HISTORIC CONDITIONS AND PROCESSES

GEOLOGY

Ouray NWR is located within the Uinta Basin of northeastern Utah. The modern day Green River flows approximately 730 miles from its headwaters in the Wind River Range in Wyoming to its confluence with the Colorado River (Woolley 1930). The path of the river is a result of geologic processes that began 2.5 billion years ago; most of the present day landscape and course of the Green River at Ouray NWR is a result of processes that began during the Tertiary period beginning about 65 million years ago. During the Tertiary period the Rocky Mountains including the Uinta Mountains were formed by tectonic uplifting and coincided with downwarping of adjacent asymmetrical synclinal basins such as the Uinta Basin. The Uinta Basin subsided in its interior and is bounded to the north by the east-west trending Uinta Mountains, to the south by the Tavaputs Plateau, to the east by a high area in Colorado around Douglas Creek, and to the west by the Wasatch Mountains (Baker et al. 1949). This region is connected hydrologically within the Colorado Drainage, which is an open system allowing water to flow from the basin to the Pacific Ocean (Welsch et al. 1987).

Material eroded from the Uinta Mountains has been deposited in the Uinta Basin (Osmond 1964, Hintz 1988) and the area included in the Uinta Basin is determined by the presence of these underlying Tertiary sediments (Marsell 1964) which are approximately 10,000 feet thick in some locations (Baker et al. 1949). Sediment deposition in the Uinta Basin continued throughout the Tertiary period and includes the Green River, Unita, Duchesne River, and Browns Park depositional formations. The Uinta Basin sits on past geological structures such as the stable shelf east of the Wasatch Line created during the Paleozoic period (Osmond 1964).

The Uinta Formation is comprised of interbedded sandstones, mudstones, siltstones, and bedded calcareous shale of fluviatile origin and is approximately 5,000 feet thick in the center of the Uinta Basin (Unterman and Unterman 1964, Glover 1996). The Duchesne River and Green River Formations lie above and below the Uinta Formation, respectively. The Duchesne River Formation, which is about 3,000 feet thick in the center, was created during the lower Oligocene and is comprised mostly of red-shale, sandstones, siltstone and some conglomerates of fluvial origin that came from the Uinta Mountains (Glover 1996). Depositions occurred as rivers, including the Green River, meandered across floodplains creating discontinuous sand lenses and alternating beds of sandstones, mudstone, shale, and siltstones (Williams 1950). These depositions underlie Ouray NWR floodplains.

During the Ice Age of the Pleistocene, glaciers and ice streams formed in the Uinta Mountains and influenced landscapes and current courses of rivers including the Green River. During the post-lower Pliocene a major tectonic event produced faulting and tilting which collapsed the eastern Uinta Mountain area arch and set a new course for the Green River (Marsell 1964) over the Colorado Plateau (Hunt 1969). This new course superimposed the Green River on the Browns Park Formation (derived from Uinta Mountain quartzite, limestones, and sandstones and some volcanic tuff and chert [Atwood 1909]). Continued uplifting and easily eroded materials along fault lines dramatically influenced the course of the Green River (Atwood 1909, Hunt 1969). These events suggest that the Green River is “antecedent” where a river is formed after a consequent river drainage has been folded or displaced.

The above geologic events and processes, and more recent Holocene river dynamics of deposition and scouring, have formed soils and topography at

Ouray NWR. Elevations on Ouray NWR range from 1417 m in river bottoms to 1546 m on bluffs (USFWS 2000). Currently, 18 soil types are mapped on Ouray and vary depending on parent material, slope, and juxtaposition to the Green River (Table 1, Fig. 4).

The pinkish rocks that form bluffs along the Green River at Ouray NWR are from the Uinta Formation and include cross-bedded sandstone, conglomerate and unconsolidated siltstone and mudstone layers. The siltstone and mudstone layers are easily eroded. Cobbles and gravel on top of bluffs were transported to the area by ancient streams from the Uinta Mountains mainly in the Pleistocene (Goodknight and Ertel 1987). The clay bluffs on benches adjacent to the Green River floodplain at Ouray are Morrison Formation deposits formed during the Jurassic period. Soils on upland benches, terraces, and bluffs were derived from a range of parent materials including sedimentary, metamorphic, and igneous rocks and include Badland and Greybull-Utaline rock outcrop complexes and Nakoy loamy fine sands (Fig. 4, Table 1).

Alluvial fans and terraces comprised of eroded materials from surrounding benches are dominant within the low-lying areas of the Uinta Basin and are located between bluffs and the recent alluvial floodplain of the Green River (Untermann and Untermann 1964). Remnant fans typically have 2-8% slopes and include Blackstone loam and Utaline sandy loam soils (Table 1). Sites immediately adjacent to active floodplains are relatively flat (0-2% slopes) and include desert sandy loams and alkali flat soils such as Shotnick and Turzo loams (Table 1).

The Green River has cut a series of meander loops through the Uinta Formation where it leaves the Mesa Verde Formation south of Highway 40 to its confluence with the Duchesne River. In this stretch, a series of old river terraces occur where former floodplains marked the advance and retreat of glaciers during the Pleistocene (Chronic 1990). Soils in Green River floodplains are primarily alluvium, slope alluvium, and some Eolian deposits. Green River floodplain soils range from clay loams to fine sands depending on position relative to the current and past river channels and subsequent geomorphic surfaces and include Green River and Wyasket loams in floodplains and riverwash sands on river bars and banks.

Table 1. Primary soil types on Ouray National Wildlife Refuge, Utah

Soil Type	Location	Ecological site	Native vegetation
Badland-Rock Outcrop	Upland bluffs	Desert	
Blackstone Loam	Fan remnant	Desert Loam	Indian rice grass, saltbush, sage brush, winterfat
Green River Loam	Floodplain	Stream bank, alkali bottom	Alkali sacaton, greasewood, sandbar willow, cottonwood
Greybull-Utaline Badland Complex	Upland Benches	Desert	Wheatgrass, saltbrush
Jenrid sandy loam	Floodplain	Old Point bar	Sandbar willow, greasewood, cottonwood
Nakoy loam fine sand	Upland benches	Semi-desert	Wheatgrass, saltbrush
Ohtog-Parohtog Complex	Alluvial flat	Loamy bottom	Wild rye, wheat grass, rabbit brush
Riverwash	Floodplain	River bars	Sandbar willow
Shotnick loamy sand	Alluvial flat	Desert sandy loam	Gelletz, saltbush, globemallow
Shotnick-Walkup Complex	Alluvial flat	Desert sandy loam	Ricegrass, saltbush, Torrey's joint fir
Stygee clay/silty clay	Alluvial flat	Alkali flat	Greasewood, alkali sacaton, bottlebrush
Tipperary Loam	Upland benches	Semi- desert	Wheatgrass, saltbush
Turzo Loam	Alluvial flat	Alkali flat	Alkali sacaton, greasewood
Utaline sandy Loam	Fan remnant	Desert loam	Saltbrush, wheatgrass

GREEN RIVER GEOMORPHOLOGY

The Green River at Ouray NWR is a typical sand-bed (Rosgen 1994) system and has a mild river slope of about 1.2 feet fall/mile and a channel sinuosity of 1.7 (Fig. 5, FLO Engineering, Inc. 1996). The river has a broad valley bottom and wide floodplain where it has eroded the relatively "soft" Uinta Formation. This contrasts to the steep river

slopes and narrow floodplain in the canyon reaches upstream in the Mesa Verde Formation and downstream canyonlands as the Green approaches the Colorado River (Fig. 5). The Green River at Ouray NWR is self-formed and has a "cropped" meander pattern that is restricted by resistant bedrock deposits of Pleistocene age. This bedrock influences the width of the meander belt but does not confine individual meanders within the current floodplain belt. Contact of the river with the bedrock controls slope, constrictions, erosion on outside bends of the river, and channel incision. Where the river contacts bedrock on the outside of meander bends, the river current is directed downward and creates a deep thalweg that scours the river channel during high flows and then subsequently partly refills with sediment during low flow. This action creates incised "ingrown bends" that tend to hold the position of the river at a location and limit the opportunity for the river to migrate across the floodplain. During the last 70 years, channel migration of the Green River has apparently been very limited in the vicinity of Ouray NWR (Jurado and Fields 1978, Andrews and Nelson 1989) and meander patterns may have been close to the present location for considerable time.

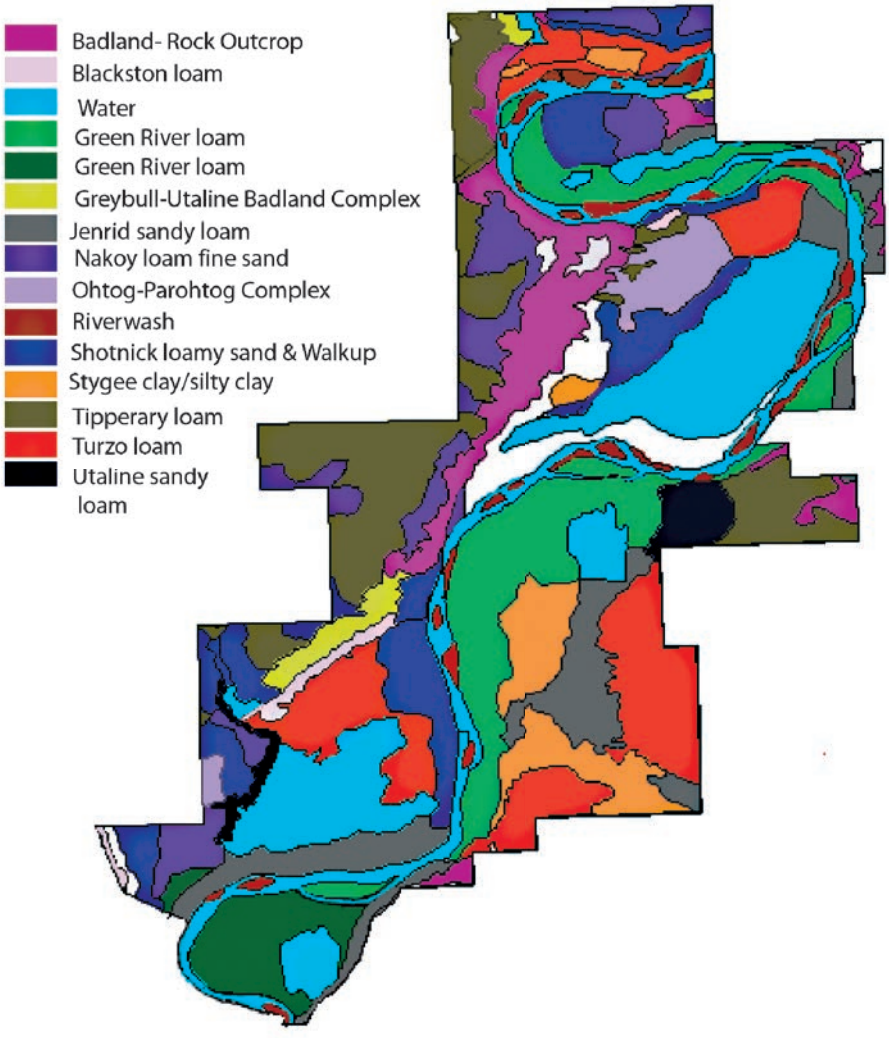

Figure 4. Soils on Ouray National Wildlife Refuge, Utah.

Channel dimensions of the Green River depend on discharge which is function of watershed size and type, sediment type, bank characteristics (such as above mentioned bedrock), and energy dissipated by the stream in transporting sediment. Sediments in the Green River at Ouray NWR originate primarily from the Upper Green and Yampa Rivers and the Uinta Basin itself. In addition to having limited channel migration, the Green River at Ouray NWR also appears to have had relatively constant bar locations in the last several decades, both before and after closure of Flaming Gorge Reservoir (Andrews and Nelson 1989). Alternating pool/bar configurations (Fig. 6) include both fixed bank and forced

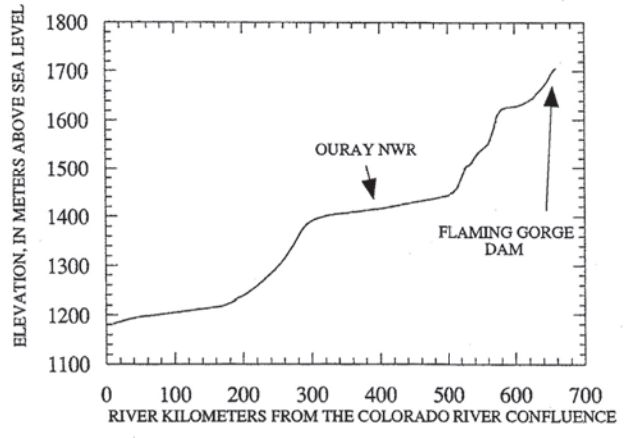

Figure 5. Longitudinal profile of the Green River between Flaming Gorge Reservoir and the confluence with the Colorado River (adapted from Schmidt 1994).

