Chapter 3—Refuge Resources and Description

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Pectoral Sandpiper

This chapter describes the environment found at Quivira Refuge that will be affected by the actions we choose to enact as a result of the planning process contained in this CCP. The environment has physical and biological parts and elements that have been created by humans, such as cultural resources, special management areas, visitor services, operations and socioeconomics.

3.1 Physical Environment

The following sections describe aspects of the physical environment of the refuge. Physical characteristics include climate, climate change, air quality, geography and physiography, water resources, and soils. Many regional descriptions of the physical environment have been completed and may be reviewed for more detail, such as a report on the Rattlesnake Creek Subbasin available through the Kansas Department of Agriculture (2006).

Climate

The refuge climate is dry sub humid, lying along the transition boundary between the rain shadow of the Rocky Mountains and the warm, moist air currents of the Gulf of Mexico. Regional weather patterns depend on the interaction of these two air masses (Sophocleous and Perkins 1992).

Refuge habitat conditions are influenced greatly by climate and management strategies, and prescriptions are adjusted based on seasonal and annual fluctuations in precipitation, temperature, and evaporation. Weather data have been recorded from a station in Hudson, Kansas, about 8 miles west of

the refuge, since at least 1941. Based on this historical data, the coldest month is January, with average low and high temperatures of 20 and 41 °F, respectively, and the warmest month is July, with average low and high temperatures of 68 and 95 °F, respectively. Annual precipitation varies between 13 and 41 inches, with a long-term average of 24–25 inches. It rains an average of 74 days per year in Stafford County and 71 percent of the precipitation falls during the growing season, which averages 185 days between April and September. Mean snowfall is 20 inches per year, yet substantial accumulations seldom occur. The average annual free-surface evaporation is about 64 inches (Sophocleous et al. 1997), with rates being highest during the summer months (Latta, 1950).

Because of its location at a climatic boundary prone to multiple air masses, Kansas is also vulnerable to strong thunderstorms, especially in the spring months. Many of these storms become super cell thunderstorms. According to statistics from the National Climatic Data Center, Kansas has reported more tornadoes (for the period January 1, 1950 through October 31, 2006) than any state except Texas, and it averages more than 50 tornadoes annually (NOAA, 2006). Prevailing winds are from the southeast during the summer months, May through September. Northeast winds are common throughout the winter months, October through April. Average wind velocities are moderately strong in all seasons and reach their greatest velocities during the spring. The mean, 0.02-mile (30-meter) wind speeds for Quivira Refuge range from 13.4 to 14.5 miles per hour (Kansas Corporation Commission 2008).

Climate Change

Climate change is the preeminent issue for conservation in the future. Over the next two decades, a warming of about 0.36 °F per decade is projected for the planet as a whole. Warming is expected to continue for centuries, even if greenhouse gas emissions are stabilized, because of the substantial time lags of climatic processes (Christensen et al. 2007).

Along with this projected warming, atmospheric moisture transport and convergence is projected to increase, resulting in a widespread increase in annual precipitation over most of the continent, except the south and southwestern part of the United States (Christensen et al. 2007). This increased precipitation is more likely to occur in winter and spring months, rather than in the summer (Christensen et al. 2007). It is also considered likely that extreme weather, such as heat waves and flooding, will become more frequent. Increases in annual precipitation may be partially offset by increases in evaporation. Moisture availability, rather than just precipitation, is an essential resource for plants and animals.

Such changes will influence many environmental factors that will affect our management of Quivira Refuge, such as the balance of water inflows and outflows, water runoff patterns, the rate and extent of erosion, aquifer recharge rates, water quality parameters, and species abundance and distributions. However, climate change predictions are generally applied at large spatial scales, and much uncertainty remains about the use of this information at local scales (Weins and Bachelet 2010). Thus, it is difficult to plan for specific management changes on the refuge based on our current understanding.

While finding specific management actions to address climate change are not possible at this time, a report on the potential effects of human-caused climate change was prepared for the Playa Lakes Joint Venture (PLJV) region with a focus on habitats (Matthews 2008) (figure 8). This report synthesized much of the relevant information available at the time, including works of the Intergovernmental Panel on Climate Change and many peer-reviewed publications. The author notes that while global and regional shifts in climate are natural, adapting to recent changes is different because of landscape modifications like habitat fragmentation, invasive species, and water quality degradation. Species most vulnerable to climate change have restricted ranges, specialized habitat needs, and are largely migrants. Predicted potential climate change effects on habitat within the PLJV region cited in this report are summarized in the list below. It is important to note differences in climate change predictions at various scales of the PLJV region, such as overall, southwest, and northeast, though all scales are important considerations in the management of natural resources that occur on the refuge. The author also qualifies predictions with the understanding that local variations in weather patterns, like the amount and intensity of precipitation, are a continuing characteristic of the region.

Predicted Potential Effects of Climate Change at the Scale of the Playa Lakes Joint Venture Region

- decreasing annual precipitation in contrast to the larger Great Plains region
- increasing winter temperatures causing less snow, or frozen, precipitation and less ice cover and more rain, with precipitation falling later and melting earlier
- decreasing water volume in wetlands in fall and winter leading to more shallow habitat

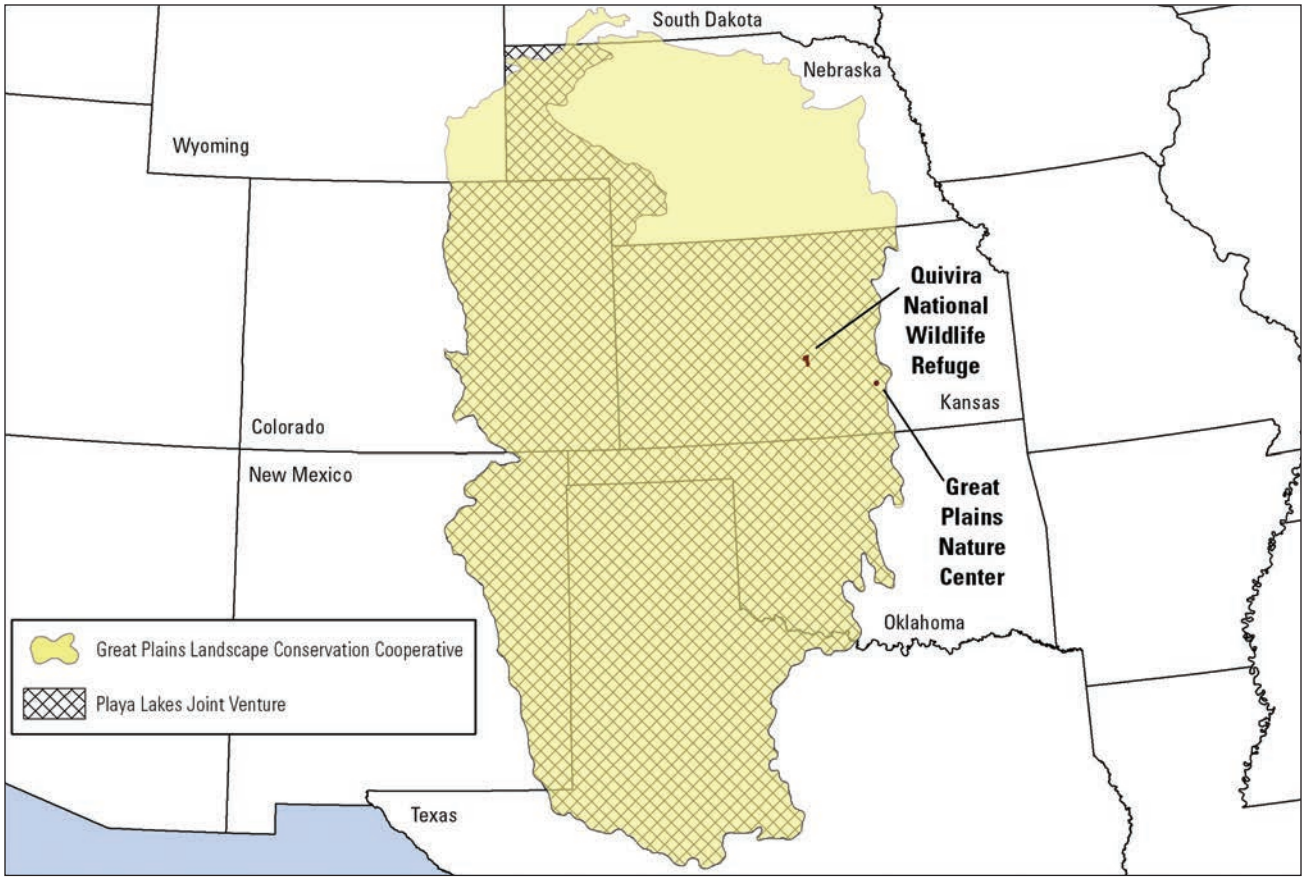

Figure 6. Playa Lakes Joint Venture region, Quivira National Wildlife Refuge, Kansas.

- decreasing presence of flooded, or functioning, wetlands, especially more ephemeral and shallow types—which compose most of the wetlands in the PLJV region—or those that respond quickly to changes in precipitation and evaporation, like playas, warm-water sloughs, floodplain marshes, and wet meadows, resulting in decreased cooler, deeper water during warm periods, particularly in the summer and early fall
- increasing rate of increase in summer temperatures
- changing plant species productivity, abundance, and ranges across all habitat types and partly related to the differences in their tolerance levels or adaptation strategies to events like drought, flooding and fire
- changing distribution of wetlands across the landscape
- decreasing connectivity among wetlands by ground water or by periods of high precipitation and flooding
- increasing likelihood of disease transmission because of higher concentrations of waterfowl in limited habitat areas, higher winter temperatures, and more
- changing species composition, or abundance, of fish
- changing water column turnover cycles for larger, deeper wetlands that leads to the reduced overall productivity of open-water habitat
- decreasing sensitivity and increasing resiliency of sandhill wetlands, or those influenced by ground water—not playas, or wetlands dependent on precipitation and with no, or limited, connectivity to ground water—to temperature and precipitation extremes during the next one to two decades or longer with changes in erosion rates possibly causing sandhills to move
- sustaining local populations of specialized arthropod species in saline wetlands may be affected by persistent dry conditions and

sustaining bird species with great dependence on saline wetlands could be negatively affected by more extreme flooding and drying events

- increasing drought frequency
- increasing abundance of fully flooded playas, or temporary, seasonal wetlands, in the spring
- increasing abundance of fast runoff events
- increasing sedimentation rates
- decreasing food availability for birds with shifts in the quality and state of wetlands, such as moving from a water condition that is dominated by plants large enough to be seen by the human eye, which results in oxygen-rich water, to one that support a dense growth of algae that depletes oxygen
- likely increasing generalist invasive exotic species
- decreasing overall water quality
- eastern shifting of the central United States and Canada migratory flyway
- decreasing sensitivity to climate changes by larger catchments and watersheds with more permanent flowing water relative to smaller catchments and watersheds with less permanent flowing water
- altering flow regimes for rivers and streams in the PLJV region, with lower flows occurring in later summer and early fall and higher flows occurring in the winter and spring and with low-order streams being more directly affected by winter and spring flooding events than the middle, and lower, reaches of rivers
- emerging economic and political trends and resultant changes in land use patterns, such as agricultural strategies and practices, urbanization, and fire suppression, will decide natural resource effects
- shifting distribution—moving north and east into the PLJV region—of nematodes, insects and other arthropod species that are native to North America but exotic to region
- increasing grassland productivity with the increased rates of spring precipitation, while increasing levels of atmospheric carbon dioxide and other complex feedback mechanisms may affect the duration of this trend
- accentuating thermal effects on grassland habitats by insects, notably plant pollinators and herbivores will affect associated predator–prey relationships and influence species abundance and phenologies, like the timing of breeding, migration, and other life events
- increasing fire on the landscape to help most grassland habitats, while creating uncertainty about what grassland types and conditions will follow burns over the long term
- affecting prairie dog communities, but how is not known, with one study suggesting that prairie dog herbivory might support their resilience to climate change

Predicted Potential Effects of Climate Change on Areas within the PLJV Region:

- An increasingly extreme annual precipitation gradient between the southwestern and northeastern parts of the PLJV region will develop—uncertainty makes drawing clear boundaries extremely difficult. It is likely that, by midcentury, areas farther north, perhaps to Nebraska, will be similar to the current thermal regime of the southern high plains.
- For northern and eastern parts of the PLJV region, including the refuge area, there may be an increase in annual precipitation of less than 10 percent by 2100 and uncertainty about specific changes in hydrologic patterns, like timing. This precipitation trend is in contrast to that at a PLJV scale and more consistent with trends at a Great Plains scale.
- For northern and eastern parts of the PLJV region, current trends suggest that ephemeral wetlands could shift to more permanent types. However, some models suggest that summers could become warmer in these areas and increase evaporation rates.
- For the southwest area of the PLJV region, increasing drought frequency and severity could turn semiarid regions into deserts.

Collectively, the potential effects of climate change described above inform us on how environmental conditions may change in the future, as well as how the roles, and relative importance, of natural resources that occur on the refuge might change within the context of the PLJV region. Many strategies used in traditional refuge management may also be used to address challenges related to climate change, like the control of invasive species, the support of native communities, the control or reduction of habitat fragmentation, the manipulation of water levels, and the periodic assessment of conservation goals and objectives, but new strategies may also have to be developed.

Land Features

Quivira Refuge is located in the Great Bend Lowland, or Prairie, which is part of the Arkansas River Lowlands section of the larger Central Lowland physiographic province (Schoewe 1949). Following the large, northward bend of the Arkansas River in central Kansas, the Great Bend Lowland is an alluvial plain, with sediment originally deposited by flowing water that has local, gently rolling hills. Refuge lands range in elevation from about 1,700 to 1,800 feet above sea level (Schoewe 1949) and are only slightly higher in elevation than the Arkansas River (Hathaway et al. 1978). Arbogast and Johnson (1998) refer to the Great Bend (Sand) Prairie as a "mosaic of sand sheets and dune fields," with dune orientations that are mostly northwesterly and southwesterly. Surface materials are mostly easily erodible sands and gravels of Quaternary Dunes (Schoewe 1949, Zeller 1968) that are generally of Rocky Mountain origin deposited from laterally shifting channels of the ancestral Arkansas River (Fent 1950). The Rattlesnake Creek is a mostly perennial tributary that meanders northeasterly through the Great Bend Lowland and flows through Quivira Refuge about 15 miles from its confluence with the Arkansas River.

Thin, unconsolidated, or undifferentiated, alluvium that is less than 20 feet thick and more-recent Eolian sand deposits are common in the area of the refuge (Arbogast 1995, Arbogast and Johnson 1998, Sophocleous 2003). The alluvial materials are poorly sorted sand, silt, and clay broadly described as silty sand, sandy loam, or loess, whereas, sands are well sorted. Poorly sorted materials are less porous, have poor drainage when compared to well-sorted materials, and are commonly associated with local depressions like wetlands. In contrast, well-sorted deposits are characteristic of higher sand dune sites and often occur in areas of ground water recharge or springs. Particle size of deposits also influence soil and water properties, which partly determine plant and wildlife communities. Dune sands generally are very fine-to-fine-sized particles, and those of the beach ridge occurring along the east and southeast side of the BSM, which were derived from a Wisconsin-age lake, are fine-to-medium sized (Arbogast and Johnson 1998, Heitmeyer et al. 2012). More detailed soil descriptions and their relationships with different communities on the refuge are provided in the soils section of this chapter.

A broad description of the geologic stratigraphy of the Quaternary alluvium in the area of the Quivira Refuge, in order from surface to bedrock, is as follows: (1) sand dunes; (2) relatively continuous near-surface silt–clay bed from a loess deposit; (3) alternating sequences of sandy silt–clay, sand, and gravel lenses; (4) basal sand and gravel beds of fluvial origin; and (5) bedrock (Latta 1950, Macfarlane et al. 1993, Fader and Stullken, 1978, Kansas Department of Agriculture 2006). The type, relative age, and position of parent material greatly influence soil formation, hydrology, and resulting plant communities. The Permian bedrock, many feet below the relatively more permeable surface materials, is up to 350 feet thick in the area of the refuge (Macfarlane et al. 1993, West et al. 2010). Fader and Stullken (1978) state that the Permian bedrock underlying the refuge is primarily associated with the Salt Plain Formation, although an area along the east boundary of the refuge is associated with the Harper Sandstone Formation. In other reports, these two Permian bedrock formations are collectively called the Harper Salt Plain Formation or "red beds." Materials in these formations consist of reddish-brown sandstone, siltstone, shale, salt, gypsum, anhydrite, and limestone, which are a source of saline water that is characteristic of the refuge (Rubin et al. 2001, Kansas Geological Survey and Kansas State University 1997). At various depths between the surface and bedrock zones are clay lenses or layers that create separation between saltwater of the bedrock aquifer and fresh water of the higher alluvium aquifer of Cretaceous bedrock (Latta 1950, Sophocleous and Ma 1998, Sophocleous 2000, Rubin et al. 2001). More detailed descriptions of geology and hydrology of the area may be found in the Water Resources Inventory and Analysis Report (Striffler 2011) and hydrogeomorphic method analysis report (Heitmeyer et al. 2012) prepared for the refuge.

Soils

Soils are diverse (figure 7) and they differ with respect to texture, moisture and nutrient retention capacities and salinities. Such differences influence

plant and wildlife community distribution and composition. Refuge lands are comprised of the following soil subgroups: 37 percent Subirrigated; 22 percent Saline Subirrigated; 17 percent Sands, choppy and subirrigated; 14 percent Aquolls; 10 percent Sandy; and less than 1 percent each of Loamy Clay and Clay Upland (Soil Survey Staff 2010). Ecological site characteristics and State transition models are described by the National Vegetation Classification System (NRCS) for each soil subgroup (Soil Survey Staff 2010), Heitmeyer et al. 2012).

