Microtus longicaudus)*, western harvest mouse, *(Reithrodontomys megalotis)*, and deer mouse *(Peromyscus maniculatus)*. Many of these small mammals are an important food resource for raptors, especially during the fall and winter.

Bats include long-eared myotis *(Myotis evotis)*, little brown myotis *(Myotis lucifugus)*, and big brown bat *(Eptescius fuscus)*. Bat species help to control the populations of insects such as mosquitoes, which can in turn help reduce the spread of disease such as West Nile virus.

Gunnison's Prairie Dog

From 2008 to 2013, the Gunnison's prairie dog (*Cynomys gunnisoni*) was listed as a candidate species for Federal protection under the Endangered Species Act. Protection of the species was considered for the following reasons: a reduction in population size and number, primarily because of sylvatic plague, habitat fragmentation, poisoning, and shooting (FWS 2009). More recent information shows that the overall prairie dog metapopulation structure seems to be stable, and no threats are causing or projected to cause the species to be at risk for extinction

(FWS 2013d). Gunnison's prairie dogs are native to the San Luis Valley, and a sizeable population occurs on the Baca Refuge.

Plague is the biggest risk to the prairie dogs, as severe outbreaks can kill more than 99 percent of the population. The disease occurs at low levels throughout the range of the prairie dog, cycling through periods of low and high intensities. Conditions such as temperature, moisture, and susceptibility of hosts can trigger a severe outbreak. When it's not causing severe disease outbreaks, the plague bacterium can persist in soil, in the flea population, or by slowly spreading among prairie dogs or other mammal species where the disease is relatively nonlethal (FWS 2013d, Biggins et al. 2010). According to the FWS 12-month finding on a petition to list the Gunnison's prairie dog as an endangered or threatened species (FWS 2013d), plague causes wide fluctuations in population numbers, but the Gunnison's prairie dog has demonstrated the resiliency and redundancy to return to pre-outbreak numbers and remain viable in the future. Conservation efforts are in place to continue to reduce the disease in the population. CPW has a program to proactively manage against plague by dusting burrows in prairie dog colonies with insecticide. Dusting reduces the abundance and occurrence of fleas, improving the chances of survival for the prairie dogs. Refuge managers will continue to work with the State to proactively manage against plague by dusting burrows with insecticide. A new vaccine-laden bait that could inoculate prairie dogs from plague is in the experimental phase and may be available in the future as a management tool to reduce the risk from plague. If the vaccine becomes available, managers will consider using it.

Gunnison's prairie dog habitat on the Baca Refuge is restricted to about 500 acres along the northern boundary. Most of their habitat is in marginal condition and is dominated by patches of bare soil and invasive weeds such as kochia, Russian thistle, hoary cress, bindweed, and Russian knapweed. The prairie dogs occupy areas that were once farmed with center pivot sprinklers and areas that were overgrazed by cattle. Refuge managers have plans to convert these areas to more suitable prairie dog habitat by reducing the abundance and distribution of invasive weeds and by promoting native grasses through plantings. Improving the habitat would promote the conservation and survival of this species.

Amphibians and Reptiles

The altitude, climate, and relative isolation of the San Luis Valley limits the number of amphibians and reptiles found on the refuge complex (L. Harvey, personal communication [date unknown]). Common species include tiger salamander *(Ambystoma tigrinum)*, Woodhouse's toad *(Bufo woodhousii)*, Great Plains toad *(Bufo cognatus)*, western chorus frog *(Pseudacris triseriata)*, Plains spadefoot toad *(Spea bombifrons)*, and western terrestrial garter snake *(Thamnophis elegans)*. On the Baca Refuge during certain times of the year, the number of Great Plains and Woodhouse's toads can be extremely large. Other species that are occasionally observed or that may occur on one or more of the refuges include northern leopard frog *(Rana pipiens)*, bullsnake *(Pituophis catenifer)*, western rattlesnake *(Crotalus viridis)*, variable skink *(Eumeces gaigeae)*, short-horned lizard *(Phrynosoma hernandesi)*, smooth green snake *(Opheodrys vernalis)*, and fence lizard *(Sceloporus undulates)*.

The northern leopard frog was proposed for Federal listing, but in October 2011, the Service concluded that listing under the Endangered Species Act was not warranted. This species continues to be a species of high management priority for us.

Amphibians and reptiles require a mosaic of habitats suitable for breeding, foraging, protection, and overwintering. Habitat linkages are required to meet all life stages, allowing animals to migrate seasonally between different areas to feed, overwinter, and reproduce. The permeable nature of amphibian skin makes these animals extremely vulnerable to contaminants such as pesticides, fertilizers, heavy metals, and acidification in the environment (Pilliod and Wind 2008, Ellison 2011).

Bullfrogs *(Rana catesbeiana)* are not native to Colorado, but early introductions as a game species by Colorado Parks and Wildlife and accidental introductions with fish stock have led to firmly established populations along the Rio Grande corridor as well as in other isolated locations in the San Luis Valley. Surveys conducted on the refuge complex have not documented any bullfrogs, even though this species is prolific just upstream on the Rio Grande from the Alamosa Refuge. We continue to be concerned about the establishment of bullfrogs on the complex because of their ability to prey on and displace native amphibians such as northern leopard frogs and tiger salamanders.

Fish Communities

Fish live on all three refuges. On the Monte Vista and Alamosa Refuges, species such as brook stickleback *(Culaea inconstans)*, red shiner *(Cyprinella lutrensis)*, and common carp *(Cyprinus carpio)* enter the deeper wetland habitats via irrigation canals originating from the Rio Grande, but most fish die in the winter when the marsh freezes. On the Alamosa Refuge, northern pike *(Esox lucius)* and common carp are common and can survive the winters both in the Rio Grande and in the deeper canals and sloughs.

Northern pike are a concern as they can prey on native amphibians such as leopard frog, chorus frogs, and tiger salamander. Common carp are a concern as they can reduce water quality by increasing turbidity, resulting in reduced aquatic submergent plant growth and aquatic invertebrate production, which can affect forage resources for a wide array of wildlife species including waterfowl and amphibians.

Crestone Creek on the Baca Refuge is particularly important because four native fish species are found: the Colorado State endangered Rio Grande sucker *(Catostomus plebeius)*; Rio Grande chub *(Gila pandora)*, a Colorado State species of special concern; fathead minnow *(Pimephales promelas)*; and longnose dace *(Rhinichthys cataractae)*. No nonnative fish are known to occur.

The Rio Grande sucker occurs exclusively in the Rio Grande basin from Colorado to Mexico (Rees et al. 2005b). In Colorado, this species is limited to small creeks within the San Luis Valley, where it has been reintroduced, and two known historic populations, including Hot Creek (off the refuges) and Crestone Creek (on the Baca Refuge), where it prefers backwaters and pools near rapidly flowing water (Rees et al. 2005b). The Rio Grande sucker feeds primarily on algae; it typically spawns from February to April and may spawn a second time in late summer (Rees et al. 2005b). This species was first documented by CPW in 2005 in Crestone Creek and associated irrigation laterals on the Baca Refuge.

The Rio Grande chub occurs from Texas north through the Rio Grande and Pecos River drainages of New Mexico into southern Colorado (Rees et al. 2005a). In Colorado, this species is found in the Rio Grande basin in pools of small streams and creeks and in a few waters in the Gunnison Basin. The Rio Grande chub prefers streams with undercut banks, overhanging bank vegetation, and aquatic vegetation (Rees et al. 2005a). The spawning period for this species is primarily in the spring. This species was first documented in 2005 by CPW in Crestone Creek, Willow Creek, and associated irrigation laterals on the Baca Refuge. In 2013, it was proposed for listing under the Endangered Species Act. Visitor Services

We record between 15,000 and 20,000 visitor use days (table 14) per year on the refuge complex. Visitors enjoy a variety of recreational activities related to the six wildlife-dependent recreational uses—hunting, fishing, wildlife observation, photography, interpretation, and environmental education—that are identified in the Improvement Act as the priority uses. Service policy guides the management of wildlife-dependent recreational uses (FWS 2006e).

Our estimates of current visitation figures come from a variety of sources including traffic counters, physical counts of visitors who come through the headquarters, and special events.

This section discusses the priority public uses and other visitor-related activities we are involved with on the Monte Vista and Alamosa Refuges (FWS Refuge Annual Performance Planning database 2012c). The Baca Refuge is not open to the public.

Table 14. Visitor use days on the Monte Vista and Alamosa Refuges.