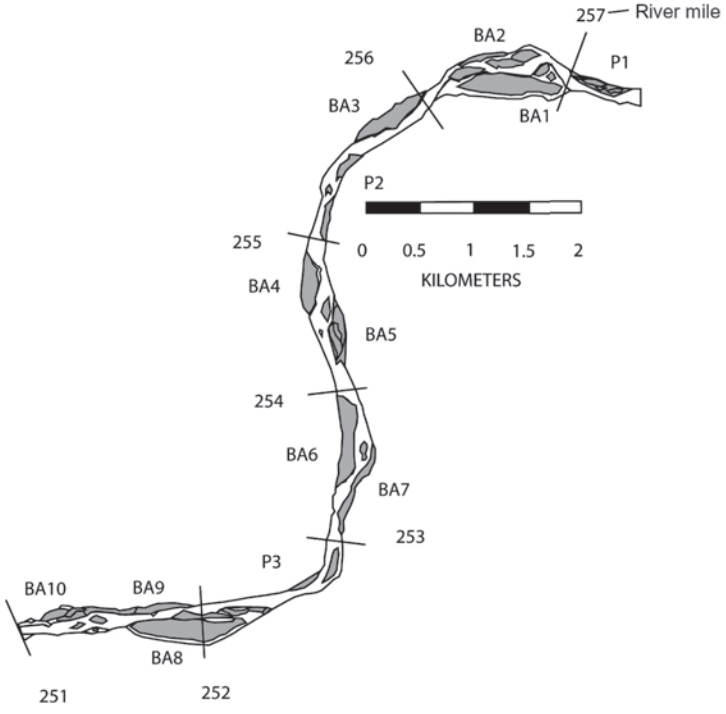

Figure 6. Map of bar locations of the the Green River next to Sheppard and Wyasket Bottoms, Ouray National Wildlife Refuge, Utah.

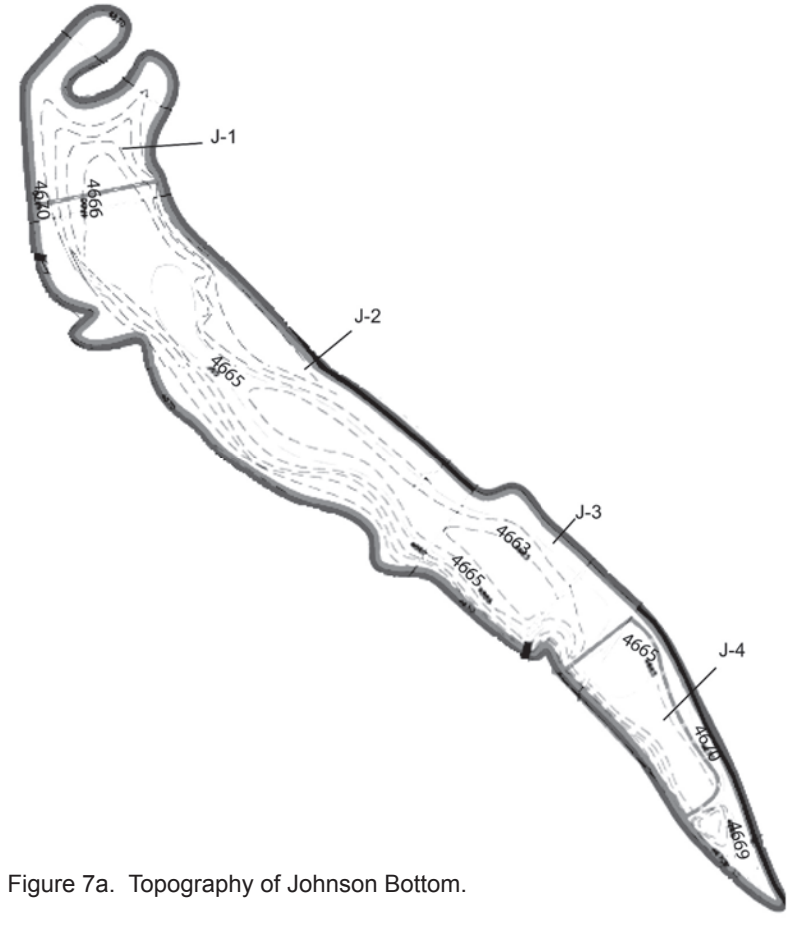

Figure 7a. Topography of Johnson Bottom.

point bars and are products of meandering flow (Ikeda 1989). In general, the Green River at Ouray NWR is, at high flow, a meandering, single-threaded channel between 2 well defined banks; at low flow it is multithreaded with flow divided by emergent midchannel bars (Rakowski 1997).

High magnitude, and highly variable, flood events on the Green River have created a complex of deposition/scour geomorphic surfaces in the Ouray NWR floodplain (see also Andrews 1986, Lyons et al. 1992). Topographic variation (Figs. 7a-e), soil type and distribution (Fig. 4), historic photographs (e.g., Fig. 8), and geomorphological patterns in similar river meander belts (Fig. 9) indicate where surfaces currently are distributed on the refuge (Fig. 10). Active point bars are immediately adjacent to inside bends of the present channel of the Green River and are predominated by sand waves capped by clay drapes (Fig. 11). Sand deposits on point bars increase in depth and width as the river approaches and departs the apex of inside bends. "Ridge-and-swale" topography is located behind active point bars and indicates progressive movement of point bars as the river has gradually moved in the direction of present point bar bends. Swales contain clay bottoms while ridges are predominantly sand. Most swales are < 5 feet lower than ridge tops and suggest relatively moderate dynamics of river movement and scouring/deposition at least in the last few decades.

Natural levees are accreted berms containing silty-clay soils along current and former channels where overbank flows slowed and deposited fine texture sediments. At Ouray NWR, natural levees seldom are more than 2-3 feet higher than river banks (Figs. 7a-e) and further indicate relatively moderate historic high flows of the Green River. Low areas behind natural levees are backswamp deposits containing clayey loams and clays. These backswamp areas represent the primary floodplain wetland "bottoms" on the refuge (Fig. 3). Remnant fans and terraces of eroded bluff material adjoin backswamps on upland sides of backswamps. Few

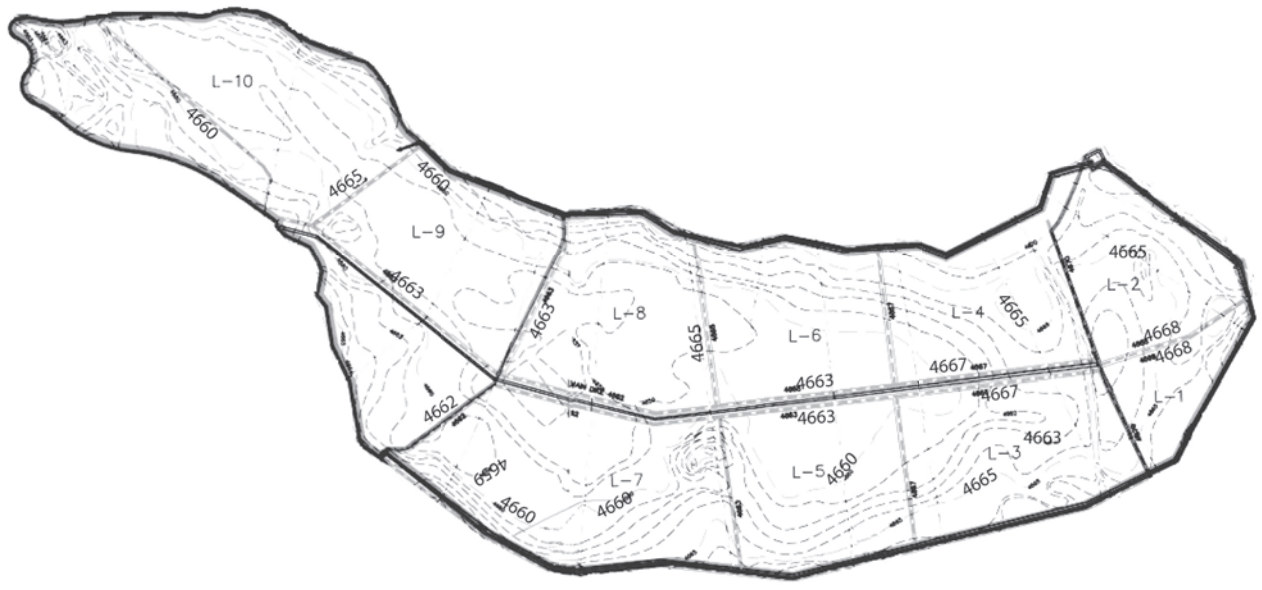

Figure 7b. topography of Leota Bottom.

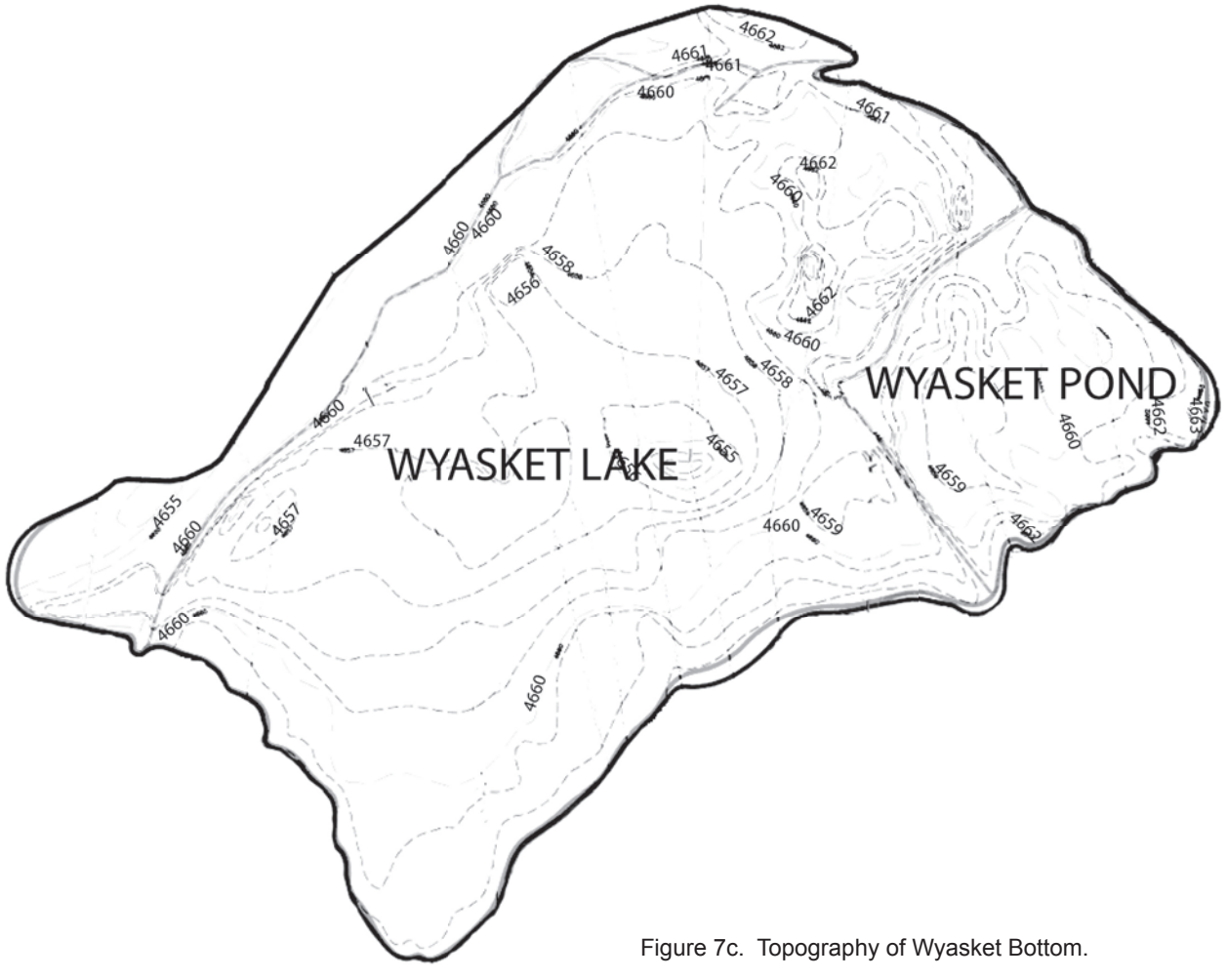

Figure 7c. Topography of Wyasket Bottom.

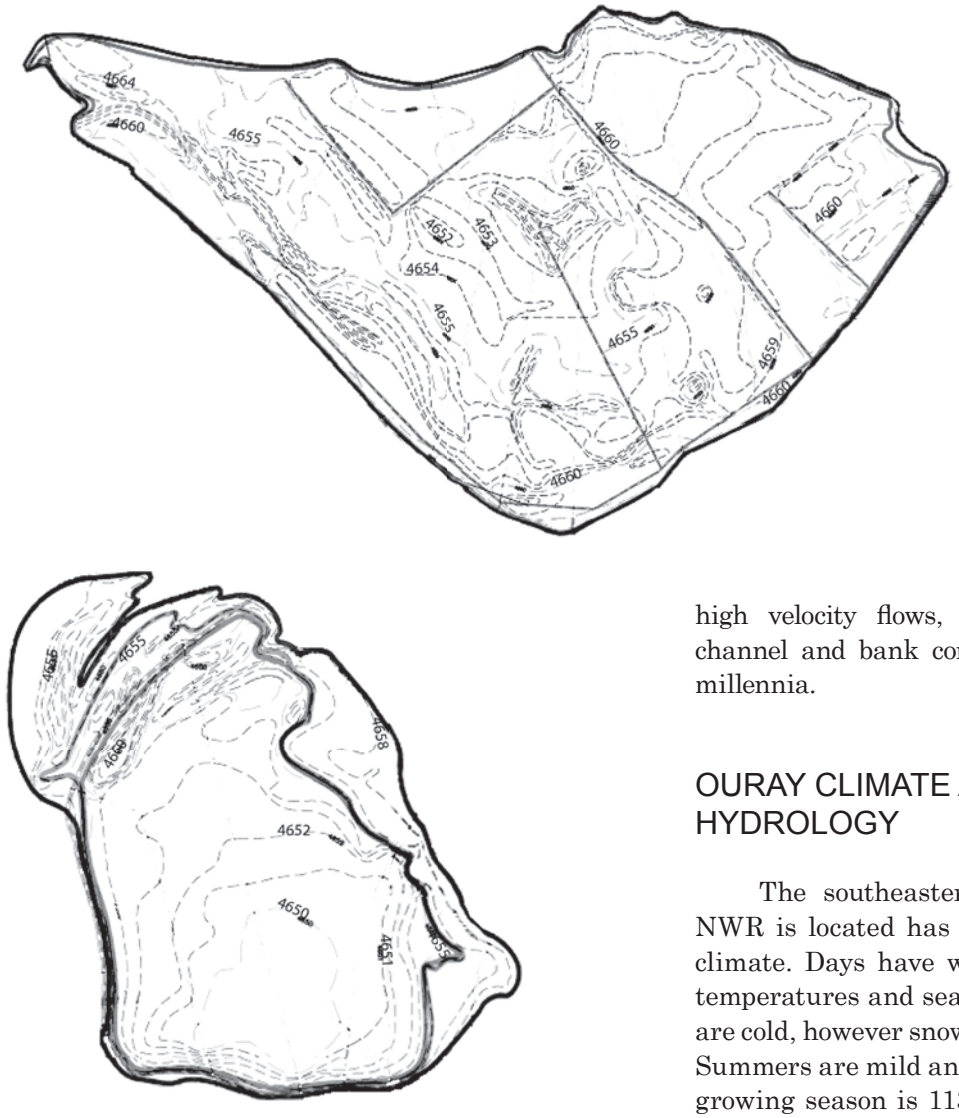

Figure 7e. Topography of Woods Bottom.

