HYDROGEOMORPHIC EVALUATION
OF
ECOSYSTEM RESTORATION
AND MANAGEMENT OPTIONS FOR
QUIVIRA NATIONAL WILDLIFE REFUGE

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EXECUTIVE SUMMARY

This report provides an evaluation of ecosystem restoration and management options for Quivira National Wildlife Refuge (NWR) located in south-central Kansas. Hydrogeomorphic information (HGM) about geology and geomorphology, soils, topography, hydrology, plant and animal communities, and physical anthropogenic features was obtained for the Quivira NWR region. Objectives of the HGM evaluation were to: 1) Describe the pre-European settlement ecosystem condition and ecological processes; 2) Determine the changes from the Presettlement period with specific reference to alterations in hydrology, landform, and vegetation communities; and 3) Identify restoration and management options and ecological attributes needed to restore specific habitats and conditions that have been altered.

Quivira NWR was originally established in 1955 as the "Great Salt Marsh NWR" in recognition of two historic salt marshes, the "Little" and "Big" Salt Marshes on the site. In 1958, the name of the refuge was changed to "Quivira NWR." The refuge contains 22,135 acres and includes a mixed-grass sand prairie ecosystem with diverse grassland and wetland associations of variable salinity that surround the historic Little and Big Salt Marshes. Rattlesnake Creek flows through Quivira NWR to its confluence with the Arkansas River about 15 miles northeast of the refuge.

Quivira NWR is within the Great Bend Sand Prairie physiographic province of south-central Kansas and the surficial geology of the region is dominated by unconsolidated Quaternary deposits of eolian and alluvial origin. Most of the NWR is Quaternary-age alluvial deposits along the Rattlesnake Creek floodplain. Smaller areas on the edges of the alluvial plain are eolian sand dunes and hills. The relatively flat depression areas of the Little and Big Salt Marsh areas are underlain by < 15 feet of clay, silt, sand, and gravel derived from nearby sand dunes and Meade and Kiowa shale. A ridge of beach sand derived from a large Wisconsin-age lake occurs along the east and southeast sides of the Big Salt Marsh. Soils at Quivira NWR include many loamy sand types with varying salinity. Certain soils have high water tables and are considered “subirrigated.”

At the time of this evaluation, topographic information was obtained from the Natitonal Elevation Dataset at 10 meter resolution, and as visually depicted using the USGS 7.5 minute quadrangle topographic map. Generally elevations on the refuge slope from about 1,815 feet above mean sea level (amsl) in the south to about 1,716 feet amsl in the northeast parts of the refuge. Local topography reflects historical migration of Rattlesnake Creek, the salt marsh depressions, and windblown sand hills and dunes.

The climate of Quivira NWR is dry subhumid. Average annual precipitation is about 24 inches, with about 75% occurring as rain between April and September. Evapotranspiration rates average about 64 inches, which causes quick drying of water in hot summer months and concentration and accumulation of salts in wetlands. Long-term precipitation records indicate relatively regular alternating high (> 30 inches) vs. low (< 20 inches) amounts of annual precipitation with occasional spikes of very high and low precipitation. Drought periods of 3-4 years have been common.

Rattlesnake Creek is a primary source of surface water at Quivira NWR. Average annual runoff of Rattlesnake Creek at Zenith, just upstream from the refuge, is about 34,000 acre-feet/year and average streamflow is about 47 cubic-feet/second but varies significantly among seasons and years in relationship to regional precipitation and groundwater recharge. Rattlesnake Creek and its tributaries act as both sources and sinks of groundwater for the underlying Great Bend Prairie Aquifer system. Quivira NWR lies in a discharge zone for groundwater exiting this aquifer and the lower bedrock. This groundwater subsequently becomes surface flow in Rattlesnake Creek and also contributes direct groundwater seepage into alluvial depressions, especially the Big Salt Marsh. Groundwater discharge into Quivira NWR, and depth to groundwater, varies among years depending on precipitation in the basin and aquifer-source areas.