Water Resources

Hydrology is one of the most important factors influencing ecosystem structure and function. Consequently, hydrology also is of primary importance in planning our refuge management activities. However, hydrology involves complex relationships that exist at multiple spatial scales that are difficult to characterize in a CCP and EA. Therefore, a review of the Water Resources Inventory and Analysis Report (Striffler 2011) and the hydrogeomorphic method analysis report prepared for the refuge, as well as models and reports that provide detailed descriptions of water resources in the Rattlesnake Creek basin, is recommended. For purposes of this CCP and EA, a more general description of water resources is provided below.

Regional Context

Refuge lands occur within the Rattlesnake Creek watershed, which is approximately 95 miles long and 18 miles wide and encompasses parts of 10 counties (Basin Management Team 2010). Within the watershed, Quivira Refuge is located at lower elevations in the eastern part of the watershed and Big Bend Ground-Water Management District No. 5 (USGS 2012b, Sophocleous and McAllister 1987, Rattlesnake Creek/Quivira Partnership 2000). Refuge resources and management are dependent on surface water from the Rattlesnake Creek, but surface and ground water interactions are common, most noticeably in the form of seeps, springs, and underflow.

Surface Water

The drainage area of the watershed is 1,047 square miles, but the upstream area that actually contributes runoff to the area of the refuge is only 519 square miles, as identified by the contributing drainage area for USGS Zenith gaging station #07142575 (USGS 2012d). Rattlesnake Creek flows are checked continuously at the Zenith station, a distance of about 2 aerial miles before entering the southwest boundary of the refuge.

Traditionally, total annual flows in the creek are positively correlated with annual precipitation amounts. However, data from the Zenith gauge show a declining trend in average annual streamflow during recent years that is related to an increased use of ground water for irrigation coupled with reduced precipitation (Striffler 2011). But of equal or greater, importance are the observed changes in the timing of within-year flows. In part because of land use activities upstream from the refuge, water often has been unavailable when needed during the growing season to manage plant communities or to provide habitat for wildlife.

Ground Water

The Rattlesnake Creek watershed overlies the Great Bend Aquifer, which is part of the High Plains Aquifer. In general, ground water flow at a regional scale is eastward (Hathaway et al. 1978), but local variation occurs (figure 5). Near the refuge, the depth to ground water is generally 1–4 feet (Sophocleous 2003, Hathaway et al. 1978). Ground water pumping is a primary water source for irrigated crops, including small grains such as wheat and some corn. In general, most farmland presently lies west of the rangeland and woodland tracts that are next to the refuge boundary.

Water Quality

Major factors affecting water quality in the Rattlesnake Creek Subbasin include complex interactions between aquifers and soil stratigraphy (Sophocleous and Ma 1998, Rubin et al. 2001), irrigation practices (Hathaway et al. 1978, Rubin et al. 2001), and oil and gas activities (Rubin et al. 2001). While mineral composition varies within the watershed, northeastern Stafford County—of which the refuge area is a part—is referred to as a mineral intrusion area. Here, water in the aquifer has contact with salt-bearing Lower Permian bedrock, causing chemical reactions of dissolved solids and the natural occurrence of sodium chloride-type salts (Hathaway et al. 1978). As a result, saline and sodic soils and waters are produced, depending on soil drainage capacities and evaporation patterns (Hathaway et al. 1978, Rattlesnake Creek/Quivira Partnership 2000). High rates of ground water pumping in the Rattlesnake Creek corridor may disrupt the natural discharges of saltwater because of decreased surface flows and increased saltwater entry into the freshwater aquifer (Rubin et al. 2001). Differences in the conductance of water occurs throughout the water-

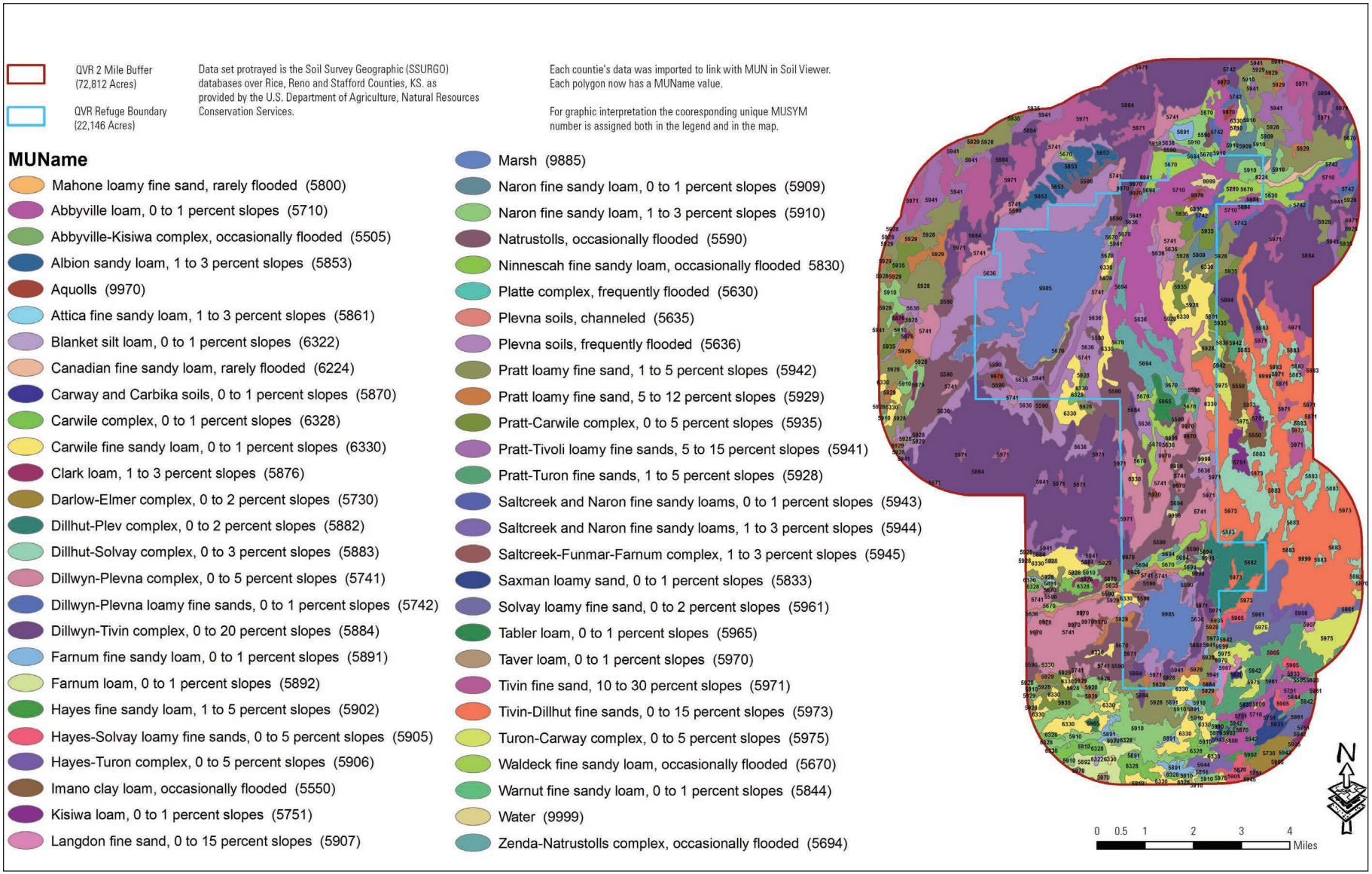

Figure 7. Refuge soil map, Quivira National Wildlife Refuge, Kansas. *Source: Soil Survey Staff 2010.*

shed, with wide ranges possible in the area of the refuge (less than 750, 750–2,250, and up to greater than 2,250 micromhos) (Hathaway et al. 1978). More well test results of chemical quality data sampled at certain points in time in the Great Bend Prairie may be found in a report by Hathaway et al. (1978).

Abnormally high nutrient levels in different states, such as nitrates found in oxygenated conditions, may have adverse ecosystem effects (Christensen 2001). Nitrate concentrations in the Great Bend Prairie aquifer are commonly affected by irrigation well density, subsurface clay lenses, and land use practices. Land managers who use grazing or who manage herbivores in areas of high nitrate concentrations, especially when using more intensive grazing in drought conditions, are often concerned about differential effects to forage plants. For example, cornstalks may hold more nitrates than some bluestem grasses, and the lower 6 inches of a plant may have the highest nitrate concentrations. Land managers adjust strategies to decrease, or prevent, potential adverse effects, such as toxicity and poisoning that can lead to cattle asphyxiation. Nitrate levels reported before in the Great Bend Prairie aquifer are relatively high, often greater than 0.000083454 pound per gallon (10 milligrams per liter), compared to many other samples of uncontaminated ground water collected throughout the United States, which average less than or equal to 0.000025036 pound per gallon (3 milligrams per liter) (Townsend and Young 1995). Based on 42 samples of ground water collected in Stafford County, Townsend and Young (1995) reported that nitrate nonpoint-source contamination was more evident in shallow wells typically used for domestic and stock, with a mean (range) depth of well equal to 60.04 (28.87–93.83) feet (18.3 [8.8–28.6] meters), compared to deep wells typically used for irrigation, with a mean (range) depth of well equal to 83.99 (41.99–135.17) feet (25.6 [12.8–41.2] meters). Nitrate–N values had a mean (range) of 0.00005508 (0.000010849–0.000095972) pound per gallon (6.6 [1.3–11.5] milligrams per liter) for shallow wells and 0.000032547 (0.000011684–0.000079281) pound per gallon (3.9 [1.4–9.5] milligrams per liter) for deep wells. There were no substantial differences in nitrate–N concentrations between sandy and loamy soils or flood versus center-pivot irrigation methods. A thicker clay layer above well screens was positively associated with lower nitrate concentrations in the study. Results of this research may be used in evaluating the potential effects of existing wells in a given area, or considered, when planning the addition or removal of wells on refuge lands.

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Rattlesnake Creek flows into Little Salt Marsh on Quivira Refuge.

Recent Trends in Water Quantity

Recent regional trends in water quantity that are important in refuge planning include: (1) the encroachment of woody vegetation into open prairie, which likely has resulted in higher water use when compared to the natural plant communities that occurred before human settlement (Striffler 2011, Heitmeyer et al. 2012); and (2) declines in the ground water table and streamflows that are inadequate to meet refuge management needs (Sophocleous 1997, Rattlesnake Creek/Quivira Partnership 2000).

Water Rights and Management

Refuge hydrology is complex, largely because of dynamic precipitation and flow patterns, surface–ground water interaction, and a highly altered landscape that uses extensive ground water pumping within the watershed. Overall, the main sources of surface water entering the refuge are precipitation, ground water discharge, and Rattlesnake Creek surface inflows. Primary surface outflows are evaporation, plant transpiration, ground water recharge, and surface drainage outflows. As discussed above, short- and long-term shifts in the water balance occur in response to precipitation patterns and land use activities within the watershed.

The refuge senior water right [Permit #7571] allows quantities of 14,632 acre-feet per year (AFY) and flows of 300 cubic feet per second (cfs). This water right seems adequate for current refuge management except that often the refuge does not receive water sufficient to meet our water right and water is not always available at a time when it is most critical for refuge management. The refuge waterflow system, or infrastructure, allows various levels of control in flooding, dewatering, and moving water among more than 30 water units (figure 5, Striffler 2011).

In high flow years, excess water may be transferred downstream or used to support desirable water depths in water units, such as impoundments or wetland areas. Sediment and water chemistry may be altered through the periodic flushing and draining of water through the refuge water conveyance system. Occasional dewatering of wetlands is desired to promote the nutrient cycling required for supporting the long-term productivity of wetland systems and for the management of plants with different germination and growth needs (Mitsch and Gosselink 2003). Water depths are often regulated to increase the availability of food resources or structural conditions for waterbirds that have different nutritional needs and adaptations used in acquiring resources.

Air Quality

The Clean Air Act requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (EPA 2011a). In accordance with this need, the EPA has set standards for the following six pollutants to protect the health of humans and the environment: carbon monoxide, lead, nitrogen dioxide, ozone, particle pollution, and sulfur dioxide. Other primary functions of EPA are to provide regulatory authority and technical help to State and local control agencies, as well as to conduct programs that research many different aspects of air science and technology (EPA 2011b). Of particular interest to natural resource managers is current EPA research linking air quality to ecosystem exposure (EPA 2011c), which may provide new insights about the relative importance of sustaining natural resources to improving air quality and interactions between air quality and ecosystem health.

The Kansas Department of Health and Environment's Bureau of Air is the agency that checks, regulates, and reports air quality in Kansas and sends data to the EPA's Air Quality System. Cold winters, warm dry summers, and high winds cause ozone and particulate matter to be criteria pollutants of particular concern in Kansas, especially during events of blowing soil and surface inversions (Kansas Department of Health and Environment 2010). Because of the remoteness of Quivira Refuge, it is presumed that farming and burning activities that affect air quality are of most concern for the refuge. However, the refuge is mostly in Stafford County, where the population density is in the 6,000–9,000 category, and is not included in any Kansas Department of Health and Environment monitoring area or in any designated statistical area. Hutchinson, Great Bend, and Salina are cities close to the refuge that are listed as Micropolitan Statistical Areas, but the Kansas Department of Health and Environment only operates monitors in the Salina Micropolitan Statistical Area, which covers Ottawa and Saline Counties. Salina is downwind of Wichita and is a proposed ozone monitoring site for the next 5 years.

Thus, based on available information, air quality is not a current issue near the refuge, but it may be a consideration in the near future, depending on activities at a larger landscape scale.

3.2 Biological Resources

Evaluating refuge lands in the appropriate ecological context is needed for developing management

goals and objectives that will best meet the purposes of the refuge and optimize contributions to the conservation of biological resources at larger spatial scales. Among the factors that contribute to the diversity and abundance of refuge flora and fauna is the refuge's central location within the mixed-grass transition zone where characteristically short western and tall eastern grasses meet, northern cool-season grasses and southern warm-season grasses converge, and many species range distributions overlap. Thus, depending on shifting short- and long-term environmental conditions, biological resources of the refuge are dynamic within, and among, years. In addition, wetland habitats that tend to be fewer and less reliable in this geographic region attract some species that rely on both wetland and grassland resources for life events. For example, dry shoreline and salt flat habitat provides nesting sites for waterbird species, such as interior least tern, western snowy plover, black-necked stilt, and American avocet. Also, the complex of upland and wetland habitats produces a high abundance and diversity of plants, invertebrates, and vertebrates and, therefore, is an attractive source of food for species associated with both communities. Collectively, these factors contribute to a diverse flora and fauna, because the distributions of many western and eastern wildlife and plant species overlap, such as with the presence of both the eastern and western meadowlark and kingbird.

Quivira Refuge supports a diversity of wetland types that each provide resources like invertebrates, plant foods, and cover in unique combinations that are important for meeting the life requisites of focal species. In addition, each wetland provides multiple plant communities simultaneously, such as tall emergent and wet meadow, and plant communities tend to change temporally in response to abiotic factors like bare mudflats in spring that can be colonized by annual emergent vegetation later in the same year.

Within created wetlands, the partial drawdown or flooding of a unit and brief periods of inundation during the spring has resulted in sparse vegetation interspersed with expanses of mudflats that provide suitable foraging habitat for spring and fall migrating shorebirds. If partial drawdown or flooding is prolonged through the summer, bare mudflats next to shallowly flooded habitats have provided shorebird nesting habitat. Conversely, if water is maintained on units for longer periods, perennial emergent vegetation tends to colonize sites. Local interspersion of emergent herbaceous wetland cover and open water is reported to benefit a high diversity of marshbirds, provided long-term wetland cycling is sustained (Weller and Spatcher 1965, Bolenbaugh et al. 2011), and wetland size is a reported influential factor of habitat use for some waterbirds (Brown and Dinsmore 1986). Depending on the type of perennial vegetation, suitable nesting and foraging habitat has been provided for grebes and bitterns (cattail or bulrush) or rails and phalaropes (sedge or rush). In addition, semipermanent units that support emergent vegetation interspersed with open water have offered suitable breeding habitat for amphibians and thermal cover for waterfowl during early winter.

In grasslands, differences in species niche selection allow cohabitation within the same community. Bird habitat selection differs largely based on behavioral interactions and needs of various life activities, such as for foraging, mating, nesting, brooding, or protection from weather or predators (Wiens 1973, Cody 1985a, Cody 1985b). In general, sand prairie grassland for this region has been described as being dominated by grasses with lesser amounts of forbs and woody vegetation (Küchler 1974, Natural Resource Conservation Service 2010). Ecological site descriptions report potential woody coverage of less than 5–15 percent on some soil associations and up to about 30–40 percent on others, with amounts changing largely dependent on management history. Some shrub cover exists as a natural part of the grassland community to provide valuable wildlife food and different types of cover for nesting, resting, escape, and thermal protection. During winter, a combination of grassland and shrub habitat contributes to bird use diversity and abundance, including focal species (Davis 2001). However, some woody vegetation has been managed to conserve native grassland communities because, for example, extensive tall, dense shrub cover is avoided by some breeding grassland birds (Cooper 2009) and has been associated with higher rates of predation (Klug et al. 2009, 2010).

All biological resources of the refuge are dynamic within, and among, years, depending on short- and long-term environmental conditions. Therefore, evaluating the potential contribution of refuge lands to wildlife is complex and requires consideration of short- and long-term community dynamics relative to the status and importance of species and communities at various spatial scales.

Populations of many species native to the area have declined because of habitat loss and degradation caused by factors such as land use changes, the spread of invasive species, habitat fragmentation, urbanization, and management actions that affect the quantity and quality of water resources. The importance of each of these factors depends on the scale considered. In this planning process, we examined several plans and documents at scales ranging from local to national that were relevant to the purposes and goals of Quivira Refuge. These included our lists of species of management and conservation concern (FWS 2008a) that consider various national and international bird conservation plans and other locally important status reports, or designations.

The descriptions of plant and wildlife communities that follow are not comprehensive.

Plant Communities

This sections includes details on the various plant communities found on Quivira Refuge

Landscape Context: Status and Trends of Plant Communities

Saltmarsh and sand prairie are two distinct ecological communities of Quivira Refuge and the western Great Plains that are of importance at both the global and State scale (Kansas Natural Heritage Program, Kansas Biological Survey 2008). Based on the Natural Plant Communities of Kansas status list dated October 9, 2003, saltmarsh is globally ranked as an imperiled community because of its rarity or its vulnerability to extinction, but is now not able to be ranked at a State level because of the lack of, or conflicting, information. Sand prairie, on the other hand, is a secure community at a global level, but is State listed as imperiled because of its rarity and vulnerability to extirpation in Kansas.

