ECOSYSTEM RESTORATION OPTIONS

GUIDING PRINCIPLES

Many areas of Ouray NWR retain at least parts of historic community structure and ecological processes despite considerable alterations to the hydrologic condition of the Green River, extensive development in some floodplain bottoms, and invasion of nonnative plants. Floodplain wetlands comprise the largest, but also the most altered, habitat type on Ouray NWR. In contrast, most upland grasslands are relatively unchanged from when the refuge was first established. Restoration of degraded floodplain habitats on Ouray NWR will require that each bottom be carefully evaluated to: 1) understand geomorphic surfaces; 2) realistically assess opportunities to emulate ecological processes especially flooding frequency, duration, and extent; and 3) determine relative costs and benefits of management actions. We offer certain ecological principles that can help guide decisions about restoration activities.

What is the appropriate conservation objective?

The type and magnitude of alteration to structure (e.g., vegetation composition) and ecological processes (e.g., frequency of overbank flooding) of habitats should determine what type of conservation action is appropriate for individual sites on Ouray NWR. If an area has minimal degradations to historic structure and processes, then protection of the site and its habitat(s) is needed (Fig. 22). An example of low degradation on Ouray NWR is upland grasslands. In contrast, if either structure or processes are highly degraded then a combination of enhancement and restoration is needed. Riparian woodlands on Ouray are an example of this type of degradation where structure (i.e., cottonwood trees) is mostly intact, but significant alterations to flood frequency have reduced scouring actions and exposed soil surfaces needed for germination and survival of cottonwood. In this case, structural parts of the riparian woodland need enhancement (e.g., control of saltcedar) and processes need restoration (e.g., some means to create bare soils where good groundwater is present). In the most severe cases of degradation, many floodplain wetlands on Ouray NWR have greatly altered structure (extensive cross levees) and processes (reduced flood frequency) and restoration efforts will be more difficult, if they are possible at all.

The various floodplain bottoms on Ouray NWR have different degrees of alteration to process and structure (Fig. 22). Wyasket Bottom has the least amount of degradation and Leota and Sheppard Bottoms have the most altered conditions. Most of Wyasket Bottom has minor structural alteration because no levees were built in this area, except for the old Wyasket Pond levees. Although Green River flows and flooding are altered from pre-Flaming

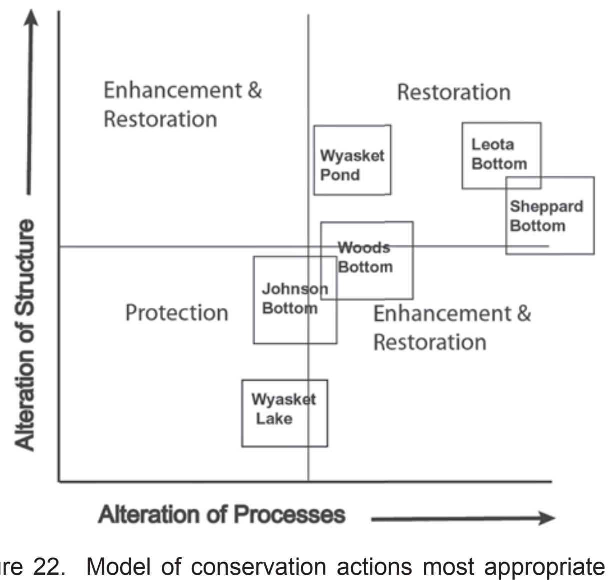

Figure 22. Model of conservation actions most appropriate for floodplain “bottoms” on Ouray National Wildlife Refuge, Utah.

Gorge Reservoir periods, periodic overbank flooding does occur in Wyasket Bottom and its large area allows both sheet and flood water to flow across it unimpeded. Consequently, protection of the Wyasket Bottom area with no, or limited, future development seems most appropriate.

In contrast to Wyasket Lake, the Wyasket Pond area has greatly altered structure because of the old levee surrounding it and construction of inlet canals to allow flooding of the area at low water levels of the Green River. Because Wyasket Pond is located on a higher point bar area, it historically (pre-levee) was not flooded as often or as long as lower backswamp areas. Consequently, it needs restoration of both structure (i.e., removing levees) and processes (i.e., shorter duration and less frequent flooding). Because Leota and Sheppard bottoms also have high alteration in both structure and processes, complete restoration may not be possible, or desirable, because of the significant infrastructure in these areas, potential contamination from selenium, and a desire to provide complexes of floodplain wetlands with different water regimes.

Woods and Johnson Bottom have medium levels of alteration to structure and processes. Johnson is somewhat less altered than Woods Bottom because interior cross-dikes have been removed in Johnson Bottom. For these bottoms, enhancement of processes (restoring overbank flooding at pre-1963 recurrence intervals) and restoration of structure (e.g., partial levee removal) seems most appropriate.