Wildlife observation	*Special events*	*Contact stations*	*Hunting*
Monte Vista National Wildlife Refuge			
6,850	7,000	700	400
Alamosa National Wildlife Refuge			
2,650	150	675	500

In 2011, USGS completed a visitor survey of visitors to the Monte Vista Refuge (USGS 2011b). Of 227 survey participants, about 56 percent had only been to the refuge once in the 12 months before, while 44 percent had been to the refuge multiple times. About 35 percent of the visitors lived within 50 miles of the refuge, and 65 percent were considered nonlocal. Nonlocal visitors travelled an average of 253 miles to the refuge, and 90 percent were from Colorado.

Surveyed visitors enjoyed a variety of refuge activities. The top three activities reported were birding (83 percent), wildlife observation (71 percent), and driving the auto tour route (60 percent).

Hunting

Hunting for waterfowl, upland birds, and small game is a popular activity on the Monte Vista and Alamosa Refuges. We estimate that 900 to 1,000 hunt visits occur annually. Waterfowl is the most frequently hunted game. Hunting is allowed in designated areas, and the refuge provides parking areas, informational kiosks, directional signage, accessible blinds, and vault toilets (see figures 13 and 14, chapter 3)

The waterfowl hunting season is busiest in early October. Starting in November, the wetlands freeze and birds move out of the valley. In the past, when waterfowl hunting at the refuges was in high demand, a refuge-specific hunt permit was required to limit the amount of hunters in the field. This improved hunter satisfaction with the experience and made it a safer environment. Since the extended drought began in the early 2000s, the refuges haven't been able to support as many fall migrating birds. Because there have been fewer birds, there has been less hunting pressure.

Fishing

In general, the shallow water in the refuge complex wetlands does not support a viable fishery. The Rio Grande does support a fishery, but because of several issues, including disturbance to other wildlife species, fishing has not been allowed. However, we host an annual Kid's Fishing Day event which is led by our Friends group at the Monte Vista Refuge during National Fishing Week. A pond (less than 2 acres in size) is stocked with trout donated by the Hotchkiss National Fish Hatchery. The event is geared toward teaching children how to fish. After the main event, children with special needs and senior citizens are allowed to fish the pond until it is dewatered, which usually happens within 2 to 3 weeks. The event reaches approximately 100 to 150 children every year. Local merchants donate more than $500 in prizes annually for this event. The Friends group donates lunch to all attendees.

Wildlife Observation and Photography

The Monte Vista Refuge is nationally known for large numbers of sandhill cranes during spring and fall migration, and many visitors come to the refuge to enjoy the spectacle. Visitors also enjoy watching other wildlife species in their native habitats, including ducks, white-faced ibis, black-crowned night-herons, Swainson's hawks, coyotes, and elk. Several parking areas offer excellent crane viewing, and an auto tour loop and short walking trail provide opportunities throughout the year to see other wildlife.

Visitors to the Alamosa Refuge can experience the unique wildlife and habitats that surround the Rio Grande. Species that are commonly seen along the Rio Grande Nature Trail at different times of the year include beaver, porcupine, bald eagle, yellow warbler, and the endangered southwestern willow flycatcher. The auto tour loop provides glimpses of many wetland-dependent bird species, including American bittern, Virginia rail, marsh wren, white-faced ibis, American avocet, and various waterfowl species. The Bluff Overlook provides a sweeping view of the refuge's wetlands and surrounding valley's mountainous horizon. Elk can sometimes be been seen from the overlook. The Bluff Nature Trail also gives visitors a chance to get out and walk or bike the trail though upland habitats that provide a beautiful late-summer display of native sunflowers.

Photography opportunities are limited to open public use areas on Monte Vista and Alamosa Refuges.

Interpretation

The Alamosa and Monte Vista Refuges provide self-guided interpretation through panels, brochures, and informational kiosks. The auto tour loop interpretive signs on the Alamosa Refuge and crane-specific panels on the Monte Vista Refuge are in poor condition. Both refuges share one general brochure, which limits opportunities to educate visitors about the different refuges. The Alamosa Refuge visitor center's educational resources are only available at times when volunteers are able to open the center, as the refuge complex does not have full-time interpretive staff. Interpretive talks are provided on an as-needed basis if staff or volunteers are available.

Environmental Education

We work with the Friends group to organize several educational events, including the Monte Vista Crane Festival, Kid's Fishing Day, and Kids Crane Festival. Environmental education programs are provided to a variety of groups, including teachers and students, on an as-needed basis. The Alamosa and Monte Vista Refuges have several site-specific educational activities that meet Colorado State Education Standards led by refuge staff, volunteers, our Friends group, and teachers.

Outreach

Limited outreach occurs through the local welcome centers, chambers of commerce, and other Federal agency visitor centers. Our website is out of date and needs to be updated and upgraded to current standards. At this time, because of limited refuge staff, we are unable to easily keep visitors updated with current conditions or wildlife sightings.

Commercial Recreation

Various types of commercial recreation that are compatible with the refuge complex's mission are allowed through a special use permit process. Typically, these are short-term requests for wildlife photography or filming.

Facilities and Staff for Visitor Contacts

The operations office for the refuge complex is located at the Lillpop office on Emperius Road in Alamosa. This building is unsatisfactory for many reasons: it is tucked away from visitors, vendors, and other people who may need information or services; it is not designed for an office environment; it is not universally accessible for members of the public or employees with disabilities; and it has poor ventilation, which is not conducive to a productive working environment. Current access to the building is from Emperius Road, which necessitates a blind railroad crossing with no gates, and which presents a major safety hazard for visitors and employees that is impossible to remedy.

Most refuge complex visitation occurs at the Monte Vista Refuge. The existing small refuge office is not designed to be a visitor contact station and is not capable of handling the visitation that occurs during the crane festival. Alamosa Refuge has a visitor contact station that is open part-time and is often staffed by volunteers. A new main office and visitor contact station is being built at the Baca Refuge.

We do not have an Outdoor Recreation Planner (staff person dedicated to providing visitor services). The potential for increased visitation to the refuges is enormous given their nearness to Alamosa, the largest community in the San Luis Valley. They are also within a few hours of the greater Denver area, Colorado Springs, and Santa Fe.

Roads and Access

On the Monte Vista Refuge, there are nearly 14 miles of roads that provide public access to facilities. Of these, several miles are county roads and Highway 15 that border or cross through the refuge in some way. There is a 2.5-mile auto tour route that visitors can drive nearly year round. There are about 9 miles of trails and roads that are available only during the hunting season. There is a 0.24-mile nature trail (see figure 13, chapter 3). In addition, there are a number of refuge roads that support habitat management activities on the refuge (figure 50).

On the Alamosa Refuge, there are about 18 miles of roads that provide access to refuge facilities. Of these, access to facilities occurs off several county roads that are open to the public. There is a 3.2-mile auto tour route that is graveled and open most of the year, weather permitting. There are 7 miles of trails that provide for access during the hunting season only and 2 miles of nature trails (see figure 14, chapter 3). In addition, there are a number of refuge roads that support habitat management or other activities on the refuge (figure 51).

On the Baca Refuge, there are about 9 miles of county roads that intersect or follow the boundary or provide a short access to the headquarters area. No other facilities are open to public access (see figure 15, chapter 3). There are a number of refuge roads that support other management activities on the refuge (figure 52) including the operation of BOR's Closed Basin Project.

Table 15. Public access on the Refuge Complex.

Monte Vista National Wildlife Refuge	
Miles of open roads along boundary or through refuge	14*
Miles of trails open during hunting only	9
Miles of nature trails (interpretive)	0.24
Miles of auto tour route open	2.5*
Alamosa National Wildlife Refuge	
Miles of open roads along boundary or through refuge	18*
Miles of trails open during hunting only	7**
Miles of nature trails (interpretive)	2
Miles of road closed except for hunting	3**
Miles of auto tour route open	3
Baca National Wildlife Refuge	
Miles of roads along boundary or through refuge	9
Miles of trails open for public use	0
Miles of nature trails open for public use	0
Miles of auto tour route for public use	0

**includes* refuge roads, State roads, or county roads that traverse through or along refuge boundary and are open year round

***these* roads are only open to hunters during hunting season

4.4 Human History and Cultural Resources

Humans have inhabited the San Luis Valley for more than 12,000 years. The following summary of the prehistory and history of the valley provides an overview of some of the major themes and events that illustrate the human interaction with the land. There is an abundance of prehistoric evidence, early historical accounts, photographs, and local histories for the valley.