More than 97 percent of lands in Kansas are in private ownership, and most are highly altered from conditions that occurred before European settlement. For example, an evaluation of land cover maps and remotely sensed data shows that current plant community alliances differed substantially from before settlement times—or before about 150 years ago, and more recent times of about 5 years ago (Peterson et al. 2004). Changes in land use from the historical period include 48 percent of lands cultivated in Kansas, and a dramatic reduction in the area of native short, and tall, grass communities. Recent changes in land use affected less than 20 percent of Kansas lands and included conversion of grassland to cropland—greater than 2,471,053 acres (1,000,000 hectares)—and woodland, as well as the conversion of cropland to grassland. The latter can be attributed to enrollments in the Conservation Reserve Program, rather than to the reconstruction, or restoration, of native grassland conditions that occurred historically (Heisler et al. 2003, Briggs et al. 2005).

Rachel Laubhan/FWS

Insects thrive in Quivira Refuge plant communities.

Presettlement Conditions

Küchler (1974) characterized potential natural vegetation for Kansas at a landscape scale. Based on that report, Quivira Refuge's potential natural vegetation includes: saltmarsh (saltgrass–seepweed), floodplain vegetation (cottonwood–willow) and prairie cordgrass, and sand prairie (bluestem–sandreed). While historical surveys vary with respect to the presence of little, or no, woody vegetation, there seems to be agreement that woody vegetation was not a dominant feature, and trees were generally cottonwood and willow (Wilcox 1870, Gates 1937, Thompson 1871, unpublished refuge reports on file at Quivira Refuge headquarters, Stafford County, Kansas).

Küchler's vegetation descriptions, relevant to refuge lands, are provided in table 3. More detail on ecological site potentials are provided by the soil survey staff (2010), which were used to describe potential presettlement conditions of refuge lands in figure 8 and table 4 (Heitmeyer et al. 2012).

Table 3. Vegetation descriptions for Quivira National Wildlife Refuge, Kansas.

Küchler's classification	*General description*	*Major plants*	*Other characteristic parts*	*Location (Kansas and landscape)*
Saltmarsh	Dense to open stands of short-to-medium-tall grasses, few forbs	*Dominants*: saltgrass, seepweed *Local Codominants*: spikerush, three-square, prairie bulrush, prairie cordgrass, alkali sacaton	Wood bluegrass, western ragweed, prairie dogbane, white heath aster, woolly-fruit sedge, Canada wildrye, foxtail barley, inland rush, plains bluegrass, tall or yellow knotweed, drooping bulrush, sea purslane	Alkaline, periodically flooded depressions in central and north-central Kansas

Table 3. Vegetation descriptions for Quivira National Wildlife Refuge, Kansas.

Küchler's classification	*General description*	*Major plants*	*Other characteristic parts*	*Location (Kansas and landscape)*
Floodplain vegetation (western and central Kansas)	*Savanna*: tall, medium-tall, and low broadleaf deciduous scattered trees and shrubs with "impoverished" bluestem prairie understory *Freshwater marsh*: dense stands of tallgrasses with forbs common but not prominent	*Dominants*: cottonwood, peachleaf willow, and, in eastern Kansas, black willow and American elm *Codominant in western Kansas*: sandbar willow *Dominants*: prairie cordgrass	Nearly 30 species and combined species found in eastern and western Kansas *** Wood bluegrass, big bluestem, rice cutgrass, whitegrass, Michigan lily, Virginia bunchflower, switchgrass, cup plant or squarestem rosinweed, hardstem and softstem bulrush, Indiangrass, eastern gamagrass, broadleaf or common cattail	Floodplains and streambanks with permanent and intermittent flooding (note differences in eastern and western Kansas) *** Shallow depressions of floodplains, periodically flooded or with high water table; common in eastern Kansas and in bluestem prairie
Sand prairie	Medium dense stands of grasses that are medium-tall to tall, forbs common	*Dominants*: big bluestem, little bluestem, sandreed, switchgrass	Sand bluestem, field sagewort, sand milkweed, sideoats grama, sandbur, sand lovegrass, umbrella plant, field snakecotton, flaxflowered gilia, prairie sunflower, golden aster, roundhead lespedeza, fourpoint evening primrose, sand paspalum, chickasaw plum, hardstem and softstem bulrush in wet spots, sand dropseed, and broadleaf or common cattail in wet spots	Sandy sites in south-central Kansas

Source: Küchler 1974.

Table 4. Hydrogeomorphic relationship of historical distribution of vegetation communities or habitat types to geomorphic surface, soils, and hydrological regime in the area of Quivira National Wildlife Refuge, Kansas.

Habitat type	*Geomorphic surface*	*Major soil types*	*Flood frequency**
Sandhills	Dune sands	Tivin	OP
Sandy grassland			
(Beach ridge)	Beach ridge	Pratt–Tivoli	OP
Saltmarsh	Alluvial or lacustrine depressions	Soil survey geographic database marsh	SGD, ROB
Saltgrass	Depression fringes	Plevna	SGD, ROB
Seasonal herbaceous	Alluvium depressions	Aquoll, Waldeck	Seasonal surface
Riparian creek corridors	Rattlesnake Creek corridor	Varied, sand	Continual creek flow
Subirrigated saline grassland	Alluvium	Abbyville, Natrisols	SGD, OP
Subirrigated nonsaline grassland	Alluvium	Dillhut–Plevna, Hayes–Solweg, Dillwyn, Zenda	GD, OP
Upland sandy grassland	Dune sands	Canadian, Carwille, Naron, Pratt, Tivin–Dillhut	OP
Upland clay or loam Grassland	Dune loess, loam	Farnum, Tabler	OP

* OP—mostly onsite precipitation; SGD—saline ground water discharge; GD—ground water discharge with low salinity; ROB—Rattlesnake Creek overbank and backwater surface flows; Seasonal surface—mostly seasonal surface water runoff and minor creek overbank flooding, relatively fresh or slightly brackish water; Continual creek flow—sustained flows in Rattlesnake Creek.

Sources*:* relationships were found on land cover maps prepared for the Government Land Office survey notes taken in the late 1800s, historical maps and photographs, current and historical U.S. Department of Agriculture soil maps (Dodge et al. 1978, NRCS 2010), geomorphology maps, region-specific hydrology data (Fader and Stullken 1978, Sophocleous 1997, Jian 1998, Estep 2000, Striffler 2011), and various botanical accounts and literature (NRCS 2010, Ungar 1961).

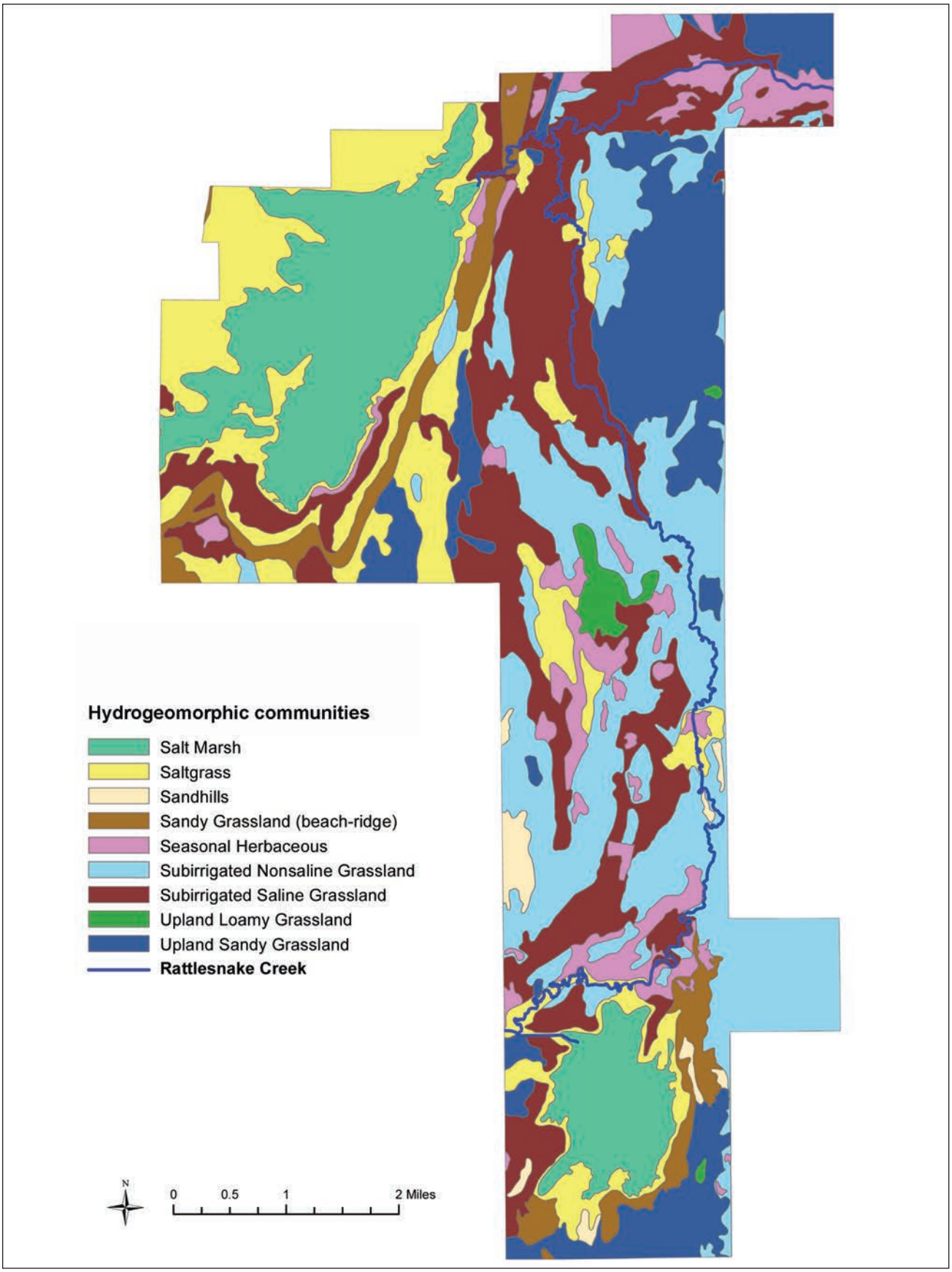

Figure 8. Potential presettlement conditions, Quivira National Wildlife Refuge, Kansas. *Source: Heitmeyer et al. 2012.*

Historical biological information on the saltmarshes of Quivira Refuge is extremely limited. There are a few aerial photos, drawn maps, and miscellaneous notes in published and gray literature. However, hydrologic inputs to the LSM historically occurred only from periodic overbank flooding of Rattlesnake Creek and from precipitation. It was not until the late 1920s–early 1930s that a ditch was constructed to divert Rattlesnake Creek flows directly into the LSM. Likely, this essential hydrologic change generated various short- and long-term transformations of the marsh ecosystem, such as water quantity and quality changes and the introduction or increased presence of carp. For example, at the time of refuge establishment, notes in Quivira Refuge's master plan suggest that the estimated size of the LSM was about 640 acres and its greatest depth was 4 feet. However, a comparison of aerial photographs ranging from the 1920s to today shows that the historical size of the marsh was much smaller (Heitmeyer et al. 2012).

During the 1958–1960 growing seasons, an intensive ecological study of vegetation in, and around, the BSM was conducted by Ungar with emphasis on salt tolerance and its resulting effects on plant distribution (1961, 1964, and 1965). At the time, the marsh covered parts of 12 sections, and water depths rarely reached 2–3 feet, partly because of constructed ditches that had been dug to control drainage before the refuge's establishment.

Seasonal fluctuations in water depth and quality in the BSM were because of characteristic sporadic rains and drying in July and August. The main source of salts in the BSM was found to be sodium chloride. Water and soil samples collected in 1959 and 1960 found similar monthly changes in chloride ion concentration and total salinity, and variability occurred among sampling sites. The lowest salinities occurred in the adjacent prairie and the highest salinities occurred in the barren salt flats, with a general increase in salinity values as the marsh dried in July. In the water, the chloride ion concentration range was equal to 0.008–1.65 percent, and the total salinity range was equal to 0.02–2.96 percent. In the soil surface from 0–3.94 inches (0–10 centimeters), the chloride ion concentration range was equal to 0.001–2.34 percent, and the total salinity range was equal to 0.003–2.96 percent. Salts were greater at the surface, from 0–3.94 inches (0–10 centimeters), than in the soil subsurface, from 23.62–27.56 inches (60–70 centimeters). Soil salinity had more of an effect on the distribution of rooted plants than water salinity, and extremes in salinities—where survival was equal to, or greater than, 1-percent salinity—were most limiting to plant distribution, when compared to averages. Ungar's research and other biological studies conducted since (Reinke 1981, Harris 1999) have identified many unique features of Quivira Refuge's inland saltmarsh systems.

Fine-scale descriptions of lands where created wetlands now occur are limited, however, the following observations were noted from Quivira Refuge's original master plan (FWS 1962):

- In general, refuge infrastructure development was intended to increase the availability of water, such as coverage, depth, and duration, by converting temporally and seasonally flooded areas to more permanently flooded wetland types to help resources of concern at the time, which were primarily migratory waterfowl during migration.

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Prairie cordgrass is an important component of meadows on Quivira Refuge providing relatively taller conditions for wildlife.

- Unit 7 was a low sump area of about 15 acres fed from the LSM.
- Drainage from unit 11 went northeast through a natural channel.
- Units 14a and 14b occurred along an old creek channel, and dominant plants were alkali sacaton and saltgrass.
- Unit 16 was a natural sump dominated by alkali sacaton and saltgrass flats.
- Unit 21 was a natural low area in an old creek channel.
- Units 22 and 23 were natural ponds and depended on surface runoff for water, and both had a good history of waterfowl use, including dabbling and diving ducks.
- Unit 24, or Darrynane Lake, was an existing 16-acre impoundment on Rattlesnake Creek, part of an old hunting club property that had a washed concrete spillway.
- Unit 25 was a natural, low saltgrass–sacaton area between sand knolls.
- Unit 26 contained about 90 acres of good farmland.
- Unit 28 was surrounded by tallgrass to the south and east.
- Unit 34 was in a low area in a tallgrass pasture.
- The plan for Unit 44 was to have it drain into scattered sump areas on the flats to the north.
- Units 47 and 55 were saltgrass flats that characteristically flooded in spring and were used by 50,000 ducks in 3–4 inches of water.
- Units 48 had 75 surface acres and unit 49 had 100 surface acres.
- Unit 50 was an old hunting club property.
- Unit 57 was a natural lake called McCandless or East Lake.
- Unit 60 had a history of heavy duck use in late winter, indicating that it had some deep water and remained ice free longer than other wetland habitats.
- Unit 62 was covered by a dense stand of prairie cord grass.
- Dead Horse Slough was an existing slough at the time.
- The BSM was unit 72, and it was planned to be the storage unit for habitat area in the northwestern part of the refuge that was attractive to diving ducks like scaup, redhead, and canvasback.

Current Conditions

Since presettlement times and refuge establishment in 1955, more environmental changes have occurred on refuge lands (Heitmeyer et al. 2012). In 1954, a reconnaissance map of the area was completed that described cover types, associated dominant plants, and miscellaneous notes of vegetation conditions for the purpose of assessing property values before acquisition of lands by the Federal Government. Our refuge staff recently recreated the hand-drawn map of 1954 in a geographic information system (GIS) (figure 9) and recoded cover types to use as a general baseline cover map to facilitate its comparison with a recent vegetation map of refuge lands made in 2011 (figure 10). While important shifts in plant communities mapped in 1954 and 2008 are evident (table 5), results should be viewed with caution partly because of differences in the purposes for which the two maps were developed; methodologies, such as observer bias, minimum mapping unit, equipment, and technology; and environmental conditions occurring at specific points in time, such as certain days, months, years during relatively wet and dry periods.

Some of the more notable differences include: (1) an increase in the occurrence of nonnative and invasive species in both grassland and wetland communities; (2) an increase in the coverage of shrubs and trees, especially in uplands and riparian zones; (3) the establishment and spread of Phragmites and cattail in wetlands; (4) the extensive development of artificial infrastructure; (5) an increase in the area of surface water; and (6) indications of a decline in shortgrass species. However, the 1954 appraisal and other refuge reports described much of the refuge land area as being overgrazed at the time of establishment, and this grazing regime likely favored shortgrass over tallgrass species, as reported by Aldous (1935) in central Kansas.