Structure and function

Restoration must seek to repair both the structure and functions of habitats. Functions of habitats are created and maintained by both structural and process elements of ecosystems. For example, nursery sites for razorback suckers require periodic river flooding of floodplain wetlands that contain dense stands of emergent and submergent vegetation (Modde 1997). Restoring only structure or process without the other will not replicate natural ecosystem functions and values and will require greater management intensity to maintain the site. In the above example, reintroducing regular spring flooding without creating annually dynamic water regimes including periodic dry years that sustain floodplain wetland communities may allow fish to enter floodplains, but will not provide high primary and secondary productivity needed for growth and survival of young. Conversely, manipulating water levels to sustain plant and invertebrate productivity without reintroducing flood flows will not provide access for entrainment and subsequent growth and recruitment of native fishes.

On Ouray NWR it will not be possible to completely restore all structure and processes to every site. Any return to historic structure and process usually is better than the currently degraded condition. However, some sites may be so altered that either structure or processes can not be restored and these areas may be permanently shifted to another condition. In these "irreversible" areas, managers must understand the "new" condition and not try to manage the site for "old" habitats or processes that can not be reinstated or sustained without extremely intensive management.

Like-for-like

True restoration of ecosystems involves trying to reestablish vegetation communities and processes that previously were present on a site. In this report we use the mid-1900s period prior to construction of Flaming Gorge Reservoir as the baseline for determining types, distribution, and abundance of habitats historically present on Ouray NWR and as a model for restoration. Modeling historic distribution of habitats depends on understanding the distribution of habitats relative to soils, geomorphic setting, topography, and hydrologic regime. This "base" information provides the first-level criteria for deciding what habitat type(s) should be restored at specific locations and also how basic processes (e.g., overbank flooding) operate and should be restored, or replicated, if possible.

Wyasket Pond provides an example of using base abiotic information to make sustainable habitat restoration decisions. Wyasket Pond historically was a higher elevation point bar surface with interspersed riparian woodland habitat on ridges and herbaceous seasonal wetland in swales (Fig. 23). The point bar surface at Wyasket Pond graded into alluvial and upland terrace that contained finer alluvial sediments and upland grassland and semi-desert shrubs. These soils were conducive to crop production and in the mid-1900s a protective levee was built in this area by a private landowner to exclude flood waters from the Green River. After Ouray NWR was established, managers reversed use of the Wyasket Pond levee from an exclusion purpose to an inclusion purpose used to impound water. Clearly, this change created a different wetland condition than historically occurred on the site and management of Wyasket Pond has traditionally been difficult and intensive, because