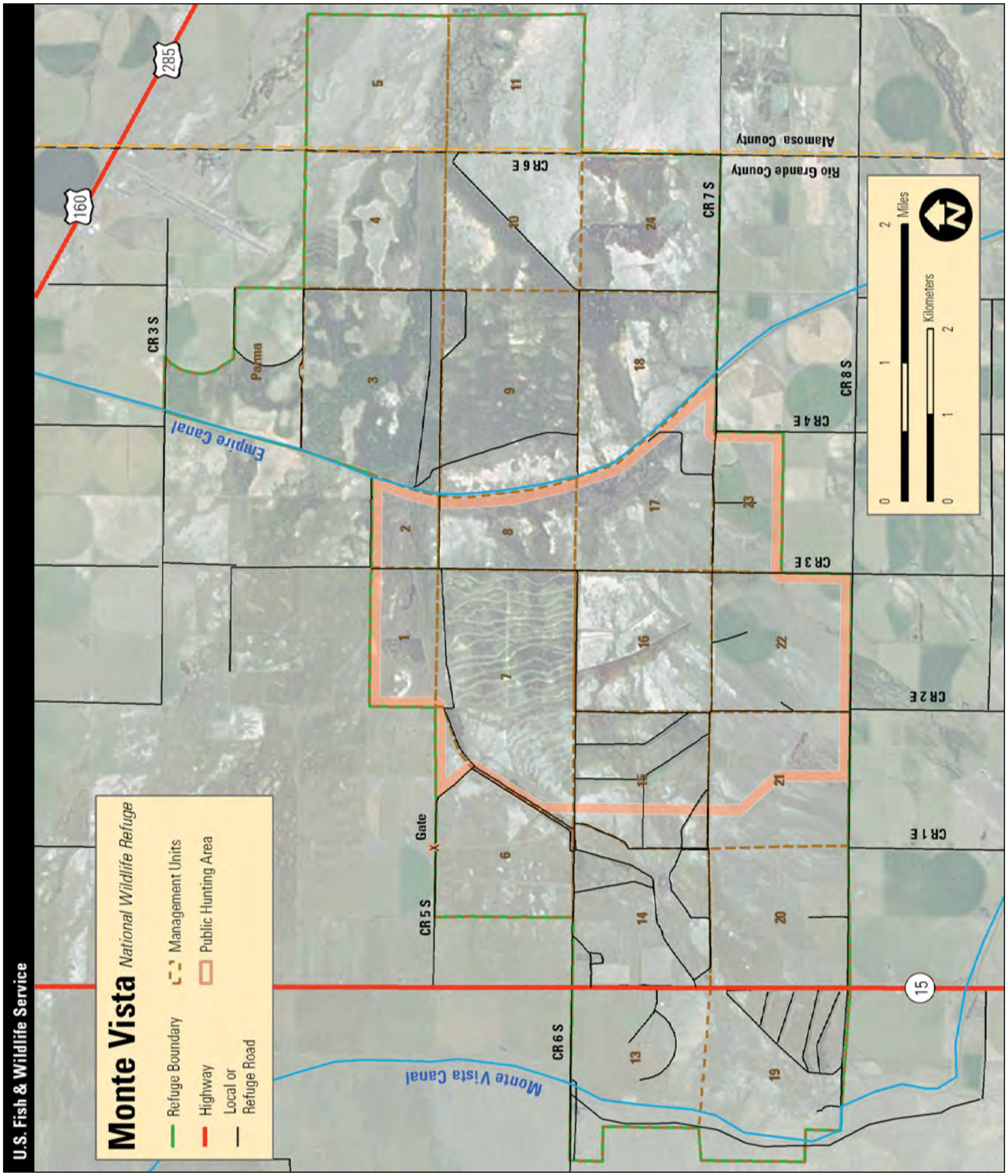

Figure 50. Roads and management activities on Monte Vista National Wildlife Refuge, Colorado.

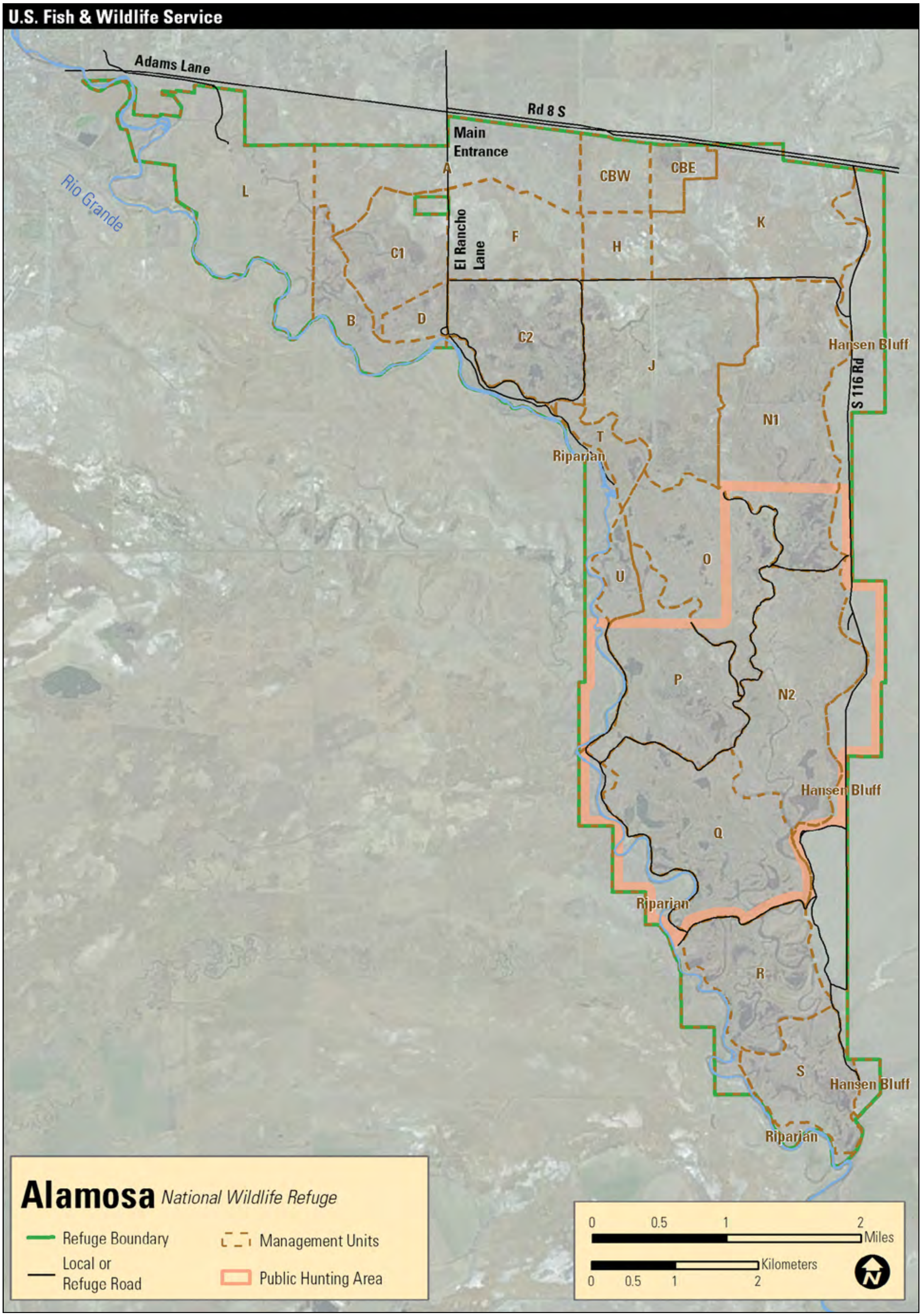

Figure 51. Roads and management activities on Alamosa National Wildlife Refuge, Colorado.

