CHANGES IN THE OURAY ECOSYSTEM

Major changes have occurred in the hydrology, river geomorphology, topography, and plant and animal communities at Ouray NWR since it was established in 1960. Each of these changes has affected basic ecological processes that control ecosystem functions and values and the distribution and abundance of plant and animal species.

HYDROLOGY AND RIVER GEOMORPHOLOGY

Perhaps the most basic and important alteration to the Ouray NWR ecosystem has been a marked reduction in the frequency, magnitude, and duration of flooding from the Green River after Flaming Gorge Reservoir was built and its dam closed in November 1962 (FLO Engineering, Inc. 1996). Mean annual discharge at the Jensen, Utah gage decreased from 4360 cfs prior to closure of Flaming Gorge Dam to 4210 cfs after 1963. In contrast, base flow of the Green River at Jensen increased from 1260 cfs during 1947-63 to 2560 cfs after 1963 because of more regular releases of water from Flaming Gorge for hydro-power generation. During this same time, mean annual peak flow in the Green River at Jensen decreased from 24,000 cfs prior to 1963 to 17,400 cfs after 1963. The ratio of mean peak discharge to mean base flow decreased from 19.7 pre-1963 to 6.8 post-1963. Prior to closure of Flaming Gorge Dam, the average monthly temperature of water in the Green River below the damsite ranged from 0-19.5^0 C compared to 3.5-10^0 C after closure (Bolke and Waddell 1975).

The total amount of water released from Flaming Gorge Reservoir is not different now from total annual river discharges prior to closure of the dam, but the timing is altered such that spring flood peaks now are lower (on average), shorter duration, and less frequent (Figs. 12,13). Historic flows that would result in 2-, 5-, and 10-year flood recurrences at Ouray NWR now have been reduced 26%, 19%, and 13%, respectively, from the period prior to dam closure (Table 4, Fig 14). The mean peak flow of 24,000 at the Jensen gage prior to dam closure historically occurred about every 2.4 years; now that same flow occurs on average every 8+ years (Table 3).

The duration of flood events also has changed significantly at Ouray NWR. Prior to 1963, the mean peak of 24,000 cfs was exceeded on average about 5 days/year. Now, that same discharge is equaled or exceeded only about 1 day/year (Figs. 14,15). The current mean flood peak of 17,400 cfs now is exceeded an average of about 6 days/year, where in the past this discharge was exceeded on average of 15-16 days/year. Consequently, flood events at Ouray NWR now are narrower "spikes" of high flow compared to more prolonged "pulses" of flow prior to closure of Flaming Gorge Dam. Prior to 1963, some overbank flooding of the Green River into at least some areas of flood-plain bottoms on Ouray NWR occurred almost every

Flaming Gorge Dam on the Green River north of Ouray National Wildlife Refuge, Utah.

year. Now, substantial overbank flooding occurs on average only about 2 of every 5 years.

Because most sediments carried by the Green River at Ouray originate from low elevation areas below Flaming Gorge and from the Yampa River, the total sediment loading in the Green River has not changed significantly since dam closure (FLO Engineering, 1996). However, lower peak discharges and shorter duration high flows have reduced mean annual sediment discharge near Jensen, Utah by up to 54% (Andrews 1986). Currently, sediment transported into the Green River between the Yampa River and the southern end of Ouray NWR is about equal to the amount of sediment transported out of that reach (Andrews 1986).

The channel morphology of the Green River at Ouray NWR has become narrower, and perhaps more incised, since closure of Flaming Gorge Dam. Most channel narrowing was completed by 1974 (Lyons et al. 1992), but complete adjustments to reduced flows, decreased sediment discharge, and fewer shorter flood peaks may require a century or more before stabilization occurs (Andrews 1986). In general, the river stretch at Ouray NWR now has a smaller channel width-depth ratio, enlarged sand bars, more bars attached to channel banks, dense vegetation on many in-stream bars, and reduced scouring and movement of sediments (FLO Engineering, Inc. 1996). Invasion of saltcedar also has exacerbated channel narrowing because it has colonized bank and bar deposits causing additional deposition of sediments by vertical accretion (Friedman et al. 1996). Reduced scouring flows now may be insufficient to remove young saltcedar which stabilizes deposits, adds channel "roughness" that slows water velocities, and causes additional sediment deposition. These events create further elevated saltcedar-covered bank deposits that are inset between older natural levees dominated by cottonwood and the river channel.