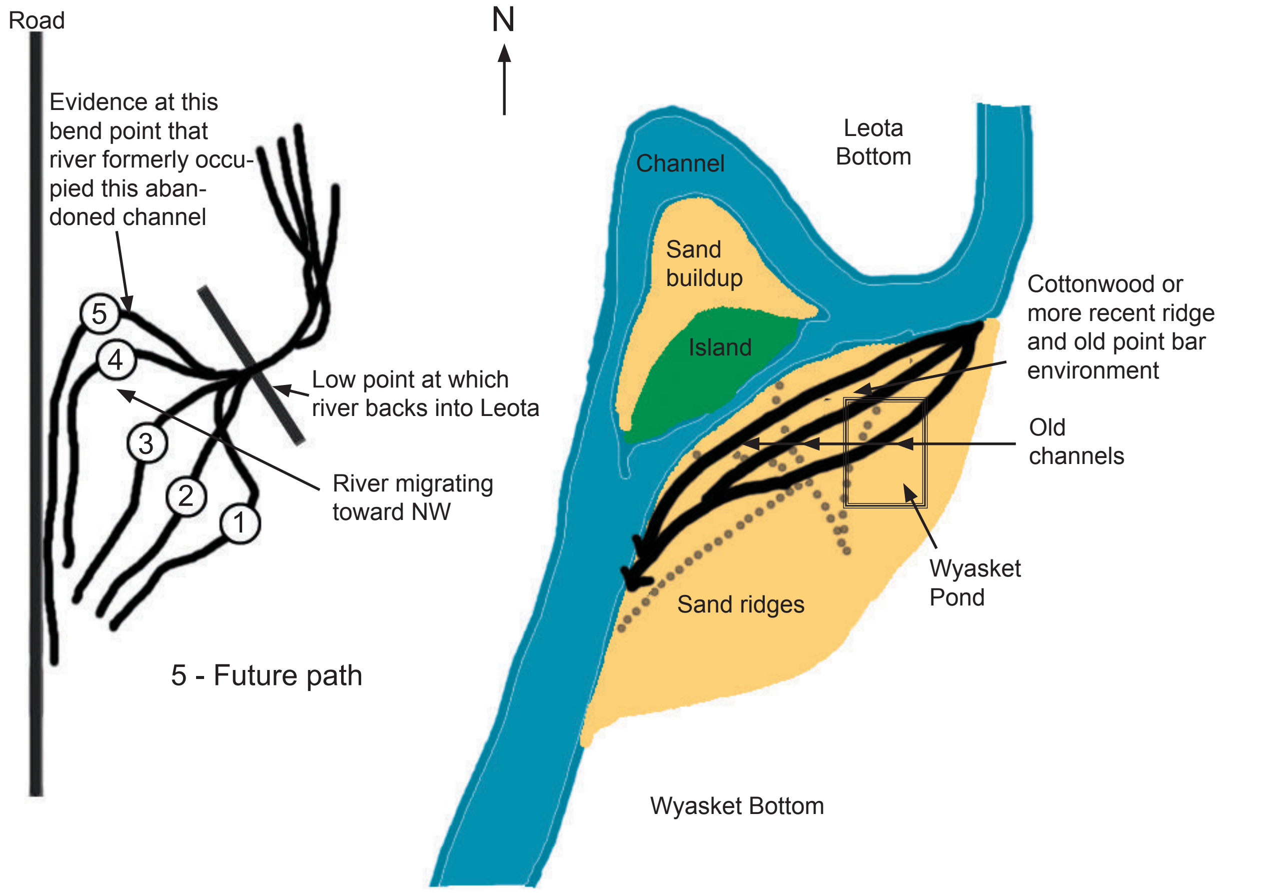

Figure 23. Green River channel migration (1= oldest, 4= current, 5 = projected future path) that formed point bar ridge and swale complex at the north end of Wyasket Bottom. Location of Wyasket Pond includes former channel paths and sand-based ridges and swales.

soils are sandy and topography is heterogenous. Impounding water for extended periods in Wyasket Pond was desired to attract and increase breeding waterfowl on the site, but this required regular pumping and construction of a low elevation inlet to deliver water to the pond each year. Over time, dense emergent stands of cattail and bulrush dominated the area and created an artificial wetland condition. Dense monotypic stands of emergents gradually reduced the use of this area by breeding waterfowl and regular mechanical disturbance and nest structures were required to improve the attractiveness of the area for breeding ducks and geese.

Restoring Wyasket Pond to a more natural condition that is suited for the soils, topography, and geomorphology of the site will require restoring structure (i.e., a complex of ridge-and-swale riparian forest and seasonal wetland) and processes (i.e., irregular, short duration, flooding). If this is done, then a like-for-like restoration will be accomplished.

As previously indicated, some sites on Ouray NWR may have highly altered conditions and warrant management that attempts to create a slightly different habitat type than what was historically present. This creation does not emulate historic site-specific conditions, but may help restore "landscape mosaics" that have been reduced or eliminated on the area. For example, low elevations in some floodplain bottoms were inundated for extended periods by flood waters of the Green River. During wetter periods these low "spots" may have held surface water for 1-3 years, but then dried in subsequent years. These long-term dynamics recycled nutrients and maintained system productivity during dry periods and then provided periodic nursery sites for native fish such as razorback suckers, breeding sites for birds that nest over water, brood sites for waterfowl, and sites for growth and survival of amphibians in wet times. Because of changes in Green River flood frequency and magnitude, and construction of levees in bottoms, these low elevation wetland sites became drier and shifted wetland communities to seasonal or semipermanent water regimes. While it may not be possible to restore Green River flows, it may be possible to use the alterations (e.g., levees) to emulate periodic extended inundation in some impoundments and thereby restore some elements of historic landscapes at Ouray NWR.

River ecology and floodplain connectivity

Attempts to restore hydrological processes on Ouray NWR will be compromised because of alterations to Green River flows following closure of Flaming Gorge Dam. While it may be possible to alter future releases from Flaming Gorge Reservoir to more closely emulate seasonally- and annually-dynamic flows and flood pulses, many competing uses and objectives will influence decisions and changes are not likely to occur soon. Conservation interests should continue to advocate changes in releases from Flaming Gorge to more closely emulate natural dynamics. In the near future, some management opportunities may be possible on Ouray NWR to help restore seasonal flood patterns. These management actions must understand and replicate basic hydraulic patterns and geomorphology of the Green River channel and floodplain system and include natural patterns and locations of connectivity between the river and floodplain.