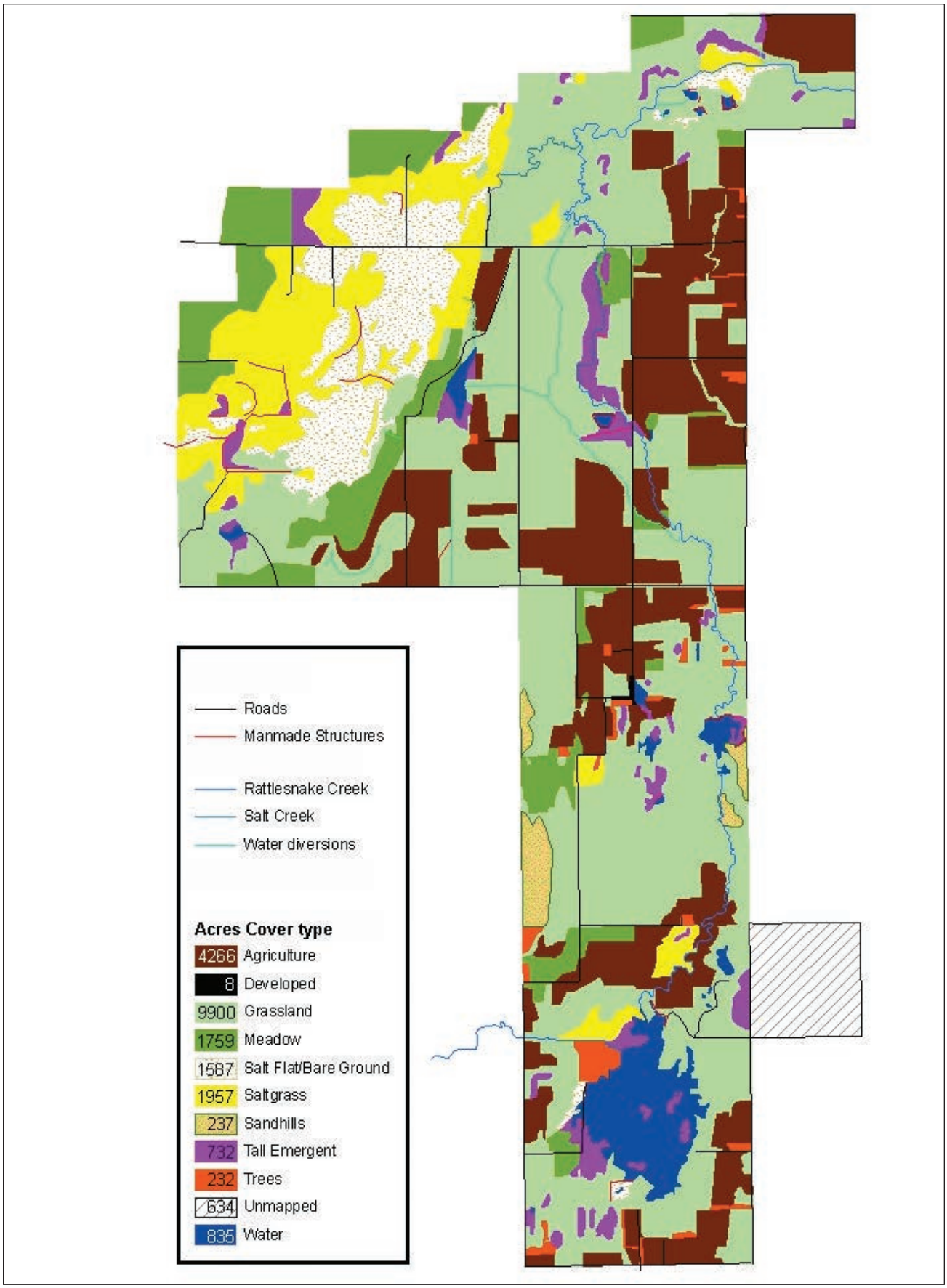

Figure 9. Vegetation cover types in 1954, Quivira National Wildlife Refuge, Kansas.

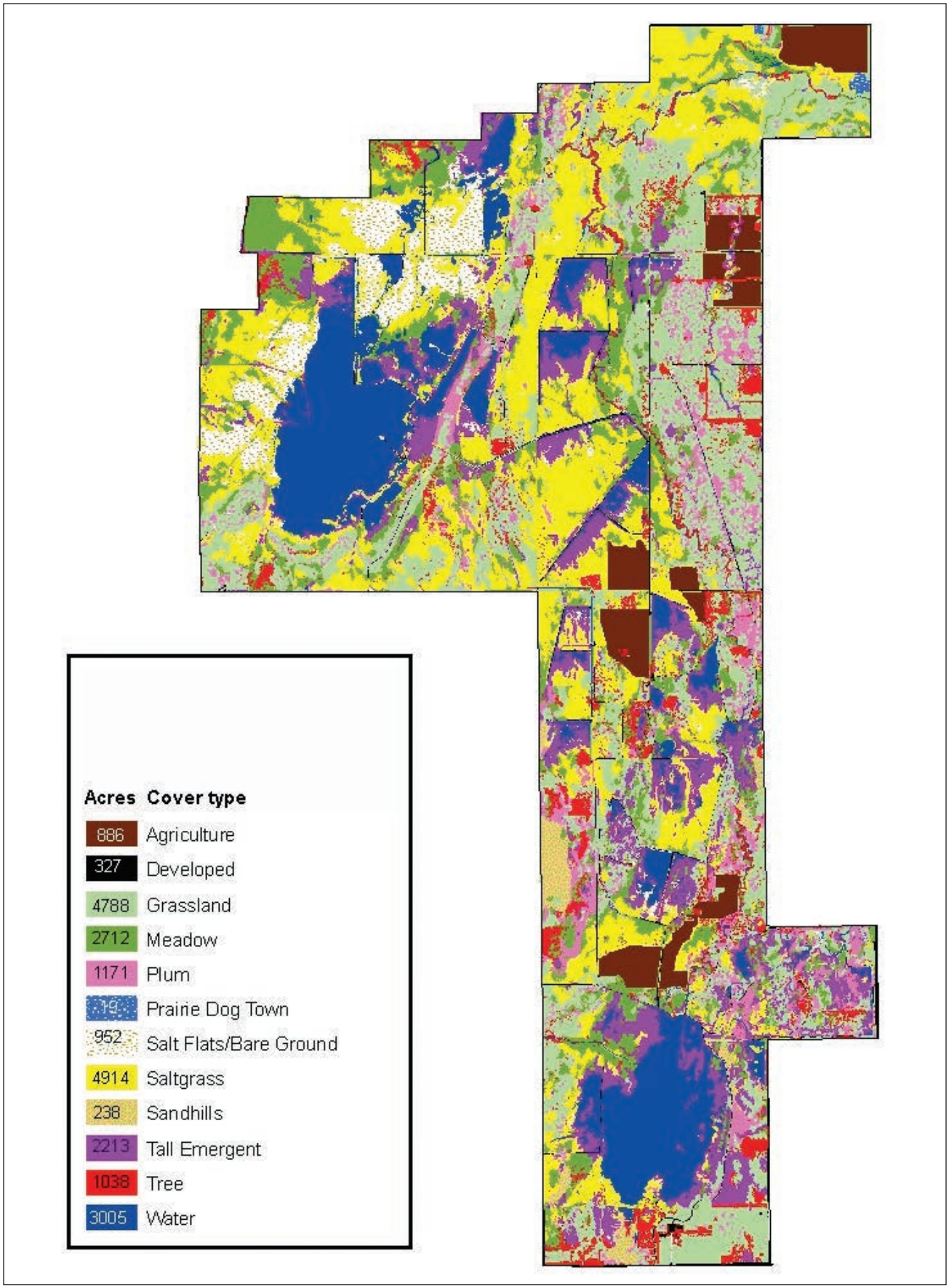

Figure 10. Vegetation cover types in 2008 (NVCS), Quivira National Wildlife Refuge, Kansas.

Table 5. Comparison of vegetation cover types between 1954 and 2011 on Quivira National Wildlife Refuge, Kansas.

Cover type	*Map**	*Descriptions (dominant plant species)*
Grassland	1954	big and little bluestem, switchgrass, Indiangrass, sand lovegrass, buffalograss, blue grama, sideoats grama, three-awn, sand dropseed, wild barley, wild rye, bluestem wheatgrass, panic grass, saltgrass (G1 and G2 symbols on original map)
	2011	big and little bluestem, switchgrass, Indiangrass, and less of other prairie grasses and forbs (sometimes lesser amounts of meadow species present)
Sandhills	1954	Sandhills with carrying capacity of >5 acres of cow and calf for 6 months because of low vegetation density. Based on our soil survey geographic database soil map, this is most of the Tivin fine sand with 10––30% slope sites on Quivira Refuge. (G3 symbol on original map is comprised of the Sandhills and Saltgrass cover types)
	2011	unmapped areas, polygons with >50% Tivin fine sand with 10–30% slopes (figure 7)
Saltgrass	1954	Saltgrass (G3 symbol on original map includes Sandhills and Saltgrass cover types)
	2011	Saltgrass
Salt flat, bare ground	1954	bare soil, mostly with alkaline salts (white) on surface (Af symbol on original map)
	2011	bare ground areas, some with alkali and sparse cover of saltgrass
Meadow	1954	little bluestem, Indiangrass, three-square, sedges, rushes (H symbol on original map, "wild hay")
	2011	Medium-short emergent plants, primarily prairie cordgrass, three-square, sedges, rushes (not tall bulrushes, sometimes lowland prairie grasses mixed in this cover type)
Tall emergent	1954	three square bulrush, hardstem bulrush, nutgrass [*Scirpus paludosus*], sedges, rushes (M symbol on original map; for Marsh, fresh; in swales and depressions and next to wetland areas)
	2011	cattail, Phragmites, tall bulrushes (mostly softstem bulrush)
Water	1954	surface water (W symbol on original map)
	2011	surface water
Trees	1954	mostly shelterbelt strips or groves near buildings and cultivated fields. One site with saltcedar on the delta where Rattlesnake Creek enters the LSM. Several groves of open, mixed oaks scattered in the "grazing type" (B, T symbols on original map)
	2011	black locust, tamarisk, cottonwood, Russian olive, Siberian elm, and some tall shrubs that were not plum
Plum	1954	not included in map description
	2011	sand plum with little coverage (<5%) of American plum and other shrubs
Agriculture	1954	farmed areas and few small sites that were primarily forbs (weeds)
	2011	farmed areas
Prairie dog towns	1954	not included in map description
	2011	active prairie dog towns

*The 1954 map was adapted to improve visual clarity. The current map used 2008 aerial photos that were ground truthed in 2010 and 2011 and was completed in 2011. Of note, descriptions of certain cover types are similar but not exactly the same for the 1954 and current maps. For instance, current "tall emergent" plant types are taller than what occurred in the past.

A recent inventory of refuge vegetation was completed in 2011, and approximately 22,262 acres of refuge lands were mapped to plant association classes. The inventory excluded a small tract of refuge land that occurs a few miles west of the main refuge boundary, but includes at least parts of boundary road areas, which accounts for the seeming discrepancy in refuge acreage. Protocol largely followed National Vegetation Classification System (NVCS) standards (Federal Geographic Data Committee 2008) and other guidance. The minimum mapping unit of the aerial photos was 0.5 acre, but ground truthing only included plum stands 0.2 acre or greater. Ground truthing used 2008 aerial photographs and was conducted in 2010, which was relatively wet, and 2011, which was relatively dry. Thus, it is presumed that certain plant species were more conspicuous under wetter conditions and other species were more conspicuous under dry conditions. A plant key was used to classify different combinations

of 20 herbaceous, 5 shrub, and 15 tree-dominant plant species into suitable categories, which resulted in the identification of 43 vegetation associations (table 6) (Farr and Laubhan 2011).

Based on this inventory and on estimates from summed GIS acreage data, Quivira Refuge is comprised of the following association types: 48.6 percent (10,819 acres) herbaceous wetland zones, 13.5 percent (3,005 acres) open water, 22.0 percent (4,898 acres) grassland, 6.6 percent (1,469 acres) shrubland, and 3.9 percent (868 acres) riparian area and upland woodland categories combined. It is important to understand that this coverage estimation is scale dependent. For instance, shrub associations were only classified as such if stands were equal to, or greater than, 0.2 acre and shrub coverage was equal to, or greater than, 50 percent. This minimum mapping unit was chosen because it was reasonable for both mapping and for our management planning and implementation. Therefore, smaller shrub stands may exist that are mapped as grassland. Similarly, existing ephemeral or seasonal wetlands measuring less than 0.2 acre were classified as different herbaceous and woodland associations of which they were a part. The most abundant plants for each association type were: saltgrass, cattail, and three-square in wetlands; little bluestem, switchgrass, and Indiangrass in grasslands; plum and saltcedar—also considered a small tree—in shrubland; and locust, Russian olive, and cottonwood in forest or woodland.

Table 6. National Vegetation Classification System (NVCS) associations, Quivira National Wildlife Refuge, Kansas.

Vegetation associations	*Acres*	*Hectares*
Boxelder woodland	0.3	0.1
Agriculture vegetation	885.9	358.5
Tree-of-heaven forest	7.8	3.1
Big bluestem–helianthus herbaceous vegetation	551.2	223.1
Big bluestem–western Great Plains herbaceous vegetation	426.4	172.6
Sand bluestem herbaceous vegetation	62.5	25.3
Bare ground	18.9	7.6
Black-tailed prairie dog town grassland complex	18.9	7.6
Cheatgrass seminatural herbaceous vegetation	82.1	33.2
Northern catalpa forest	11.9	4.8
Hackberry woodland	0.6	0.3
Roughleaf dogwood shrubland	22.7	9.2
Inland saltgrass herbaceous vegetation	4926.1	1993.5
Russian olive woodland	29.2	11.8
Spikerush fascicularis herbaceous vegetation	329.3	133.3
Green ash forest	3.1	1.3
Kentucky coffeetree forest	16.2	6.6
Eastern redcedar seminatural forest	85.4	34.5
Osage orange woodland	5.6	2.3
Mullberry woodland	8	3.3
Switchgrass vegetation	431.8	174.8
Switchgrass–Indiangrass vegetation	1245	503.8
Common reed western North American temperate seminatural herbaceous vegetation	72.5	29.3
Plains cottonwood–black willow forest	389.5	157.6
Plum shrubland	1231.1	498.2
Fragrant sumac shrubland	28.1	11.4
Riverine sand flats–bar sparse vegetation	936.3	378.9
Black locust or honeylocust forest	253.8	102.7
Sandbar willow or mesic graminoids shrubland	57.1	23.1
Soapberry woodland	1.6	0.6

Table 6. National Vegetation Classification System (NVCS) associations, Quivira National Wildlife Refuge, Kansas.

Vegetation associations	*Acres*	*Hectares*
Little bluestem–sideoats grama western Great Plains herbaceous vegetation	2058.8	833.2
Common threesquare herbaceous vegetation	1107.6	448.2
Softstem bulrush semipermanently flooded herbaceous vegetation	167.9	68
Softstem bulrush–cattail herbaceous vegetation	366.9	148.5
Prairie cordgrass –spikerush and sedge herbaceous vegetation	1293.6	523.5
Saltcedar seminatural temporarily flooded shrubland	126.4	51.2
Cattail Great Plains herbaceous vegetation	1615	653.6
American elm woodland	1.9	0.8
Siberian elm woodland	50.6	20.5
Para grass herbaceous vegetation	2.8	1.1

The Boiling Springs has an artesian well and an associated freshwater habitat of small streams and pools that form a few acres. In the area of the artesian well, water cress is abundant as well as a source population of State-threatened Arkansas darters. All of our alternatives in this CCP and EA suggest the need to further evaluate potential future management to support the Arkansas darters. Besides mapped vegetation associations, other important factors to consider include the current existence of a pipe where water from the spring flows to the surface and increasing woody vegetation. The pump remains from an oil well that has been removed, and it is unknown if the removal of the pipe would result in more springs or if habitat suitability would increase for the Arkansas darter. Increasing woody vegetation in the area may also create changes in water quality or habitat use. A beaver downed one large tree in 2011, creating a dam in the area where Arkansas darters live. Casual observations suggest that larger pools in the area would encourage use by predator fish, such as the green sunfish, and that would likely adversely affect Arkansas darter populations.

Wildlife Communities

This sections includes details on the various wildlife communities found on Quivira Refuge

Status and Trends of Wildlife Communities

While national wildlife refuges are managed for wildlife first, a particular refuge cannot be managed for all associated wildlife every year. Habitat conditions constantly change over time generally favoring a broad diversity of wildlife species. Thus, planning that evaluates trade-offs in management effects on wildlife at various spatial and temporal scales may better sustain native communities.

As part of this process, various regional and national conservation plans and species of concern lists are considered collectively within the context of the refuge bird list and other relevant local conservation factors such as: (1) the refuge purposes and relevant policies and mandates; (2) a species native or nonnative status; (3) species population trends; (4) species range distribution in relation to refuge location; (5) species current and potential occurrence on refuge lands; (6) species tolerance of grassland fragmentation, urbanization, and agricultural activities; and (7) the availability and condition of habitat outside refuge boundaries. A detailed analysis of species tolerance of grassland fragmentation is presented in appendix H. Collectively, these considerations helped us to develop a list of priority management species we call focal species (table 3).

Presettlement Conditions

Consideration of changes in wildlife since presettlement is important for understanding the full range of native habitat conditions and for evaluating current management potential. For instance, knowledge of native species life needs and behavior may be used to describe what the environment used to look like and how it functioned. Many native herbivores and predators that were an inherent part of the historical natural system no longer occur on refuge lands or in the region, and, consequently, their absence likely has altered fundamental ecosystem processes. For example, grazing or browsing by bison, pronghorn, elk, and prairie dogs in central Kansas used to variably influence many indigenous prairie plants and wildlife

that have unique adaptations, and now their roles or functions are only partially replaced by domestic cattle, sheep, or goats.

Similarly, the use of prescribed fire and artificial manipulation of hydrology do not completely mimic the historical frequency, intensity and magnitude of historical fires and water movement on the landscape. Thus, complete restoration of historical processes and associated native plant and wildlife community will not be possible regardless of the alternative we select in this CCP and EA, however, the extent to which restoration will occur differs among the alternatives. In managing for wildlife, strategies may be used for various purposes, including compensating for one, or more, of the many long-term, or permanent, imbalances that have been created in the landscape.

Conditions of wildlife communities since refuge establishment have not been summarized, but have been recorded in the refuge master plan, annual narratives, and other files and documents. Of particular relevance to our alternatives, the deer count on the refuge at the time of establishment was less than 20, and turkey were not present. Also, the master plan showed our intention to manage habitat to encourage use by greater prairie-chickens, noting their former occurrence on refuge lands and their absence in the early 1950s. Because birds are a primary focus of the Refuge System and changes in communities have been many and complex, it is worth referring those interested in more details to a discussion by Johnsgard (2009) of the changes in bird communities and range distributions over the past three decades.

Current Conditions

The refuge is recognized nationally and internationally for its importance in wildlife conservation. Quivira Refuge is a Ramsar Wetland of International Importance, a Western Hemisphere Shorebird Reserve Network site, and a Globally Important Bird Area. The most current inventory of Quivira Refuge wildlife is provided in appendix G, but some highlights are described below.