TOPOGRAPHY

The local topography and hydrology of Ouray NWR has been altered greatly with construction of roads, levees, water control structures, spillways, ditches, building compounds, ponds, and facilities of the Ouray National Fish Hatchery. Each development has altered overland flow of water in, out, and through the various floodplain bottoms of Ouray and ultimately changed vegetation composition and system processes. Specific changes that have occurred in each bottom are describe below:

Johnson Bottom

After Ouray NWR was established, levees were constructed perpendicular to the length of Johnson Bottom and old natural and man-made levees along the Green River were raised and lengthened. This development divided Johnson Bottom into 4 separate "ponds" (Fig. 7) that were managed for more permanent water regimes and waterfowl production. Culverts with rudimentary water control structures were placed between cross levees, a gravity flow inlet was constructed at the upper end of the J-1 unit, and an outlet structure was built in J-4. Water flowed into Johnson Bottom through the inlet structure at Green River flows > 3000 cfs. A pump station was constructed along the Green River to pump water into this bottom and an electric line was built to operate this pump. Several small islands were built in the ponds for waterfowl nesting sites. Over time the interior levees of Johnson Bottom deteriorated, the inlet ditch at J-1 silted in and was inoperable at the flows it was originally designed for, and changes in river flows and bar locations made pumping water from the Green River inefficient. Subsequently, the electric line into the pump station was removed in 1988. A 200 foot portion of the levee along the southeast corner of J-4 was removed in 1998 and this breach site allowed the Green River to flow into Johnson Bottom at discharges >13,000 cfs. A new drain structure/fish kettle was built in the southeast corner of J-3 in 1999. In 2000-2002, most of the old interior cross levees and some islands in Johnson Bottom were removed.

Leota Bottom

Leota Bottom is the most altered and developed of the floodplain areas on Ouray NWR. Since the refuge was established Leota Bottom has been developed into 11 separate "units" each with levees and water-control structures. The 11 wetland units have been managed for varying water levels and frequencies ranged from nearly permanent regimes to seasonal flooding. Some low-level levees were built along the Green River prior to refuge establishment to restrict Green River flooding, and to facilitate agricultural production, in this bottom. Ouray NWR enhanced these old "protective" levees and also built new ones along the Green River for similar purposes of restricting flood flows into Leota; these levees do not control extent or depth of flooding in the wetland

West side of Johnson Bottom, point bar surface.

Johnson Bottom river bar/channel geomorphology.

Green River channel dynamics creating ridge-and-swale surfaces.

Fish hatchery located between Green River and Leota Bottom.

Alkali flat habitat on the west side of Leota Bottom

Leota Bottom L10

South end of Leota Bottom along river cottonwood corridor.

Sheppard Bottom semi-permanent wetland.

units. Interior cross levees were built to divide the wetland units to regulate timing, depth, and extent of flooding. The Ouray National Fish Hatchery is located in the northern part of Leota Bottom and consists of leveed ponds, drainage ditches, pumps, and pipelines to supply water to hatchery ponds.

Draining and flooding wetland units in Leota Bottom are facilitated by a ditch that runs through the center of the bottom and an interconnected system of water-control structures. Green River water can be pumped or gravity fed into Leota Bottom through an inlet structure in L-2. This inlet is operational at Green River flows > 7500 cfs. A new inlet structure was built in L-10 in 1996 to make gravity flow into the area easier. Pelican Lake water can be gravity fed via pipeline into L-10. In 1998, short portions of the levee along the Green River adjacent to L7 (350 foot upper river) and L7A (600 foot lower spillway) were removed (breached) to allow flood flows of 15-20,000 cfs to enter Leota Bottom. A new drain structure/fish kettle was constructed at the south end of the bottom in 1999. Spillways were built between L-1/L-2, L-2/L-4, L1/L3, L4/L6, and L6/L8 in 1999 to facilitate movement of water between wetland units during flood periods. Likewise, a portion of the cross levee between L7 and L7A was removed in 2001 to allow flood water coming into Leota at the L7 upper river breach site to flow through units L7 and L7A and exit at the lower spillway breach site in L7A.

