# OPTIONS FOR ECOSYSTEM RESTORATION AND MANAGEMENT

## SUMMARY OF HGM INFORMATION

Information obtained in this study helps identify and evaluate the historical and current ecological attributes of the Quivira NWR ecosystem. Quivira NWR historically contained predominantly sand, mixed-grass, prairie that was dissected by Rattlesnake Creek and that had two relatively large salt marshes fed by annual spring overbank flows from Rattlesnake Creek (Little Salt Marsh) and saline groundwater discharge from the underlying Great Bend Prairie Aquifer. Annual surface water inputs to the ecosystem were dynamic and likely caused significant annual variation in amount and distribution of flooded salt marsh wetland area including their heterogeneous open water, salt flat, salt grass, and emergent vegetation communities. The driving ecological process of alternating flooding and drying from seasonal and inter-annual inputs of slightly saline Rattlesnake Creek and hypersaline groundwater seepage created and maintained the important salt marsh ecosystem. A wide range of salinities, and other water quality measures, occur on Quivira NWR and change within and among years. The mixed-species grassland in the region historically contained diverse assemblages related to topography, geomorphology, soil type, and presence of high ground water levels that caused subirrigation of alluvial surfaces. Regular fire and occasional intense herbivory sustained grassland communities and prohibited encroachment of woody vegetation.

The primary changes to the Quivira ecosystem have been: 1) alterations to the amount, timing, duration, and quality of surface water flowing into, and through, naturally occurring salt marshes and floodplain depressions; 2) extensive construction water-control infrastructure to manage the distribution and retention of water in constructed and altered wetland impoundments and natural basins; 3) conversion of native grassland to agriculture and increased presence of woody vegetation; and 4) 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. A major challenge for future management of Quivira NWR will be to determine how potentially more limited surface water availability will affect efforts to restore and provide critical habitats and communities. Past attempts to plan management of the refuge were largely designed to continue prior water management strategies to store water in the Little Salt Marsh and subsequently divert this stored water to seasonally flood wetland impoundments and divert some water to the Big Salt Marsh. Future management plans that affect timing, distribution, and movement of water on the NWR must consider how, and if, they are contributing to desired objectives of restoring native communities and inherent ecological processes on the refuge.

## GENERAL RECOMMENDATIONS FOR ECOSYSTEM RESTORATION AND MANAGEMENT

This study is an attempt to evaluate restoration and management options that will protect, restore, and sustain natural ecosystem processes, functions, and values at Quivira NWR. Quivira NWR provides key resources to meet annual cycle requirements of many plant and animal species in the Great Bend Sand Prairie Region of the central U.S., and the signature salt marshes of Quivira NWR are especially critical habitats for migrant waterbirds. Likewise the extensive sand mixed-grass prairie habitats that formerly extended throughout the High Plains region, are key components of the holistic Quivira NWR ecosystem. This study does not address where, or if, the many sometimes competing uses of the refuge can be accommodated, but rather this report provides information in context of evaluating potential future management alternatives and The National Wildlife Refuge System Improvement Act of 1997, which seeks to ensure that the biological integrity, diversity, and environmental health of the (eco)system (in which a refuge sets) are maintained (USFWS 1999, Meretsky et al. 2006). Administrative policy that guides NWR goals includes mandates for: 1) comprehensive documentation of ecosystem attributes associated with biodiversity conservation, 2) assessment of each refuge's importance across landscape scales, and 3) recognition that restoration of historical processes is critical to achieve goals (Mertetsky et al. 2006). Most of the CCP's completed for NWR's to date have highlighted ecological restoration as a primary goal, and choose historical conditions (those prior to substantial human related changes to the landscape) as the benchmark condition to evaluate system changes (Meretsky et al. 2006). General USFWS policy, under the Improvement Act of 1997, directs managers to assess not only historic conditions, but also "opportunities and limitations to maintaining and restoring" such conditions. Furthermore, USFWS guidance documents for NWR management "favor management that restores or mimics natural ecosystem processes or functions to achieve refuge purpose(s) (USFWS 2001).