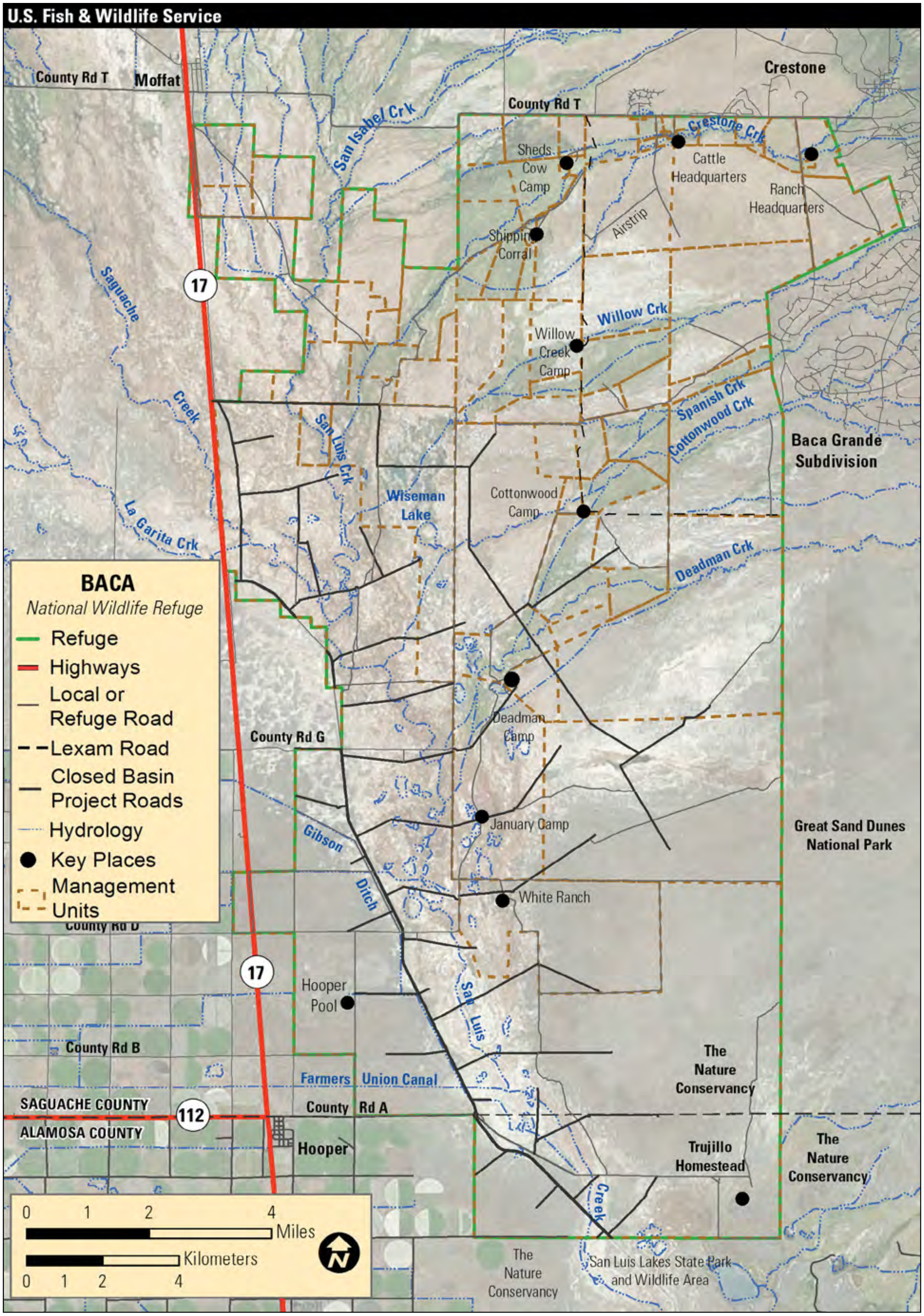

Figure 52. Roads and management activities on Baca National Wildlife Refuge, Colorado.

Prehistoric History

The prehistoric history is subdivided into the Paleoindian Stage, Archaic Stage, Late Prehistoric Stage, and Protohistoric Stages.

Paleoindian Stage

Current archaeological evidence indicates that the earliest humans, called the Paleoindians, migrated to the region near the close of the last Ice Age approximately 12,000 years ago. These people had highly mobile lifestyles that depended on the hunting of large, now-extinct mammals, including mammoths and the huge ancient bison *(Bison antiquus)* which are not the same species as the American bison *(Bison bison)*. The hallmark of most Paleoindian sites are the beautiful but deadly spear points that were launched with the aid of a simple yet expertly engineered spear-thrower called an atlatl. These projectile points are generally recovered as isolated occurrences or in association with animal kills, butchering sites, or small temporary camps. Although the timing of this stage varies throughout the region and is constantly being refined as more information becomes available, it lasted until about 7,500 years ago.

According to the Colorado Office of Archaeology and Historic Preservation, 62 Paleoindian archaeological sites or projectile points have been found within the San Luis Valley. These are often located near wetlands and along the shorelines of ancient lakes, reflecting the use of abundant plant and animal resources available in these locations. Several Paleoindian sites in the surrounding mountains have been excavated, including the high-altitude Black Mountain site (5HN55) located at 10,000 feet in the San Juan Mountains south of Lake City on the western edge of the San Luis Valley. This campsite dates from approximately 10,000 to 7,000 years ago and has yielded a variety of stone tools suggesting animal hunting and processing (Jodry et al. 1999a).

Several Paleoindian sites on the San Luis Valley floor have been excavated and provide an extensive record of the early occupations. Three of these sites, the Cattle Guard site (5AL101) (which is on NPS lands), the Linger site (5AL91), and the Zapata site (5AL90), are all located just south of Great Sand Dunes National Park and Preserve and represent camps with an abundance of bison bones and associated stone tools (Cassells 1997, Jodry et al. 1999a). The Reddin site (5SH77) near the town of Hooper yielded nearly 500 Paleoindian artifacts suggesting a variety of activities (Cassells 1997, Jodry et al. 1999a).

Climatic fluctuations during the Holocene Epoch, which started about 12,000 years ago and continues to the present, are often reflected in the archaeological record. Pollen remains, faunal assemblages, and geomorphological deposits suggest periods of significant and rather abrupt vegetation changes and variations in the amount of moisture (Jodry et al. 1999b, Martorano 1999a). Bison remains associated with archaeological sites on the Southern Plains also show that bison numbers rose and fell in response to climatic conditions (Creel et al. 1990). Although more research is needed and our ability to discover and interpret prehistoric artifacts and data is continually improving, the studies done thus far offer an intriguing look into the evidence for and consequences of long-term climatic change.

Archaic Stage

Human use in the region had a gradual but definite shift to a new stage that began about 7,500 years ago and continued until approximately 1,500 years ago. The changes were the result of a combination of regional climatic fluctuations, an increasing population, new technological innovations, and regional influences. Although this stage is better represented in the archaeological record than the preceding Paleoindian Stage, the identification and interpretation of the artifacts and remains continue to be expanded and refined. Evidence of a greater diversity of tools and the use of a larger variety of plants and animals is found on many sites.

There have been 618 Archaic Stage archaeological sites or points recorded in the Colorado portion of the analysis area. As with the earlier inhabitants, the Archaic peoples made extensive use of the valley's wetland resources, and occupied rock shelters and several other high-altitude locations found in the surrounding mountains. When speaking of Archaic sites in the northeastern valley, Hoefer et al. (1999) state: "Most of the Closed Basin archaeological sites are open camps containing debitage and fire-cracked rock scatters, approximately half of which contain ground stone implements such as metate fragments or manos. Many of these sites are located around seasonal wetland marshes and lakes." The use of the atlatl with spear points continues, and basketry, cloth, and cordage come into use. Although still highly mobile, the population increasingly makes short-term use of small groupings of structures with storage features. Hunting blinds and other rock structures are fairly common although often difficult to interpret. Archaic Stage rock art is scattered throughout the region and the influences of surrounding regions, particularly the Plains and the Great Basin, are identifiable at several sites.

Late Prehistoric Stage

Beginning approximately 1,500 years ago, several innovations greatly influenced life in the valley (Martorano 1999b). Although these changes were adopted at different rates and degrees throughout the area, the advent of pottery and the bow and arrow, coupled with a larger and more sedentary population, defines the period until approximately 600 years ago. Early archaeological research in the valley found numerous regional influences, with several sites exhibiting pueblo-inspired attributes (Renaud 1942). In 1694, Don Diego de Vargas documented his visit to the valley, thus providing an early written historical account and ushering in the historic period.

The 442 Late Prehistoric resources in the State's Office of Archaeology and Historical Preservation database are listed under a variety of designations for this stage but all date to about the same time period. The distribution of Late Prehistoric sites in the valley shows a continuation of the trend of intensive use of wetland habitats (Martorano 1999b). This is not surprising as the available resources—both floral and faunal—would have continued to be abundant in these areas. Site types include camps, stone tool scatters, rock art, rock alignments and enclosures, and quarries where the lithic material for stone tools was collected.