Levee breaches at L7 and L7A have changed elevation (and thus impacted levels at which the Green River enters and exits Leota) since their construction as deposition and scouring have occurred (FLO Engineering, Inc. 1999). In 1998, peak flows of the Green River were high and floodwater drained quickly in Leota (declines of several thousand cubic feet/second and 1-2 feet/day) and caused large changes in the hydraulic gradient between the flooded bottoms and the Green River. This rapid fall of the river caused extensive scouring at the L7A outlet with 2-3 foot down cutting over a 20 foot wide area. In contrast, in 1997, longer sustained connection of the Green River with Leota induced 2-3 foot deposition of sediments at the L7 inlet breach. Protective geowebbing material has been placed along a concrete pad at the L7A outlet breach, however some erosion and deposition continues at breach sites.

Wyasket Bottom and Wyasket Pond

Wyasket Bottom is a large undeveloped floodplain area except for the ca. 250-acre Wyasket Pond that is surrounded by a man-made levee. Levees around Wyasket Pond were built by a private landowner prior to establishment of Ouray NWR to prevent Green River flooding into this area. After the refuge was established, the old protection levees around Wyasket Pond were refurbished and included water-control structures to purposefully flood this pond annually. An inlet ditch was dug from Wyasket Pond to the Green River to allow Green River water to be pumped into the pond during low flows and gravity-flowed into the pond at Green River flows >5000 cfs. In 1986, this inlet structure was replaced to allow more efficient gravity flow into the area. Water also can be diverted to Wyasket Lake through the Wyasket Pond inlet structure, but this practice was discontinued in the late 1990s because of reoccurring botulism outbreaks in Wyasket Lake during natural drawdowns of ponded water in this area during summer. Wyasket Bottom does not have a constructed outlet location and water trapped in this bottom evaporates and creates stagnant pools that are anoxic. The pump station on the inlet structure into Wyasket Pond has not been used since 1991 and water levels have not been maintained in Wyasket Pond since 2000.

Sheppard Bottom Area

After the refuge was established, Sheppard Bottom was developed into 5 separate wetland units with interconnected inlet and outlet structures. Water for flooding Sheppard Bottom historically was provided via a gravity flow inlet and pump station along the Green River. Originally, the Ouray National Fish Hatchery was located in the northeast corner of Sheppard Bottom. The inlet structure was rebuilt and the pump station abandoned in 2000. Water gravity flows into a series of canals that move water into Sheppard units at Green River flows >5000 cfs, however, flows >10,000 cfs are needed to provide flows sufficient to flood all Sheppard units.

Historically, agricultural irrigation runoff and seep/spring water draining from the Roadside Draw flowed into Sheppard Bottom. Small levees were built in the Roadside Draw area to impound water for waterfowl production in the 1970s. In the l980s, water in the Roadside Draw ponds were determined to contain high selenium concentrations that posed health risks to wildlife (Fig. 19). Consequently, the Roadside Ponds were retired from impoundment use in 1996. To offset loss of the Roadside Ponds, 5 independently controlled moist-soil impoundments were constructed in 1997 adjacent to the north part of Sheppard Bottom Unit S-4. These moist-soil