Table 2. Mean temperature and precipitation at Fort Duchesne, Uinta County, Utah.

Month	Temperature (ºF)	Precipitation (inches)
Jan	13.3	0.46
Feb	20.8	0.39
Mar	35.5	0.56
Apr	48.0	0.62
May	55.6	0.70
Jun	64.0	0.46
Jul	71.9	0.51
Aug	69.9	0.67
Sep	61.0	0.98
Oct	48.0	0.79
Nov	33.6	0.39
Dec	20.1	0.49

abandoned channels of the Green River are present on Ouray but many flow paths of recent flood events are evident as slight depression corridors across backswamp areas (Fig. 8). Collectively, the narrow width and shallow undulation of point bar ridge-and-swales, low natural levees, moderate flow paths across backswamp deposits, and few old abandoned channels suggest that the Green River at Ouray NWR has not experienced extremely high velocity flows, nor substantially changed its channel and bank configurations in the last several millennia.

OURAY CLIMATE AND GREEN RIVER HYDROLOGY

The southeastern Uinta Basin where Ouray NWR is located has a semiarid to arid continental climate. Days have wide variation in high and low temperatures and seasons are well defined. Winters are cold, however snowfall is relatively light (Table 2). Summers are mild and dry. The average length of the growing season is 113 days; the average date of the last killing frost in spring is 29 May and the average date of the first killing frost in fall is 19 September. Strong winds in spring and early summer cause high rates of evaporation and rapid drying of soils (Waltemeyer 1982). Likewise, high temperatures, wind, and limited rainfall cause evapotranspiration rates to be high in summer (Thomas 1962).

Because of relatively limited local precipitation and runoff, the hydrology of the Green River is controlled by spring snowmelt in the Rocky Mountains of Wyoming, Colorado, and Utah. Principal tributaries of the Green River near Ouray NWR include the Little Snake, Yampa, and White rivers in Colorado; Blacks Fork and Little Snake in Wyoming; and Duchesne, Price, and San Rafael rivers in Utah. Most of the water in the Green River at Ouray NWR originates in mountainous headwater regions, whereas most of the sediment is contributed by lower elevation semiarid regions, especially the Yampa River (Iorns et al. 1965). Snow melt and river flows in the Yampa

are earlier and of shorter duration (flashier) than the later more sustained flows from the Upper Green River watershed.

Annual discharge and peak yearly flows in the Green River are highly variable (Figs. 12, 13). Mean annual discharge of the Green River at Jensen, Utah about 37 miles upstream from Ouray NWR (arithmetic mean of all mean daily discharges) was 4360 cubic feet/second (cfs) from 1947 to 1962, prior to when Flaming Gorge Dam was closed. Historically, the Green River at Ouray began to rise in March, had a mean annual peak flow in late May (27 May for the 51 years of record at Jensen, UT), and declined significantly in July (Fig. 12). Prior to 1963, peak annual discharge at Jensen averaged 24,000 cfs and ranged from ca. 8000 cfs to 37,000 cfs among years. During the last 100 years, only 5 peak annual flows have occurred outside the months of May and June. One of these peaks occurred in February 1962, 1 in July 1959, and the other 3 peaks were in March and April. Generally, the higher the peak discharge, the later in the season the peak occurs. Base flows in the Green River at Ouray occur from September through March. At Jensen, UT the base flow from 1947 to 1963 was 1260 cfs. The historic ratio of mean peak discharge to mean base flow was 19.7 at the Jensen gage.

Figure 8. 1963 aerial photograph of Leota and Johnson Bottoms on Ouray National Wildlife Refuge, Utah.

The frequency of historic flows of the Green River at Jensen, UT varied from an almost annual return interval (1.01 with a probability of 0.99) of 7600 cfs to a 500-year flood event frequency at 48,300 cfs (Table 3). The historic mean annual peak discharge of 24,000 cfs occurred at a frequency of about 2.3 years with an annual probability of 0.43. From 1923-1962, the recurrence intervals of 1.25, 2, 5, and 10 years were associated with flows of 15,764 cfs, 21,967 cfs, 27,952 cfs, and 30,707 cfs, respectively (Table 4, Fig. 14). Flow duration curves of the Green River at Jensen, UT (Fig. 15) allow the average annual flow duration (days/yr) for discharges to be computed by multiplying the corresponding % exceedance from the duration curve (Fig. 15) by 365 days (FLO Engineering, Inc. 1996). Using this calculation, the mean annual discharge of 24,000 cfs historically was equaled or exceeded 1.3% of the time (about 5 days/yr). The duration of the pre-1963 base flow of 1260 at the Jensen gage was equaled or exceeded about 68% of the time.

Table 3. Green River flood frequency at Jensen, Utah prior to, and after, closure of Flaming Gorge Dam.

Return period	Probability	Jensen Gage (cubic feet/second) 1947-1962[a]	Jensen Gage (cubic feet/second) Post -1963
1.01	0.99	7600	5300
1.11	0.90	13800	9700
1.25	0.80	16500	11700
2.00	0.50	22500	16500
2.33	0.43	23900	1700
5.00	0.20	29400	22700
10.00	0.10	33400	26400
25.00	0.04	37700	30900
50.00	0.02	40500	34000
100.00	0.01	43100	37000
250.00	0.004	45500	39900
500.00	0.002	48300	43500
Mean Annual Peak		24000	17400
Mean Annual Flow		4360	4210
Mean Base Flow		1260	2560

[a] Includes 1895-1899 and 1904-1962.

Prior to construction of levees on Ouray NWR and closure of Flaming Gorge Dam, water from the Green River naturally began overtopping banks of the river and extensively flooded floodplain bottoms at Ouray NWR from 14,000 cfs to 18,600 cfs (Table 5). Some small, low areas on natural levees are overtopped at lower flows (the lowest entry elevation shown in Table 5), but areas flooded at these lower flows were small and isolated. Although the floodplain bottoms on Ouray NWR have different sizes and flood frequencies (Tables 5, 6), the recurrence intervals of initial flooding for all bottoms historically was from 1.2 to 1.7 years (Table 3). Johnson and Woods bottoms are smaller than other bottoms on Ouray NWR (FLO Engineering, Inc. 1997) and most areas in these bottoms are quickly filled once Green River flows overtop natural levees. In contrast, the large Wyasket Bottom begins to flood at about 19,000 cfs, but flows >22,000 cfs are required to fill it. Sheppard and Leota bottoms are completely inundated only during very high flood events. From 1947 to 1962, Green River discharges > 13,000 cfs (and thus some overbank flooding at Ouray NWR) occurred in 15 of 16 years and averaged 1.94 flood pulses/year, 37.8 total days of flooding, and 23.4 days/flood pulse (Table 7). At a discharge of 20,300 cfs (considered current "bankfull" discharge at Ouray) historic flows exceeded this level an average of 12 days/year with a return interval of about 2.4 years (FLO Engineering, Inc. 1996).

Historically, the Green River first began to enter floodplain bottoms on Ouray NWR at low elevation sites along natural levees at downstream ends of the bottoms and last at higher elevation point bar surfaces on inside bends of the river (Fig. 16). This pattern of flooding caused most flooding of Ouray NWR bottoms to occur as relatively slow "backwater" floods that entered floodplains at downstream ends of the bottom, usually at sites where fixed bank bars raised river flows. Higher velocity "headwater" floods that caused flood water to flow across bottoms only occurred when discharges were sufficient to rise above point bar elevations and allowed water to flow from upstream to downstream parts of the floodplain bottom. For example, at Leota, slow backwater floods entered the south part of the bottom near L7A (Fig. 7b) at flows of about 13-14,000 cfs at a return interval of about 1.1-1.2 years, whereas headwater floods that overtopped the inside bend point bar at L3 occurred only at flows > 27,000 cfs at a return interval of >5 years.

Backwater floods typically enter and exit floodplains at the

Table 4. Recurrence interval, in years, of peak discharge for the Green River near Jensen, Utah. Discharge in cubic meters/second (cubic feet/second in parentheses) for the periods before (1923 to 1962) and after (1963 to 1993) closure of Flaming Gorge Dam (from Schmidt 1994).

Year	Recurrence interval (years) 1.25	2	5	10
1923-1962	446.4 (15764)	622.1 (21967)	791.6 (27952)	896.6 (30707)
1963-1993	326.3 (11521)	463.0 (16347)	640.5 (22617)	753.3 (26598)

same general location and usually deposit fine texture sediments into floodplains; little scouring action occurs except for moderate exit channels. During backwater floods, the depth of water in floodplains is relatively shallow and has a lower hydraulic gradient (head) between the height of the flood water and the elevation of the "in-bank" river channel surface. Consequently, when backwater floods recede, the rate of fall typically is gradual and with a lower head, thus reducing the velocity of water draining from the floodplain bottoms and reducing scouring at exit sites. In contrast to backwater flood events, headwater floods enter at higher elevation upstream locations, exit at lower elevation downstream points, have high velocity flows that scour flow paths across floodplains, deposit coarse sands at high bank entry sites usually on point bars, and have greater depth and hydraulic gradients that cause extensive scouring at exit sites when floodwaters drain from floodplain bottoms. If headwater floods are prolonged and deep, some fine silts are deposited in deeper floodplain locations the farthest distance from higher velocity channel and flow path flows.

Table 5. Discharge (cubic feet/second) and elevation (feet above mean sea level) when extensive overbank flooding occurs with no levees present in floodplain bottoms on Ouray National Wildlife Refuge, Utah[a]

Floodplain bottom	Discharge	Flooding elevation (Lowest Entry)	Lowest elevation in bottom
Johnson	18,400	4672 (4668)	4663
Leota	14,000	4666 (4664)	4658
Wyasket	16,000	4661 (4655)	4653
Sheppard	18,500	4660 (4657)	4652
Woods[b]	18,600	4657 (4657)	4650

[a] From FLO Engineering Inc. 1996, 1997.
[b] Excludes the small man-made ditch leading to woods which floods at 13,000 cubic feet/second.

All Ouray NWR floodplain bottoms exhibit a similar pattern of floodwater entry and exit. In "S-shaped" meandering sand-based riffle(bar)/pool rivers such as the Green River at Ouray NWR it is typical for overbank flooding to occur first at downstream ends of floodplain bottoms (Fig. 16). These downstream locations usually correspond with gradually decreasing heights of natural levees and where fixed bank bars are present. Consequently,

Table 6. Area[a] of inundation versus discharge of floodplain bottoms on Ouray National Wildlife Refuge with levees, based on pre-and post-1963 hydrology[b]

Discharge[c]	Pre – 1963 return[d]	Post – 1963 return	Floodplain bottom				
			Johnson	Leota	Wyasket	Sheppard	Woods
13,000	1.0	1.1	250	-	-	-	350
18,600	1.5	2.6	280	-	500	-	490
20,300	1.9	3.4	300	-	530	245	500
22,700	2.1	5.0	400	775	1854	1400	570
26,400	4.5	10.0	420	1300	1880	1425	583
37,000	50.0	100.0	434	1650	2060	1440	600

[a] Acres.
[b] Modified from FLO Engineering, Inc. 1996.
[c] Cubic feet/second.
[d] In years.

these downstream sites have relatively flat low natural levee elevations and allow flood water to enter floodplains in a wide flow path. River flows accelerate at bends of a river and the increased energy and river current moves downward to scour the thalweg of the outside bend while simultaneously depositing coarse material on the inside of bends. Downward pressure of river flow at bends tends to create bluffs at bends and inhibits upward overbank flow at this location unless very large high velocity flows occur. Simultaneously, deposition of coarse material at the inside bend creates high elevation point bars which are not overtopped unless flows are very high. If high velocity flows occur, water typically crosses point bars first in the narrow "swale" locations and further scours the entry location.

After river flows exit bends of the river channel, the currents slow and move upward, and fine silts and clays are deposited in a gradually decreasing depth on natural river levees and in-channel bars as distance from the bend increases up to a point where flows accelerate at the entry of the next bend. In this flow pattern, the lowest bank location nd upward flow of water typically ccurs on the downstream part of ends on the bank side opposite rom the next bend (where point ar deposits start to accumulate oward the inside bend) (Fig. 16). As discharges increase, river levels ncrease and have multiple entry points into floodplains including ld scoured swales on the higher levation point bars. Often new iver "chutes" and "cutoffs" provide ntry spots at these higher flows nd allow river flow across the floodplain. If flood flows are large nd of high velocity for extended periods, these flow paths across he floodplain may scour shallow hannels or depressions (e.g., Fig.).