Historically, most wetlands at Quivira NWR were seasonally flooded by surface water runoff and local precipitation, overbank flows from Rattlesnake Creek, and groundwater seepage/discharge from the Great Bend Prairie Aquifer. The Little Salt Marsh seems to have been recharged primarily by overbank flow from Rattlesnake Creek. In contrast, the Big Salt Marsh received water mostly from groundwater discharge. Recent monitoring of groundwater discharge into the Big Salt Marsh suggests about 5,000 acre-feet/year while the Little Salt Marsh loses about 545 acre-feet/year of surface to the underlying aquifer.

Quivira NWR historically was dominated by mixed-grass prairie, the Rattlesnake Creek corridor, scattered small wetland depressions, and the unique Big and Little Salt Marshes. The Rattlesnake Creek channel has migrated frequently across its floodplain and the size of the historical Little Salt Marsh was much smaller than the currently developed marsh area, which was altered by directly connecting it with Rattlesnake Creek in the late 1920s or early 1930s. Ecologically distinct vegetation communities, largely defined by soil type and hydrology included: 1) sand dunes and hills, 2) choppy sand beach-ridge grassland, 3) salt marsh, 4) saltgrass "flats", 5) creek channels with narrow riparian corridors, 6) seasonal herbaceous wetland, 7) subirrigated saline grassland, 8) subirrigated nonsaline grassland, 9) upland sandy grassland, and 10) upland loess-loam grassland. Trees and woody vegetation historically were present in only very limited sites such as scattered small patches of sand plum and occasional willow along the Rattlesnake Creek channel. The primary ecological processes and disturbances for these communities were annually- and seasonally-variable inputs of surface and ground water of varying salinity, fire, herbivory, wind, and other weather events. A HGM matrix of relationships of the communities to geomorphic surface, soil, general topographic position, and hydrology was developed to map the potential distribution of historical communities, and to compare with current conditions, on Quivira NWR. The heterogeneity of grassland communities coupled with the unique salt marshes and diverse wetland habitats provided important resources used by a diversity of animal species at Quivira, especially migrant waterbirds.

Few alterations to the Quivira NWR area occurred until the late 1800s. Early land uses included salt extraction and manufacturing, hay and cattle production, and eventually small grain agriculture. The salt marshes were used as commercial and recreational hunting areas and hunting clubs began to ditch, dike, and divert surface waters along Rattlesnake Creek and other small wetland sites in the early 1900s. By the 1930s, many upland prairie areas had been converted to cropland and pasture and by 1954; about 4,266 acres of Quivira NWR lands were in agricultural production.

The original development plans for Quivira NWR were designed to hold water in the salt marshes using local drainage if possible and also to divert "surplus" Rattlesnake Creek water into the marshes and developed wetland units. Ultimately, 34 constructed wetland management units were developed and water was diverted to the units through a complex series of ditches, dikes, and water-control structures. In 1957, the U.S. Fish and Wildlife Service (USFWS) filed for a "senior" right to divert 22,200 acre-feet of water from Rattlesnake Creek to refuge wetlands. In 1996, the Kansas Division of Water Resources certified a permit to the USFWS for only 14,632 acre-feet of water diversion from Rattlesnake Creek that reflected historical actual diversion due to frequent insufficient flows of water in the creek and the fill capacity of refuge wetlands.

Since the early 1970s, development of groundwater irrigation for agricultural production in the Rattlesnake Creek Basin has increased greatly, and groundwater withdrawals have caused precipitous declines in the baseflow of Rattlesnake Creek and also decreased discharge from natural groundwater seeps and springs, especially during summer when irrigation is occurring. Changes in amount and timing of surface water and ground discharge has reduced flow from Rattlesnake Creek into Quivira NWR and altered water quality. Attempts have been made to increase groundwater levels in the Rattlesnake Creek Basin and to support long-term sustainability of streamflow in Rattlesnake Creek using a variety of approaches developed in part as a "Rattlesnake Creek Subbasin Management Plan." Certain planned activities have proven unsuccessful. Despite efforts of the Rattlesnake Creek Partnership Group to encourage voluntary water conservation measures, the average change in groundwater levels since 2001 has been a decline of 1.43 feet. Groundwater levels declined over three feet along Rattlesnake Creek in Quivira NWR between 2010 and 2011.