Birds

More than 300 species of birds are thought to use Quivira Refuge. Some main attractions for visitors to the refuge are spring and fall bird migrations that include hundreds of thousands of geese and ducks, more than 30 species of shorebirds, many sandhill cranes, and the occurrence of rare species, such as the whooping crane, interior least tern, and snowy plover. Quivira Refuge wetlands provide migration and wintering habitat used by large populations of Canada geese, greater white-fronted geese, and, increasingly in recent years, snow geese. From 2009 to 2010, more than 11,000 ducks, 300,000 Canada geese, 402,500 white-fronted geese, and 425,000 snow geese were estimated to visit the refuge on independent, bimonthly survey dates. More than half of the fall surveys in 2009–2010 and 2008–2009 showed use by more than 20,000 geese, and three of the fourteen 2009–2010 surveys each reported more than 30,000 sandhill cranes. From 2002 to 2006, an annual average of more than 30,000 shorebirds were counted on Quivira Refuge during biweekly migration surveys (Hands 2008). In 2010, biweekly data counted 55,491 shorebirds on the refuge during the migration periods surveyed. With Cheyenne Bottoms Wildlife Management Area only about 30 miles away from the refuge and with high local variation in weather patterns, many birds rely on both areas to acquire necessary life resources. It has been suggested that these areas, combined, often hold more than 90 percent of the world's population of such species as stilt sandpipers and white-rumped sandpipers.

While many rare birds may be observed at Quivira Refuge, some receive much more attention than others. Whooping cranes are usually observed in small family groups during migration on Quivira Refuge. In recent years, the highest recorded season total for whooping cranes observed using areas on and near the refuge is 91 in the spring and 112 in the fall. Thus, the relative importance of the refuge to whooping cranes during migration is substantial, considering that the population in recent years has ranged from approximately 250 to possibly 300 during the winter of 2011–2012. Whooping cranes may stay on the refuge for up to 5 to 6 weeks in the fall, but spring migration stays are typically shorter and last from several days to weeks. Bald eagles are also a common wintering attraction, with a high of 204 eagles reported on the Quivira Refuge during the Christmas Bird Count in 2010. Only recently has one bald eagle pair been reported nesting on the refuge,

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Harris' sparrow, reported on Quivira Refuge, has been identified as a priority species by the Great Plains Landscape Conservation Cooperative.

and they successfully fledged two young annually during 2010 and 2011. Quivira Refuge is one of the few sites in Kansas with nesting black-necked stilt, interior least tern, snowy plover, and various rail species. Production of interior least tern on Quivira Refuge fluctuates, but colonies of equal to, or greater than, 10 nesting pairs are common, and young raised to flight stage has been as high as 36 to 40 individuals. More information on threatened and endangered species and other species of concern may be found in the appendixes.

Quivira Refuge is primarily a migration refuge, but, as shown above, many birds use habitat for nesting as well. Of the birds reported nesting on Quivira Refuge, 23 species are considered Birds of Management Concern (FWS 2008a). Of these, 13 species are Birds of Conservation Concern in Region 6, and 11 species are Birds of Conservation Concern in Bird Conservation Region 19, Central Mixed-grass Prairie (FWS, Mountain–Prairie Region 2008a). For a comparison, the total number of birds listed as Birds of Conservation Concern for Region 6 and Bird Conservation Region 19 include 43 and 16 breeding species, respectively. Based on available published information on how climate affects bird breeding in the region, most nesting activities begin in April and extend to August. But, bird use and timing of different breeding events vary within, and among, community types. Because management of wooded habitat is a current topic of interest in considering alternatives, it is important to note that many nesting bird species associated with wooded habitat on the refuge are generalists that have not exhibited population declines and may occur in more than one habitat type or have benefited from the expansion of urban and residential areas or constructed habitats like bridges, nest boxes, and farmland.

The presence of upland grassland passerines on Quivira Refuge is often overshadowed by the more easily identifiable and popular wetland-associated birds. However, many of these species are adversely affected by increasing woody vegetation, and refuge management has traditionally struggled with successfully reducing trees and shrubs to levels more characteristic of natural prairie. Some of the more common native passerines that characteristically breed on the refuge include: upland sandpiper, both eastern and western meadowlark, bobolink, dickcissel, grasshopper sparrow, field sparrow, lark sparrow, and brown-headed cowbird.

Many of the species associated with woodlands on refuge lands have benefited from human modifications to the landscape (table 7).

Table 7. Observed woodland bird use at Quivira National Wildlife Refuge, Kansas.

Bird species	*Woodland units*												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
wood duck		X											1
wild turkey		X							X				2
great blue heron					X								1
green heron		X											1
yellow-crowned night-heron									X				1
Mississippi kite									X				1
bald eagle											X		1
Cooper's hawk									X				1
red-tailed hawk											X	X	2
American kestrel					X								1
mourning dove												X	1
yellow-billed cuckoo	X	X		X					X			X	5
eastern screech owl	X	X					X		X				4
great horned owl		X		X	X		X						4
barred owl	X				X				X				3
chuck-will's widow									X				1
chimney swift					X								1
red-headed woodpecker												X	1
red-bellied woodpecker	X	X			X			X	X				5
downy woodpecker	X	X		X	X		X	X	X				7

Rachel Laubhan/USFWS

Egrets and Ibis

Table 7. Observed woodland bird use at Quivira National Wildlife Refuge, Kansas.

Bird species	*Woodland units*												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
hairy woodpecker	X	X			X			X	X				5
northern flicker		X					X	X	X				4
eastern wood-pewee	X							X	X			X	4
great crested flycatcher	X	X	X	X	X	X	X	X	X	X			10
western kingbird												X	1
eastern kingbird												X	1
Bell's vireo											X		1
warbling vireo	X	X			X	X		X		X	X	X	8
red-eyed vireo	X	X							X				3
blue jay		X							X			X	3
American crow									X				1
black-capped chickadee	X	X							X				3
white-breasted nuthatch	X	X			X				X				4
Carolina wren	X				X				X				3
house wren	X	X	X			X	X	X	X	X		X	9
blue-gray gnatcatcher	X	X			X	X	X	X	X				7
eastern bluebird	X	X		X		X		X	X				6
American robin		X	X						X	X		X	5
gray catbird	X												1
northern mockingbird						X							1
brown thrasher	X		X						X	X		X	5
yellow warbler	X	X		X				X			X	X	6
field sparrow				X					X				2
Northern cardinal	X	X		X	X		X	X	X	X	X	X	10
indigo bunting	X	X		X	X				X				5
common grackle												X	1
orchard oriole				X				X				X	3
Baltimore oriole		X		X				X	X	X	X	X	7
American goldfinch						X		X				X	3
Total species	21	24	4	11	15	7	8	15	29	7	7	18	49

Mammals

There are many information gaps about mammal populations and habitat use on the refuge. However, casual observations, limited refuge studies, and available literature were used to develop a refuge species list—which may be found in appendix G—and to gain knowledge of refuge habitat–mammalian community relationships. For example, while small mammals are widely known as an important prey base for many birds characteristic of the prairie, certain species have unique associations with open, sandy environments, such as the plains pocket gopher, eastern mole, plains pocket mouse, and Ord's kangaroo rat.

Prairie dogs are well-known associates of Great Plains grasslands, especially in shortgrass and mixed-grass prairie, and there are two prairie dog towns on Quivira Refuge (figure 11). The expansion of prairie dog towns on the refuge is limited by the high ground water table. Roads, canals, and other artificial infrastructure factors likely influence ground water conditions in certain areas of the refuge, thereby restricting the prairie dog colonies to an area that is likely smaller than what occurred historically.

There are various species associated with habitat in and around wetlands, such as beaver and muskrat. The least and short-tailed shrew are often found in mesic, or lowland, prairie here. With increasing coverage of woody vegetation, it is likely that the mammal community has shifted from what historically occurred in this area. The nine-banded armadillo is one obvious addition since refuge establishment, though the population seems to be low. The various potential effects to the sand prairie system resulting from mammalian community shifts are largely unknown, but it is presumed that supporting species characteristic of this unique environment would also promote important functions, such as soil disturbance, plant dispersal, burrow production as habitat for various wildlife, and food web interactions.

In the early to mid-1800s, deer in Kansas generally occurred along wooded parts of streams and in large, timbered areas in the eastern part of the State (Sexson et al. 1985a). Deer were considered extirpated in Kansas in 1904, and were still largely absent in 1933. By refuge establishment in the mid-1950s, it was estimated that there were easily less than 20 deer in the area of the refuge. In other words, it was an extremely rare event, and exciting, to see a deer on refuge lands in the mid-1950s. Since refuge establishment, legal harvest of deer has not been permitted on the refuge. In 1960, it was noted that, "An occasional white-tailed deer was seen on the refuge area, deer observations were becoming more frequent, and that the manager saw three deer between January and April." (from refuge narrative on file at the refuge). By 1971, deer sightings were described as common, and about 100 deer were estimated to be using the refuge area during the summer months, with a buck-to-doe ratio of 1:3. By 1980, deer were described as being "frequently seen throughout the refuge" (from refuge narratives on file at the refuge). Results of a statewide, 1984–1985, landowner deer survey showed deer populations were increasing throughout Kansas (Sexson et al. 1985b). Results of spotlight surveys conducted on Quivira Refuge between 1989 and 2005 found continued, substantial increases in the deer population (Althoff et al. 2006). While hunting was occurring on private lands next to the refuge, the numbers of deer counted during the prerifle season were not greater when compared to numbers counted during rifle season and after. No data were collected that could be used to definitively explain the results. Researchers noted evident browse lines in wooded areas and concurrent declines in the percentage of does with twins, which is commonly linked to poor herd health. Recent and ongoing distance sampling documents extremely high deer densities in areas of the refuge—19 groups per square kilometer, or 41 individual deer per 0.39 square mile (1 square kilometer), (Blecha et al. 2011). However, preliminary results of a September 2011 assessment found sampled deer—5 bucks and 5 does from ages 1.5 to 7.5 years—were healthy.

Although deer numbers on the refuge at the time of establishment were less than 20, relatively intense studies of white-tailed deer have occurred on the refuge in recent years because of their increasing population. Among many findings, some, in particular, are worth noting for planning purposes: (1) surveys show high, localized densities of both groups—19 groups per square kilometer—and individuals—41 deer per 0.39 square mile (1 square kilometer), (2) doe survival rates are relatively high compared to bucks because of poaching and hunting; (3) deer prefer existing woodland canopy and canopy edge; (4) use of private land is substantially higher during fall and winter; (5) male deer use private land more than females during winter and summer; and (6) during winter, male deer are in closer proximity with other males, in comparison to female-to-male or female-to-female associations, (Blecha et al. 2011).

Observations and preliminary data from a deer health assessment conducted on Quivira Refuge in 2011 suggest the population is now healthy. However, woodland canopy edge and food plots and fields where deer congregate could be key habitats for potential future chronic wasting disease transmission (Blecha et al. 2011). Method of spread is unknown. Frequent contact between younger males suggests that management actions targeting that age class might cause reductions in contact rates and lessen the chance of disease transmission. Because

Barry Jones/FWS

Tiger Salamander

deer within the Quivira Refuge population extensively use private lands, researchers believe that management of deer would be most successful if conducted on both private and refuge lands.

Reptiles and Amphibians

Reptiles and amphibians, or herptile species, recently documented as occurring on Quivira Refuge include three toads, four frogs, one salamander, six turtles, two lizards, and 13 snakes; see appendix G. Other herptile species have reported distributions in the area, but have not been documented on Quivira Refuge. Of significance to us, many herptile species may spend their entire lives on refuge lands. Thus, our refuge management actions could substantially alter metapopulation dynamics —or the spatially separate populations—of these species.

Furthermore, changes in herptile communities may effectively show how our management affects them, depending on the objectives. For instance, amphibians are often used in research and monitoring programs as sensitive indicators of water quality. At the same time, observing herptiles is not always easy, because many species spend considerable time underground, or have active periods that vary seasonally or that occur at night.

Like many birds and mammals, several herptiles have associations with open prairie, loose sandy soils, and wet environments that are characteristic of Quivira Refuge, such as Great Plains and Woodhouse's toads, yellow mud and spiny softshell turtles, lesser earless and prairie lizards, Graham's crayfish snake, western plains garter, and eastern and western hognose snakes. The six-lined racerunner and ornate box turtle are particularly abundant in sand or open prairie, and the latter is commonly observed on the refuge. The western massasauga is only abundant in a few locations in Kansas, one, of which, is the refuge.

Fish

Management of fish communities on the refuge is largely constrained by the species that enter it via Rattlesnake Creek. Those who frequently fish the LSM report that carp and channel catfish are common. A published survey of Rattlesnake Creek fish that included areas on, and near, the refuge found that the upper parts of the stream with low chloride concentrations supported communities dominated by red shiners or common carp; and lower, more saline, parts of the stream supported communities dominated by plains killifish (Eberle et al. 1996). Fathead minnows and sand shiners were other common species found in samples.

Arkansas darters were documented in the area of the Boiling Springs. The presence of a healthy source population of Arkansas darters at the Boiling Springs area was confirmed through observations of many fish of different ages by local experts in 2011. Casual sampling of Quivira Refuge creek and spring habitat by local experts in 2011 also found river carpsucker, mosquito fish, black bullhead, green sunfish, bluegill, and one goldfish.

Other

There are 10 species of crayfish reported to occur in Kansas (Ghedotti 1998). The northern crayfish is distributed throughout Kansas and is the most commonly observed species in streams (Ghedotti 1998). A baseline survey of crayfish species is unknown for Quivira Refuge, but crayfish and their burrows are a common occurrence. Various birds, fish, reptiles, amphibians, and mammals, eat crayfish, and many of them also compete with crayfish for food. Crayfish have been reported as a potential food item of whooping cranes (Armbruster 1990) and various waterbirds (Huner 2000). Reptiles and amphibians use crayfish burrows as shelter (Collins et al. 2010).

Other wildlife, such as butterflies, are listed in appendix G. Past refuge inventories of other wildlife are incomplete or nonexistent, and efforts to expand inventories have occurred in recent years. However, much remains to be learned of these species and associations on Quivira Refuge.

Federally and State-Listed Species

Quivira Refuge habitats support Federal and State threatened and endangered species, Federal candidate species, and State Species in Need of Conservation, including those species with designated critical habitat on the refuge and those that most commonly depend on refuge resources (table 8).

Table 8. Threatened and endangered species and species of concern, Stafford County, Kansas.

Species	*Federal status*	*State status*
Whooping crane*	endangered (CH)	endangered (CH)
Interior least tern*	endangered	endangered (CH)
Eskimo curlew	endangered	endangered
Piping plover	threatened	threatened (CH)
Arkansas darter *	Federal candidate species	threatened (CH)
Lesser prairie-chicken	Federal candidate species	
Sprague's pipit	Federal candidate species	
Western snowy plover *		threatened (CH)
Eastern spotted skunk		threatened
Plains minnow		threatened

* Those species that most commonly depend on refuge resources

CH indicates species with designated critical habitat on Quivira Refuge lands.

State Species in Need of Conservation that occur in Stafford County include: black rail, black tern, bobolink, Chihuahuan raven, eastern and western hognose snake, ferruginous hawk, glossy snake, golden eagle, long-billed curlew, mountain plover, short-eared owl, southern bog lemming, and whip-poorwill. In general, habitat conditions on Quivira Refuge should be suitable for most of these species, though several are not known to regularly use the area.

The KDWPT (2011) periodically updates descriptions and State distributions of species that are State listed or are of management concern. Information on status and occurrence of these species on the refuge are available in appendix G. Additional information is available on listed species and associated information for Stafford County (FWS 2012c, KDWPT 2011).

3.3 Management Tools

We use prescribed treatments to manage habitat primarily to promote the long-term sustainability of native wildlife and their associated ecosystems.

Native prairie vegetation and wildlife of the Great Plains evolved with periodic ecological disturbances from herbivory in the form of grazing, fire, flooding, drought, wind, ice, and other natural forces. In other words, long-term ecosystem sustainability is dependent on periodic disturbance. Landscapes, increasingly, have not incurred their characteristic, historical disturbances largely because land uses have been altered and concerns of human safety have arisen as human populations have grown. For example, wildfires generally do not grow large and burn across millions of acres of prairie, huge herds of bison do not migrate across the plains, and streamflow peaks and lows are relatively less dynamic.

A primary purpose of management uses on refuges is to conduct strategies that produce effects similar to historical disturbances to support, or restore, ecosystems. Quivira Refuge uses various management strategies to accomplish goals and objectives that promote a diverse plant community dominated by native vegetation that supports many different migratory and resident wildlife species. Management uses carried out in recent years include combinations of rest; water management; prescribed grazing and fire; mechanical treatments such as mowing, haying, farming, or tree cutting; and chemical use for control of exotic or invasive species (FWS 1994).

But, human-caused landscape changes and our management affect how uses are carried out. For example, some disturbance types are used more frequently than what occurred historically to control invasive plants or nonnative plants that have different tolerance thresholds than native species. Flooding is highly controlled on the refuge to regularly provide required resources for waterbirds and other wildlife, and wetlands have been created and altered. Brief overviews of primary refuge management uses are provided below.

Rest

For planning purposes, rest is a product of management decisions related to disturbance frequencies. In this case, we use this term to refer to the time when we choose not to graze, flood, drain, burn, or otherwise directly affect an area using an active form of management. It is important to recognize rest as a management use because community responses to prairie stressors, such as grazing, burning, and climate, are inherently variable in space and over time (Helzer 2010). Thus, management actions may produce changes in communities that last years, even during "rest," while natural forces also continue to occur. As referenced throughout the document, allowing many years of rest from disturbance in Great Plains grasslands runs contrary to natural ecosystem processes and may lead to adverse habitat conditions, such as the invasion by woody species and

an excessive accumulation of standing dead plant material that inhibits new plant growth.

Water Management

Water management on Quivira Refuge has been used to provide food and different types of habitat for waterbirds and other wetland-dependent wildlife throughout the year. Even before the refuge's establishment, water was impounded by various duck clubs to promote the area's use by waterfowl. Development of refuge infrastructure has occurred over decades, generally following the original refuge master plan.

Water management involves an extensive system of impoundments and dikes, canals, and associated control structures (figure 5). Maintaining water control infrastructure is essential for us to manage the refuge efficiently, and system operations, such as manipulating water levels, can be time-consuming and planning intensive.