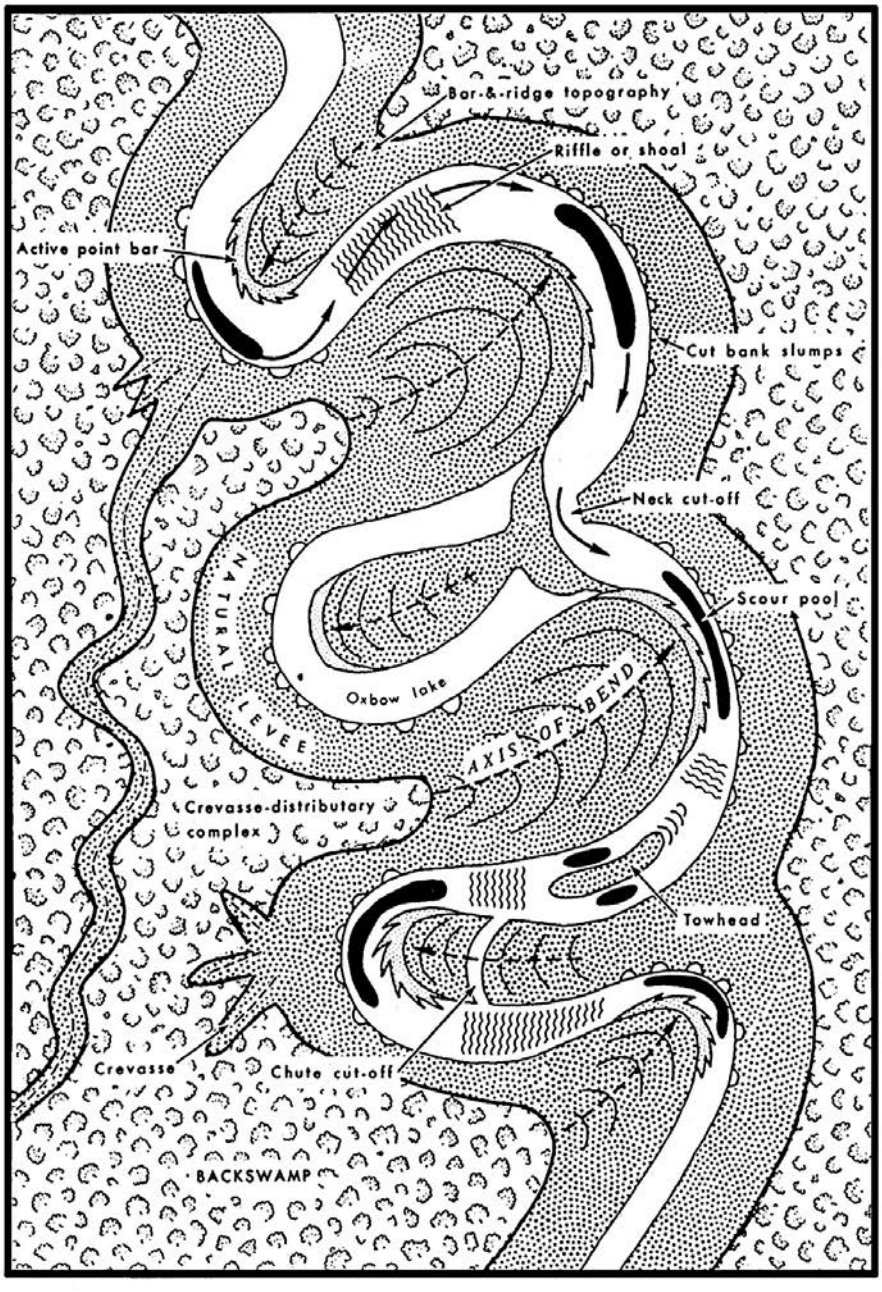

Figure 9. Topographic relationships of Holocene point-bar environments (from Saucier 1994).

Groundwater levels under Ouray NWR floodplains are influnced by geomorphic surfaces, soil ypes, and subsurface connectivity with the Green River. Where oils are relatively porous (coarse exture), groundwater moves etween floodplain soils and the Green River and consequently, roundwater, and perhaps even ome surface, water tables are nfluenced by stage of Green River flows. The degree and location of ubsurface connectivity between floodplain wetlands on Ouray NWR and the Green River has not een determined, however sites hat probably have the greatest onnection include sites immediately behind point bars (Fig. 10)

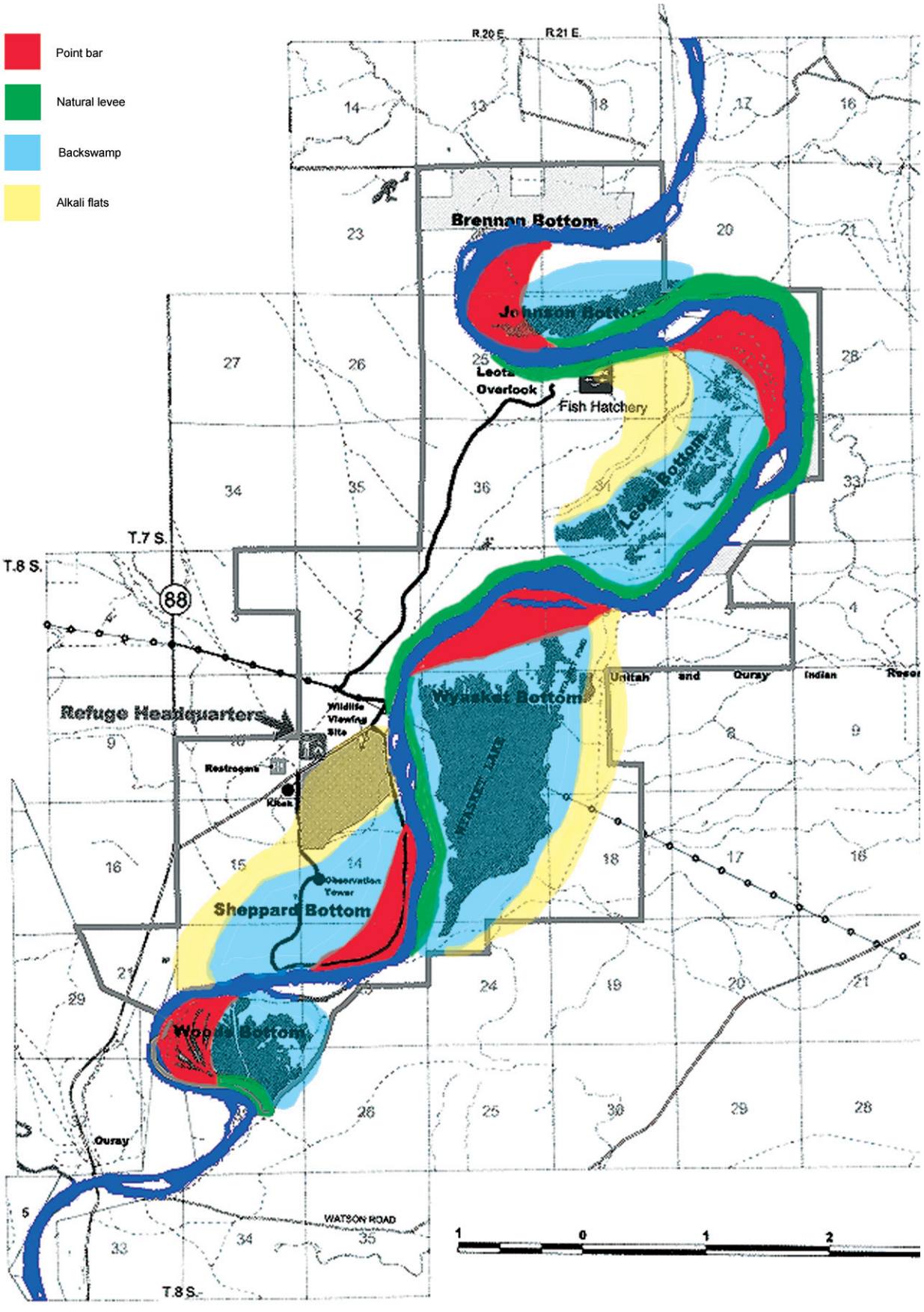

Figure 10. Geomorphic surfaces on Ouray National Wildlife Refuge, Utah.

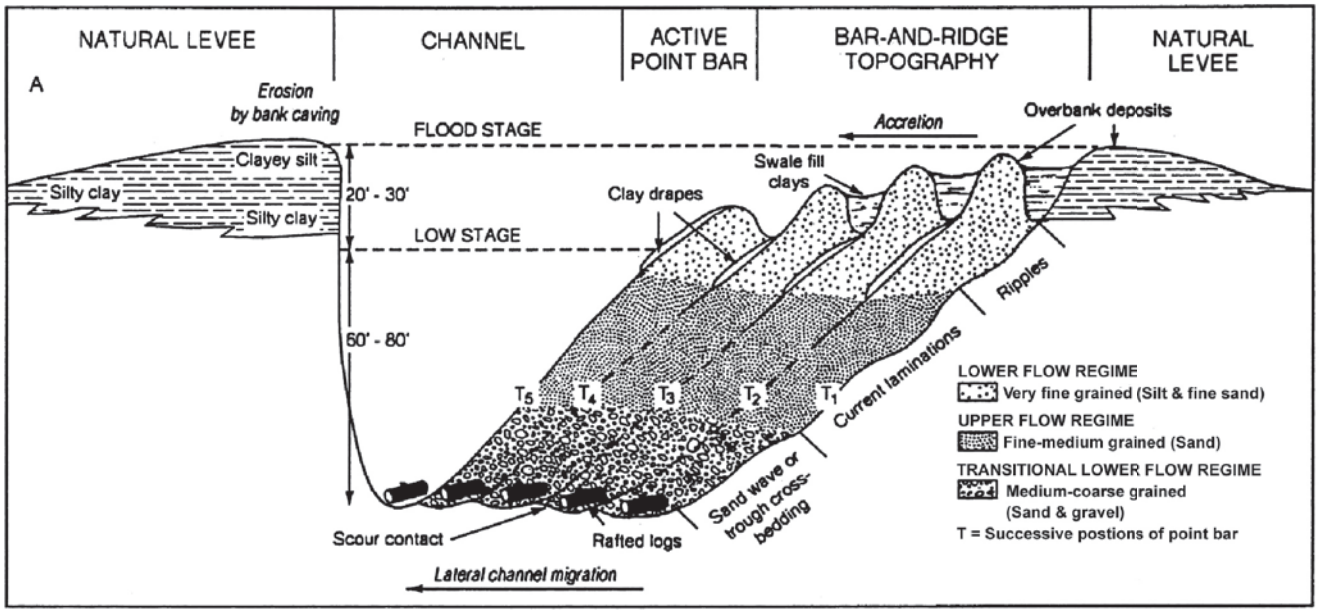

Figure 11. Topographic variation in relation to river processes that create meander belts in large sand bed rivers (from Saucier 1994).

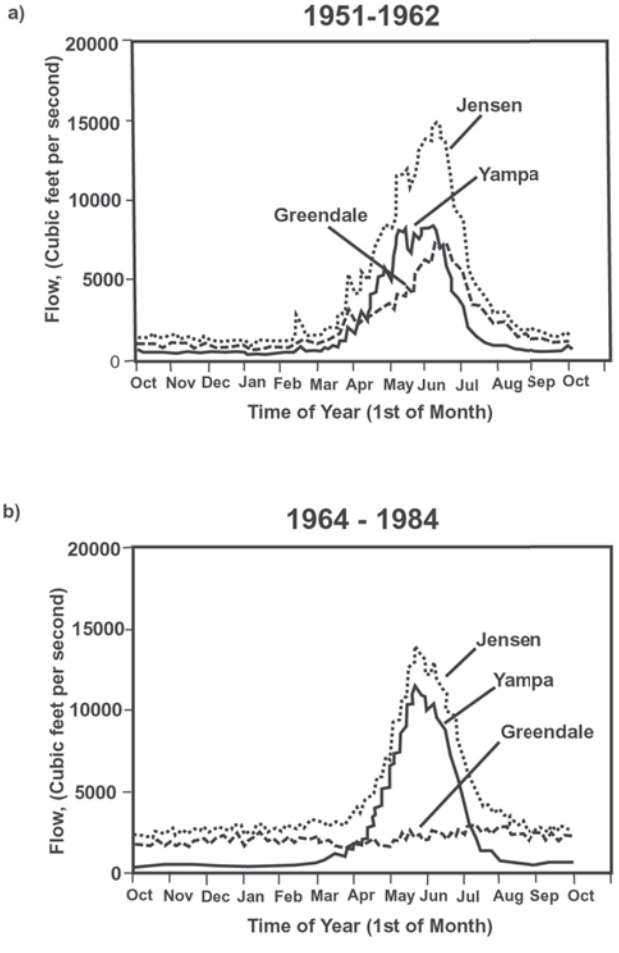

Figure 12. Green River basin flows at 3 gage stations above Ouray National Wildlife Refuge, Utah: a) prior to, and b) after closure of Flaming Gorge Dam in 1963.

where water can move through the sandy point bar areas into and out of backswamp depressions. In these wetland sites, some seasonal surface ponding of water may occur when the Green River is at a high stage, even if the river does not overflow natural levee banks and backflood these areas.