In general, it is desirable to improve the connectivity between the Green River and Ouray NWR floodplain bottoms during spring flood pulses. Historically, some parts of most, but not all, floodplain bottoms on Ouray NWR flooded at recurrence intervals of 1.5-2.5 years. From 1923-1962, a 2-year recurrence flow was 21,967 cfs but since 1963 a 2-year recurrence interval is only 16,347 cfs. Consequently, if a recurrence interval of 2 years was desired on Ouray NWR, entry points on natural or man-made levees would need to be provided at elevations that allowed flows of >16,000 cfs to enter floodplain bottoms.

At Ouray NWR, overbank flooding historically occurred first at low elevation sites along natural levees at downstream ends of floodplain bottoms and last at higher elevation point bar surfaces on inside bends of the Green River (Fig. 16). Consequently, most flooding of Ouray bottoms was from slow "backwaters" that deposited some fine sediments in bottoms and had limited scouring at entry and exit points. Backwater floods typically occurred in some areas of Johnson, Leota, and Woods Bottoms almost every year. Higher floods were needed to back water into Sheppard and Wyasket Bottoms because these areas had higher elevations and more pronounced natural levees. Headwater floods that crossed point bars into Ouray bottoms historically occurred only at flows >27,000 cfs at a return interval of >5 years. A similar recurrence interval now is >23,000 cfs.

The above geomorphological patterns and hydrological data for Ouray NWR suggest that altering existing natural or man-made levees to restore backwater flood connectivity to floodplain bottoms should occur at low downstream ends of bottoms to allow flows of 14-16,000 cfs to enter Johnson, Woods, and Leota bottoms and 17-20,000 cfs to enter Wyasket and Sheppard bottoms. Lowering entry points on levees at upper ends of bottoms or across point bar surfaces generally is not desirable at elevations that allow flooding <23,000 cfs. Artificially lowering entry sites at upper ends of bottoms or at locations that cause flooding <14,000 cfs will create more headwater type flooding that: 1) deposits coarse texture sediments at entry sites and 2) increases scouring at unarmored exit locations. In contrast, constructing entry sites at the downstream end of bottoms >16,000 cfs will create slow sluggish backwater flooding that: 1) reduce scouring of natural levees and exit sites, 2) deposits moderate amounts of silt at entry sites that may enhance cottonwood regeneration and 3) periodically deposit thin veneers of silt in floodplain wetlands that sustains wetland productivity.

Flood flows across Ouray NWR floodplains generally occurred at wide slow sheetflow that gradually rose and fell. Structural developments that impede sheetflow across bottoms or that accelerate rates of rise and fall should be removed where possible.

Practicality and management intensity

Decisions about restoring native ecosystems on Ouray NWR must understand the relative "costs" and constraints of restoring and maintaining a site in relation to the degree of ecosystem degradations (Fig. 22). Certain structural alterations may be reversible, while others are not. For example, some interior cross-levees in floodplain bottoms may be easily removed and not compromise management of other units (e.g., the levee between L7 and L7A in Leota Bottom) while others can not be removed because of interconnected water movement, concerns about selenium contamination, etc. In general, intensity and expense of restoration and management will be greatest in the areas that have the most severe degradations (e.g., Leota, Sheppard - Fig. 22). Also, restoring Green River flows and overbank flooding of Ouray NWR bottoms will be difficult, if not impossible. Consequently, other more practical modifications will be needed, especially those modifications that do not require intensive management.

RESTORATION DECISIONS ON OURAY NWR

The specific goals and priorities for restoring and managing habitats on Ouray NWR will depend on many biological, social, and economic factors. This report does not attempt to prioritize habitat restoration opportunities, but does offer suggestions on how certain restoration and enhancement of habitats on Ouray NWR can help restore and sustain the ecological integrity of the area and region. Important general goals for restoration on Ouray NWR are to:

1. Maintain a complex of habitat types on Ouray that match historic distributions related to soils, geomorphological surface, topography, and hydrological regime.
2. Improve the connectivity between the Green River and floodplain wetlands.
3. Emulate natural hydrological regimes in floodplain wetlands where possible.
4. Enhance riparian woodlands to provide a corridor of cottonwood-dominated forest along the Green River.
5. Enlarge the size of habitat "patches" where possible and reduce compartmentalization and/or restrictions to surface water flows into and across floodplains.

Specific recommendations for each habitat type and area are provided below:

Upland grassland, clay bluffs, semi-desert shrublands

The high elevation benches and terraces that border the Green River floodplain contain unique assemblages of plants and animals that add diversity, buffers, and continuity to floodplain habitats at lower elevations on Ouray NWR. Most upland, bluff, and shrubland areas are relatively unchanged from the mid-1900s and should be protected. Plant communities on these sites are adapted to older eroded soil types and limited soil moisture. Annual primary production in these communities is low and sustained by low-levels of herbivory and occasional fire. Recommendations include:

- Protect uplands, bluffs, and shrublands from development and unusual erosion. Roads, trails, and human access should be limited in these areas and soils should not be mechanically disturbed.
- Sustain grass-dominated communities with moderate levels of herbivory from native mammals and periodic fire.

