THE HISTORIC COKEVILLE MEADOWS ECOSYSTEM

GEOLOGY

Cokeville Meadows NWR is located in the Bear River Valley in southwestern Wyoming (Fig. 1). The head waters of the Bear River are in the Uinta Mountains in northern Utah (Laabs et al. 2007). The river flows northward into southwestern Wyoming and passes near Evanston before looping back into Utah. As the river continues northward it crosses back into Wyoming just north of US Highway 30, southwest of the town of Cokeville, WY. The southern boundary of the Cokeville Meadows NWR acquisition boundary is near the site where Bear River reenters Wyoming. After leaving the northern Cokeville Meadows NWR acquisition boundary, the Bear River loops into Idaho near Border, WY and then descends southward into Utah. It then flows generally south and westward near Logan, UT and eventually enters Bear River Migratory Bird Refuge and the Great Salt Lake west of Brigham City, UT. The longitudinal profile of the river is steep near its headwaters but flattens quickly as it reaches the Wyoming border near Evanston. At Cokeville Meadows NWR, the river gradient is about 2 feet/mile. The uplands to the east of the Bear River Valley constitute the divide between the Great Salt Lake and Green River watersheds/basins. The uplands to the west of the Bear River Valley are the divide between the circuitous drainage of the Bear River and the direct drainage into the Great Salt Lake.

The Bear River Valley reaches its maximum width (about 3 miles) just north of the south border of Wyoming. Then the valley narrows to < ¼-mile wide at Myers Narrows, about nine miles south of Evanston and then to < 100 yards wide at The Narrows, north of Evanston. The Bear River Valley rewidens to about 2 miles at Cokeville Meadows NWR and then narrows again just north of the town of Cokeville, WY, where it is < ¼-mile wide.

Southwestern Wyoming, west of the Green River Basin, is characterized by north-trending mountain ranges, ridges, and valleys that represent diverse geological formations (Veatch 1907). Collectively, the area under Cokeville Meadows NWR

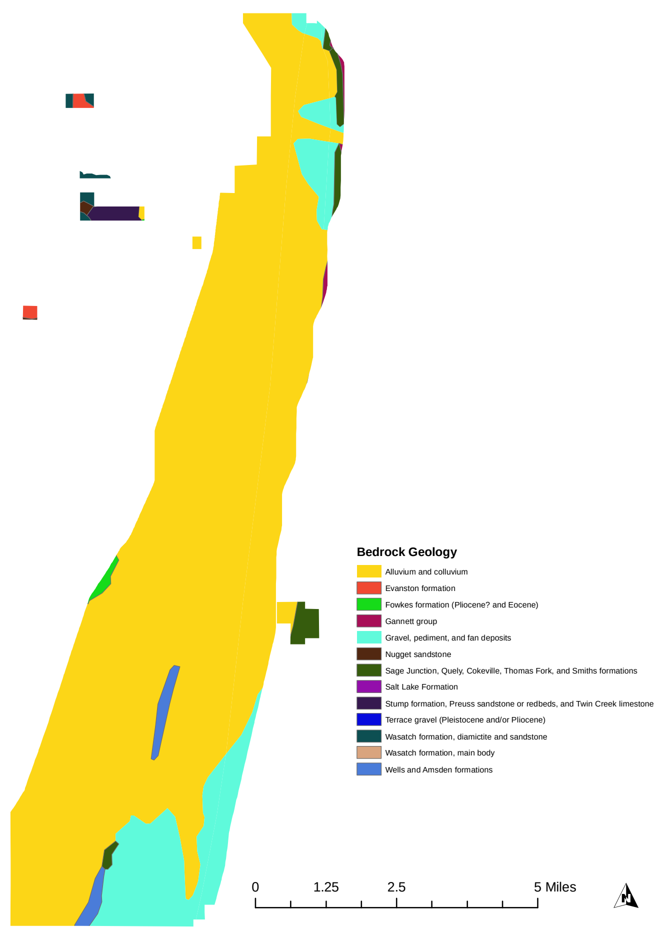


Figure 2. Bedrock geological surfaces of the Cokeville Meadows region.