HISTORIC VEGETATION, FISH AND WILDLIFE COMMUNITIES, AND ECOLOGICAL PROCESSES

The types and distribution of historic vegetation communities at Ouray NWR can be determined using a combination of historic and contemporary information. Contemporary vegetation present in relatively unmodified locations of different geomorphological, soil, topography, and flood frequency settings (e.g., USFWS 2000, Crowl and Goeking 2002) provide an initial basis for determining which species typically occur at different sites. For example, cattail is found only on backswamp deposits and swales in point bars, in low elevations typically <4660 feet above mean sea level (amsl), in Green River and Wyasket soils, and in the 1-2 year floodplain. These contemporary data can be compared with historic accounts (e.g., Powell 1875, Dale 1918, Reagan 1934), botanical collections (e.g., Graham 1937), and notes from early soil mapping (Wilson et al. 1959) to confirm and extrapolate historic plant occurrence

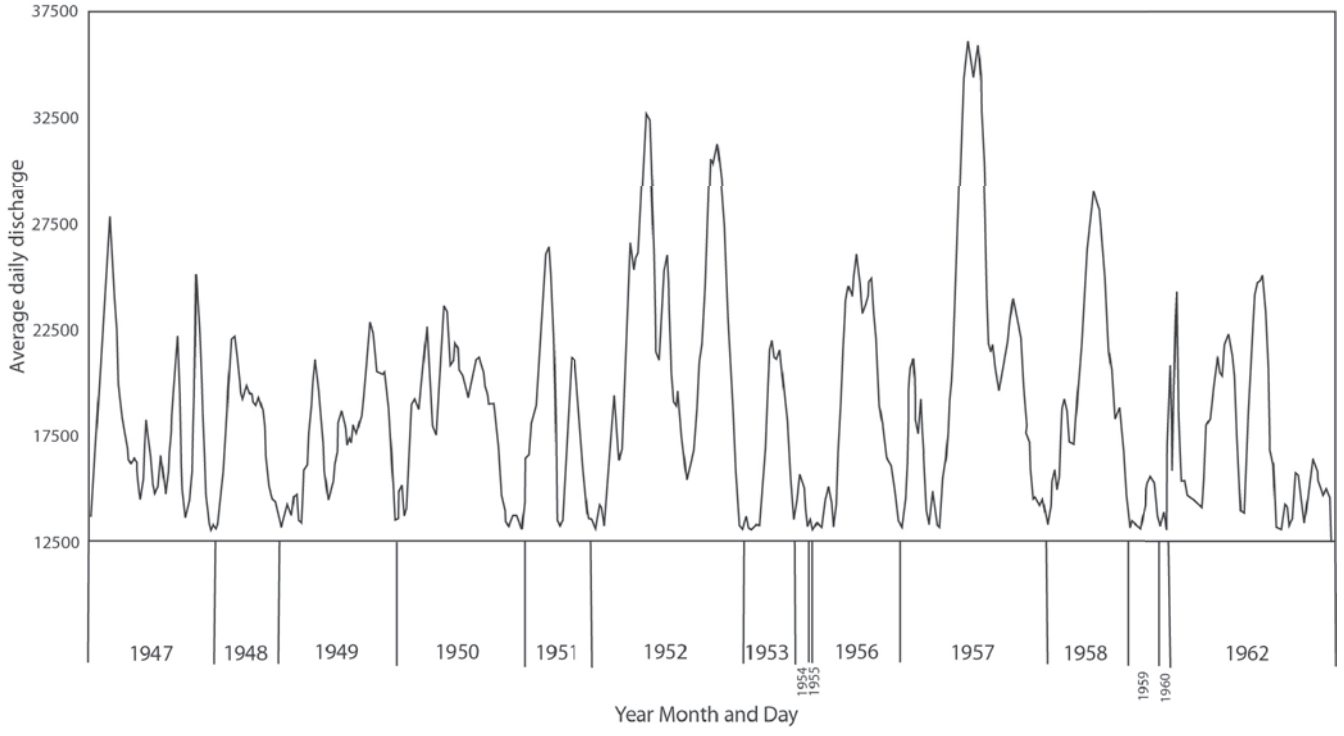

Figure 13. Green River average discharge 1947-1962 at Jensen, Utah.

and distribution. Historic and current surveys of animals associated with different vegetation communities provide a basis for determining species occurrence and resource use among habitat types. Other ecological information identifies the basic ecological processes, both abiotic and biotic, that control these ecosystems. Collectively, historic and contemporary information suggest a gradation of vegetation types and ecological processes from high elevation upland benches to the present river channel at Ouray NWR (Fig. 17).

Upland Grasslands, Clay Bluffs, Semi-Desert Shrublands

The high elevation upland benches formed by the Uinta Formation contain grassland plant and animal communities; low shrubs also are present in many locations and add structural and resource diversity. Soils on upland benches typically are Badland, Rock outcrop, and Cadrina-Casmos types (Table 1, Fig. 17) and support desert-type plant species including wheatgrass, purple three-awn, saltgrass, wildrye, bucksheath, milk vetch, ricegrass, rabbitfoot grass, alkali sacaton, and needle-and-thread grass (Table 8). Horsebrush and tall tumble mustard are common low shrubs. Clay bluffs support almost no vegetation and typically are barren highly dissected and eroded bluffs. Terrace fan remnants

Table 7. Mean number of flood (>13,000 cubic feet second) pulses, number of total days of flooding /year, and mean number of days/flood pulse of the Green River at Jensen, Utah 1947-1962.

Year	# Pulses	Total days	Days pulses
1947	1	60	60.0
1948	2	32	16.0
1949	3	55	18.3
1950	2	62	31.0
1951	3	32	10.7
1952	2	74	37.0
1953	4	24	6.0
1954	1	7	7.0
1955	1	1	1.0
1956	3	43	14.3
1957	1	75	75.0
1958	1	40	40.0
1959	1	14	14.0
1960	1	4	4.0
1961	0	0	-
1962	5	81	16.2
Total	1.94	37.8	23.4

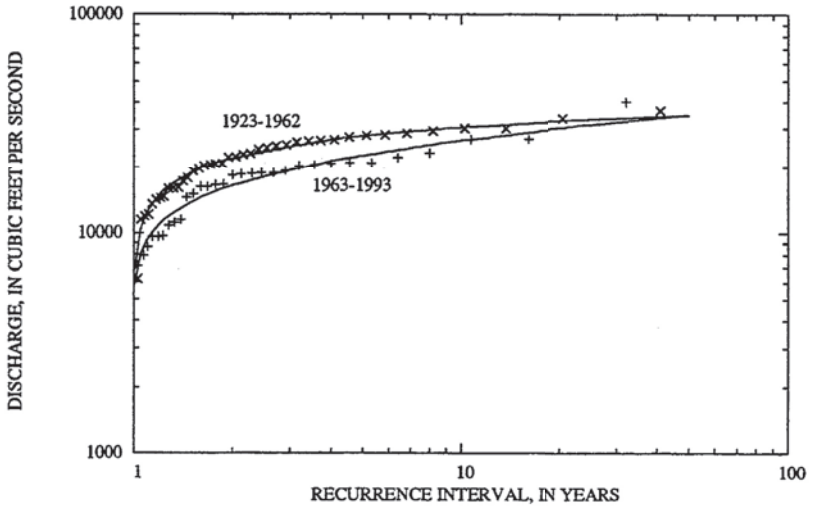

Figure 14. Recurrence interval of instantaneous peak flow for the Green River near Jensen, Utah (from Schmidt 1994).

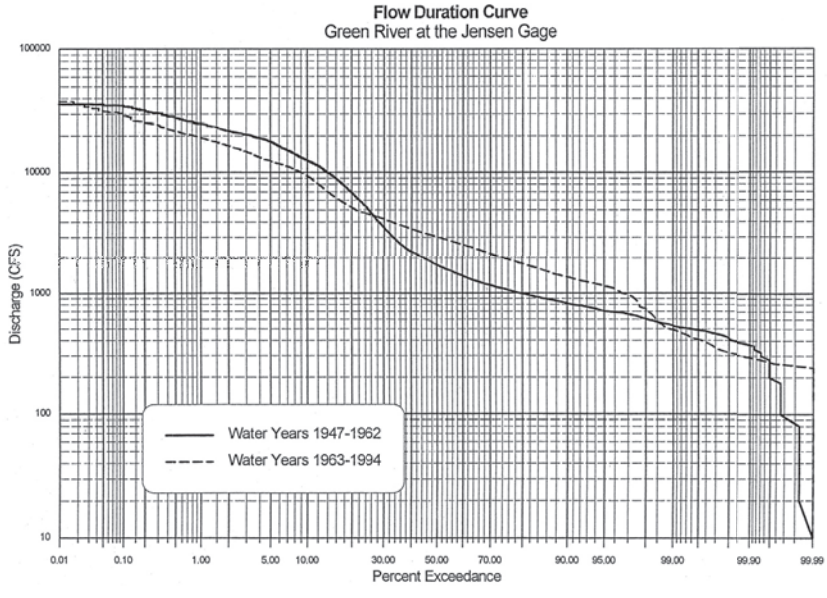

Figure 15. Pre- and Post- 1963 flow duration curves for the Jensen, Utah gage (from FLO Engineering, Inc. 1996).

that contain material eroded from upland benches have semidesert shrubland communities at upper elevations near bluffs and transition to alkali flats at lower elevations adjacent to alluvial floodplains. Common shrubs on terrace fans include greasewood, horsebrush, saltbush, hopsage, and tall tumble and tansy mustard. Many grassland birds are present in uplands and shrublands including several species of sparrows, western meadowlark, snow bunting, sage thrasher, sage grouse, and birds-of-prey (Table 9). Badgers, marmot, prairie dog, antelope squirrel, Ord's Kangaroo rat, white- and black-tailed jackrabbit, desert cottontail, mule deer, and pronghorn are common mammals in these habitats. Common reptiles included fence, side-blotched, and horned lizards along with whiptail and gopher snakes (Table 9).

The ecological processes that sustain grassland and shrubland communities on upland benches and terraces are driven by local precipitation, occasional fire, and soils. The arid conditions of the region, coupled with high elevations that do not flood from the Green River create an environment that is water limited, especially on upland benches. Small amounts of precipitation occur in most months, with modest snow packs contributing to groundwater levels in winter and early spring preceding growing seasons. Grasses that occur on benches occur in clumps interspersed with bare soil and with scattered shrubs where soil moisture is higher. Periodic fire and moderate levels of grazing by native herbivores recycle nutrients in these communities.

Downslope remnant fans and terraces receive modest runoff and sediments from upland benches and bluffs depending on the topographic slope and magnitude of individual and annual precipitation events. Increased soil moisture on terraces compared to uplands allow shrubs to become established on terrace fans and they increase in abundance from top to bottom of slopes. Historically, fires periodically recycled nutrients, however, primary productivity is relatively low compared to other habitats in the region.

Alkali Flats

Alkali flats occur between the bottom slopes of shrubland terraces and upland sides of floodplain wetlands. Water flows into and through alkali flats from upland slope runoff and groundwater seeping from terraces and benches. Seasonal presence of surface water in alkali flats depends on magnitude of annual precipitation, especially snowmelt, in the local area and seasonal temperature. Runoff and seepage water typically occurs on alkali flats in spring. As this water evaporates in depressions, salt

accumulates on soil surfaces and creates alkaline soil conditions. During very high flood events on the Green River, alkali flats may be shallowly flooded for short periods. Alkali flats typically have Stygee and Turzo soils; the amount of loam and sand depends on source of eroded material and topography. Common plants in alkali flats include black greasewood, alkali sacaton, bottlebrush, squirreltail, shadscale, saltbush, dock, Indian ricegrass, galleta, seepweed, globemallow, and winterfat (Table 8). On some locations, l predominantly saltgrass occurs. alkali flats include species from upland, semidesert, and wetland communities depending on the season and wetness of the site (Table 9). During high flood events on the Green River, alkali flats attract large numbers of shorebirds, gulls, swallows, wading birds, and waterfowl.

g g

Floods introduce sediments and nutrients to these wetland during backwater flood events, but may scour and remove bottom sediments and nutrients during headwater floods. Seasonal drying of these wetlands sustains productivity by recycling vegetation and nutrients.

Backswamp Floodplain Wetlands

Backswamp wetlands are present in all of the floodplain bottoms on Ouray NWR (Fig. 17), however, each bottom has slightly different water regimes and dynamics depending on topography of the bottom and frequency of inundation from the Green River. The depth, duration, and extent of flooding in these wetlands historically was driven primarily by flood pulses of the Green River and were highly variable among years; the norm being a relatively short pulse (1-2 weeks) of flood entry followed by gradual drying through summer and fall. Some depressions in floodplains behind point bars also may have been influenced by high Green River levels in spring, if subsurface connections of groundwater occurred. Consequently, most of the area (excepting deeper depressions) in floodplain wetlands at Ouray NWR had seasonal or semipermanent water regimes in most years.

Plant and animal communities in floodplain wetlands reflect seasonal and annual dynamics of flooding, especially timing, depth, duration, and extent of flooding. Primary and secondary productivity and biodiversity of these wetlands is high (e.g., Crowl et al. 2002), but is annually variable and

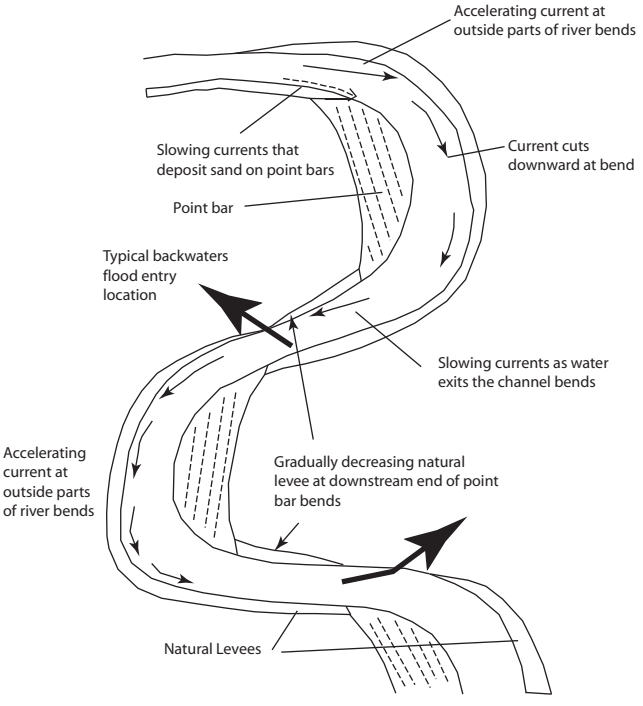

Figure 16. Schematic of typical geomorphic surfaces, river flows, and flood entry locations on sand bed rivers that have "S"-shaped channel configurations.