Protohistoric Stage

By the late 1600s, Spanish incursions into the valley were beginning to affect the lives of the native populations. The Utes, who, based on archaeological evidence, came to the valley sometime after A.D. 1100 (Reed 1994) and who were the most numerous occupants of the valley, quickly acquired horses and other trade items. Although many other Native American groups probably visited or traveled through the valley, the Comanche, Apache, Navajo, Arapaho, Cheyenne, and several northern Pueblos also had a significant if not sustained presence (Martorano 1999c).

There are 59 sites from this stage in the State's Office of Archaeology and Historical Preservation files, which include the traditional stone tools and ceramics mixed with utilized and flaked glass, trade beads, and metal projectile points. Wickiups (conical timbered structures) and trees with peeled bark indicating the harvesting of the edible cambium layer are found, as is rock art with motifs and depictions of post-contact goods.

Early History

The historical period for the valley began with the recurring contact of native peoples with people of European descent and ends in the mid-20th century. This interaction followed many years of occasional contact, often for the exchange of trade goods.

In 1598, the Spanish explorer and newly appointed Governor of New Mexico, Don Juan de Onate, claimed for Spain all lands, structures, and people along the Rio Grande—including the San Luis Valley—forever. This followed several years of sporadic Spanish incursions into northern New Mexico and southern Colorado and ushered in several decades of trade, conflict, and settlement. Many Spanish travelers used the Northern Branch of the Spanish Trail, which had both western and eastern routes through the valley. Although Spain lost ownership of the valley in 1821 when Mexico gained independence, Spanish influence survives as a vital part of the landscape and people today.

There are numerous other explorers and settlers who left a legacy of journals, maps, and other accounts of their time in the valley. The examples summarized below provide a glimpse into the types of information and insight available in these early accounts. Several other documents are available and offer a wide variety of historic and environmental information.

Don Diego de Vargas: 1694

The 1694 journal of Don Diego de Vargas survives as the earliest written account of the San Luis Valley. The journal is a wealth of information about the native peoples, topography, and environment (Colville 1995). After leaving Santa Fe, De Vargas followed the North Branch of the Spanish Tail northward, traveling east of the Rio Grande and entering the San Luis Valley just southeast of Ute Mountain. From there he continued north, crossing what would become the New Mexico–Colorado State line and paralleling the western side of San Pedro Mesa before heading west along Culebra Creek. Reaching the Rio Grande, he turned south and crossed the river about 5 miles south of the confluence with Culebra Creek. His return trip to Santa Fe took him along the Rio San Antonito on the west side of the Rio Grande, and he exited the valley on the west side of San Antonio Mountain (Colville 1995).

His six days in the San Luis Valley included contact, trade, and occasional skirmishes with the Yutas (Utes), confrontations with Taos Puebloans, and observations of large herds of bison and some "very large deer." This reference is the earliest known historical account of bison in the valley (Colville 1995), the last being a brief mention of bison by Juan Bautista Silva along the Rio San Antonio south of present-day Antonito in the spring of 1859 (Kessler 1998). During their travels, the use of sign language and smoke signals for communication is well documented, as is the need to be near water during the mid-summer travels.

Juan Bautista de Anza: 1779

Eighty-five years later in 1779, Juan Bautista de Anza, the Governor and Military Commander of New Mexico, left Santa Fe and headed north to quell the Comanche raids that were devastating Spanish settlements in the region. Traveling by night to avoid detection, de Anza followed the North Branch of the Spanish Trail along the eastern foothills of the San Juan Mountains through Poncha Pass, and then headed east to the plains near Pike's Peak. From there, he headed south along the foothills through the areas that would become Colorado Springs and Pueblo, fighting several successful battles with the Comanche. He concluded his campaign by crossing back into the San Luis Valley at Sangre de Cristo Pass (now La Veta Pass) and taking the eastern route of the North Branch of the Spanish Trail back to Santa Fe (Kessler 1998). He initially entered the San Luis Valley on August 19, 1779, and by September 4 of that year he re-entered the valley near Fort Garland on his return trip to Santa Fe.

Zebulon Montgomery Pike: 1807

Unlike the earlier Spanish explorers, Captain Zebulon Montgomery Pike entered the valley from the east, traveling west from St. Louis across Missouri, Kansas, and the plains of Colorado. Pike's mission was to map and describe the southern parts of the newly acquired Louisiana Purchase. Pike's journal in the days preceding the descent into the San Luis Valley often mentions seeing "a gang of buffalo," including in the Wet Valley (which is on the east side of the Sangre de Cristo Range), but there is no mention of bison after he enters the San Luis Valley. In contrast, deer are often mentioned in the San Luis Valley and goose was a part of at least one meal. Pike grew fond of the San Luis Valley and concluded that "...it was at the same time one of the most sublime and beautiful prospects ever presented to the eyes of man" (Hart and Hulbert 2006).

Jacob Fowler: 1821-1822

The 1821-1822 journal of Jacob Fowler, which *The New York Times* referred to as "quaint and interesting" (The New York Times 1898), is a wealth of information about the environment and the interactions between the various peoples who occupied the valley (Coues 1965). *The New York Times* further describes the journal—just published by noted ornithologist Elliott Coues—as "…a notable contribution to our knowledge of early adventure and pioneering in the Great West. His style is straightforward and his wonderful power of observation has made the narrative very attractive."

Fowler was a fur trader who entered the valley via La Veta Pass on February 4, 1822. For the next 3 months, he traveled between Taos and the center of the valley, going as far north as the area where Fort Garland would be later established. Many animals are noted in the valley, including beaver, elk, deer, bear, caberey (pronghorn), otter, big horned sheep, wild horses, geese, ducks, and a wolf. Although great herds of "buffelow" were noted on the Great Plains and as far west as the Wet Valley, there is no mention of them once they reach the San Luis Valley. As with the references to animals, the descriptions of plants, particularly the distribution (or lack) of cottonwoods and willows along specific creeks, is frequent and often detailed. These descriptions are mixed with accounts of life in the numerous small Spanish settlements that dotted the landscape as well as interactions with the native peoples.

Numerous other explorers and settlers visited the valley and left behind journals of varying detail (Hart and Hulbert 2006, Kessler 1998, Preuss 1958, Richmond 1990, Sanchez 1997). Among these are:

- George Frederick Ruxton, 1846
- John C. Fremont, 1848-1849
- Charles Preuss, 1848-1849 (traveling with Fremont)
- Gwinn Harris Heap, 1853
- John Williams Gunnison, 1853
- John Heinrich Schiel, 1853 (traveling with Gunnison)
- Randolph Barnes Marcy, 1858
- William Wing Loring, 1858
- Juan Bautista Silva, 1859

Political Boundaries, Land Grants, and Public Lands

The San Luis Valley has seen many changes in governance over the last 300 years. Following nearly 12,000 years of sovereignty by various Native Americans, control (or at least declared control) and the political boundaries of the region shifted continually until Colorado and New Mexico obtained statehood. The brief timeline below summarizes some of these changes in "ownership" of the San Luis Valley:

1598 Don Juan de Onate claims the San Luis Valley and surrounding areas for Spain.

1763 The Treaty of Paris at the end of the French and Indian War divides much of the North American interior between Spain and France. The San Luis Valley is considered Spanish territory.

1803 The Louisiana Purchase is negotiated between the United States and France, but the western boundaries are not clarified and remain ambiguous.

1819 The U.S. negotiates the Adams-Onis Treaty with Spain to clarify the boundaries of the Louisiana Purchase. The San Luis Valley remains part of Spain's New Mexico Territory.

1821 Mexican War of Independence (1810-1821). The San Luis Valley becomes a part of the new nation of Mexico.

1836 The Republic of Texas achieves independence from Mexico. Texas claims lands in the San Luis Valley, east and north of the Rio Grande. Mexico does not recognize the Republic, disputes this boundary, and continues to claim the entire valley.

1837 U.S. recognized the Republic of Texas, including the San Luis Valley.

1845 U.S. annexes Texas, including the San Luis Valley, and Texas achieves statehood.

1848 Following the Mexican-American War (1846–1848), the Treaty of Guadalupe Hidalgo establishes the present Mexico–United States border except for the later 1853 (southern Arizona and southern New Mexico).

1850 Texas surrenders its claim to New Mexico and the New Mexico Territory, including the San Luis Valley generally south of the Rio Grande (38th parallel), is established.

1854 Kansas Territory, which includes the northern part of the San Luis Valley (above the 38th parallel), is established out of previously unorganized lands of the Louisiana Purchase.

1861 Colorado Territory is created by the Colorado Organic Act with the same boundaries that would later become the State of Colorado.