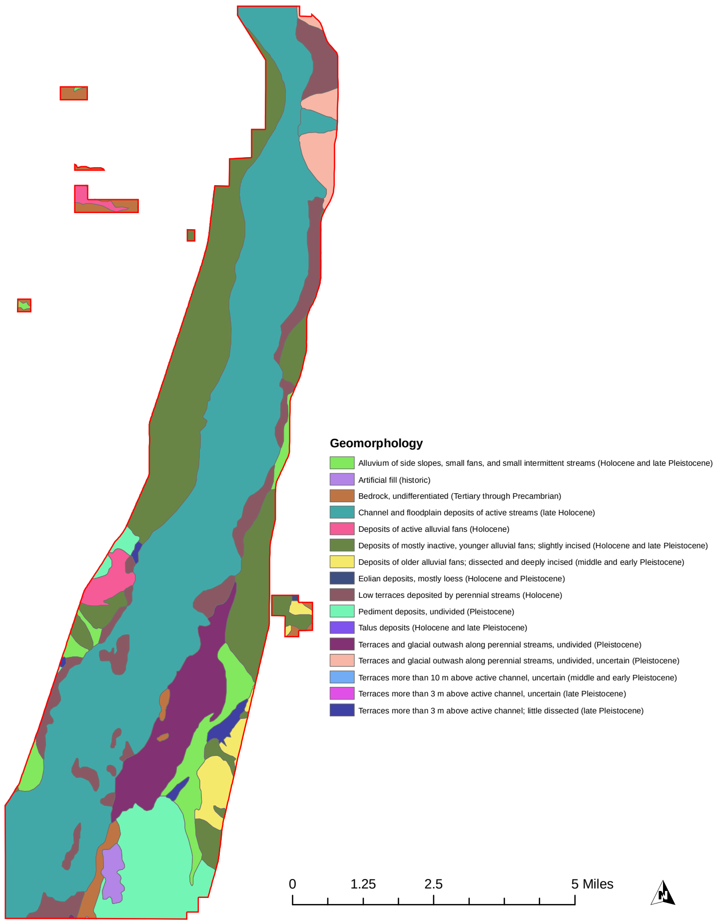


Figure 3. Surficial geomorphology of the Cokeville Meadows region.

includes complex folded and eastward-thrust rocks of Paleozoic, Mesozoic, and early Tertiary age (Appendix A provides a geological time scale) overlain by only slightly deformed later Tertiary and Quaternary sediments (Fig. 2). The north-south belt of mountains and overthrust faults is known as the "Overthrust Belt" Geologic Province of western Wyoming, southeastern Idaho, and northeastern Utah (Blackstone 1977). The Overthrust Belt is part of an extensive belt of folding and faulting that runs north-south from Canada to Mexico, also known as the Cordilleran Fold Belt (Ver Ploeg and DeBruin 1982). The Overthrust Belt contains numerous inactive north-south trending thrust faults, one of which, the Crawford Thrust, reaches the surface within the Cokeville Meadows NWR boundary and dips west under the refuge. Several high-angle thrusts occur in the subsurface on and near the refuge (Lines and Glass 1975, Rubey et al. 1980). The Laramide orogeny that produced the folding and faulting began during Cretaceous time and may have lasted into Eocene time. The most seismically-active fault system in the area is the Rock Creek fault, approximately 15 miles east of Cokeville.