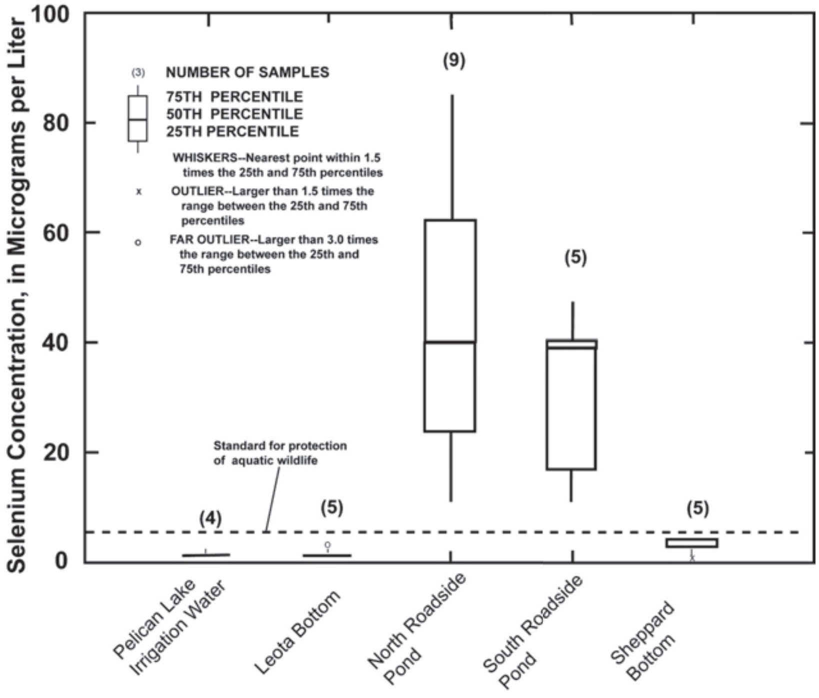

Figure 19. Selenium concentration in areas of Ouray National Wildlife Refuge, Utah, during 1988 and 1989 (from Stephens et al. 1992).

impoundments receive water from a newly constructed pipeline coming from Pelican Lake. Each impoundment has separate inlet and outlet structures that connect with a drain canal that empties into the S-1 Sheppard Bottom Unit. Green River water also can be backed into these units from the Sheppard Bottom inlet during high flows. In 2002, part of the protective levee on the south end of S-3 was removed as was the cross-levee between S-3 and S-5. Also, a ca. 50 foot wide drain canal was built in the southeast corner of S-3 to the Green River. Removing levees and construction of the drain canal allowed selenium-laden water to drain from Sheppard Bottom into the Green River and also allowed the Green River to flood this area during high flows and further dissipate and dilute selenium concentrations (Fig. 20).

About 150 acres of Sheppard Bottom are in farm fields. These fields typically are cropped each year on a rotation basis for alfalfa, small grains such as barley, and row crops including grain sorghum.

Woods Bottom

Levees were constructed in Woods Bottom beginning in the 1960s to create 2 impoundments: a diked backside unit and a larger main unit (Fig. 3) Water from the Green River is diverted into Woods Bottom by gravity flow through an inlet structure and ditch on the north side of the bottom at Green River flows of >10,000 cfs and from water backing into the bottom through the drain structure on the south side of the main unit. No pumpsites were developed in this bottom. Woods Bottom was the first bottom on Ouray NWR to be developed and managed to benefit native endangered fishes. The drain structure on the southeast corner of the bottom was modified in 1993 with a fish kettle to process fish and a bottom elevation to allow the Green River to back into the bottom at about 4000 cfs. In 1997, a 100 foot wide section of the south levee of the backside unit along the Green River was removed to allow overbank flooding at about 13,000 cfs. Since that time, part of the natural levee along the Green River at the southeastern part of Woods Bottom was scoured and now the 100 foot wide constructed breach operates more as an outlet than an inlet for flood flows.

VEGETATION AND ANIMAL COMMUNITIES

The general location of habitat types (i.e., upland grassland, floodplain wetland, etc.) have not changed much since Ouray NWR was established, however, species composition of some areas are different than in the past and invasive species have become widely distributed over the refuge.

The major changes in distribution and species composition of native habitats on Ouray NWR are within riparian woodland and floodplain wetland habitats. Reductions in flooding frequency and intensity have reduced scouring of natural levees and point bar areas that is needed to provide new exposed surfaces for wind-blown seeds of cottonwood to land and germinate. Typically, newly scoured areas contain fine-textured alluvium that is saturated by spring floods and provides adequate soil moisture needed for late-summer cottonwood seedling survival (Cooper et al. 1999). Reduced flooding and lower flows of the Green River reduced soil moisture and also have allowed many river bars to become densely vegetated with willow and saltcedar which further slows river flows and reduces scouring action. The combination of reduced flows and floods, willow-dominated bars, and saltcedar invasion have caused additional accretion of natural levees and river bank areas, caused denser stands of vegetation that shades cottonwood seedlings, increased competition for water and light, and increased the depth to which cottonwood roots must grow to get adequate water to support tree growth and survival. In these situations, regeneration, growth, and survival of cottonwood is reduced. In contrast, saltcedar has a higher drought resistance than cottonwood, grows quickly, and has greater root elongation in response to declining water tables or depth to groundwater (e.g., Horton and Clark 2001 and references within). Consequently, saltcedar is out competing cottonwood in many areas of Ouray NWR and is gradually replacing and reducing cottonwood-dominated riparian areas. Reduced cottonwood stands on the refuge are potentially impacting the diverse animal community that relies on these areas including species of special concern such as the yellow-billed cuckoo, common yellowthroat, Lewis' woodpecker, blue grosbeak, Swainson's hawk, and smooth green snake.