1876 Colorado becomes a State.

1912 New Mexico becomes a State.

Numerous Mexican land grants were issued in the San Luis Valley as a direct result of the political turmoil noted above and the desire by Mexico City to keep control over the distant northern borderlands of their newly independent nation. These land grants were intended to encourage Mexican settlement in the borderlands, thereby dissuading any thoughts of Texas independence and discouraging encroachment by American fur traders.

The first grants consisted of numerous small parcels along the Conejos River in Colorado in 1833 (Athearn 1985, Simmons 1999). These small grants were ineffective in establishing permanent settlements, but the much larger 1842 Conejos Grant proved to have more success in persuading the founding and settling of farms and towns. The grant covered more than 2.5 million acres and included all of what would become the counties of Conejos and Rio Grande and parts of the counties of Mineral, Saguache and Alamosa. As with other Mexican land grants in the valley, the grants were considered invalid following the Mexican-American War. The Court of Private Land Claims in 1900 ruled against the grantees and negated the claim (Colorado State Archives 2001).

The Sangre de Cristo grant included all of what is now Costilla County and extended a short distance into the current State of New Mexico. The grant consisted of 1 million acres and was originally awarded to two Mexican nationals in 1844, but, following their deaths during the Pueblo Revolt of 1847, was sold to Charles (Carlos) Beaubien. Unlike the Conejos Grant, Charles Beaubien's claim to the land was upheld by the courts in 1860. The land was later sold to William Gilpin (Colorado's first territorial governor) in 1864. Large tracts of the grant have been sold to various developers, and disputes over the rights of local people to use the land continued through 2009 (Hildner 2009).

The Baca Land Grant was the result of a land dispute. The Baca grants, of which there are five, were granted to the heirs of Luis Maria Baca in replacement for his 1825 grant near Las Vegas, New Mexico, which was also claimed by Juan de Dios Maiese in 1835. These conflicting claims came to light when the U.S. took control of the lands in the mid-1840s. The Baca claim was settled in 1860 and patented in 1903, when the Baca heirs were given five parcels of land: two in New Mexico, two in Arizona, and one in the San Luis Valley, which was known as Baca #4. In various configurations and sizes, the Baca #4 lands changed hands many times over the next 100 years. Today, a large part of it makes up the Baca Refuge.

Native Peoples

The post-contact history of Native Americans in the San Luis Valley involves both cooperation and conflict and ends with the establishment of reservations outside of the valley. Although several Native American tribes are represented in the valley today, they are less than 4 percent of the current population (U.S. Census Bureau 2012).

The Utes (Yutas) consisted of several bands and at the time of contact were the primary Native American inhabitants of much of central and western Colorado, Utah, and parts of northern New Mexico. Increased Euro-American settlement after the United States gained possession of the valley in 1848 and the Gold Rush of 1859 brought new people to the valley and ushered in several decades of escalating pressure to remove the Utes (Ellis 1996). Fort Massachusetts (1852–1858) and Fort Garland (1858–1883) were established in the valley primarily to protect settlers from Ute attacks. The 1863 and 1868 treaties between the United States and the Utes gave parts of Colorado, including the San Luis Valley, to the United States. Over the next four decades, a series of treaties and agreements continued to reduce Ute lands and relocate the Ute peoples, with the eventual establishment of three reservations in southwestern Colorado and northern Utah by the early years of the 20th century.

Numerous other Native Americans visited or lived in the valley, including the Apache, Arapaho, Cheyenne, Comanche, Kiowa, and Navajo (NPS 2011b). Early historical accounts frequently mention various members of pueblos along the Rio Grande coming north into the central San Luis Valley to hunt bison, which caused occasional confrontations with the Utes (Carson 1998, Colville 1995). The first Pueblo revolt of 1680, a response to the expanding Spanish control in northern New Mexico, effectively ceased Spanish rule in the region until Don Diego de Vargas reestablished control over the pueblos in 1692 and 1696. The Taos Pueblo rebelled against the occupation of U.S. Troops during the Mexican-American War in 1847, but the rebellion was soon repelled, effectively ending major conflicts in the region.

Euro-American Settlement

Euro-American settlement of the San Luis Valley reflects cultural, economic, and political influences as well as creative adaptation to a unique environment. Slowly, following the establishment in 1610 of Santa Fe as the capital of the New Mexico province, explorers and traders made their way north into the central San Luis Valley. Jacob Fowler encountered several small Spanish settlements during his 1821–1822 travels north of Taos and into southern Colorado (Coues 1965).

The Catholic Church, which was a primary influence during the initial exploration of the region, continued to play a major role in the establishment of settlements and in the day-to-day lives of most of the inhabitants. Members of various church orders were often part of the early explorations, including the 22 Franciscans who accompanied de Onate during his 1598 exploration and settlement in northern New Mexico (Athearn 1989). The Church was instrumental not only in matters of faith, but also as educators, trade coordinators, keepers of public records, and builders of comparatively grand architecture. On the other hand, the oppressive condemnation and suppression of the Native religious practices was a major contributor to the unrest that led to the Pueblo Revolt of 1680 and the destruction of several missions. Nonetheless, the church began the 18th century as one of the only institutions to prosper, and soon missions were established throughout the region (Athearn 1989).

Early settlements in the valley were established based on the traditional pattern of the Spanish plaza with homes, churches, and public buildings clustered around a central square and long narrow fields radiating out around the buildings and fronting a nearby creek, sometimes referred to as cordillera or plaza farming (Colville 1995). The extensive systems of early irrigation canals and water control structures supported small grain fields and gardens and many elements are still in use today.

Several large canals and their associated laterals, including the Travelers Canal, the Empire Canal, and the Monte Vista Canal, were all built in the 1880s in response to the increasing demand for the valley's beans, corn, grains, and other vegetables and crops. The extensive irrigation in the valley was recognized early on as a source of future problems, as noted by Major John Wesley Powell in his 1890 testimony before the Senate Special Committee on Irrigation and Reclamation of Arid Lands:

> "Passing into New Mexico, then, the water that practically heads in the high mountains of Colorado is largely, almost wholly, cut off from the Rio Grande, so that no portion of the water that heads in these mountains where there is great precipitation will cross the line into New Mexico (in the dry season). In a dry season nothing can be raised in the lower region and sometimes the dry seasons come two or three together" (Siebenthal 1910).

The mining boom in the surrounding mountains in 1859, the completion of the Denver & Rio Grande Railroad over the Sangre de Cristo Mountains and into the San Luis Valley in 1877, and a vigorous advertising effort by land speculators led to a slow but steady increase in population in the latter half of the 19th century. Before the discovery of gold in 1859, the valley was the home of Colorado's largest non-Native American population, and by 1870, the population of Conejos, Costilla, and Saguache Counties is estimated to have been approximately 5,000 (Wyckoff 1999).

By the early 1870s, the effects of hunting and development were already taking a toll on Colorado's wildlife. In 1872, Colorado Territorial Governor Edward N. Cook passed the first game laws to protect certain birds, bison, deer, elk, and bighorn sheep (Colville 1995).

Summary of Known Historic Resources

Information about the recorded historic resources in the San Luis Valley is summarized from data obtained from the Colorado Office of Archaeology and Historic Preservation. Similar trends can be extrapolated for the parts of the area that are in New Mexico. These data represent the efforts of hundreds of agencies, organizations, and individuals to document and study the past. The counts include sites, buildings, structures, and isolated finds, bearing in mind that an individual resource may have many of these elements and may represent more than one time period and therefore be counted more than once. It is also important to note that cultural resources are often found where modern activities have mandated cultural resource surveys, and recorder bias may be a factor as much as actual prehistoric or historic settlement or use patterns.

The 4,091 historic components in the area include standing buildings or structures and historic archaeological deposits. Many of these are homes, commercial buildings, or public buildings within the towns in the valley, with 100 or more each recorded in Alamosa, San Luis, and Monte Vista. Rural sites with historical components often include water control structures (111 recorded), cabins or homesteads (68 recorded), roads or trails (62 recorded), and railroad-related features (28 recorded). The 1,635 historical archaeology components include isolated rubbish scatters and small features as well as artifacts or deposits associated with a building or structure.

Two resources in the San Luis Valley have been designated as National Historic Landmarks. These include Pike's Stockade (5CN75) from 1808 and the Pedro Trujillo Homestead (5AL706) from the late 19th century. Approximately 100 cultural resources in the San Luis Valley are listed on the National or State Register of Historic Places. Another 435 resources are officially eligible to be listed on the National or State Registers but have yet to be formally nominated.