Prescribed Fire

Historical prairie fires of the central Great Plains have been described as occurring about once every 3–4 years in tallgrass areas and once every 5–8 years in mixed-grass prairie, and they ranged in size from less than 0.25 acre to millions of acres (Helzer 2010). Fire characteristics and its resulting effects are dependent on fuel, weather, and topographic conditions at the time and place of ignition, and, historically, there were few natural fuel breaks in the open prairie and no suppressions by humans. Fire influences environmental conditions, such as light, moisture, and nutrients, that affect plant competition and wildlife use and promotes biodiversity and health, such as through increased nutrient cycling, the reduction in the amount of residual and woody vegetation, and by decreasing the potential effects of certain insects and of certain diseases caused by moisture and nutrient stress.

Over the past century, aggressive wildland fire suppression and the lack of prescribed fire implementation in the prairie have resulted in unnaturally altered habitats. Fire exclusion and the substantial increase of agricultural land uses are two major factors that are undoubtedly responsible for the declining abundance of some wildlife species.

Prescribed fire is now used in all major habitat types on the refuge to achieve fire program objectives involving both hazardous fuel reduction and habitat management. Prescriptions require specific procedures that set priorities for human safety, and, therefore, particular environmental and fire-behavior parameters regulate when burning may, or may not, occur to accomplish habitat objectives. In recent years, prescribed fire has been conducted on about a third of the refuge each year. There are 15 predefined fire treatment units, several, of which, may be further subdivided into 2–4 smaller units, using natural and constructed features to decide boundaries, such as water units and roads. For individual prescribed burns, boundaries may also be adjusted based on changing conditions, such as moisture, vegetation, and adjacent treated areas, to meet our refuge management objectives and to maximize safety and efficiency considerations associated with the prescription.

Because most of the available fuel within the refuge is grass, fires consume the fuel and go out quickly. Overall, fuel load varies by soil type and disturbance history, often ranging from 2,500 to at least 8,000 pounds per acre. Grass and forb responses vary because of the time of year, intensity, and duration of the fire, but they most often reestablish in place of woody vegetation. Other fuel types are present on the refuge, but they are seldom contiguous enough to be the primary carrier of fire. Between mid-October and mid-May, fuel in the form of dead grass and marsh vegetation is present in amounts that are greater than 2 tons per acre, or 4,000 pounds per acre. While fire generally results in little wildlife mortality, a large wildfire during drought conditions or occurring late in the growing season could reduce cover and forage availability for wildlife to the point that would increase mortality, especially if cover and forage are limited in the larger landscape, a situation that seldom occurs. All wildfires occurring on the refuge are now suppressed.

Grazing

Prescribed grazing on Quivira Refuge, usually involving cattle, consists of the clipping and removal of plant parts and soil disturbance caused by associated hoof action. As with other treatments, the main parts of grazing are timing and intensity. Its effects vary by timing in relation to climate influences on plants, the frequency and duration that plants are exposed to grazing, the number and type of livestock involved, environmental conditions, management history of the site, and infrastructure such as fence configuration and the distribution of water sources.

Specific plans are developed for each grazed area of the refuge, but they may change annually, or more frequently, depending on conditions. Traditionally, grazing occurs on the refuge between April and Sep-

tember or October, but it may occur earlier to control cattail growth or cheatgrass. Maintenance grazing periods typically last 5–7 consecutive days. More intensive, restoration grazing may occur onsite, such as when controlling large, dense stands of cattail.

Mechanical Treatments

A variety of mechanical treatments are used on Quivira Refuge.

Haying, Mowing, Tree cutting

These management uses are used to remove the buildup of residual vegetation in grasslands and wetlands or to manage the coverage of invasive woody vegetation. As with other mechanical activities, guidance and policy is appropriately followed to help avoid disturbing breeding birds. Timing and other considerations are made to encourage our desired plant species and habitat conditions and to discourage undesirable plant species.

Farming, such as Plowing, Disking, Planting, and Harvesting, and Restoration Activities

Many acres on the refuge were farmed before its establishment. Afterward, farming on poorer soils was retired, and those acres were replanted with native seed. In the 1960s, during the time of refuge development, there were about 2,500 acres under cultivation on the refuge to primarily provide supplemental grains and browse foods for migrating waterfowl. For decades, cropland management consisted of cooperative farmers conducting a winter wheat–milo–fallow crop rotation using strips 50–1,000 feet wide. Traditionally, a quarter-to-one-third of the total crop shares have been either sold or left in the field as the refuge crop shares. Even in the 1980s, it was estimated that refuge grain fields provided less than 10 percent of foods needed to support waterfowl use and that surrounding lands were a much greater source of grain and browse foods for wildlife.

There are 885.24 acres of refuge lands dryland farmed through cooperative agreements with local farmers. Acreage of farmed land on the refuge has been gradually decreasing, partly because of the low productivity of crops. Also, since establishment, there has been a shift in the understanding and need of refuge crops to supplement wildlife food resources. As refuge lands are retired from farming, management starts activities, such as the treatment of noxious weeds and the seeding of desired plants, to encourage the restoration of native vegetation. Genetically modified crops have never been used on the refuge, but current policy allows for the future use of such crops to reestablish native plants.

Disking of Wetlands

Disking is sometimes used in dry wetlands to stimulate the germination and growth of desired plants during subsequent flooding, or to manage undesirable conditions, such as cattail growth.

Chemical Treatments

The application of chemicals is used to effectively manage undesirable plants, such as exotic, noxious weeds. Use of chemicals on the refuge follows required guidance and policy with an approved integrated pest management plan and with annual pesticide use proposals that provide specific guidance on the use of herbicides.

3.4 Human History and Cultural Resources

This section describes what is known about the human history and cultural resources of the refuge.

Prehistoric Resources

Available archaeological studies used certain methods to date artifacts that suggest native people first occupied the south-central Kansas region 10,000 to 12,000 years before the present (Buller 1976). These people had a highly mobile lifestyle that depended largely on big game hunting. About 9,000 years before the present, regional patterns of human use began to change in response to regional climate fluctuations and increasing populations of people. Archaeological evidence suggests that these changes included more localized, less mobile, population centers and a greater diversity of tools.

Prehistoric Occupation

Certain dating methods suggest that by about 3,000 years before the present, larger campsites that

received repeated use occurred along floodplains of the Arkansas River and, presumably, Rattlesnake Creek. Inhabitants of the area collected wild plants, hunted large and small animals, and created chipped and ground tools. Human populations in south-central Kansas continued to increase and, by about 2,000 years before the present, small villages were established, and there is evidence that early agriculture was present along some waterways.

Protohistoric and Historic Native Americans

When the Spanish explorer Don Francisco Vasquez de Coronado reached the region in 1541, several Native American groups were present in central Kansas, including the Pawnee, Wichita, Plains Apache, Kansa, Kiowa, and Osage (Grajeda 1976, Wedel 1942). Throughout recorded early history, native people were attracted to the Quivira Refuge region because of the presence of salt, camp sites on higher elevation sandhills and uplands, and abundant wildlife. Although many tribes moved in and out of the region, the influx of European settlers was prevalent by the mid-1800s and, by the late 1870s, most tribes had been relocated to Oklahoma.

Historic Euro-Americans

The Spanish word "Quivira" is a form of the Native American name "Kirikuru," which is what local people called themselves when Coronado visited the region in search of the fabled Seven Cities of Cibola. After following the course of what is now the Arkansas River into the central Great Plains, the Coronado expedition spent several months encamped with the native peoples in a semipermanent village. The precise location of this village is not known, but it is believed to be northeast of the present-day Quivira Refuge. Thereafter, only a few trappers and

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A member of the Wichita Tribe posing for famed photographer Edward S. Curtis sometime around 1927.

explorers visited the area until the mid-1800s (Dolin 2010).

The first European definitively known to visit the Great Bend region of Kansas after Coronado was the French explorer Etienne de Bourgmont in 1724. Western explorers and fur trapping expeditions traveled through the Great Bend region in the mid- and late 1800s, and the Santa Fe Trail was established within 12 miles of the current refuge boundary (Cutler 1883, Blackmar 2002).

From May through July 1843, Captain Nathan Boone led an expedition of Army dragoons from Fort Gibson, Oklahoma. The route looped through south-central Kansas, and mentioned several prominent landmarks, including Salt Creek, a large salt lake, and the Arkansas River. Boone's journal provides a decent glimpse of the landscape from that period, including descriptions of the area both near, and within, present-day Quivira Refuge, including the following excerpts:

- June 10th: "after travelling 5 miles S.W. came to the Arkansas river at a point where for miles up and down, not a tree was growing." The crossing is believed to be near present-day Alden.

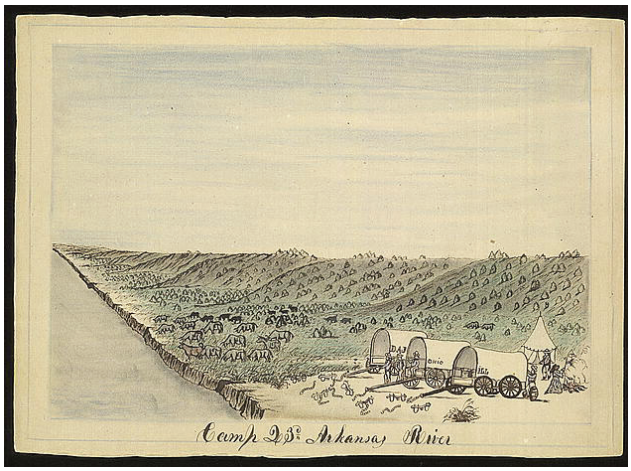
- June 11th: "Their first 4 miles were through Sand hills or drifting sand and in one place, a lake near a mile long of salt water." This is thought to be the BSM.

- June 11th: "Near 200 elk seen within 10 miles of camp and plenty of buffalo S.W. within 5 miles beyond a range of sand hills." The location of this camp is estimated to be directly north of present-day Quivira Refuge along the Arkansas River.

- June 22nd: "Started at 7 A.M. and marched 15 miles S. 3o W. and en-camped on open prairie on the head of the Creek, supposed to be the creek [a branch of present-day Rattlesnake Creek] on which we encamped on the 4th of June. No timber in sight since we left the river. Saw some buffalo, and passed some of the largest buffalo roads bearing to the E.S.E. probably to the salt in that region."

History

The General Land Survey was conducted in this region in 1871. The following year, surveyors for the



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A drawing by Daniel A. Jenks depicts his party's encampent on the Arkansas River in 1859 near present-day Great Bend, Kansas.

Santa Fe Railroad explored and documented a wide swath across Kansas, describing every other section of land along their route. Detail can often be found in the journals, field notes, and maps from both surveys. Below are excerpts from the Railroad Survey:

- April, 1872; section 33, T21S, R11W [For all but the S.E. 1/4, this is the BSM.] "embraces an area of some five Sec and has the appearance of a shallow lakebed—the top soil all being gone makes it about a foot lower than the adjacent land—Its surface to the subsoil is a light or whitish color and seems to be impregnated with alkali."

- Section 17, T22S, R11W [Entire section, 2 miles west of what is now the Migrants Mile area] "All pure sand without any vegetation. All hills and hollows. Constantly drifting. Worthless." It is important to note that, for the survey, land was being evaluated for farming, grazing, or other uses.

- E 1/2, section 13, T22S, R11W [Just southeast of present-day Migrants Mile]. "Dog village over most of both quarters."

- E 1/2, section 1, T23, R11W [East half of the section on which the present-day headquarters is located] "Surface mostly covered with drifting sand. In some small basins, good grass is found."

The first European settlement in Stafford County occurred in the 1860s, and, by 1876, a few people located near the BSM on Quivira Refuge (Cutler 1883, Ogle and Company 1904, Steele 1953). A company was organized for the purpose of manufactur-

ing salt, which was soon found to be unprofitable, and the homesteaders began using the marshes and adjacent grasslands for pasture, hayland, and cattle production (Sheridan 1956). The artesian wells, seeps, and springs near the BSM were relished by people in the area and believed to have health benefits. Early settler accounts from the region commonly speak of the abundance and desirability of wild haylands next to the BSM basin (Hay 1890). By the early 1900s, some upland areas at Quivira Refuge had been converted to small grain agriculture and some native prairies were modified with the introduction of non-native species.

Besides agriculture expansion in the Quivira Refuge area, the saltmarshes were used for commercial and recreational waterfowl hunting after the turn of the 20th century. Private hunting clubs, including the Hutchinson Gun and Hunting Club, Stafford Gun Club, Ellinwood Club, Park Smith Club and the McGuire Club either owned or leased much of the marsh lands, and, in the late 1920s or early 1930s, they dug a permanent ditch to connect, and divert, water from Rattlesnake Creek to the LSM. Other wetland areas along Rattlesnake Creek were also partly impounded by hunting clubs with small dikes and ditches, such as the 16-acre Darrynane Lake (Unit 24) impoundment.

By the 1930s, many upland areas on, and next to, Quivira Refuge had been converted to cropland and pasture. By 1954, about 4,266 acres of what is now Quivira Refuge were in agricultural production (figure 9).

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George Spangerberger's Privy

Library of Congress

This barn is on George Spangerberger's farmstead located in South Hutchison, Kansas.

3.5 Special Management Areas

We established the Santana Research Natural Area on Quivira Refuge in 1967 to preserve 347 acres of native bluestem prairie—classified as K–74, Bluestem Prairie—which includes 15 acres of a century-old cottonwood timber claim. Research natural areas are intended to represent the full array of North American ecosystems with their biological communities, habitats, natural phenomena, and geological and hydrological formations. As with designated Wilderness Areas, natural processes are allowed to predominate without human intervention.

Under certain circumstances, deliberate manipulation may be used to support the unique features for which a research natural area was established. This is the case with Santana Research Natural Area, as the 1984 management plan for the area described a current and future need to control woody vegetation, specifically listing cottonwood, black willow, Russian olive, sand plum, dogwood, and skunkbush as potential invading species. Our activities to support the habitat and biological communities here include prescribed fire, grazing, mowing, and cutting woody plants to prevent their spread.

Activities such as hiking, birdwatching, hunting, fishing, wildlife observation, and photography are permissible, but not mandated, in research natural areas. These special areas also may be closed to all public use if such use is found to be incompatible with primary refuge purposes. The Santana Research Natural Area on Quivira Refuge is open to the public but is not within the hunting area, and no fishing opportunities are available. Because our intent is to not alter or disrupt the characteristic bluestem grasslands found here, no trails or facilities have been, or will be, established in the area.

3.6 Visitor Services

Visitors can enjoy a variety of wildlife-dependent activities, such as hunting, fishing, wildlife observation, photography, environmental education, and interpretation. Most who come use the 14-mile auto tour route. Brochures containing area maps, public use regulations, bird species, and general information are available. Our refuge office is open Monday–Friday, 7:30 a.m.–4:00 p.m. The auto tour route and the rest of the refuge are open from 1 and one-half hours before dawn to 1 and one-half hours after dusk, except during hunting season when hunters are allowed a reasonable amount of time to access hunting areas before dawn and to leave after dusk.

No fees or registration are required for visiting the refuge. There are many access roads, and several county and township roads pass through the refuge. Therefore, attempts to estimate visitation present a challenge for our refuge staff. Visitors are asked to sign the guest register at the headquarters visitor center, but registration is not mandatory. Nonhunting use is estimated each year based on the guest register, head counts of education and interpretation groups, and estimates of visitors on the tour route during various seasons. Current annual visitation is estimated to be 65,000.

Visitors also make use of educational and interpretive activities in the classrooms and auditorium at the GPNC's large visitor center building as well as on the adjacent grounds.

Traditional tribal uses are also allowed on the refuge with a special use permit.

Hunting

Currently, about 8,062 of the refuge's 22,135 acres are within the hunting area. Hunting is permitted for ducks, geese, quail, pheasant, squirrel, rabbit, snipe, and rail. Hunting is not allowed for deer, turkey, or cranes. Hunting season runs from September 1 to February 28, with specific seasons within this period coinciding with State seasons. An accessible hunting blind is available by reservation in Unit 30.

Hunting rules, such as licensing needs and daily possession limits, follow applicable Federal and State regulations. Refuge-specific regulations include:

- Persons possessing, transporting, or carrying firearms on national wildlife refuge lands must comply with all provisions of State and local law. Persons may only use, or discharge, firearms in accordance with refuge regulations—50 CFR 27.42 and specific refuge regulations in 50 CFR Part 32. Discharge of a firearm is prohibited for any reason other than for the taking of game animals in legal hunting areas.

- Hunting is not permitted outside of the public hunting areas or from across roads, trails, or parking areas.

- Vehicle travel and parking is restricted to roads, pullouts, and parking areas.

- Steel shot, bismuth, or other nontoxic shot is required in all gauges when hunting any game on the refuge. The possession of lead shot in the field is prohibited.

- Trapping and baiting are prohibited.
- Retrieving game from areas closed to hunting is prohibited.
- The use of dogs for hunting and retrieving is encouraged. Dogs and other pets must be under their owners' control. From March 1 through August 31, all dogs and other pets must be leashed.
- Portable devices or temporary blinds of natural vegetation are permitted, though we encourage preventing the spread of nonnative invasive vegetation. Permanent blinds or pits may not be constructed. All equipment and blinds must be removed daily.

Many lands next to, or near, the refuge boundary are leased for private hunting. Thus, hunting activities are quite prevalent in the area.

Hunting on the refuge will expand and change as a result of this CCP, see chapter 4 for details.

Fishing

Fishing is allowed on all refuge waters in accordance with State fishing regulations, however, access is generally restricted to the LSM, the Kids' Fishing Pond, and a few points on Rattlesnake Creek. Accessible fishing piers are located at the north end of the LSM and at the Kids' Fishing Pond. The Kids' Fishing Pond is open for kids up to 14 years, although adults may fish there if they are accompanying a youth. Only one fish may be taken per person per day.

Fish species listed in the State fishing regulations may be taken. All other wildlife species, including turtles, frogs, and snakes are protected and may not be disturbed or removed from the refuge. Fishing with trotlines and setlines is prohibited. The use of seines for taking bait is not permitted. Fishing from water control structures and bridges, and the use of live bait is prohibited.