In summary, the major contemporary ecosystem changes in the Quivira NWR region have been: 1) alterations to the distribution, chronology, quality, and abundance of surface and groundwater; 2) extensive construction of water-control infrastructure to manage the distribution and retention of water in constructed wetland impoundments and the Little Salt Marsh; 3) conversion of native grassland to agriculture and the increased presence of woody vegetation; and 4) the increased presence of invasive species. A critical overriding issue for future management of Quivira NWR is the increased extraction of groundwater for irrigation in the Rattlesnake Creek Basin and the serious consequences of continued over-drafting of the underlying Great Bend Prairie Aquifer. Further, a major challenge for future management of Quivira NWR will be to determine how a potentially more limited availability of water will affect efforts to restore and provide critical habitats and communities.

This HGM evaluation contributes to previous studies and suggests the following general ecosystem restoration and management goals for Quivira NWR:

1. Maintain and restore functional mixed-grass sand prairie communities within the Rattlesnake Creek alluvial floodplain and adjacent sand hills and dunes.
2. Promote efforts to protect and restore critical groundwater aquifers, and natural seasonal groundwater discharge, in the Rattlesnake Creek Basin, specifically within Rattlesnake Creek and seeps originating on the west side of the Big Salt Marsh. Also, management should seek to emulate natural surface water regimes in the Big and Little Salt Marshes and the small wetland depressions on the refuge.
3. Restore the natural topography, water regimes, and physical integrity of surface water flow patterns in and across the Rattlesnake Creek floodplain corridor, salt marshes, and adjacent sand dune/hills uplands where appropriate and feasible.

4. Restore and maintain the diversity, composition, distribution, and regenerating mechanisms of native vegetation communities in relationship to topographic and geomorphic landscape position.

Specific management recommendations to help meet the above goals include:

Goal #1

- Delineate specific grassland types and design management prescriptions to the respective community types.
- Continue to use fire to sustain grasslands and remove and discourage woody vegetation.
- Control invasive species.
- Restore natural hydrological regimes to grasslands.
- Protect sand hills and dunes by appropriately adjusting management prescriptions to the associated HGM communities.

Goal #2

- Consider recommendations from the recent Water Resources Inventory Assessment to protect and restore ground and surface water in the Rattlesnake Creek Basin.
- Manage historic wet meadow and seasonal herbaceous wetland depressions for annually variable, seasonal water regimes.
- Restore at least some regular drawdown and seasonal surface water dynamics in the Little Salt Marsh.
- Restore natural surface water sheetflow into small temporary wetland depressions in grasslands.
- Reduce or eliminate diversion of Rattlesnake Creek water to unnaturally high elevation dune surfaces.

Goal #3

- Evaluate restoring some water flow into former channels of Rattlesnake Creek.

- Evaluate all roads, ditches, levees/dikes, and water-control infrastructure to determine the need for, and effectiveness of the structures.
- Remove water diversion infrastructure into higher elevation Quaternary dune surfaces and upland grasslands where artificial wetlands formerly were created.

Goal #4

- Restore basic ecological disturbance practices in naturally occurring patterns and times.
- Carefully target grassland and wetland restoration to appropriate HGM sites, especially related to soils and hydrology.

Future management of Quivira NWR should incorporate active monitoring and evaluation to determine how factors related to ecosystem structure and function are changing, regardless of whether the restoration and management options identified in this report are undertaken. Critical information needs include:

- Ground and surface water quality and quantity
- Method and effects of attempts to restore natural topography, water flow patterns, and natural water regimes
- Long-term changes in vegetation and animal communities

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