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The Pedro Trujillo Homestead, located within the acquisition boundary on Baca Refuge, dates back to 1879-1902 and has been designated as a National Historic Landmark.

Native American Graves Protection and Repatriation Act

We have finalized a Memorandum of Understanding with our agency partners in the NPS, BLM, and USFS, as well as the Ute Mountain Ute Tribe, the Southern Ute Indian Tribe, the Jicarilla Apache Nation, the Uintah and Ouray Ute (the Northern Ute Tribe of Utah), the Pueblo of Zuni, the Navajo Nation, the Ohkay Owingeh (San Juan Pueblo), the San Ildefonso Pueblo, the Pueblo of Santa Ana, the Santa Clara Pueblo, the Pueblo of Laguna, the Cochiti Pueblo, and the Pueblo of Acoma for projects that require compliance with the Native American Graves Protection and Repatriation Act of 1990. Other tribes may be added to the agreement. The agreement addresses the treatment and disposition of all Native American human remains, associated and unassociated funerary objects, sacred objects, and objects of cultural patrimony which are defined as agency collections or are found as a result of an inadvertent discovery or intentional excavation on lands managed by all the agencies within the San Luis Valley.

All the agencies recognize the deep cultural and historic affiliation with the lands and resources held by all the Native American tribes that are party to the agreement. A variety of disturbances with respect to human remains could occur on lands managed by the agencies, including the refuge complex. These include natural processes such as sand blowouts, erosion, and animal activity; pedestrian foot traffic and various recreational activities; illegal digging and vandalism; surveys and inventories of sites; and fire suppression. The agreement provides for a process for notification to the tribes and repatriation of remains and sacred objects. The agencies agree to hold periodic government-to-government consultation meetings to address issues related to the agreement.

4.5 Socioeconomic Environment

Socioeconomic conditions in the area surrounding the refuge complex were analyzed with the help of the USGS through the Policy and Science Assistance Branch of the Biological Resources Division in Fort Collins, Colorado.

For CCP planning, the economic analysis provides a means of estimating how our current management (no-action alternative) and proposed management activities (action alternatives) would affect the local economy. This type of analysis provides two important pieces of information: 1) it illustrates the refuge complex's contribution to the local community, and 2) it can help in determining whether economic effects are or are not a real concern in choosing among management alternatives.

The economic value of the refuge complex isn't limited to the regional economy. The refuge complex also provides substantial nonmarket values (values for items not exchanged in established markets), such as protecting endangered species, preserving wetlands, educating future generations, and adding stability to the ecosystem (Carver and Caudill 2007). However, quantifying these types of nonmarket values is beyond the scope of this study.

This report first provides a description of the local communities and economy near the refuge complex. In section 5, the methods used to conduct a regional economic impact analysis are detailed, followed by an analysis of the final CCP management strategies that could affect stakeholders, residents, and the local economy. The management activities of economic concern in this analysis are:

- Revenue sharing payments
- Refuge complex staff salary spending
- Refuge complex purchases of goods and services within the local economy
- Spending in the local economy by visitors to the refuges

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Biologists perform work on the Baca Refuge.

Regional Economic Setting

The regional economic setting for the CCP includes the three national wildlife refuges: Alamosa Refuge, Monte Vista Refuge, and Baca Refuge. The combined area of the three refuges is roughly 112,801 acres (FWS 2013a). Alamosa, Costilla, Rio Grande, and Saguache counties make up the economic study area of the refuge complex. Collectively, these four counties have a population of 37,059 people and a total area of about 6,031 square miles (U.S. Census Bureau 2010).

Population

Table 16 shows the population estimates and trends for the counties in the San Luis Valley. In 2010, Alamosa County accounted for approximately 0.3 percent of Colorado's population, while Costilla, Rio Grande, and Saguache Counties accounted for approximately 0.1 percent, 0.2 percent, and 0.1 percent, respectively (U.S. Census Bureau 2010). While Colorado's population grew 16.9 percent from 2000 to 2010, Alamosa and Saguache Counties grew by only 3.2 percent. Costilla and Rio Grande Counties experienced a decrease in population, declining by 3.8 percent and 3.5 percent, respectively (U.S. Census Bureau 2010).

Ethnically, each of the four counties in the study area has a relatively higher percentage of people identifying themselves as Hispanic or Latino than Colorado's overall figure of 20.7 percent. As a percentage of the population within each county, 45.3 percent in Alamosa County, 64.7 percent in Costilla County, 43.8 percent in Rio Grande County, and 39.4 percent in Saguache County identify themselves as Hispanic or Latino (U.S. Census Bureau 2010).

Racially, Colorado has a percentage of the population identifying themselves as being of White ancestry that is comparable to the four counties in the study area. Colorado's percentage of the population that identifies as White is 88.1 percent, while in Alamosa, Costilla, Rio Grande, and Saguache Counties, 88.7 percent, 89.5 percent, 94.0 percent, and 93.2 percent self-identify as White, respectively (U.S. Census Bureau 2010). These four counties have a lower percentage of the population identifying themselves as Black or African-American than the State of Colorado. The percentage of the population in Colorado that self-identifies as Black or African-American is 4.3 percent, while in Alamosa, Costilla, Rio Grande, and Saguache Counties, the percent of population that self-identifies as Black or African American is 1.6 percent, 1.4 percent, 0.6 percent, and 0.6 percent, respectively (U.S. Census Bureau 2010).

Income, Employment, and Education

Table 17 gives the median household income, unemployment rate, percentage of the population living below the Federal poverty line, and percentage of the population with a Bachelor's degree or higher for each county in the study area. The population within the study area is relatively less affluent than the State of Colorado or the nation. According to the U.S. Census Bureau, each of the four counties in the study area had a median annual household income level lower than both the State of Colorado ($57,685) and the U.S. ($51,914). Of the four counties, Alamosa County had the highest median household income at $38,299 per year, while Costilla County had the lowest at $25,949 per year (2010).

From 2009 to 2011, each of the counties in the study area except for Alamosa experienced an increase in the unemployment rate (U.S. Census Bureau 2010). With the annual U.S. unemployment rate in 2011 at 9.0 percent, the Colorado unemployment rate remained relatively lower at 7.6 percent (U.S. Department of Labor, Bureau of Labor Statistics 2012). Conversely, each county in the study area had unemployment levels higher than the national average in 2011, with Alamosa, Costilla, Rio Grande, and Saguache Counties experiencing unemployment rates of 9.5 percent, 10.8 percent, 11.0 percent, and 12.5 percent, respectively (American Community Survey U.S. Census Bureau 2012).

The percentage of Colorado's population with a Bachelor's degree or higher is greater than the national average (36.3 percent compared with the national rate of 27.9 percent). Each of the four counties in the study area, however, has a percentage of the population with a Bachelor's degree or higher that is below the national average, with the highest percentage being Alamosa County at 24.7 percent and the lowest being Costilla County at 15.3 percent (U.S. Census Bureau 2010).

Table 16. Population of counties in the San Luis Valley, Colorado.

	Population (2010)[a]	*Persons per square mile (2010)*[a]	*Percent population change (2000-2010)*[a]	*Projected percent population change (2010-2040)*[b]	*Median age (2010)*[a]
Colorado	5,029,196	48.5	16.9	54.1	36.1
Alamosa County	15,445	21.4	3.2	65.8	32
Costilla County	3,524	2.9	-3.8	25.1	46.8
Rio Grande County	11,982	13.1	-3.5	36.4	41.2
Saguache County	6,108	1.9	3.2	49.5	43.1

Sources:
[a]U.S. Census Bureau 2000, U.S. Census Bureau 2010
[b]Colorado Department of Local Affairs 2012

Table 17. Income, unemployment, and poverty statistics.

	Median household income (2010)[a]	*Percentage of population with Bachelor's degree or higher (2010)*[a]	*Persons below poverty level, (2010)*[a]	*Unemployment Rate*[b]	
				2009	*2011*
United States	$51,914	27.9	13.8	7.2	9.0
Colorado	$57,685	36.3	12.5	6.2	7.6
Alamosa County	$38,299	24.7	21.7	10.7	9.5
Costilla County	$25,949	15.3	22.2	8.1	10.8
Rio Grande County	$37,885	19.2	17.3	10.3	11.0
Saguache County	$33,672	20.1	25.3	99.6	12.5

Sources:
[a]U.S. Census Bureau 2010
[b]American Community Survey, U.S. Census Bureau 2012

Though only 12.5 percent of people in Colorado are living below the poverty level, which is less than the national average of 13.8 percent, each of the four counties in the study area has a percentage of people living below the poverty level that is higher than the national average. Saguache has the highest percentage of the population living below the poverty level in the four-county study area: 25.3 percent. Though still above both the State and national average, Rio Grande County has the lowest percentage of the population living below the poverty level within the study area: 17.3 percent (U.S. Census Bureau 2010).