Given the above USFWS policies and mandates for ecosystem restoration and subsequent management of NWR's, this HGM study has attempted to objectively understand: 1) the fundamental physical and biological processes that historically formed and sustained the structure and functions of the system and its communities and 2) what changes have occurred that caused degradations and that might be reversed and restored to historic and functional conditions within a "new desired" environment. This HGM approach helps identify the historic "role" of ecosystem types and resources at Quivira NWR in meeting larger conservation goals and needs at different geographical scales. In many cases, restoration of functional ecosystems on NWR lands, such as at Quivira NWR, can help the refuge lands serve as a "core" of critical, sometimes limiting, resources than can complement and encourage restoration and management on adjacent and regional private and public lands.

The HGM evaluation process, and discussion of restoration and management options, used in this report is not species-based, but rather seeks to identify options to restore and maintain system-based processes, communities, and resources that ultimately will help support local and regional populations of endemic species, both plant and animal, along with other important ecosystem functions, values, and services. Consequently, recommendations from the HGM evaluation in this study are system-based first, with the goal of restoring and sustaining native communities and their inherent resources, with the assumption that if the integrity of the system is maintained and/or restored, that key resources for species of concern can/will be accommodated. This approach is consistent with recent recommendations to manage the NWR system to improve the ecological integrity and biodiversity of landscapes in which they set (Fischman and Adamcik 2011). Obviously, some systems are so highly disrupted that all natural processes and communities/resources cannot be restored, and key resources needed by some species may need to be replaced or provided by another, similar habitat or resource. However, where appropriate, a primary consideration of refuges should be to attempt to restore the basic features of former functional landscapes.

Based on the context of information obtained and analyzed in this study, we believe that future restoration and management of Quivira NWR should consider the following goals:

1. Maintain and restore sustainable sand (mixed-grass) prairie communities within the Rattlesnake Creek alluvial floodplain and adjacent sand dune/hills uplands.

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.

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 feasible and appropriate.

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

The following general recommendations are suggested to meet these ecosystem restoration and management goals for Quivira NWR.

***1. Maintain and restore functional sand (mixed-grass) prairie communities within the Rattlesnake Creek alluvial floodplain and adjacent sand dune/hills uplands.***

Quivira NWR is located within the large Great Bend Sand Prairie Province that supported extensive contiguous mixed-grass prairie. The extensive historic grasslands at Quivira contained both alluvial and upland-type species assemblages differentiated by: 1) whether the area was in relict alluvial floodplains or loess sand hills, 2) whether alluvial areas were subirrigated by high groundwater tables and 3) the salinity of soils. Additionally, the region contained unique grassland assemblages associated with choppy sands deposited by relict Wisconsin-age lake beach ridges and on sand dunes/hills. The potential historical HGM vegetation map (Fig. 20) identifies the relative distribution and juxtaposition of these grasslands and sand dunes/hills, which created high diversity and interspersion of grass-dominated species and provided critical resources to many animal species.

Over time, the integrity of grasslands at Quivira has been degraded because of changed land use and management philosophies at some level, conversion to other land covers, and altered ecological drivers such as recurrence intervals of fire and grazing intensity. These system alterations have reduced the overall diversity and occurrence of native grass and forb species and increased the presence of woody vegetation and expansion of invasive plant species. Restoring the general nature of the once expansive grasslands at Quivira NWR will require reconnection of grassland areas, restoration of native plant communities, control of woody and invasive species, and reestablishment of the basic drivers of the grassland system including use of fire and herbivory in more natural patterns and recurrence. Further, the relatively sensitive sand dunes/hills are subject to significant alteration if they are exposed to high or unnatural disturbances such as high grazing rates, road construction, and other physical developments. The more delicate ecological nature of these sand dunes/hills will require careful protection and use.