Alkali flats

Alkali flats are bands of habitat between shrublands and floodplain wetlands that have high evapotranspiration rates. Runoff water and groundwater seeps provide seasonal surface moisture and short-duration shallow flooding that supports diverse grass and herbaceous plants adapted to more saline conditions. The key to sustaining alkali flats is maintaining seasonal sheet water flow into and across these areas. Historically, alkali flats were occasionally (20-30-year flood events) flooded for short periods during very high flow events of the Green River. Most alkali flats on Ouray NWR are not highly degraded, but in some places sheetflow to, and across, these flats is interrupted by roads, levees, and culverts that concentrate and divert flows laterally. Alterations to the hydrology of the Green River and levees in and around floodplain bottoms have virtually eliminated floodwater inundation of alkali flats. Recommendations include:

- Protect undisturbed alkali flats from additional development where possible.
- Improve surface water sheetflow across alkali flats by removing unnecessary roads and ditches.
- Where roads cross alkali flats, construct multiple culverts and/or low spillways to allow water to cross flats in many locations and flow into floodplain wetlands.
- If roads must cross alkali flats they should be low wide berms to allow the rare, but important, high flood waters of the Green River to flow into alkali flat areas.

Riparian woodland

Most of the historic riparian woodland areas on Ouray NWR are still present, but patch size is diminished and the species composition is gradually changing as cottonwood is being replaced by saltcedar. River processes that perpetuated cottonwood included periodic high flows that scoured point bars and deposited a thin veneer of silt on natural levees and ridges. These newly exposed substrates, adequate soil moisture, and light allow cottonwood seedlings to germinate and survive. In the absence of any of these 3 conditions, germination and survival of cottonwood is compromised and is subject to increased competition from saltcedar. Changes in flow of the Green River and levees constructed along the river have reduced overbank flooding at higher elevation natural levee and point bar locations. Interestingly, some areas within levees especially in Sheppard and Leota bottoms have many young cottonwood along higher elevation contours that have been periodically disturbed in attempts to control saltcedar or from road and levee construction. Recommendations include:

- Improve frequency of overbank flooding of the Green River at appropriate sites and elevations (see discussion of floodplain bottoms below).
- Evaluate cottonwood and saltcedar response to mechanical soil disturbance on point bar ridges inside protection levees in Sheppard and Leota bottoms.
- Protect existing stands of cottonwood-dominated stands of riparian forest.

Wyasket Bottom and Wyasket Pond

With the exception of the old Wyasket Pond site, this floodplain bottom is less disturbed and degraded than other bottoms on Ouray NWR. Green River water begins to flow into Wyasket Bottom at about 19,000 cfs but most of the area is not flooded until the river discharge exceeds 22,000 cfs (Tables 5, 6). Although flood frequency at Ouray has changed since Flaming Gorge Reservoir was built, a 16-17,000 cfs flow still occurs about every 2-3 years and a 22,000 cfs flow occurs about every 5 years. Consequently, although less frequent, Wyasket Bottom continues to flood at regular intervals and retains many historic processes and water flow patterns that are not restricted by roads, levees, ditches, and water control structures. In contrast, Wyasket Pond is ringed with levees and is at a higher elevation old point bar location that historically was not flooded except at high flows. Recommendations include:

- Protect Wyasket Bottom by retaining its topography and water flow patterns, eliminating roads and ditches where possible, and not developing the area further.
- Remove all levees and water-control structures in the old Wyasket Pond area and restore the ridge-and-swale topography and plant communities to this site by re-creating and connecting depressions and ridges.
- Abandon the inlet structure and ditch that provided water to Wyasket Pond at flows of > 4000 cfs.
- Evaluate mechanical soil disturbance on point bar ridges on the north side of Wyasket Bottom and the former Wyasket Pond area to encourage cottonwood regeneration.