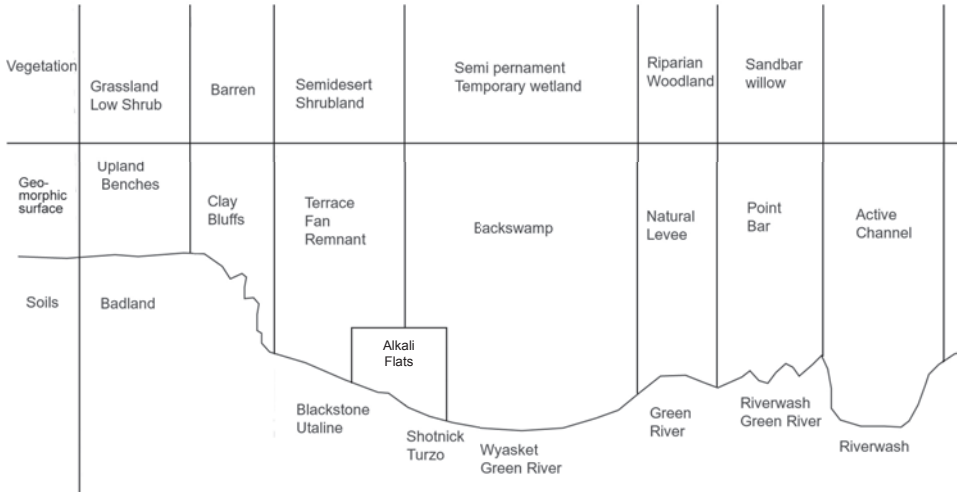

Figure 17. Cross-section of habitats on Ouray National Wildlife Refuge, Utah, indicating vegetation type, geomorphic surface, and soils.

Most floodplain bottoms on Ouray NWR have low depressions in the middle of the bottoms that slope upward toward natural levees and point bar deposits next to the Green River. When extensive flooding occurs, water may be up to 7-9 feet deep in these locations (Table 5). Woods and Johnson bottoms each contain a single relatively deep "bowl-shaped" depression in the middle of the bottom while other bottoms have more gently sloping topography that contain large shallow flats (Wyasket), multiple shallow depressions of moderate size (Leota), or only a few small shallow depressions surrounded by wide higher elevation flats (Sheppard) (Figs. 7, 18).

Depressions in floodplain wetlands on Ouray NWR hold water for the longest periods following inundation from flood waters and vegetation in these locations reflects more permanent water regimes. Many robust emergents such as cattail and bulrush occur in these depressions and if water permanence is prolonged (such as in very high flows or successive years of high river stages) dense mats of submerged aquatic vegetation also are present (Table 8). Flats and shallow areas in floodplains have shorter duration flooding and contain vegetation typically found in seasonally and temporarily flooded locations including a wide diversity of annual and perennial herbaceous plants (Table 8). Common species in seasonally-flooded areas include smartweed, spikerush, dock, sedges, wiregrass, and salt heliotrope. Flooding at the highest elevations in floodplains typically is of very short duration (perhaps only a few days) and vegetation at these sites represents a transition from wetland to upland species. This transition zone may move to lower elevations during dry (low or no flood events) periods and then retreat to higher elevations in wet periods.

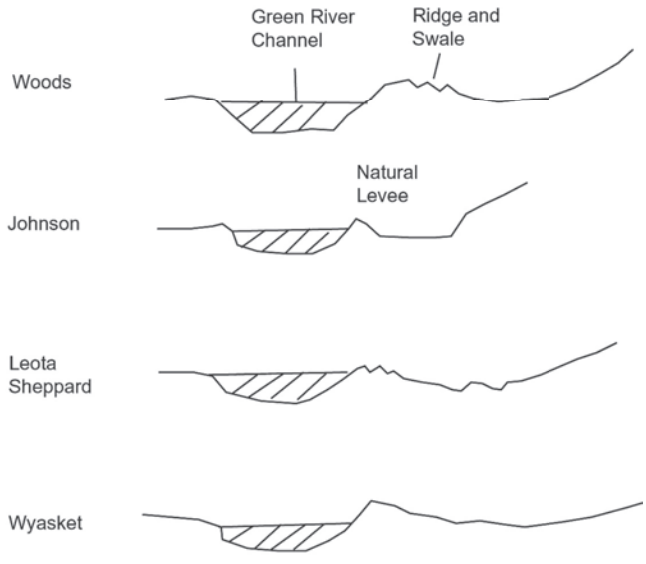

Figure 18. Cross-section of elevation and topography of floodplain "bottoms" on Ouray National Wildlife Refuge, Utah.

During wet periods with extended flooding many species of fish and more aquatic-dependent birds, mammals, and amphibians use floodplain wetlands. During wet years many waterbirds nest in or near these bottoms including migrant redhead, lesser scaup, gadwall, cinnamon teal, shoveler, ruddy duck, canvasback, western and eared grebe, coots, rails, moorhen, ibis, yellow-headed and red-winged blackbird, and marsh wrens (Sangster 1976, USFWS 2000). In contrast, during dry years or times of low, short duration Green River floods, floodplain wetlands historically held surface water only during spring and summer, if at all. Some waterbirds may attempt to breed during dry years, but nest success is relatively low compared to wet periods and most species and individuals move elsewhere for breeding (Sangster 1976). Natural summer drying of floodplain wetlands provide abundant and concentrated prey (e.g., invertebrates, amphibians, fish) for many birds such as pelicans, cormorants, gulls, herons, egrets, ibis, and shorebirds and also for mammals including otter, raccoon, fox, and coyote.

Table 8. Common plant species present on Ouray National Wildlife Refuge, Utah. Data from Folks 1963, Goodrich and Neese 1986, Laison 1993, USFWS 2000.

Common Name	Scientific Name
Grasses	
Crested Wheatgrass	*Agropyron cristatum*
Western Wheatgrass	*Agropyron smithii*
Slender Wheatgrass	*Agropyron trachycaulum*
Creeping Bentgrass	*Agrostis stolonifera*
Purple Three-awn	*Aristida purpurea*
American Sloughgrass	*Beckmannia syzigachne*
Cheatgrass	*Bromus tectorum*
Inland Saltgrass	*Distichlis spicata*
Barnyard Grass	*Echinochloa crusgalli*
Nodding Wildrye	*Elymus canadensis*
Low Creeping Wildrye	*Elymus simplex*
Sixweeks Fescue	*Festuca octoflora*
Galleta	*Hilaria jamesii*
Foxtail Barley	*Hordeum jubatum*
Scratchgrass	*Muhlenbergia asperifolia*
Indian Ricegrass	*Oryzopsis hymenoides*
Old Witchgrass	*Panicum capillare*
Common Reed	*Phragmites australis*
Sandberg Bluegrass	*Poa secunda*
Rabbitfoot Grass	*Polypogon monspeliensis*
Squirreltail	*Sitanion hystrix*
Alkali Sacaton	*Sporobolus airoides*
Sand Dropseed	*Sporobolus cryptandrus*
Needle-and-Thread Grass	*Stipa comata*
Forbs and Weeds	
Lowland Purslane	*Sesuvium sessile*
Redroot Amaranth	*Amaranthus retroflexus*
Springparsley	*Cymopterus acaulis*
Onion Springparsley	*Cymopterus bulbosus*
Uintah Basin Springparsley	*Cymopterus duchesnensis*
Purple Springparsley	*Cymopterus purpurascens*
Hemp Dogbane	*Apocynum cannabinum*
Pallid Milkweed	*Asclepias cryptoceras*
Labriform Milkweed	*Asclepias labriformis*
Showy Milkweed	*Asclepias speciosa*
Bur Ragweed	*Ambrosia tomentosa*
Leafy Aster	*Aster frondosus*
Nodding Beggarticks	*Bidens cernua*
Russian Knapweed	*Centaurea repens*
Douglas Chaenactis	*Chaenactis douglasii*
False Yarrow	*Chaenactis stevioides*
Creeping Thistle	*Cirsium arvense*
Bull Thistle	*Cirsium vulgare*
Dandelion Hawksbeard	*Crepis runcinata glauca*
Enceliopis	*Enceliopsis nutans*
Fleabane	*Erigeron bellidiastrum typicus*
Low Fleabane	*Erigeron pumilus*
Lowland Cudweed	*Gnaphalium palustre*
Curlycup Gumweed	*Grindelia squarrosa*
Broom Snakeweed	*Gutierrezia sarothrae*
Orange Sneezeweed	*Helenium autumnale*
Wild Sunflower	*Helianthus annuus*
Sunflower	*Helianthus petiolaris*
Showy Goldeneye	*Heliomeris multiflora*
Fineleaf Hymenopappus	*Hymenopappus filifolius luteus*
Poverty Sumpweed	*Iva axillaris*
Chicory Lettuce	*Lactuca tatarica*
Heath Aster	*Leucelene ericoides*
Skeleton Plant	*Lygodesmia grandiflora*
Purple Aster	*Machaeranthera canescens*
Discoid Tansyaster	*Machaeranthera grindelioides*
Desert Dandelion	*Malacothrix sonchoide*
	Platyschkuhria integrifolia
	Prenanthella exigua
Canada Goldenrod	*Solidago canadensis*
Missouri Goldenrod	*Solidago missouriensis*
Western Goldenrod	*Solidago occidentalis*
Field Sowthistle	*Sonchus arvensis*
Prickly Sowthistle	*Sonchus asper*
Wirelettuce	*Stephanomeria pauciflora*
Wirelettuce	*Stephanomeria runcinata*
Nuttall Horsebrush	*Tetradymia nuttallii*
Cottonthorn Horsebrush	*Tetradymia spinosa*
Townsendia	*Townsendia grandiflora*
Townsendia	*Townsendia incana*
Yellow Salsify	*Tragopogon dubius*
Rough Cocklebur	*Xanthium strumarium*
Desert Daisy	*Xylorhiza venusta*
Cryptantha	*Cryptantha ambigua*
Yellow Cryptantha	*Cryptantha flava*
Cryptantha	*Cryptantha paradoxa*
Desert Stickseed	*Lappula redowskii*
Persoon	*Tiquilia nuttallii*
Beauty Rockcress	*Arabis pulchra*
Rough Wallflower	*Erysimum asperum*
Prairie Pepperweed	*Lepidium densiflorum*
Giant Whitetop	*Lepidium latifolium*
Mountain Pepperweed	*Lepidium montanum*
African Mustard	*Malcolmia africana*
Common Twinpod	*Physaria acutifolia*
Blunt-leaf Yellowcress	*Rorippa curvipes*
Marsh Yellowcress	*Rorippa islandica*
Cress	*Rorippa lyrata*
Flaxleafed Plainsmustard	*Schoencrambe linifolia*
Tall Tumble Mustard	*Sisymbrium altissimum*
	Thelypodiopsis elegans
Yellow Bee-plant	*Cleome lutea*
Rocky Mountain Bee-plant	*Cleome serrulata*
Fendler Sandwort	*Arenaria fendleri eastwoodiae*
	Chenopodium atrovirens
Fremont Goosefoot	*Chenopodium fremontii*
Oakleaf Goosefoot	*Chenopodium glaucum*
Green Molly	*Kochia americana*
Kochia Weed	*Kochia scoparia*
Povertyweed	*Monolepis nuttalliana*
Russian Thistle	*Salsola iberica*
Halogeton	*Halogeton glomeratus*
Field Bindweed	*Convolvulus arvensis*
Dodder	*Cuscuta spp.*
Spurge	*Euphorbia albomarginata*
Fendler Euphorbia	*Euphorbia fendleri*
Locoweed	*Astragalus amphioxys*
Cicada Milkvetch	*Astragalus chamaeleuce*
Lesser Rushy Milkvetch	*Astragalus convallarius*
Duchesne Milkvetch	*Astragalus duchesnensis*
Yellow Milkvetch	*Astragalus flavus*
Geyer Milkvetch	*Astragalus geyeri*
	Astragalus hamiltonii
Woolly Locoweed	*Astragalus mollissimus*
Draba Milkvetch	*Astragalus spatulatus*
American Wild Licorice	*Glycyrrhiza lepidota*
Dwarf Lupine	*Lupinus pusillus*
Yellow Sweetclover	*Melilotus officinalis*
Silvery Sophora	*Sophora stenophylla*
Tall Centaury	*Mentaurium exaltatum*
	Nama densum
Scorpionweed	*Phacelia crenulata*
Scorpionweed	*Phacelia ivesiana*
Geyer Onion	*Allium geyeri*
Wild Onion	*Allium textile*
Asparagus	*Asparagus officinalis*
Sego Lily	*Calochortus nuttallii*
False Solomon's Seal	*Smilacina stellata*
Whitestem Mentzelia	*Mentzelia albicaulis*
Brushy Mentzelia	*Mentzelia dispersa*
Wingseed Mentzelia	*Mentzelia pterosperma*
Purple Ammannia	*Ammannia robusta*
Alkali-mallow	*Malvella leprosa*
Scarlet Globemallow	*Sphaeralcea coccinea*

Table 8, cont'd.