***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.***

The critical importance of the regional groundwater system in the Rattlesnake Creek Basin to sustaining the ecological integrity of the Quivira NWR ecosystem cannot be overstated. The increased unsustainable uses of groundwater in the region, particularly the Big Bend Groundwater Management District No. 5, has reduced the groundwater levels in the Rattlesnake Creek Basin, and ultimately caused reduced surface water flows into and through Quivira NWR. Also, changed groundwater use and seasonal extraction threatens the unique groundwater seepage system that historically maintained the Big Salt Marsh ecosystem. Ultimately, development of regional water conservation plans that have effective and enforceable groundwater use reductions are needed to achieve sustainability (Striffler 2011). Unfortunately, voluntary incentive programs to reduce groundwater use have not been effective to date and Kansas State administrative action will be needed to achieve water use and distribution changes. Land management in the Great Bend region will need to change to protect and recharge surface and groundwater quantity and quality. Certain changes to water use may be possible on Quivira NWR proper, but the most significant gains will require efforts to enhance regional aquifer recharge, restrict groundwater pumping, and protect riparian corridors and historic stream channels-water flow pathways (see below).

***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.***

The highly heterogeneous and productive Quivira ecosystem was created and sustained by its unique physiographic landscape position where the relict Arkansas River course dissected the Holocene eolian-derived sand hills and dunes. Quivira NWR lies in a discharge zone for groundwater exiting the Great Bend Prairie aquifer and basement rock layers. Contact of the shallower Great Bend alluvial aquifer with the Permian saline basement rocks causes' groundwater (and its subsequent surface discharges) to be saline, thus creating the "salt" nature of the Quivira ecosystem and the namesake salt marshes. The variable source and flow of ground and surface waters across and through Quivira NWR created the variable soil salinities, subirrigation from high water tables, and seasonal hydroperiods in the heterogeneous communities. Historic water flow pathways at Quivira had: 1) the signature contemporary and relict channels of Rattlesnake Creek, 2) intricate labyrinth channels where ground water discharge contributed annual flows into and through the Big Salt Marsh system, and 3) sheetflow of surface water from upland drainage and periodic overbank flooding of Rattlesnake Creek. Unfortunately, all of these three flow systems have been altered from varied activities including altered topography, altered Rattlesnake Creek channels, and diversions of surface water via the extensive water-control infrastructure on the refuge. Restoring at least some portions of the former water flow system at Quivira seems desirable to restore basic hydrologic processes, communities, and resources.

Past water management on Quivira has promoted water storage in the Little Salt Marsh and then diverted this water to over 30 wetland impoundments and the Big Salt Marsh. It is understandable that water storage, especially in dry years and over time as seasonal discharges in Rattlesnake Creek has decreased, was desired. The long-term annually consistent pattern of water storage and diversion, however, has altered the natural water flow pattern and inundation regimes in the area. With uncertain, but probably reduced, surface and ground water availability to the refuge, future water management plans and diversions/storage on Quivira should be reevaluated in the context of restoring more natural water regimes in the various wetlands. This HGM evaluation identifies the general distribution of historic wet meadow/seasonal herbaceous marsh habitats, but unfortunately did not have detailed topographic information to delineate the small grassland depressions or elevation contours of the larger depressions and the salt marshes. Nonetheless, general natural water regimes for these sites are understood and can form a basis for future water management plans.

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

As previously stated and evaluated in the HGM approach, the heterogeneous complex of ecological communities at Quivira NWR was created by the unique mix of geomorphology, soils, topography, and hydrology. Future restoration and management of Quivira should promote sustainability of this geographic, hydrologic, and resource pattern by clearly targeting community restoration and management to appropriate HGM-determined sites. The mix of grassland assemblages discussed under #1 above provides an example of this targeting. Here, the grassland assemblages are determined by: 1) which geomorphic surface the site is in (i.e., relict alluvial or sand hills/dunes), 2) the subirrigation capacity of the site (i.e., high seasonal water tables or nonsubirrigated levels), and 3) the salinity of the soils (i.e., saline or nonsaline). The distribution of vegetation assemblage "zones" in and around the salt marshes also is determined by the source and amount of water, soils, topography, and water flow pathways. Much of this information for the salt marshes is available, but future detailed understanding of salt marsh vegetation zones will require more refined topographic information.