Johnson Bottom

The structure and processes of floodplain wetlands in Johnson Bottom have been partly restored in recent years by removing internal levees and by the construction of a 200 foot levee breach at the southeast corner of J-4. Low portions of this bottom historically flooded about every 1.5 years at Green River discharges >18,000 cfs. Presently, some Green River water flows through the breach at discharges >13,000 cfs at a recurrence interval of about 1.5 years. Construction of the fish kettle and modified water-control structure allows water to be retained in Johnson Bottom for extended periods, perhaps longer than historic regimes. Given past development for fisheries concerns, this bottom now can be managed for prolonged flooding, however, care will be needed to sustain the long-term plant communities and primary and secondary productivity of this area. Recommendations include:

- Promote slow backwater flooding of Johnson Bottom by widening the current 200 foot breach and by constructing at least one additional breach (of at least 200 foot) along the Green River at J-4 to allow flood water to enter Johnson Bottom in a wider flow pattern. Wider and multiple breaches are desirable to allow more natural water flows into floodplains and to reduce excessive scouring and/or deposition of silt that occurs at constricted inlets and outlets.
- Do not construct breaches at the upstream end of Johnson Bottom - such a breach would cross a point-bar surface and cause excessive deposition of silt and sand into Johnson Bottom.
- Abandon and fill the old inlet ditch and structure at J-1.
- Manage Johnson Bottom for dynamic water regimes including regular seasonal, and periodic annual, drying. Do not continuously flood Johnson Bottom for more than 2-3 years.

Woods Bottom

Woods Bottom has been modified similar to Johnson Bottom in that an area in the southern part of the Main Unit now has a fish kettle and modified outlet water-control structure. Woods Bottom also has a short levee breach in the Backside Unit. These modifications have attempted to provide more regular flooding of the bottom to enhance entrainment and recruitment of native fishes. The levee breach allows flood water to enter the western diked part of Woods Bottom, however this water can not inundate the entire bottom because the internal levee between the Backside and Main units restricts flow throughout the area except at very high flows. Restoration of more natural flood flows into and through Woods is needed and future management should seek to maintain natural wetland vegetation communities and dynamics. Recommendations include:

- The upstream inlet and interior drain canals in Woods Bottom are in unnatural locations and tend to silt in during flood flows and are difficult and costly to maintain. The inlet structure should be maintained to provide management flexibility during low flow periods, however, the interior drains should be filled because their excavations may perforate bottom seals of the wetland and reduce water holding capability. Future habitat management plans should address when and how the inlet structure should be operated.
- Remove all interior levees in Woods Bottom to facilitate sheetflow of water across the floodplain wetlands. This removal includes both the long internal levee that separates the Backside and Main units and the short levee spur into the east central part of the bottom that led to an old abandoned gas well site.
- Construct a new levee breach at least 400 foot wide at the southern part of the Main Unit of Woods Bottom immediately west of the fish-kettle/outlet structure to allow slow backwater flooding.
- Manage Woods Bottom for long-term dynamic water regimes to sustain plant and animal communities and long-term productivity. Do not continuously flood Woods Bottom for more than 2-3 years, and then periodically dry the bottom.

Leota Bottom

Although Leota Bottom is highly modified because of the extensive levees, ditches, and water control structures, opportunities exist to enhance the connectivity between the Green River and Leota Bottom and also use remaining infrastructure to provide diverse and dynamic floodplain wetland types that have been lost throughout the Green River floodplain ecosystem. Historically, some backwater flooding into low elevations at the south end of Leota occurred almost every year at Green River discharges >14,000 cfs. Changes in river flows have reduced this flooding frequency, however, the levee breaches at L7 and L7A allow water to flow into and out of Leota at ca. 15,000 cfs. The breach at L7A is more appropriately located to allow backwater to flow into Leota than is the L7 breach site, however, the entry flow at L7A is compromised by its narrow width and by the modified outlet structure and fish kettle at this location. Future management of Leota should seek to simultaneously enhance backwater flooding into this bottom, reduce constrictions or diversions of flood water across the bottom, and maintain many units in an intensive wetland management. Recommendations include:

- Remove levees along the river-side of Leota and cross levees that impede sheetflow of water across the bottom. Specific levees that could be removed without sacrificing significant area of managed wetland include levees between and on the north sides of L1 and L2, the levee between L7 and L7A, and the levee between L8 and L9. Removing these levees would create a more natural flow corridor both for backwater flooding and occasional headwater floods along the east side of Leota and still allow intensive management of wetlands in the western side of the bottom.
- Widen the levee breach at L7A and armor it to prevent excessive scouring.
- Do not construct levee breaches or low elevation river entry spillways along point bar locations at the upper part of Leota in L1, L2, and L3. Even though the frequency of high Green River flows is reduced from historic patterns, causing more regular river entry at these locations at relatively low flows (i.e., < 20,000 cfs) of the Green River would increase sediment deposition in Leota and possibly cause unnatural flows across the bottom that could increase velocity and

scouring at exit locations at lower ends of the bottom.