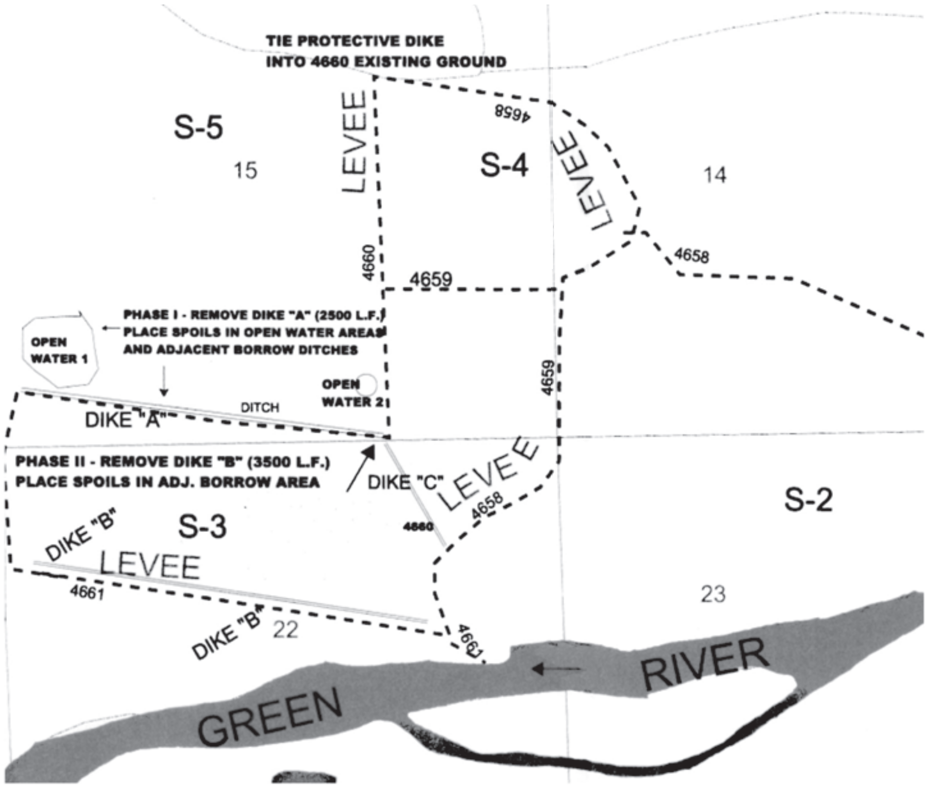

Figure 20. Structure modifications to Sheppard Bottom for dilution of selenium concentrations.

Historically, most wetlands in floodplains along the Green River near Ouray were seasonally inundated and recharged, but did not retain water year round except in depressions and following years of exceptionally high flood events. Wetland vegetation in floodplains ranged from annual grasses and herbaceous species at higher elevations at the edges of floodplains to water tolerant macrophytes and submergents in low depressions (Fig. 17). As floodplains were leveed and managed for extended water regimes for breeding waterfowl, wetland vegetation shifted to water tolerant communities dominated by dense stands of cattail and bulrush (Sangster 1976). Wetland units on Ouray periodically were drained and disturbed (e.g., by disking) to control dense monotypic stands of emergent vegetation. Despite periodic disturbance, robust emergents have become more dominant than during historic conditions. In recent years, management has attempted to use more seasonal flooding to encourage moist-soil vegetation and to control dense stands of emergents.

More permanent water regimes and dense emergent vegetation in floodplain wetlands may have increased the number of waterbirds nesting on Ouray NWR compared to historic periods, but the more prolonged inundation also reduced vegetation and food resources used by migrant waterbird species. Long-term surveys of nesting waterbirds on Ouray do not indicate increasing populations nor high recruitment. Surveys of migrant waterbirds are incomplete, but suggest reduced numbers during periods when Ouray wetlands were permanently flooded. Extended water regimes also increased muskrat and beaver populations on Ouray NWR. These mammals have caused delays in drainage of some units by obstructing flows through water-control structures and increased herbivory both in the wetlands and on cottonwood saplings along the Green River. This increased herbivory on cottonwood saplings may be further suppressing cottonwood abundance in the Green and Yampa river floodplains (e.g., Breck et al. 2003).