In addition to understanding of the relative position and proximity of various communities at Quivira, a key management/restoration criterion is determining how and to what degree basic ecological processes or "drivers" have been altered. At Quivira, these basic "drivers" are source, timing, and duration of flooding (hydrology); recurrence intervals of fire; and timing, type, and severity of herbivory, mostly from large ungulates. Future management of all communities at Quivira NWR must match the process with the HGM-location of the community. As an example, the sedge-rush dominated wet meadows/seasonal herbaceous marshes were located in alluvial depressions along Rattlesnake Creek and in small depressions within some grassland sites. In general these wetlands historically had seasonal water regimes, usually caused by overflow of Rattlesnake Creek or sheetwater flow of water draining from uplands. The sites received variable water among years, and in dry years many of the depressions may not have been inundated at all. The sites therefore had both seasonal (winter-spring flooding) and long-term dynamic water regimes. Attempts to more regularly flood these depressions, extend hydroperiods, or sustain flooding in unnatural ways with few drying, fire, or herbivory disturbances usually causes these wetlands to become choked with persistent emergent vegetation, have nutrients bound in vegetation and detritus, and ultimately lose productivity.

## SPECIFIC RECOMMENDATIONS FOR ECOSYSTEM RESTORATION AND MANAGEMENT OPTIONS

### *1. Maintain sand mixed-grass prairie and sand hills/dunes*

Protecting, restoring, and maintaining the diverse grasslands on Quivira NWR are priority management actions to improve the integrity and productivity of not only the refuge lands, but also the larger regional Great Bend Sand Prairie Ecoregion. Management actions specific to the refuge should include:

- Delineate the various grassland types relative to the HGM categories and design management prescriptions specific to the community type.
- Introduce fire at more natural recurrence intervals to sustain specific assemblages and production, at least once an area is beyond the restoration phase and in more of a maintenance phase of management.
- Remove and discourage woody vegetation in grassland areas.
- Control invasive species.
- Restore appropriate grassland communities in some retired agricultural fields.
- Restore natural hydrological regimes to specific grassland types, where appropriate. For example, upland Quaternary dune geomorphic surface grasslands are supported by seasonal unimpeded sheetflow of surface water from local precipitation and runoff. In contrast, alluvial floodplain subirrigated grassland is supported by high groundwater tables and occasional short duration overbank flooding from Rattlesnake Creek.
- Use recently completed LIDAR topographic survey to delineate the many small wetland depressions in the grasslands and protect these depressions from future physical and hydrological disturbance and degradation.
- Protect sand dune areas from harmful disturbances of cattle, vehicles, and other activities.
- Develop careful deferred grazing plans for specific grassland units.

### 2. *Protect and Restore Ground and Surface Water Resources and Manage for Natural Hydroperiods*

The Water Resources Inventory and Assessment (WRIA) completed for Quivira NWR (Striffler 2011) and additional information provided in this report identify the primary hydrological issues for the refuge. The WRIA provides recommendations about protecting and restoring ground and surface water in the Rattlesnake Creek Basin and GMD No. 5 that are consistent with the HGM information. We concur with these recommendations and suggest:

- Implement the recommendations provided in the WRIA to revise the refuge water management plan and address threats associated with regional water depletion. These recommendations specifically address the critical need for the USFWS to continue efforts, with the Rattlesnake Creek Subbasin Partnership Group, to protect refuge water rights and restore groundwater resources through voluntary and enforceable water use reductions and changed land use and land use policy.
- Manage historic wet meadow and seasonal herbaceous marsh depressions (now mostly in managed impoundments) for annually variable, seasonal water regimes. Past management over four decades has shifted many wetland impoundments to more seimpermanent and annually consistent water regimes. These water management regimes can be reversed back to more naturally occurring seasonal regimes with spring inputs, summer drawdowns, and some modest reflooding in fall. Water management in the units should periodically include prolonged year-long drawdown to emulate the natural interannual patterns of periodic drying in this system.
- Restore at least some regular drawdown and seasonal surface water dynamics in the Little Salt Marsh to restore and recycle productivity, vegetation diversity, and resource availability to wetland associated species.
- Restore and maintain the sustained groundwater flow system into and through the Big Salt Marsh to create seasonal inundation related to natural topography, soils, and subirrigation.
- Restore natural sheetflow into small temporary and ephemeral wetland depressions in grasslands.
- Reduce or eliminate diversion of scarce Rattlesnake Creek water flow to higher elevation Quaternary dune geomorphic surface areas.

### 3. *Restore natural topography and water flow patterns*

The Quivira landscape historically contained heterogeneous land forms and topography that enabled complex and sometimes intricate patterns of water flow into, through, and within the region. Hopefully subsurface groundwater pathways can remain intact, albeit perhaps with reduced or changed temporal aspects of groundwater movement. In contrast, alterations in topography and development of water-control infrastructure at Quivira NWR have changed surface water movement patterns. Generally, restoring at least some aspects of natural water flow patterns is desirable to restore hydrological regimes associated with, and required by, the different communities on the refuge. Specific management recommendations to restore topography and water flow include:

- Evaluate restoring high water, or some seasonal flow, into former main and abandoned swale channels of Rattlesnake Creek. This would include some limited managed bypass of water within the old Rattlesnake Creek channel around the Little Salt Marsh.
- Evaluate all roads, ditches, levees/dikes, and water-control infrastructure to determine structures that are not critical to, or that are impeding, water conservation and management and remove or modify unnecessary ones. The many new and old structures in the historic Big Salt Marsh area should be carefully considered for removal or modification to allow natural patterns of water movement into, across, and within the salt marsh basin including the salt flats and pans on the edges of the marsh.
- Improve water flow through road levees and corridors where the road is retained. This can be achieved with low water crossings, permeable fill, multiple culverts or bridges, etc.
- Remove water diversion infrastructure into higher elevation Quaternary dune upland grasslands where artificial wetlands were formerly created. Restore previous modified upland topography, especially the integrity of former small wetland depressions and their small watersheds.
- Do not further compartmentalize wetland units or natural floodplain areas with levees and water-control structures unless the new structure is consistent with restoration objectives.

### 4. *Restore appropriate vegetation communities related to HGM attributes.*

In most locations on Quivira NWR, the current types and distribution of major vegetation communities are relatively similar to historic conditions, but some changes have occurred in species composition and hydrology (see above). The primary changes are within the various grassland assemblages (addressed under #1 above), alluvial wetlands, the Little Salt Marsh, and northeastern parts of the Big Salt Marsh. The native mixture of communities at Quivira provided critical resources to many animal populations throughout the mid-continent U.S. Maintaining and restoring, where possible, the distribution and types of historic habitats is important to the long term capability of the Quivira, Great Bend, and mid-continent U.S. Certain future management actions to restore native communities are addressed above, but additional specific considerations include to the extent possible:

- Control invasive species in all plant communities.
- Restore natural water regimes and sources within communities. Much of this is discussed above, but restoring the appropriate surface water sheetflow and runoff to loess sand hill and dune grasslands and depressions, subsurface subirrigation of alluvial grasslands, periodic overbank flow of Rattlesnake Creek into alluvial wetland depressions, and the intricate groundwater discharge into and through the Big Salt Marsh is critical.
- Restore basic ecological disturbance practices in naturally occurring patterns and times including drought, flooding, fire, grazing, and soil disturbance (e.g., that would emulate ground and vegetation disturbance from large numbers of native ungulates).
- Carefully target grassland and wetland restorations to appropriate HGM sites, especially related to soils and hydrology.