Common Name	Scientific Name
Nelson Globemallow	*Sphaeralcea parvifolia*
Sandverbena	*Abronia elliptica*
Narrowleaf Umbrellawort	*Mirabilis linearis*
	Tripterocalyx micranthus
Barestem Camissonia	*Camissonia scapoidea*
Small-flowered Gaura	*Gaura parviflora*
Tufted Evening-primrose	*Oenothera caespitosa*
Evening-primrose	*Oenothera elata*
Pale Evening-primrose	*Oenothera pallida*
Plantain	*Plantago asiatica*
Broadleaf Plantain	*Plantago major*
Woolly Plantain	*Plantago patagonica*
Ballhead Gilia	*Gilia congesta*
Gilia	*Gilia leptomeria*
Gilia	*Gilia polycladon*
Dwarf Gilia	*Gilia pumila*
Common Prickly Phlox	*Lepodactylon pungens*
Hood Phlox	*Phlox hoodii*
Wild Sweet William	*Phlox longifolia*
	Eriogonum batemanii
	Nodding Eriogonum
	Eriogonum cernuum
Big Wild Buckwheat	*Eriogonum corymbosum*
	Eriogonum flexum
Gordon's Umbrella Plant	*Eriogonum gordonii*
	Eriogonum hookeri
Desert Trumpet Eriogonum	*Eriogonum inflatum*
Slenderbush Eriogonum	*Eriogonum microthecum*
	Eriogonum salsuginosum
Shockley Wild Buckwheat	*Eriogonum shockleyi*
Green Eriogonum	*Eriogonum viridulum*
Western Virgin-bower	*Clematis ligusticifolia*
Nuttall Larkspur	*Delphinium nuttallianum*
Biennial Cinquefoil	*Potentilla biennis*
Brook Cinquefoil	*Potentilla rivalis*
Desert Paintbrush	*Castilleja chromosa*
Marsh Paintbrush	*Castilleja exilis*
Black Nightshade	*Solanum nigrum*
Prostrate Verbena	*Verbena bracteata*
Aquatic and Wetland Plants	
Narrowleaf Water-plantain	*Alisma gramineum*
Bur-head	*Echinodorus berteroi*
Upright Burhead	*Echinodorus rostratus*
Arrowhead	*Sagittaria cuneata*
Salt Heliotrope	*Heliotropium curassavicum*
Saltmarsh Sandspurry	*Spergularia marina*
	Chara spp
Awned Flatsedge	*Cyperus aristatus*
Needle Spikerush	*Eleocharis acicularis*
Common Spikerush	*Eleocharis palustris*
Dwarf Spikerush	*Eleocharis parvula*
Hardstem Bulrush	*Scirpus acutus*
Alkali Bulrush	*Scirpus maritimus*
Bulrush	*Scirpus saximontanus*
Softstem Bulrush	*Scirpus validus*
Smooth Scouring-rush	*Equisetum laevigatum*
Alpine Rush	*Juncus alpinus*
Wiregrass	*Juncus arcticus*
Toad Rush	*Juncus bufonius*
Torrey Rush	*Juncus torreyi*
Marsh Hedgenettle	*Stachys palustris pilosa*
Water Smartweed	*Polygonum amphibium*
Dooryard-grass	*Polygonum aviculare*
Pale Smartweed	*Polygonum lapathifolium*
Curly Dock	*Rumex crispus*
Canaigre	*Rumex hymenosepalus*
Golden Dock	*Rumex maritimus*
Bitter Dock	*Rumex obtusifolius*
Western Dock	*Rumex occidentalis*
Longleaf Pondweed	*Potamogeton nodosus*
Sago Pondweed	*Potamogeton pectinatus*
Hairleaf Water-buttercup	*Ranunculus aquatilis*
Rocky Mtn. Buttercup	*Ranunculus cymbalaria*
Pennsylvania Buttercup	*Ranunculus pennsylvanicus*
Meadowrue	*Thalictrum spp*
Hedge Hyssop	*Gratiola neglecta*
Mudwort	*Limosella aquatica*
Water Speedwell	*Veronica anagallis-aquatica*
Common Cattail	*Typha latifolia*
Fogfruit	*Phyla cuneifolia*
Woody Plants	
Squaw Bush	*Rhus trilobata*
Biennial Wormwood	*Artemisia biennis*
Tarragon	*Artemisia dracunculus*
Prairie Sage	*Artemisia ludoviciana var. ludoviciana*
Black Sagebrush	*Artemisia nova*
Bud Sagebrush	*Artemisia spinescens*
Big Sagebrush	*Artemisia tridentata*
Mohave Brickellbush	*Brickellia oblongifolia*
Rubber Rabbitbrush	*Chrysothamnus nauseosus*
Low Rabbitbrush	*Chrysothamnus viscidiflorus*
Silverscale	*Atriplex argentea*
Fourwing Saltbush	*Atriplex canescens*
Shadscale	*Atriplex confertifolia*
Mat Saltbush	*Atriplex corrugata*
Castle Valley Saltbush	*Atriplex gardneri cuneata*
	Atriplex heterosperma
Fivehook Bassia	*Bassia hyssopifolia*
Winterfat	*Ceratoides lanata*
Spiny Hopsage	*Grayia spinosa*
Black Greasewood	*Sarcobatus vermiculatus*
Russian-olive	*Elaeagnus angustifolia*
Silver Buffaloberry	*Shepherdia argentea*
Torrey Mormon Tea	*Ephedra torreyana*
Woods Rose	*Rosa woodsii*
Fremont Cottonwood	*Populus fremontii*
Peach-leaf Willow	*Salix amygdaloides*
Narrow-leaf Willow	*Salix exigua*
Whiplash Willow	*Salix lasiandra*
Tamarisk	*Tamarix ramosissima*
Cactus	
Ball Cactus	*Coryphantha vivipara*
Plains Pricklypear	*Opuntia polyacantha*
Uintah Basin Hookless Cactus	*Sclerocactus glaucus*

Birds (*Indicates confirmed nester on the Refuge.)

Loons		
Common Loon		*Gavia immer*
Grebes		
Pied-billed Grebe*		*Podilymbus podiceps*
Horned Grebe		*Podiceps auritus*
Eared Grebe*		*Podiceps nigricollis*
Western Grebe*		*Aechmophorus occidentalis*
Pelicans		
American White Pelican		*Pelecanus erythrorhynchos*
Cormorants		
Double-crested Cormorant*		*Phalacrocorax auritus*
Bitterns, Herons, and Egrets		
American Bittern		*Botaurus lentiginosus*
Least Bittern		*Ixobrychus exilis*
Great Blue Heron*		*Ardea herodias*
Great Egret		*Ardea alba*
Snowy Egret*		*Egretta thula*
Little Blue Heron		*Egretta caerulea*
Green Heron		*Butorides virescens*
Black-crowned Night-Heron*		*Nycticorax nycticorax*
Ibises and Spoonbills		
White-faced Ibis*		*Plegadis chihi*
New World Vultures		
Turkey Vulture*		*Cathartes aura*
Swans, Geese, and Ducks		
Greater White-fronted Goose		*Anser albifrons*
Snow Goose		*Chen caerulescens*
Canada Goose*		*Branta canadensis*
Trumpeter Swan		*Cygnus buccinator*
Tundra Swan		*Cygnus columbianus*
Wood Duck		*Aix sponsa*
Gadwall*		*Anas strepera*
American Wigeon*		*Anas americana*
Mallard*		*Anas platyrhynchos*
Blue-winged Teal*		*Anas discors*
Cinnamon Teal*		*Anas cyanoptera*
Northern Shoveler*		*Anas clypeata*
Northern Pintail*		*Anas acuta*
Green-winged Teal*		*Anas crecca*
Canvasback*		*Aythya valisineria*
Redhead*		*Aythya americana*
Ring-necked Duck		*Aythya collaris*
Greater Scaup		*Aythya marila*
Lesser Scaup		*Aythya affinis*
Bufflehead		*Bucephala albeola*
Common Goldeneye		*Bucephala clangula*
Barrow's Goldeneye		*Bucephala islandica*
Hooded Merganser		*Lophodytes cucullatus*
Common Merganser*		*Mergus merganser*
Red-breasted Merganser		*Mergus serrator*
Ruddy Duck*		*Oxyura jamaicensis*
Osprey, Kites, Hawks, and Eagles		
Osprey		*Pandion haliaetus*
Bald Eagle		*Haliaeetus leucocephalus*
Northern Harrier*		*Circus cyaneus*
Sharp-shinned Hawk		*Accipiter striatus*
Cooper's Hawk		*Accipiter cooperii*
Northern Goshawk		*Accipiter gentilis*
Swainson's Hawk*		*Buteo swainsoni*
Red-tailed Hawk*		*Buteo jamaicensis*
Ferruginous Hawk		*Buteo regalis*
Rough-legged Hawk		*Buteo lagopus*
Golden Eagle*		*Aquila chrysaetos*
Falcons and Caracaras		
American Kestrel*		*Falco sparverius*
Merlin		*Falco columbarius*
Peregrine Falcon		*Falco peregrinus*
Prairie Falcon*		*Falco mexicanus*
Gallinaceous Birds		
Ring-necked Pheasant*	Introduced	*Phasianus colchicus*
Sage Grouse		*Centrocercus urophasianus*
Rails		
Virginia Rail*		*Rallus limicola*
Sora*		*Porzana carolina*
Common Moorhen		*Gallinula chloropus*
American Coot		*Fulica americana*
Cranes		
Sandhill Crane		*Grus canadensis*
Whooping Crane		*Grus americana*
Plovers		
American Golden-Plover		*Pluvialis dominica*
Snowy Plover		*Charadrius alexandrinus*
Semipalmated Plover		*Charadrius semipalmatus*
Killdeer*		*Charadrius vociferus*
Stilts and Avocets		
Black-necked Stilt*		*Himantopus mexicanus*
American Avocet*		*Recurvirostra americana*
Sandpipers and Phalaropes		
Greater Yellowlegs		*Tringa melanoleuca*
Lesser Yellowlegs		*Tringa flavipes*
Solitary Sandpiper		*Tringa solitaria*
Willet		*Catoptrophorus semipalmatus*
Spotted Sandpiper*		*Actitis macularia*
Long-billed Curlew*		*Numenius americanus*
Marbled Godwit		*Limosa fedoa*
Western Sandpiper		*Calidris mauri*
Least Sandpiper		*Calidris minutilla*
Baird's Sandpiper		*Calidris bairdii*
Dunlin		*Calidris alpina*
Short-billed Dowitcher		*Limnodromus griseus*
Long-billed Dowitcher		*Limnodromus scolopaceus*
Common Snipe*		*Gallinago gallinago*
Wilson's Phalarope*		*Phalaropus tricolor*
Red-necked Phalarope		*Phalaropus lobatus*
Skuas, Jaegers, Gulls, and Terns		
Franklin's Gull		*Larus pipixcan*
Bonaparte's Gull		*Larus philadelphia*
Ring-billed Gull		*Larus delawarensis*
California Gull		*Larus californicus*
Herring Gull		*Larus argentatus*
Caspian Tern		*Sterna caspia*
Common Tern		*Sterna hirundo*
Forster's Tern*		*Sterna forsteri*
Black Tern*		*Chlidonias niger*
Pigeons and Doves		
Rock Dove	Introduced	*Columba livia*
Band-tailed Pigeon		*Columba fasciata*
Mourning Dove*		*Zenaida macroura*
Cuckoos and Anis		
Yellow-billed Cuckoo*		*Coccyzus americanus*

Table 9, cont'd.