Levee construction on Ouray NWR has reduced the frequency of overbank flooding of the Green

River into floodplain wetlands and restricted access to these sites by river fishes. Restricted access to floodplains and increases in nonnative fishes in the Colorado and Green River system have caused reductions in the state and federally endangered bonytail, Colorado pikeminnow, humpback chub, and razorback sucker (e.g., Modde et al. 1996). Other species of special status on Ouray NWR that rely on floodplain wetlands include bald eagle, peregrine falcon, roundtail chub, black tern, American white pelican, northern river otter, long-billed curlew, and Caspian tern.

In addition to saltcedar, other nonnative plants that have invaded large areas of Ouray NWR include tall whitetop, Russian-olive, and Russian knapweed The exact area of coverage of these species is not entirely known and apparently is expanding (Fig. 21) Many chemical and mechanical techniques have been used to control nonnative plants including disking, burning, cutting, and application of herbicides, especially Round-up, Arsenal, and 2,4-D amine (USFWS 2000, Gardner 2002).

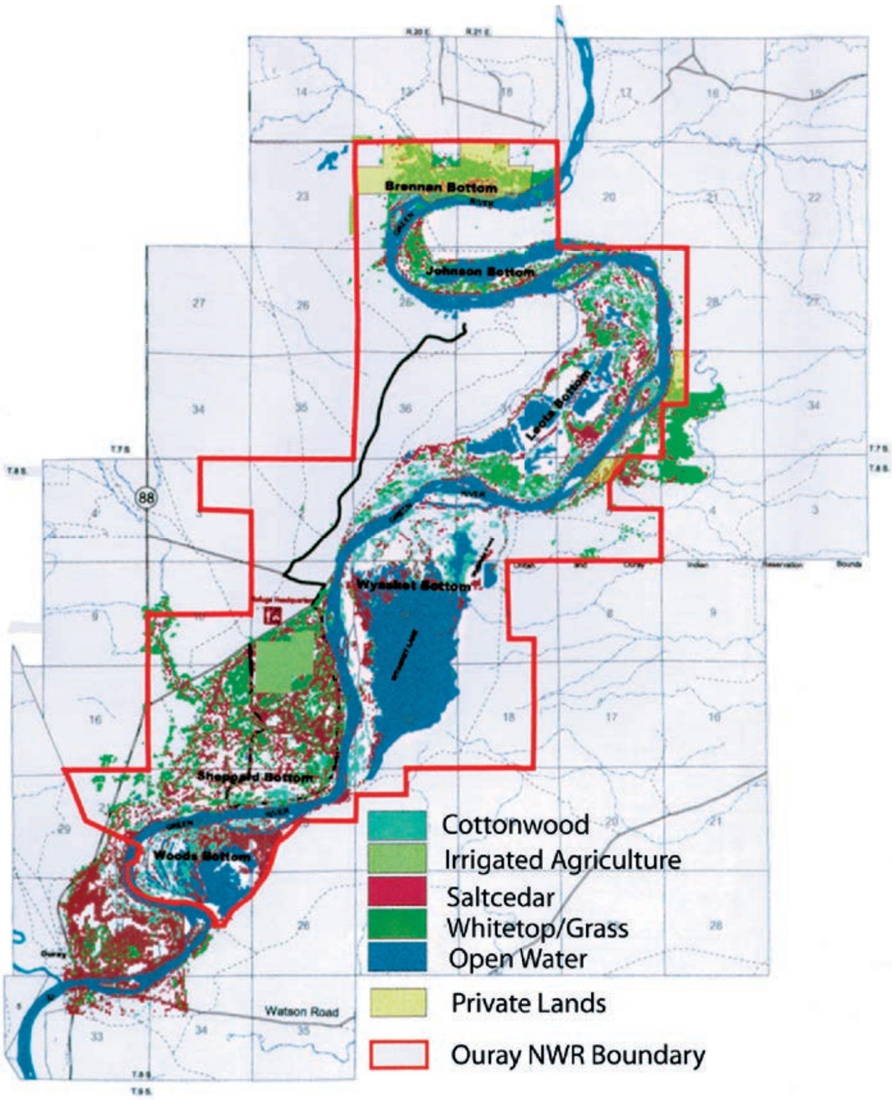

Figure 21. Distribution of saltcedar and tall whitetop on Ouray National Wildlife Refuge, Utah, during 2000.