Table 18 shows the percent employment by sector within the four-county area. More than 22,000 people were employed in the four-county area in 2011 (Bureau of Economic Analysis 2012). Farm employment accounted for nearly 9 percent of the workforce. The highest percentage of total employment, 19.3 percent, was found in the government and government enterprise sector. This sector has both local and non-local government agencies. The second and third highest percentage of total employment was in retail trade (9.7 percent) and accommodation and food services (5.7 percent). Please note that many employment estimates were not provided to avoid disclosure of confidential information.

Agriculture and Livestock

Agricultural sales estimates are presented in table 19. The State of Colorado is a productive region for both crops and livestock. In 2007, Colorado had an agricultural output of more than $6 billion, with crop output contributing nearly $2 billion and livestock output contributing more than $4 billion. The top five commodities produced in the State were layers (hen egg production), cattle and calves, wheat, forage, and corn (USDA 2007).

As of the 2007 Census of Agriculture, the four-county area was home to 1,189 farms, with 1.04 million acres in agriculture (USDA 2007). In 2007, within the four-county area, Rio Grande County had the greatest number of farms (390 farms) and Costilla County had the most acreage in production (401,147 acres). Costilla County also had the fewest number of farms (241 farms), and Alamosa County had the least acreage in production (176,629 acres) (USDA 2007).

The four counties in the study area are relatively agriculturally productive, with a combined gross annual agricultural output in 2007 of nearly $295 million, of which $265 million was the market value of crops and $30 million was the market value of livestock (USDA 2007). With regard to sales of the commodity group "vegetables, melons, potatoes, and sweet potatoes," Saguache, Rio Grande, Alamosa, and Costilla ranked first, second, fourth, and fifth, respectively, out of the 64 counties in Colorado (USDA 2007)

Table 18. Employment by sector.

Industry	*2011*	*Percent of total*
Total employment	22,062	
Wage and salary employment	15,502	70.3
Proprietors employment	6,560	29.7
Farm proprietors employment	1,033	4.7
Nonfarm proprietors employment	5,527	25.1
Farm employment	1,937	8.8
Private (non-farm) employment	20,125	91.2
Forestry, fishing, and related activities	0	0.0
Mining	0	0.0
Utilities	158	0.7
Construction	1,189	5.4
Manufacturing	405	1.8
Wholesale trade	647	2.9
Retail trade	2,131	9.7
Transportation and warehousing	572	2.6
Information	164	0.7
Finance and insurance	861	3.9
Real estate and rental and leasing	699	3.2
Professional, scientific, and technical services	635	2.9
Management of companies and enterprises	0	0.0
Administrative and waste management services	56	0.3
Educational services	41	0.2
Health care and social assistance	123	0.6
Arts, entertainment, and recreation	227	1.0
Accommodation and food services	1,265	5.7
Other services, except public administration	952	4.3
Government and government enterprises	4,253	19.3
Federal, civilian	344	1.6
Military	101	0.5
State and local	3,808	17.3

Source: Bureau of Economic Analysis 2012

Table 19. Market value of agricultural products sold, employment in agriculture.

	Total value of ag. products sold, in $1,000 (2007)	*Value of crops sold, in $1,000 (2007)*	*Value of livestock sold, in $1,000 (2007)*
Colorado	$6,061,134	$1,981,399	$4,079,735
Alamosa County	$91,413	$86,046	$5,367
Costilla County	$26,660	$22,840	$3,820
Rio Grande County	$85,360	$78,057	$7,302
Saguache County	$91,456	$78,536	$12,920

Source: USDA Census of Agriculture 2007

Recreation and Tourism

Angling, hunting, and wildlife viewing are popular recreational activities across Colorado and within the four-county area. According to the recent 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, approximately 2.3 million residents and nonresidents enjoyed wildlife-associated activities in Colorado (DOI, FWS, Department of Commerce, U.S. Census Bureau 2011). For the purpose of the National Survey, wildlife watching is categorized as follows:

- away-from-home (activities taking place at least 1 mile from home)
- around-the-home (activities taking place within 1 mile from home)
- All visitors to the refuge that engage in wildlife watching are considered away-from-home participants.

Of all participants, 40 percent identified as hunters or anglers, and 70 percent reported engaging in wildlife-watching activities. The number of hunting days by both residents and nonresidents totaled 2.2 million, with residents of the State of Colorado accounting for 71 percent of hunting days. The number of fishing days by residents and nonresidents totaled 8.4 million, with Colorado residents accounting for 89 percent of fishing days. In 2011, residents and nonresidents spent 6.9 million days watching wildlife away from home, with residents accounting for 69 percent of wildlife watching days. The in-State spending associated with all wildlife recreation totaled $2.98 million in 2011, with $1.24 million spent on trip-related expenditures, $1.56 million spent on equipment, and $189,000 spent for other items (DOI, FWS, Department of Commerce, U.S. Census Bureau 2011).

Economic Importance of Water

The refuge complex holds several water rights within the Rio Grande hydrologic system. Water in the San Luis Valley has largely been decreed to be used for irrigation purposes. Water is highly valued for agriculture in the area, but it is also a vital element for wildlife habitat. The refuge complex uses much of its water to provide crucial habitat for wildlife, including wet meadow, playa wetland, riparian areas, desert shrubland, grassland, and cropland. These diverse habitats within the refuge complex support songbirds, water birds (including sandhill cranes), raptors, mule deer, and coyotes.

Though the water used by the refuge complex may not directly contribute to the agricultural economy of the study area, many of the visitors to the refuge complex come to observe the wildlife that is drawn to the artificial wetlands on the refuges. As described above and in chapter 5, these visitors have a positive economic effect on the local area and contribute to the overall economy of the region.

4.6 Special Management Areas

Sangre de Cristo Conservation Area

The Sangre de Cristo Conservation Area is a unit of the Refuge System and is part of the refuge complex. (Refer to figures 4 and 6.) It is in central southern Colorado and northern New Mexico, and it includes the San Luis Valley, the adjoining Sangre de Cristo Mountains, and the Sangre de Cristo's tributaries to the Rio Grande between Blanca Peak and the watershed of Costilla Creek. Within this project boundary, we will strategically find and acquire from willing sellers a proper interest in upland, wetland, and riparian habitats on privately owned lands (FWS 2012b). We plan to buy or receive donated conservation easements on those identified areas within the project boundaries, and would consider accepting donated fee-title lands as well. In total, the project calls for protection of 250,000 acres of uplands, wetlands, and riparian areas through conservation easements (FWS 2012b). Management of the conservation area does not directly affect management of the three national wildlife refuges; however, it protects a diverse array of plant communities, ranging from rabbitbrush shrub and sagebrush on the valley floor to alpine tundra and scree fields on the peaks of the surrounding mountains. These habitats are crucial for breeding and migratory birds and provide important opportunities for persistence and reintroduction of species that are protected under the Endangered Species Act.

San Luis Valley Conservation Area

Similar to the Sangre de Cristo Conservation Area, the proposed San Luis Valley Conservation Area seeks to protect the remarkable ecological values of the San Luis Valley largely through the acquisition of conservation easements. It could include limited acquisition of fee-title lands. (Refer to figures 4 and 6.)

Sangre De Cristo National Heritage Area

The refuge complex lies within the Sangre de Cristo National Heritage Area, which was established on March 30, 2009 in Public Law 111-11 for the "protection, enhancement, and interpretation of the natural, cultural, scenic, and recreational resources of the Heritage Area" (see figure 6). Heritage areas present opportunities for residents and visitors to recognize and celebrate a region's cultural and natural values. The heritage area encompasses more than 3,000 square miles of the upper headwaters of the Rio Grande (NPS 2012b).

Other Jurisdictions

As discussed under water resources above, BOR is authorized by Public Law 92-514 (October 20, 1972) to operate and maintain the Closed Basin Project in parts of the San Luis Valley (including both the Alamosa and Baca Refuges) for the transport of water into the Rio Grande for the fulfillment of the United States' obligation to Mexico and for furnishing water downstream of Alamosa for deficient areas of Colorado, New Mexico, and Texas. This is accomplished through direct diversion of water out of the Closed Basin system. BOR operates hundreds of wells on the Alamosa and Baca Refuges, which are accessed by a network of gravel and two-track roads