Typical Owls	
Western Screech-Owl	*Otis kennicottii*
Eastern Screech-Owl	*Otus asio*
Great Horned Owl*	*Bubo virginianus*
Burrowing Owl*	*Athene cunicularia*
Long-eared Owl	*Asio otus*
Short-eared Owl	*Asio flammeus*
Northern Saw-whet Owl	*Aegolius acadicus*
Nightjars	
Common Nighthawk*	*Chordeiles minor*
Common Poorwill	*Phalaenoptilus nuttallii*
Swifts	
White-throated Swift	*Aeronautes saxatalis*
Hummingbirds	
Black-chinned Hummingbird	*Archilochus alexandri*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Rufous Hummingbird	*Selasphorus rufus*
Kingfishers	
Belted Kingfisher	*Ceryle alcyon*
Woodpeckers	
Lewis' Woodpecker*	*Melanerpes lewis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Downy Woodpecker*	*Picoides pubescens*
Hairy Woodpecker*	*Picoides villosus*
Northern Flicker*	*Colaptes auratus*
Tyrant Flycatchers	
Western Wood-Pewee	*Contopus sordidulus*
Willow Flycatcher	*Empidonax traillii*
Say's Phoebe*	*Sayornis saya*
Vermilion Flycatcher	*Pyrocephalus rubinus*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Western Kingbird*	*Tyrannus verticalis*
Eastern Kingbird	*Tyrannus tyrannus*
Shrikes	
Loggerhead Shrike*	*Lanius ludovicianus*
Northern Shrike	*Lanius excubitor*
Vireos	
Warbling Vireo*	*Vireo gilvus*
Crows, Jays, and Magpies	
Pinyon Jay	*Gymnorhinus cyanocephalus*
Black-billed Magpie*	*Pica pica*
American Crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corax*
Larks	
Horned Lark*	*Eremophila alpestris*
Swallows	
Purple Martin	*Progne subis*
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachycineta thalassina*
Northern Rough-winged Swallow*	*Stelgidopteryx serripennis*
Bank Swallow	*Riparia riparia*
Cliff Swallow*	*Petrochelidon pyrrhonota*
Barn Swallow*	*Hirundo rustica*
Titmice and Chickadees	
Black-capped Chickadee*	*Poecile atricapillus*
Mountain Chickadee	*Poecile gambeli*
Nuthatches	
Red-breasted Nuthatch	*Sitta canadensis*
White-breasted Nuthatch	*Sitta carolinensis*
Creepers	
Brown Creeper	*Certhia americana*
Wrens	
Rock Wren*	*Salpinctes obsoletus*
Bewick's Wren	*Thryomanes bewickii*
House Wren*	*Troglodytes aedon*
Marsh Wren*	*Cistothorus palustris*
Kinglets	
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*Regulus calendula*
Old World Warblers	
Blue-gray Gnatcatcher	*Polioptila caerulea*
Thrushes	
Western Bluebird	*Sialia mexicana*
Mountain Bluebird	*Sialia currucoides*
Townsend's Solitaire	*Myadestes townsendi*
Swainson's Thrush	*Catharus ustulatus*
American Robin*	*Turdus migratorius*
Mimic Thrushes	
Gray Catbird	*Dumetella carolinensis*
Northern Mockingbird*	*Mimus polyglottos*
Sage Thrasher	*Oreoscoptes montanus*
Starlings	
European Starling*	*Sturnus vulgaris*
Wagtails and Pipits	
American (Water) Pipit	*Anthus rubescens*
Waxwings	
Bohemian Waxwing	*Bombycilla garrulus*
Cedar Waxwing	*Bombycilla cedrorum*
Wood Warblers	
Orange-crowned Warbler	*Vermivora celata*
Virginia's Warbler	*Vermivora virginiae*
Yellow Warbler*	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Black-throated Gray Warbler	*Dendroica nigrescens*
Townsend's Warbler	*Dendroica townsendi*
American Redstart	*Setophaga ruticilla*
MacGillivray's Warbler	*Oporornis tolmiei*
Common Yellowthroat	*Geothlypis trichas*
Wilson's Warbler	*Wilsonia pusilla*
Yellow-breasted Chat*	*Icteria virens*
Sparrows and Towhees	
Green-tailed Towhee	*Pipilo chlorurus*
Spotted Towhee*	*Pipilo maculatus*
American Tree Sparrow	*Spizella arborea*
Brewer's Sparrow	*Spizella breweri*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Sage Sparrow	*Amphispiza belli*
Lark Bunting	*Calamospiza melanocorys*
Savannah Sparrow	*Passerculus sandwichensis*
Fox Sparrow	*Passerelia iliaca*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
White-throated Sparrow	*Zonotrichia albicollis*
Harris' Sparrow	*Zonotrichia querula*
White-crowned Sparrow	*Zonotrichia leucophrys*

Table 9, cont'd.

Dark-eyed Junco	*Junco hyemalis*
Snow Bunting	*Plectrophenax nivalis*
Cardinals, Grosbeaks, and Allies	
Black-headed Grosbeak	*Pheucticus melanocephalus*
Blue Grosbeak	*Guiraca caerulea*
Lazuli Bunting	*Passerina amoena*
Blackbirds and Orioles	
Red-winged Blackbird*	*Agelaius phoeniceus*
Western Meadowlark*	*Surnella neglecta*
Yellow-headed Blackbird*	*Xanthocephalus xanthocephalus*
Brewer's Blackbird*	*Euphagus cyanocephalus*
Common Grackle	*Quiscalus quiscula*
Brown-headed Cowbird*	*Molothrus ater*
Baltimore Oriole	*Icterus galbula*
Finches	
House Finch	*Carpodacus mexicanus*
Pine Siskin	*Carduelis pinus*
Lesser Goldfinch	*Carduelis psaltria*
American Goldfinch*	*Carduelis tristis*
Evening Grosbeak	*Coccothraustes vespertinus*
Rosy Finch	*Leucosticte arctoa*
Old World Sparrows	
House Sparrow* Introduced	*Passer domesticus*

Mammals

Bears	
Black Bear	*Ursus americanus*
Raccoons	
Raccoon	*Procyon lotor*
Otters, Badgers, and Skunks	
Northern River Otter	*Lutra canadensis*
American Badger	*Taxidea taxus*
Striped Skunk	*Mephitis mephitus*
Dogs and Foxes	
Coyote	*Canis latrans*
Red Fox	*Vulpes vulpes*
Kit Fox	*Vulpes macrotis*
Cats	
Mountain Lion	*Felis concolor*
Lynx	*Lynx canadensi*
Bobcat	*Lynx rufus*
Squirrels	
Yellow-bellied Marmot	*Marmota flaviventris*
White-tailed Prairie Dog	*Cynomys leucurus*
White-tailed Antelope Squirrel	*Ammospermophilus leucurus*
Least Chipmunk	*Tamias minimus*
Kangaroo Rat	
Ord's Kangaroo Rat	*Dipodimys ordii*
Beaver	
American Beaver	*Castor canadensis*
Mice	
Deer Mouse	*Peromyscus maniculatis*
White-footed Mouse	*Peromyscus leucopus*
Vole	
Meadow Vole	*Microtus pennsylvanicus*
Muskrat	
Muskrat	*Ondatra zibethicus*
Porcupine	
Porcupine	*Erithizon dorsatum*
Hares and Rabbits	
White-tailed Jackrabbit	*Lepus townsendii*
Black-tailed Jackrabbit	*Lepus californicus*
Desert Cottontail	*Sylvilagus audubonii*
Deer	
American Elk	*Cervus elaphus*
Mule Deer	*Odocoileus hemionus*
Moose	*Alces alces*
Pronghorn	
Pronghorn	*Antilocapra americana*
Bison	
American Bison	*Bos bison*

Reptiles and Amphibians:

Reptiles:

Fence Lizard	
Eastern Fence Lizard	*Sceloporous undulatus*
Side-Blotched Lizard	
Side-blotched Lizard	*Uta stansburiana*
Horned Lizard	
Short-horned Lizard	*Phrynosoma douglassii*
Whiptail	
Western Whiptail	*Cnemidophorus tigris*
Garter Snake	
Wandering Garter Snake	*Thamnophis elegans vagrans*
Racer	
Yellow-bellied Racer	*Coluber constrictor*
Green Snake	
Smooth Green Snake	*Opheodrys vernalis*
Gopher Snake	
Great Basin Gopher Snake	*Pituophis melanoleucus*
Rattlesnake	
Western Rattlesnake	*Crotalus viridis*

Amphibians:

Toads	
Woodhouse's Toad	*Bufo woodhousei*
Rocky Mountain Toad	*Bufo woodhousei woodhousei*
Chorus Frog	
Boreal Chorus Frog	*Pseudacris triseriata maculata*
Leopard Frog	
Northern Leopard Frog	*Rana pipiens*

Fish:

Trouts	
Rainbow Trout*	*Oncorhynchus mykiss*
Brown Trout*	*Salmo trutta*

Pikes	
Northern Pike*	*Esox lucius*
Carps and Minnows	
Common Carp*	*Cyprinus carpio*
Utah Chub*	*Gila atraria*
Roundtail Chub	*Gila robusta*
Bonytail	*Gila elegans*
Humpback Chub	*Gila cypha*
Sand Shiner*	*Notropis stramineus*
Fathead Minnow*	*Pimephales promelas*
Colorado Pikeminnow	*Ptychocheilus lucius*
Speckled Dace	*Rhinichthys osculus*
Redside Shiner*	*Richardsonius balteatus*
Red Shiner*	*Notropis lutrensis*
Suckers	
White Sucker*	*Catostomus commersoni*
Bluehead Sucker	*Catostomus discobolus*
Flannelmouth Sucker	*Catostomus latipinnis*
Razorback Sucker	*Xyrauchen texanus*
Bullhead Catfishes	
Black Bullhead*	*Ictalurus melas*
Channel Catfish*	*Ictalurus punctatus*
Livebearers	
Mosquitofish*	*Gambusia affinis*
Sunfishes	
Green Sunfish*	*Lepomis cyanellus*
Bluegill*	*Lepomis macrochirus*
Smallmouth Bass*	*Micropterus dolomieui*
Black Crappie*	*Pomoxis nigromaculatus*
Perches	
Yellow Perch*	*Perca flavescens*
Walleye	*Stizostedion vitreum vitreum*
Sculpins	
Mottled Sculpin	*Cottus bairdi*
Sticklebacks	
Brook stickleback	*Culaea inconstans*

*Indicates species is not native to this area.

Several native fish species in the Green River move into floodplain wetlands on the ascending limb of flood pulses and use resources in these sites for reproductive and survival purposes, depending on the species (e.g, Wydoski and Wick 1998, Modde 1997, Modde et al. 2001). For example, larval razorback suckers move into floodplain wetlands during flood events, become entrained in deeper wetland depressions and bottoms when river levels recede in summer, exploit abundant wetland invertebrate foods that allow juveniles to grow rapidly during summer to the following spring, and, if wetlands remain flooded through the subsequent winter and spring, the young then move back into the Green River during flood events the following year(s). Survival of larvae and juveniles depends on extended flooding and retention of water in the bottoms for at least a year after flooding. Historically, at least some deeper depressions in floodplains on Ouray NWR periodically were flooded extensively enough to retain surface water through the following spring (e.g., the deeper bottoms at Johnson and Woods), however, many floodplain areas dried prior to the following spring and limited recruitment of these species. Analyses of long-term river level data (Figs.12, 13) suggests that year-long (perhaps several successive years) inundation of at least some of the deeper depressions in at least Woods and Johnson Bottoms historically occurred about every 5-7 years.

Because of seasonal dynamics, many animals use semipermanent and seasonal floodplain wetlands on Ouray NWR to exploit rich food supplies that become available during seasonal inundation or drying. For example, large numbers of waterfowl and shorebirds are present at Ouray during spring migration (Sangster 1976) where they obtain important resources used during subsequent migration and breeding. Some species of waterfowl, shorebirds, and wading birds successfully bred in these wetland during wetter periods, but rapid seasonal drying precludes significant recruitment in most years. In contrast, short duration water regimes are ideal for amphibians that time breeding to coincide with short periods of inundation in these seasonal basins that do not support populations of their predators such as fish, waterbirds, and aquatic mammals. Seasonal water regimes also are necessary to maintain productivity and nutrient recycling in semi-arid wetlands (e.g., van der Valk and Davis 1978).

Natural Levee

Natural levees along the Green River at Ouray NWR are relatively low and wide. Floodwaters overtop natural levees first at low spots and seldom overtop all natural levee areas except during high flow events. Consequently, soils on natural levees are only occasionally inundated and contain rich alluvial silts with moderate amounts of sand. Historically, dense stands of cottonwood were present on natural levees with an underlying shrub layer comprised mainly of sumac, rose, and buffaloberry (Table 8). A dense herbaceous layer is common under shrubs and includes goosefoot, buttercup, bee plant, gooseberry, cinquefoil, licorice, poison ivy, water hemlock, milkweed, sneezeweed, sunflower, sumpweed, goldenrod, and cocklebur.

During high flow events, fine texture sediments are deposited on natural levees. This periodic changing and exposure of surface sediments

provided new substrates for cottonwood to germinate, and also replenishes groundwater levels required by new seedlings to survive (Cooper et al. 1999). New sediments also provided ideal soil surfaces for germination of shrubs and perennials and maintain a dynamic balance of nutrients and regeneration of plant communities.

Riparian corridors on natural levees attract and support an abundance of animal species (Table 9). These woodlands offer abundant food supplies (e.g., arboreal arthropods, seeds, fruits), escape and thermal cover and shade, close proximity to predictable (river) and seasonal (floodplain wetland) water sources, and corridors for migration and local movement. Over 100 species of birds use these riparian areas during migration, breeding, and wintering. Many reptiles, especially lizards and snakes are present in these sites, as are numerous mammals, both small (mice) and large (elk).

Point Bar Ridge-and-Swale

Point bars on inside bends of the Green River contain complex topography of sandy higher ridges and silt- and clay-capped swales. Ridges represent different ages of sand deposits as the river has migrated over time. Ridges next to the river are often relatively barren with only scattered willows present. Older ridges may have a thin veneer of silt on top of deep deposits of sand and support a more diverse vegetation community including species commonly found on natural levees. At these locations, willow is intermixed with scattered cottonwood, rose, tumble mustard, sunflower, bee plant, sneezeweed, and saltbush. Swales typically have a clay layer on top of underlying silt and sand and this relatively impermeable clay layer allows surface water to "pond" for short periods, depending on depth and topography of the swale. Most swales are seasonally flooded and contain a mix of species including species present on natural levees and wetlands depending on duration of flooding. Because of greater and extended soil moisture, cottonwood is commonly found on the edges of older swales, with a mix of perennial and emergent herbaceous plants occurring in the bottoms of swales.

Point bar ridges are not flooded except during very high flow events of the Green River. In contrast, swales may be inundated regularly, depending on their proximity to the river and topography. During high flow events, coarse sandy sediments are deposited on ridges; swales receive a combination of both coarse and fine sediments. Changes in soil surfaces create new conditions that may either enhance or retard new germination of woody and herbaceous vegetation. Where silt is deposited, soil conditions may be suitable for cottonwood to germinate, but new deposits of sand may retard growth or survival of cottonwood and replace it with willow.

Animals that inhabit point bars typically are those species that spend most of their time in adjacent riparian or wetland areas (Table 9). Dense stand of willow on point bar ridges offer escape and thermal/shade cover and have moderate, but very seasonal, populations of insects used by many birds and reptiles. Only a few species of birds nest in willow-dominated point bar areas. Wetland-associated species of birds, mammals, and amphibians commonly use swales, but they typically are only seasonal visitors following flood events and seasonal inundation.