- Manage all areas above 4663 feet amsl for riparian woodland. These areas are remnant natural levees and point bar deposits that historically supported cottonwood and include almost all of L1, L2, and eastern parts of L3, L5, and L7. Cross levees between L3 and L5 and between L5 and L7 could be shortened to those areas < 4663 feet amsl without sacrificing wetland area.
- Manage the low elevations of L3, L5, and L7/L7A as semipermanent wetlands with occasional drying of the units to emulate natural floodplain wetland plant community dynamics.
- Manage L4, L6, L8, L9, and L10 as seasonal floodplain wetlands with shorter duration flooding regimes and regular drawdowns to create a mosaic of moist-soil and herbaceous vegetation. Where possible enhance sheet water flow from uplands and alkali flats on the western edge of Leota into these units.

Sheppard Bottom

Historically, most of Sheppard Bottom was seasonally flooded wetland with periodic extended inundation in low depressions during high flow events. With intensive development and construction of inlet structures that allow water to flow into Sheppard at flows >5000 cfs, this area now is flooded longer, deeper, and more regularly than at historic times. Also, the protective levees along the Green River restrict overbank flooding into the area except at high flows. Removing levees in S3 and S5 and part of the protective levee at the south end of S3 now provide an opportunity for more regular overbank flooding. Inadvertently, however, the narrow drain canal constructed in the southeast corner of S3 now also allows the Green River to flow into this area at flows >10,000 cfs and has caused high velocity flows through the canal which has caused head cutting in the canal near the exit point at the Green River and conversely carried coarse sediments further into S3 and caused excessive sedimentation where the canal enters floodplain flats in S3. If head cutting continues, the Green River will flow up the drain canal more frequently and cause continued sedimentation problems and unnatural inundation of parts of S3. Recommendations include:

- Isolate the drain canal in S3 from the Sheppard Bottom floodplain which is connected to the Green River. Options include raising the bank of the drain canal, placing pipes and structures between the floodplain and canal, or closing the drain canal and placing a pipe structure at the former exit point. Engineering analyses should be done to determine which options will be most efficient and effective.
- As with other floodplain bottoms, do not construct levee breaches at the upstream ends of Sheppard Bottom or across old point bar deposits. A natural low-natural levee point is on the south side of S1 and is an appropriate site for a 200-400 foot wide levee breach to emulate natural flooding entry and exit patterns in this portion of Sheppard Bottom.
- Manage S1, S2, and S4 as a complex of seasonal and semipermanent wetlands, rotating flooding and drying schedules so that no unit has prolonged inundation for more than 2-3 years. Much of Sheppard Bottom historically had short duration seasonal flooding, and restoring this water regime would more closely emulate natural hydrologic regime, reduce monocultures of robust emergents, and provide critical moist-soil type foods and habitats for migrating waterbirds.
- Manage higher elevations along the Green River as riparian woodland. Evaluate mechanical disturbance to increase cottonwood, and decrease saltcedar, germination and survival in these spots.
- Continue to manage the higher elevation crop fields in Sheppard for grains and forage for geese, sandhill cranes, and ungulates. While artificial, these fields provide valuable forage that replaces the greatly reduced browse naturally occurring along the higher elevation "edges" of wetlands in the Green River floodplain corridor.

Parker moist-soil impoundments

These moist- soil impoundments were constructed at higher elevations adjacent to S4 of Sheppard Bottom to replace wetlands lost when the Roadside Ponds units were retired because of selenium contamination. Because the Parker impoundments are at higher elevation and receive water only from Pelican Lake, they should continue to be managed as seasonally flooded units to produce herbaceous vegetation and other moist-soil foods. These units should not be flooded for extended periods and periodically should be kept dry to prevent encroachment of robust emergents and invasive woody vegetation.

MONITORING AND EVALUATION

Habitat restoration projects should be accompanied by an active monitoring and evaluation program to document biotic and abiotic responses to the project and to improve understanding of the ecosystem. At Ouray, 4 restoration and management issues have considerable uncertainty and will require careful monitoring and evaluation. These issues include: 1) long-term impacts of levee breaches, 2) mechanical disturbance to increase cottonwood germination and survival, 3) intensive management of wetland impoundments, and 4) location and degree of subsurface groundwater connection between the Green River and floodplain wetlands.

Impacts of breaching levees

Initial observations of levee breaches have indicated the potential for significant erosion and/or sedimentation at breach sites depending on the location of the breach and the magnitude of overbank flows from the Green River (FLO Engineering Inc. 1999). Levee breaches on Ouray NWR to date have been narrow and have concentrated water flowing in and out of the floodplain bottoms. Furthermore, exit sites have been modified with fish kettles in Woods, Johnson, and Leota bottoms and these structures further confine flows. If river levels are high and flood flows across bottoms are fast, the potential for erosion and scouring increases. Also, if floodwaters drop quickly, water in the floodplains exits the breach site rapidly and causes excessive scouring. Armoring breach sites seems to reduce erosion, however, very high flows have not occurred since breach sites were constructed and damage potential is unknown. It appears that widening breaches and constructing multiple breaches in close proximity to each other at the downstream ends of bottoms will more closely emulate natural overbank back flooding patterns, but this approach also needs evaluation. Also, armoring wider and multiple areas will increase costs of construction substantially.