Fishing is also allowed at Chisholm Creek Park near the GPNC, managed and maintained by the City of Wichita.

Wildlife Observation and Photography

Quivira Refuge is a premiere birdwatching site in Kansas, and one of the top sites in North America. Birders travel to the refuge from across Kansas, as well as the United States, and many return to Quivira Refuge on a regular basis. Peak birder visitation usually coincides with the peak shorebird and waterfowl migration seasons in the spring and fall.

Besides birders, Quivira Refuge is popular with more general wildlife observers who visit to view deer, beaver, bald eagles, and the considerable amount of geese, ducks, and cranes that regularly visit during the same period.

The 40-plus miles of public roads within, or alongside, refuge boundaries include a 14-mile tour road that features a 4-mile Wildlife Drive through the BSM. There is an accessible observation tower, equipped with a spotting scope and seating, at the LSM, and a similar scope and seating are located at a viewpoint along the Wildlife Drive. Photo blinds, available on a first-come, first-served basis, are located at the LSM and on the Migrants Mile Trail. Horseback riding and bicycling on established roads, not hiking trails, are also allowed along with dogs that are under their owner's control and that are leashed during the nesting season of April 1 to August 15.

A large percentage of visiting birders and general wildlife enthusiasts are also photographers. Many professional and experienced photographers use the refuge on a regular basis.

Environmental Education

Whereas general school field trips formed most school visits in the past, educational programs have been increasingly focused on topics that help schools and other educational organizations by matching State curriculum-based standards. Several curricula have been developed and used for topics such as bird migration, prairie studies, animal communication, and shorebirds. New curricula are continually under development to offer a variety of subjects to a wider spectrum of grade levels.

Programs are presented either at the refuge or at schools. For onsite visits, Quivira opened a remodeled and modernized environmental education classroom in 2010 to better accommodate and focus on children's education. The facility, designed to hold a class of up to 45 persons, has built-in audiovisual equipment and a large variety of classroom supplies. It serves as the refuge's primary indoor class space, but also as a center for outdoor education activities associated with the nearby Migrants Mile Trail. As an alternate, or added, educational space, the headquarters' conference room, is occasionally used. Virtual geocaching is also allowed to enhance environmental education on the refuge.

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The Butterfly Blossoms Pathway native prairie wildflower interpretive trail at Quivira Refuge was made possible through a partnership with The Friends of Quivira.

The emphasis at the GPNC is on providing an opportunity for people of all ages to learn about the natural resources of the Great Plains, to develop an appreciation of the beauty and value of this region, and to become stewards of the natural resources. Environmental education, a learning process that increases knowledge and awareness about the environment and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action, is one tool used with school groups to achieve our stated goals. On average, the GPNC's staff conducts nearly 1,800 presentations and programs to school groups; community organizations, such as civic, church, and Scouting groups; organized recreation groups from places like city recreation centers and day camps for latchkey children; and casual visitors. Staff provides educational programs both on, and off, site; and programs are conducted year round. With a variety of wildlife available for their use under permit, staff is able to use live animals to help make connections with their audiences.

Interpretation

We lack a current refuge visitor services plan and a primary interpretive theme to provide guidance for our refuge management and staff. However, interpretation has been a vital part of Quivira Refuge's operations for many years. Primary themes have included birds and bird migration, refuge management, fire management, and endangered species. The primary method to present interpretive information to the public is via displays and signs, programs and workshops, brochures, and by Web and other social media. Interpretive displays are available at the headquarters. Topics in permanent displays include bird migration, saltmarshes, Quivira Refuge area history, endangered species, and refuge habitats. Other displays, either temporary or permanent, are added to augment knowledge about our refuge management, flora, and fauna. Displays are also present along the refuge tour road. Nine information kiosks are situated along the route, with maps and information about refuge habitats and hunting. The tour road also features eight different wayside exhibits featuring refuge wildlife and management activities. In addition, the Migrants Mile Trail, Quivira Refuge's premier hiking trail, has many interpretive signs along its length featuring wildlife and wildlife habitat.

Our refuge staff presents interpretive programs and workshops whenever possible, either by request or by scheduling through area schools or community organizations; see the outreach section in this chapter for more details. These are topic-oriented talks, slide shows, or guided walks and auto tours.

Both our refuge-general brochure and our bird checklist were revised and reprinted in 2011. Brochures about other topics, such as whooping cranes, common wildlife, and grasses have also been devel-

oped and printed. Our headquarters also has a rack featuring brochures of other nearby sites of interest, as well as other Service topics.

Quivira Refuge's Web site, in the content management system as of 2012, has long been popular as a source of information. Quivira Refuge was one of the first sites in the content management system. The current Web site has become diverse and detailed, offering interpretive information about subjects such as birds, mammals, reptiles and amphibians, and refuge habitats. Special features include separate pages dedicated to providing a variety of information about the endangered whooping crane, climate influences on refuge plants, and changes in the refuge environment throughout the year. Especially popular are the listings of recent bird observations and road conditions. During the most recently recorded period, March 2010 through February 2011, Quivira Refuge's Web site had 38,185 total visitors and 983,667 total visitor hits. Also during this period, there was an average of 107 visitors to the Web site per day.

In 2011, Quivira Refuge also began using Facebook and Flickr to showcase refuge wildlife, wildlife management, and current happenings; see the outreach section in this chapter for more detail.

Other Uses

Quivira has more than 2 miles of supported hiking trails, including the mile-long Migrants Mile Trail, which is a popular destination. Other activities that have been found to be compatible with the priorities of the refuge include bicycling and horseback riding only on established roads and, depending on the time of the year, bringing dogs on leashes. A national and well-publicized bicycling route passes through the center of the refuge on NE. 140th Street.

Activities that are prohibited on the refuge because of conflicts with wildlife include camping, boating, picnicking, canoeing, fires, the use of all-terrain vehicles, and the collecting of plant, animal, mineral, or any other natural materials.

See appendix B for more details.

Special Events

Annual events, such as Kids' Fishing Day in June, Monarch Mania in September, and Refuge Week Celebration in October, are held by refuge staff with the support of The Friends of Quivira. The Friends of Quivira and Friends of the Great Plains Nature Center are reciprocal partners and, as such, support each other's special events as needed and as time permits.

Public Outreach

Our mission—that of the Refuge System and Quivira Refuge—is an important focus topic for the refuge's environmental and interpretive programs and is also a priority for all outreach activities. It is a goal for all programs to include at least basic information on these missions. Programs that focus on refuge management are regularly given to area communities through civic organizations, churches, public libraries, and schools. Other than these programs, the primary outlets for outreach include the Kansas State Fair, refuge special events, and the Web and other social, or online, media.

Quivira Refuge is the lead partner in the operation of our booth at the annual Kansas State Fair in nearby Hutchinson, Kansas. The primary purpose of the booth is to teach others about our mission, to showcase Kansas refuges, and to educate about various wildlife-oriented topics and programs, our Ecological Services Division, Partners for Fish and Wildlife (Partners), and other operations. Our staff from Quivira Refuge and other offices in the State are on hand to help and educate fair visitors during the 10-day event.

Several special events are held annually, all in partnership with the Friends of Quivira. Some, such as Kids' Fishing Day in June and Monarch Mania in September, each have their own recurring annual themes, such as fish for the fishing day and butterflies for the monarch day, and often involve a combination of activities, education, and, in some cases, refreshments for the participants. Others, such as the Great Migration Rally in May and the Refuge Week Celebration in October, feature topics and activities that vary each year.

Quivira Refuge's Web site, updated several times a week, is also an important outlet for public information about the refuge's mission and objectives. Regular features include new happenings around the refuge, such as improvements, construction, and management; road conditions; schedules for special events; and bird observations. The Web site also has hunting and fishing regulations and bird count tallies. Refuge staff also regularly reports similar information on its official Facebook site, which is updated several times a week. Unusual bird observations, whooping crane sightings, and road conditions are also posted on the Kansas Listserv, used by many birders statewide.

3.7 Partnerships

Quivira Refuge and the GPNC collaborate with educational, regulatory, and research institutions that support refuge goals and objectives. Our refuge has formal and informal partnerships with Fort Hays State University, Sterling College, Kansas State University, Emporia State University, Friends University, Wichita State University, and others to work on research and educational projects. These working relationships involve, among other things, offering summer classes for educators to obtain continuing education credits, offering board memberships for the GPNC, and offering students working opportunities through AmeriCorps or internships.

The refuge is part of the Rattlesnake Creek Partnership, which seeks to resolve water rights issues in Groundwater Management District 5. The refuge partners with the KDWPT on a variety of wildlife-related projects, including avian influenza surveillance, chronic wasting disease and deer health programs, fish stocking, breeding shorebird surveys, and educational and interpretive programs. Quivira Refuge is a member of the Wetlands and Wildlife National Scenic Byway's planning committee, and Quivira staff regularly attends planning meetings about the Byway and the local Byway communities.

Partnerships with Ducks Unlimited over the years have resulted in many habitat improvement projects on the refuge, and these will continue.

Quivira Refuge staff partners with the Friends of Quivira to plan and present educational programs and annual events. The Friends of Quivira operate a nonprofit bookstore in the refuge visitor center.

Barry Jones/FWS

School kids from the local community learn about issues affecting the wildlife in their area at the Stafford County, Kansas, Conservation Day.

The GPNC operates under a memorandum of agreement with the City of Wichita and the KDWPT. Together, they have partnerships with many corporate sponsors like The Coleman Company, Koch, and Spirit AeroSystems and with educational institutions like Wichita State University and Friends University. This partnership also often works informally with other universities and colleges to provide work experience for interns when available.

The GPNC is supported by the Friends of the Great Plains Nature Center, who operate a bookstore in the nature center, support educational programming at the nature center, and provide pay for six employees, including a full-time naturalist who presents environmental education programs in schools and locations throughout the Wichita metropolitan area. The Friends of the Great Plains Nature Center naturalist helps in educational programming for both the GPNC and Quivira Refuge.

The refuge and the GPNC are always open to establishing new partnerships where possible that help wildlife and habitat conservation. The refuge is looking to establish a partnership to control invasive species in the Rattlesnake Creek watershed, such as saltcedar, and a partnership with neighbors to prevent the continued encroachment of invasive woody species, such as eastern red cedar and Russian olive.

With the addition of a Partners biologist to the staff at Quivira Refuge and a new focus area that is comprised of Quivira Refuge and Cheyenne Bottoms, new partnerships should continue to be developed.

3.8 Socioeconomic Environment

Quivira Refuge is open for the compatible, wildlife-dependent uses of hunting, fishing, wildlife observation, and photography. These recreational opportunities attract visitors and bring dollars to the community. Associated visitor activity, such as spending on food, gasoline, and overnight lodging in the area, provides local businesses with extra income and increases the local tax base. Our refuge management decisions about public uses, the expansion of services, and habitat improvement may either increase or decrease visitation to the refuge and affect visitor spending in the local economy.

As part of the development of this CCP, we hired a contractor to prepare a socioeconomic study for the Quivira Refuge (USGS 2012c). This study provides the basis for the sections that follow, including population and employment, public use of the refuge, and baseline economic activity.

For the purposes of an economic impact analysis, a region (and its economy) is typically defined as all counties within a 30–60 mile radius of the impact area. Only spending that takes place within this regional area is included as stimulating changes in economic activity. The size of the region influences both the amount of spending captured and the multiplier effects. Quivira Refuge is located in south-central Kansas. Most of the economic activity related to the refuge is located within the five-county area of Stafford, Rice, Reno, Barton and Pratt Counties, therefore, these counties compose the local economic region for this analysis. The Refuge is also a partner in the establishment and daily operations of the GPNC located 90 miles from the refuge. While the GPNC lies outside the local economic region, connections with refuge activities will be discussed.

Collectively, the 5-county area has a population of approximately 116,000 people and covers a total area of 4,431 square miles (U.S. Census Bureau 2010). Within the five-county area, the cities of Ellinwood, Great Bend, Hutchinson, Larned, Lyons, Pratt, Stafford, Sterling and St. John are economically significant to the refuge and, as such, are additional areas of focus for the regional economic setting.

Population, Ethnicity, and Education

Table 9 lists population estimates and trends for the 5-county area and table 10 lists population estimates for the nine communities near the refuge. In 2010, the counties accounted for approximately 4 percent of the State's population (U.S. Census Bureau 2010). While Kansas has experienced an increase in the number of residents since 2000, 4 of the counties have experienced a decline in residents, with only Pratt showing a slight, 0.1-percent increase (U. S. Census Bureau 2010a). Ellinwood, Larned, Sterling and St. John have experienced declining populations, with St. John showing the greatest decline, losing more than 20 percent of its population since 2000.

Though Kansas is expected to grow in population, population decline is expected to continue in all five of the counties surrounding the refuge (The University of Kansas Institute for Policy and Social Research 2012). Barton and Stafford are expected to show the greatest decline, losing more than 20 percent of their populations by 2040, while Pratt is expected to show the least decline, with an expected loss of 9 percent. The overall decline in population may be due to an aging population as well as to migration to more urban areas. This trend can be observed across many of the rural counties in Kansas (Wichita State University 2011).

Table 9. State and county population estimates in the area around Quivira National Wildlife Refuge, Kansas.

	Residents (2010)[1]	*Persons per square mile (2010)*[1]	*Percent population change (2000–2010)*[2]
Kansas	2,853,118	34.9	6.8
Barton	27,674	30.9	–1.9
Pratt	9,656	13.1	0.1
Reno	64,511	51.4	–0.4
Rice	10,083	13.9	–6.3
Stafford	4,437	5.6	–7.4

Source: [1]U. S. Census Bureau 2012b. [2]U. S. Census Bureau 2010a.

Table 10. Community population estimates in the area around Quivira National Wildlife Refuge, Kansas.

	Residents (2010)[1]	*Persons per square mile (2010)*[1]	*Percent population change (2000–2010)*[2]
Ellinwood	2,131	1,966	–1.5
Great Bend	15,995	1,505	4.2
Hutchinson	42,080	1,994	3.2
Larned	4,054	1,745	–4.3
Lyons	3,739	1,736	0.2
Pratt	6,835	922	4.0
Stafford	1,159	1,233	7.8
Sterling	2,328	1,640	–11.9
St. John	1,036	575	–20.7

Source: [1]U. S. Census Bureau 2012b. [2]U. S. Census Bureau 2010a.

While the percentage of the State population with at least a bachelor's degree is higher than the national average (29.3 percent compared to 27.9 percent), each county within the 5-county area has lower than both the State and national averages (ranging from a low of 18.8 percent in Reno to a high of 22.7 percent in Pratt). Each of the nine communities surrounding the refuge also fall below State and national averages, with Stafford and Lyons having the lowest (13.2 percent) (U. S. Census Bureau 2010a).

In 2010, more than 87 percent of the population of Kansas self-identified as white, not of Hispanic or Latino origin (U. S. Census Bureau 2010a). This percent is lower than reported for each of the counties within the 5-county area (ranging from a low of 90.6 percent in Barton County to a high of 96 percent in Pratt County). Relative to the other counties in the 5-county area, Barton County had the largest percentage of the population who identified as Hispanic or Latino (13.3 percent) (U. S. Census Bureau 2012b) while Reno County had the highest percentage of the population who identified as African-American (4.1 percent) (U. S. Census Bureau 2012b).

Regional Economic Setting

Table 11 shows the median household income, poverty, and unemployment rates for the 5-county area, while table 12 lists the same for communities near the refuge. The five counties and nine communities have median household incomes below both State and national levels. Of the counties, Barton had the highest median household income at $43,763 per year, while Stafford had the lowest at $39,375. Of the communities, Great Bend had the highest median household income at $42,293 per year, while Stafford had the lowest at $33,182 (U. S. Census Bureau 2010a).

In 2010, 12.4 percent of the Kansas population was living below the poverty line, compared to 13.8 percent nationally. Poverty rates within the 5-county area are similar to State and national averages, with Pratt having the lowest rate (10 percent) and Stafford having the highest (14 percent). The communities near the refuge show substantial variability, from 6.7 percent in Larned to nearly 20 percent in St. John (U. S. Census Bureau 2010a).

Table 13 shows the percent employment by sector within the 5-county area. The combined 5-county area had a total employment of more than 73,000 individuals in 2011 (Bureau of Economic Analysis 2012). Farm employment accounted for nearly 6 percent of the workforce. The highest percentage of total

Table 11. State income, unemployment, and poverty statistics and county statistics in the area around Quivira National Wildlife Refuge, Kansas.

	Median household income (2010)	*Percentage of individuals below poverty (2010)*	*Percentage unemployed (2010)*	*Change in percent unemployed (2000–2010)*
Kansas	$49,424	12.4	4.1	1.3
Barton	$43,763	12.2	3.6	0.1
Pratt	$43,583	10.0	2.2	–0.8
Reno	$41,431	13.1	3.0	0.1
Rice	$43,164	13.7	4.2	0.6
Stafford	$39,375	14.0	2.7	0.6

Source: U. S. Census Bureau 2010a.

Table 12. Community income, unemployment and poverty statistics in the area around Quivira National Wildlife Refuge, Kansas.

	Median household income (2010)	*Percentage of individuals below poverty (2010)*	*Percentage unemployed (2010)*	*Change in percent unemployed (2000–2010)*
Ellinwood	$39,444	7.7	3.0	0.9
Great Bend	$42,293	13.7	3.9	1.3
Hutchinson	$38,880	15.7	3.2	–0.3
Larned	$37,235	6.7	2.8	0.8
Lyons	$41,552	15.7	3.7	1.5
Pratt	$39,142	11.1	2.0	0.1
Stafford	$33,182	15.2	2.5	0.5
Sterling	$36,192	14.4	6.3	–2.1
St. John	$37,589	19.0	3.4	2.2

Source: U. S. Census Bureau 2010a.

Table 13. Employment by sector in the area around Quivira National Wildlife Refuge, Kansas.