If breaches are constructed in upstream locations, significant sedimentation occurs and could quickly change elevations where flood waters can enter bottoms and also partly fill floodplain wetlands with coarse texture sediments. Where breaches or inlets are present in these upstream locations, sedimentation should be monitored carefully, and if excessive deposition occurs, these breaches and inlets should be closed. Large sediment deposits also can occur at narrow breach sites or ditches. For example, the drain canal constructed to facilitate drainage of S3 and S5 in Sheppard Bottom inadvertently served as an inlet (breach) for flood flows in 2003 and caused head cutting of the canal at the exit point where it connects with the Green River and conversely significant sedimentation where the canal connects with the floodplain. These changes ultimately may create unnatural flood entry and exit flows and compromise drainage from S3 and S5 where residual selenium concentration occurs. Sedimentation and head cutting in this canal should be carefully monitored and the canal should ultimately be redesigned. (see recommendations for Sheppard Bottom).

Cottonwood regeneration

Observations of good cottonwood regeneration inside floodplain impoundments on natural levee and point bar surfaces that have had soil disturbance suggests that periodic disturbance might be useful to increase cottonwood germination and survival in similar areas. Experimental soil disturbance coupled with active monitoring is needed. Higher elevation point bar deposits exist in impoundments in Leota and Sheppard bottoms and in inside bends in Wyasket and Woods bottoms and these sites seem appropriate for restoration of riparian woodland, not herbaceous wetland communities. Targeting point bar sites for some mechanical manipulations, followed by careful evaluation of plant communities, could provide valuable information on cottonwood restoration techniques. Also, the recommended restoration of ridges and swales in the Wyasket Pond area after levees have been removed might be an opportunity to evaluate cottonwood response to disturbance. Any disturbance must be careful not to encourage expansion of saltcedar, consequently, monitoring and evaluation is critical.

The condition of existing stands of cottonwood forest on Ouray should be continually monitored to evaluate survival, regeneration, and competition with saltcedar. Not only should the trees themselves be evaluated, but the abiotic conditions that sustain them should also be monitored. These conditions include soil moisture, frequency of inundation, flood duration, and soil disturbance. Also, occurrence of other ground, shrub, and tree species should be documented.

Wetland vegetation dynamics

Past management of floodplain wetlands at Ouray has tended to inundate wetland units for more prolonged periods than occurred naturally. This management encouraged establishment of dense stands of robust emergents such as cattail and has required regular disturbance to restore more desirable wetland plant communities and open water/vegetation interspersion. Disturbances included draining the impoundments for several years, fire, chemical application, and mechanical means. Prior to development, the floodplain bottoms on Ouray NWR had variable topography that included some deeper areas that held water for longer periods, including year round surface water following high flood events. However, historically most of the floodplain bottoms dried in summer following the periodic overbank flooding and these areas supported primarily herbaceous vegetation communities that are adapted to semipermanent and seasonal hydrology.

Future wetland management on Ouray will try to balance needs of: 1) native fishes that require extended inundation of floodplain wetlands and 2) migrant waterbirds that depend on foods and other resources in seasonally-flooded wetlands. Recommendations in this report suggest managing floodplain wetlands as a complex where intensive management of impoundments for seasonal-type flooding occurs in Sheppard Bottom and the west part of Leota Bottom, extended flooding is manipulated in Johnson and Woods bottoms, and natural overbank flooding and drainage is allowed to occur in Wyasket Bottom and the east part of Leota. This diversity of flooding regimes and management effort provides an excellent opportunity to design an experimental matrix of flooding regimes and to monitor wetland responses including both biotic and abiotic conditions.

Groundwater connectivity

Groundwater connectivity between floodplain wetlands and rivers is common in sand-based river systems such as the Green River. Generally, however, the magnitude and relative influence of these connections are poorly understood despite their potential importance in understanding and managing water levels in floodplain wetlands. It seems probable that the most subsurface connectivity at Ouray NWR may occur in floodplain backswamp deposits immediately adjacent to point bar deposits, but careful monitoring of seasonal and annual groundwater levels is needed to determine the degree of influence. Pesiometers that remotely measure and record groundwater levels could be placed at many locations in the floodplain bottoms of Ouray to determine inputs and drainage. These pesiometers should be maintained for several years to capture both high and low flow years in the Green River.