Industry	*2011*	*Percent of total*
Farm proprietors employment	3,365	4.6
Nonfarm proprietors employment	15,388	21.0
Forestry, fishing, and related activities	637	0.9
Mining	5,907	8.1
Utilities	124	0.2
Construction	3,362	4.6
Manufacturing	4,934	6.7
Wholesale trade	2,300	3.1
Retail trade	7,351	10.1
Transportation and warehousing	561	0.8
Information	828	1.1
Finance and insurance	3,354	4.6
Real estate and rental and leasing	1,628	2.2
Professional, scientific, and technical services	2,146	2.9
Management of companies and enterprises	671	0.9
Administrative and waste management services	2,731	3.7
Educational services	412	0.6
Health care and social assistance	8,406	11.5
Arts, entertainment, and recreation	867	1.2
Accommodation and food services	4,317	5.9
Other services, except public administration	3,483	4.8
Federal, civilian	397	0.5
Military	502	0.7
State and local	10,599	14.5

Source: Bureau of Economic Analysis 2012.

employment was found in the government and government enterprise sector (15.7 percent of nonfarm employment). This sector includes both local and nonlocal government agencies. The second and third highest percentages of total employment were in health care and social assistance (11.5 percent) and retail trade (10.1 percent). Forestry, fishing, and related activities accounted for less than 1 percent of the total employment by sector.

Agricultural Sector

Kansas is a highly productive region in the United States for both crops and livestock. In 2011, Kansas had an agricultural output of more than $17 billion, with crop output contributing more than $6 billion, animal output contributing nearly $9 billion, and services and forestry contributing more than $2 billion. The top five commodities produced in the State were cattle and calves, corn, wheat, soybeans, and sorghum grain (Economic Research Service 2012).

As of the 2007 Census of Agriculture, the 5-county area was home to more than 4,000 farms, with more than 2.7 million acres in agricultural production. This accounted for more than 6.26 percent of the total land in production in the State (U. S. Department of Agriculture 2007). In 2007 within the 5-county area, Reno had the greatest number of farms and acreage in production (1,749 farms, and 780,893 acres). Pratt had the fewest number of farms (538) and Rice had the smallest acreage in production (428,422) (U.S. Department of Agriculture 2007).

Recreation and Tourism

Angling, hunting, and wildlife viewing are popular recreational activities across Kansas and within the five-county area. According to the recent 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, approximately 1.2 million residents and nonresidents took part in wildlife-associated activities in Kansas (FWS 2012a). Of all participants, 46 percent identified as sportsmen and women, engaging in either hunting or fishing, and 69 percent reported engaging in wildlife-watching activities. For the purpose of the National Survey, wildlife watching is broken down into away-from-home activities taking place at least 1 mile from home and 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. The number of hunting days by both residents and nonresidents totaled 5.2 million, with Kansas residents accounting for 78 percent of hunting days. The number of fishing days by residents and nonresidents totaled 4.1 million, with Kansas residents accounting for 98 percent of fishing days. In 2011, residents and nonresidents spent a

total of 1 million days watching wildlife away from home, with residents accounting for 77 percent of wildlife watching days. The in-state spending associated with these activities totaled $820 thousand in 2011, with $293 thousand spent on trip-related expenditures, $197 thousand spent on equipment, and $330 thousand spent for other items (FWS 2012a).

The Wetlands & Wildlife National Scenic Byway connects Cheyenne Bottoms Wildlife Area in Barton County to Quivira Refuge. Along this 77-mile stretch of road, visitors have the opportunity to view more than 300 bird species and visit the remains of the Santa Fe Trail, historic sites, museums, and natural sites. The byway also connects several cities. Claflin, Ellinwood, Great Bend, Hoisington, Hudson, St. John, and Stafford are all considered Byway Communities (Kansas Scenic Byways Program).

From 2009–2010, a visitor survey was conducted by Fort Hays State University's Kansas Wetlands Education Center. The survey found that day trips were the most popular trip length for visitors to the Wetlands & Wildlife National Scenic Byway, with trips 1–3 days in length being the second most popular. In general, day visitors spent under $100 within the local area, while visitors staying 1–3 days generally spent $100–$200. Most visitors to the area were Kansas residents. According to Barton County Counselor and Administrator, Richard Boeckman (personal interview, date unknown), several byway communities are collaborating to improve marketing and increase tourism in the area. He says the byway, refuge, and Cheyenne Bottoms are all considered important assets to the local economy.

Public Use of the Refuge

The USGS headed a National Wildlife Refuge Visitor Survey (USGS 2012a) at Quivira Refuge and several other refuges to tell us more about visitor use. Data in this report, outlined in the following sections, came from survey forms completed by visitors to Quivira Refuge during the selected sampling periods of fall 2010 and spring 2011.

According to the USGS (2012a), about half of visitors, or 47 percent, had only been to Quivira Refuge once in the 12-month survey period, while the other half, or 53 percent, had been there multiple times. These repeat visitors went to the refuge an average of 7 times during the 12-month period. Fifty nine percent of visitors used the refuge during only one season, 28 percent used it during multiple seasons, and 13 percent used it year round.

Most visitors, 64 percent, first learned about the refuge from friends or relatives, 21 percent from printed information, and 18 percent from highway signs. Key information sources used by visitors to find their way to the refuge included highway signs, by 54 percent; earlier knowledge, by 46 percent; and a road atlas or highway map, by 44 percent.

Twenty-five percent of visitors live in the local area, which is within 50 miles of the refuge, whereas 75 percent are nonlocal visitors (USGS 2012a). For 79 percent of local visitors and for 59 percent of nonlocal visitors, Quivira Refuge was the primary purpose, or sole destination, of their trip. Local visitors reported that they traveled an average of 32 miles to get to the refuge, while nonlocal visitors traveled an average of 319 miles. About 60 percent of visitors travelling to Quivira Refuge were from Kansas.

Nearly all, or 99 percent of, visitors to Quivira Refuge said that they were citizens or permanent residents of the United States (USGS 2012a). Visitors were 62 percent male, with an average age of 57 years, and 38 percent female, with an average age of 59 years. On average, visitors reported they had 16 years of formal education, college or technical school. The median level of income was $50,000–$74,999.

Visitors reported that they spent an average of 5 hours at Quivira Refuge during 1 day there (USGS 2012a). However, the most frequently reported length of visit during 1 day was 8 hours, as reported by 31 percent of respondents. The key modes of transportation used by visitors to travel around the refuge were private vehicle, by 93 percent of respondents, and walking or hiking, by 11 percent. More than half of visitors, or 69 percent, said that they were part of a group on their visit to the refuge, often travelling with family and friends.

According to the USGS, visitors took part in a variety of refuge activities during the survey period (USGS 2012a). The top activities reported were birdwatching, by 77 percent of respondents; wildlife observation, by 70 percent; auto tour route or driving, by 53 percent; and photography, by 51 percent. The primary reasons mentioned for their most recent visit included birdwatching, by 52 percent of respondents; hunting, by 18 percent; photography, by 10 percent; and wildlife observation, by 9 percent. The visitor center was used by 70 percent of visitors, mostly to ask information of staff or volunteers, by 91 percent of this group; or to view the exhibits, by 82 percent; or to use the facilities, by 75 percent.

Visitor Levels

Of those who visited Quivira Refuge and took part in the USGS's National Wildlife Refuge Visitor Survey, overall satisfaction with the services, facilities, and recreational opportunities we provided were rated as follows (Sexton et al. 2012):

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Painted turtles are easily viewed at Quivira Refuge.

- Ninety-two percent were satisfied with the recreational activities and opportunities.
- Ninety-one percent were satisfied with the information and education provided about the refuge and its resources.
- Ninety-three percent were satisfied with the services provided by employees or volunteers.
- Ninety-three percent were satisfied with the refuge's job of conserving fish, wildlife and their habitats.

Satisfaction levels were divided into quadrants. All Quivira Refuge services and facilities fell into the Keep Up the Good Work quadrant (Sexton et al. 2012). Refuge recreational opportunities fell into Keep Up the Good Work except for volunteer, kayak and canoe, bicycling, fishing, and hunting, which fell into the Look Closer quadrant. The average importance of fishing, hunting, bicycling, and volunteer opportunities in Look Closer may be higher among visitors who engaged in these activities during the past 12 months. However, there were either not enough people in the sample to evaluate such responses or it is unknown how many in the sample took part in an activity. Boating is not allowed on the refuge, which may explain the low importance rating for kayaking and canoeing. All transportation-related features fell into Keep Up the Good Work.

Economic Contributions of the Refuge

Quivira Refuge affects the local economy through the visitor spending it generates and the employment it supports. Combining the effects of our employment and visitor spending, the total economic activity generated in the 5-county study area is approximately $1.015 million in added value.

U.S. Fish and Wildlife Service Employment

Refuge management activities directly related to refuge operations generate an estimated 20 jobs and $667,500 in labor income. It is estimated that salary spending by Quivira Refuge staff generates secondary effects of 5 jobs, $168,600 in labor income, and $301,700 in value added to the local economy.

Visitor Spending

A region, and its economy, is typically defined as all counties within 50 miles of a travel destination (Stynes 1998). Visitors that live within the local, 50-mile area of a refuge typically have different spending patterns than those who travel from longer distances. Approximately 25 percent of visitors to Quivira Refuge said that they live within the local area. Nonlocal visitors, or 75 percent, stayed in the local area, on average, for 2 days. Table 14 shows local and nonlocal visitor expenditures reported on a per-person-per-day basis. Nonlocal visitors spent an average of $55 per person per day, and local visitors spent an average of $45.

3.9 Operations

This section describes funding, staff and facilities at Quivira Refuge.

Table 14. Total visitor expenditures, expressed in dollars per person per day, for Quivira National Wildlife Refuge, Kansas.

Visitors	*Sample size*	*Median*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Nonlocal	100	$42	$55	$57	$0	$313
Local	30	$29	$45	$55	$0	$250

Funding and Staff

Refuge staff is comprised of 11 permanent full-time employees, 1 permanent part-time employee, 3 temporary employees, and 2 regional employees that are not paid through the refuge (table 15). The current staff level remains well below the minimum prescribed in the June 2008 Final Report—Staffing Model for Field Stations (FWS 2008b), which recommends that eight more staff, including three maintenance workers, one biologist, two biological technicians, one refuge law enforcement officer, and one GPNC visitor services specialist be added.

Table 15. Base staff budgeted in fiscal year 2012 and other staff stationed at Quivira National Wildlife Refuge, Kansas.

Staff group	*Position*
Current staff	
management	General Schedule–13 refuge manager General Schedule–12 deputy refuge manager and collateral duty law enforcement officer (vacant) General Schedule–9 wildlife refuge specialist and collateral duty law enforcement officer General Schedule–11 zone fire management officer General Schedule–7 supervisory range technician (vacant)
biology	General Schedule–11 wildlife biologist
public use	General Schedule–12 park ranger—visitor services manager at the GPNC General Schedule–9 park ranger for visitor services
administration	General Schedule–9 administrative officer General Schedule–5 office assistant, 0.5 full-time equivalent
maintenance	Two Wage Grade Schedule–8 maintenance workers
maintenance, temporary or term	Two Wage Grade Schedule–6 tractor operators, career seasonal, 6 months General Schedule–5 range technician for invasive species control, term position
Current staff stationed at, but not paid by, Quivira Refuge	
biology	Zone biologist Partners biologist

Facilities

Facilities are used to support habitat and wildlife management programs and wildlife-dependent public uses for 65,000 annual visitors. The refuge has two full-time maintenance workers and two part-time tractor operators to support buildings, water conveyance structures, fences, and roads.

Facilities have been regularly updated over the years. The refuge headquarters was built in 1964 and a visitor center with a conference room was added in 1992. In 2011, these facilities were remodeled, and space was developed for seven more offices. The shop was built in 1979 and has been kept in good condition. Two residences were built in 1964 to provide housing for refuge employees at the headquarters and shop area and have been kept in good condition.

Half of the original block building office built in 1958 houses an environmental education classroom. The other half of the building is a bunkhouse that can house six seasonal employees or volunteers. The building is in poor condition and would be difficult to remodel or improve because of its construction.

We received a three-bedroom trailer as unused excess from the Federal Emergency Management Agency in 2009 and placed it at the environmental education classroom site. It is in good condition. There are two cold storage buildings, one eight-bay building was built in 1991 and a four-bay equipment storage building was built in 2005. Two full-hookup trailer pads are also available at the environmental education classroom site for use by volunteers. A new, concrete, accessible, aboveground tornado shelter was placed there in 2010.

We own 7 acres of land at the GPNC and a 23,000-square foot visitor center and office building that was built in 1995 and is in good condition. We will also own a garage and storage building on the site pending official transfer. Remaining land there is owned by the city of Wichita, including parking lots, Chisholm Creek Park, and associated trails.

Quivira Refuge's public use facilities are shown in figure 11. More than 45 miles of public roads exist either within, or next to, the refuge's boundaries. Of these, 16.8 miles are refuge owned. The refuge maintains 55 public parking lots, ranging from being graveled to grass surfaced.

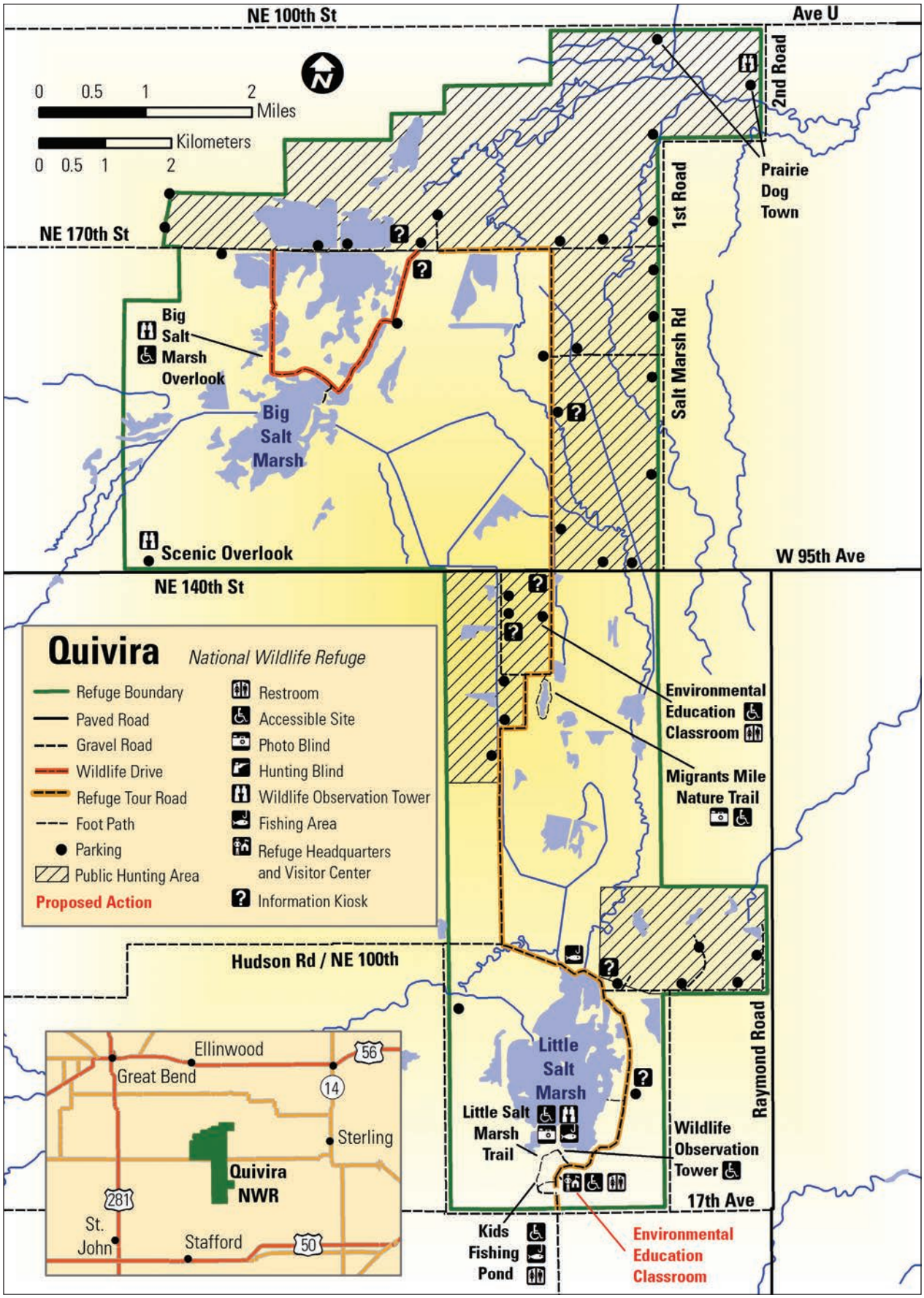

Figure 11. Public use facilities at Quivira National Wildlife Refuge, Kansas.

Refuge facilities include:

- headquarters office and visitor center building, 6,720 square feet
- maintenance shop, fire cache, and vehicle storage building, 9,200 square feet
- two 176-square foot grain bins
- eight-bay cold storage building, 6,750 square feet
- four-bay equipment storage building, 3,600 square feet
- environmental education classroom and bunkhouse, 1,900 square feet
- two 2002-square foot, three-bedroom houses for staff, with one stall, attached garage and one 400-square foot stall, detached garage for each
- oil storage building with 3 associated 1000-gallon, aboveground fuel tanks, 180 square feet
- pesticide storage building, 140 square feet
- fencing storage shed, 576 square feet
- two metal, 192-square foot pump houses for the domestic water supply
- pole shed building, 2,160 square feet
- storage building, 192 square feet
- asphalt hiking trail, 0.65 mile; earthen hiking trail, 0.57 mile; and photo blind at Migrants Mile
- earthen hiking trail at the LSM, 0.63 mile
- accessible wooden observation tower on the LSM, 6,536 square feet
- BSM overlook
- two vault toilet restrooms
- one photo blind at the LSM
- one accessible hunting blind
- nine information kiosks
- self-guided gravel auto tour route, 14 miles
- eight wayside interpretive exhibits
- two fishing piers
- fifty-five parking lots
- refuge roads, 16.8 miles
- canals, 25 miles
- one hundred and three water control structures
- nine entrance signs

FWS

The Kid's Fishing Pond has one of two fishing piers on the refuge.