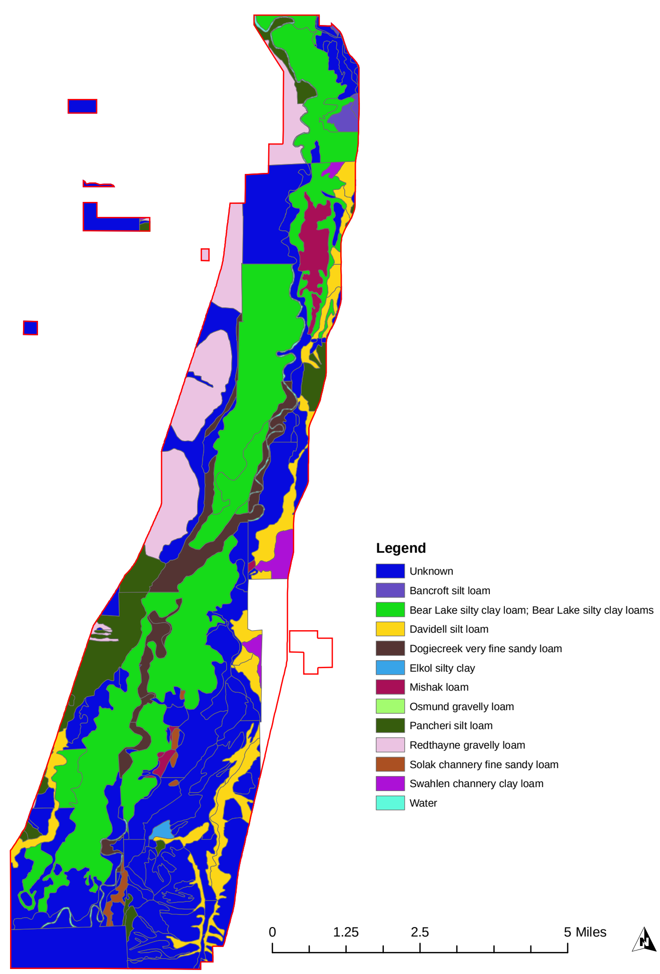
All geologic strata in the Cokeville Meadows NWR region that was deposited during the Cretaceous period resulted from alternating advance and retreat of seas (Bradley 1936). After retreat of the last sea, erosion and deposition of continental sediment formed the current surface landscape at Cokeville. During one of the last erosion cycles, the present Bear River developed along the line of least resistance in the area, presumably an uplifted and faulted zone (Laabs et al. 2007). Continued erosional down-cutting by the river formed a channel a few miles wide that cut into older deposits along the apex of the uplift. The valley of the Bear River follows approximately the north-south trend of the geologic structures and its width is closely related to the lithology of the rocks where the original bedrock-floored valley was cut (Reheis et al. 2009). Succession cycles of erosion and deposition filled the Bear River valley with thick alluvium consisting of weakly cemented clay, silt, sand, and gravel (Reheis 2005). These deposits represent accumulation of detrital material derived from upstream geologic formations. As the present valley became filled, outwash from adjacent hills accumulated along the margin of the floodplain, forming alluvial fans consisting of locally derived sand and gravel. On the west side of Cokeville, these deposits are relatively thick and overlie river alluvium in some areas. In T22N, R120W of the refuge, some outcrops of older rock including the Wells Formation are at the surface (Fig. 2).

The contemporary geomorphologic surfaces at Cokeville Meadows NWR (Reheis 2005) are primarily one to two mile wide Holocene alluvial deposits from the Bear River flanked by younger-age alluvial fans and low terraces (Fig. 3). The alluvial fill exceeds 185 feet thickness in some areas of the Bear River Valley near Cokeville Meadows NWR (Robinove and Berry 1963). Alluvial fan deposits, which extend about two-thirds up the Bear River Valley in the Cokeville Meadows region, reach a thickness of 75 feet locally. Natural levees occur adjacent to larger perennial tributary streams and some older, partly buried or scoured, natural levees are present next to former abandoned channels of the Bear River. Other important geomorphic surfaces on Cokeville Meadows NWR include active alluvial fans on the west side of the valley, older Pleistocene terraces and glacial outwash on the southeast side of the valley, Pleistocene pediment deposits, alluvium of side slopes and small intermittent streams, and older terraces and alluvial fans. Drainage within the area is through numerous streams/creeks that flow directly into the Bear River or that infiltrates into alluvial fans and terrace deposits adjacent to the river floodplain.

SOILS

Soil mapping for the Cokeville Meadows NWR region of Lincoln County, Wyoming is incomplete and contemporary detailed soil maps for the NWR are not available. Soil maps from the Bear River Valley immediately upstream of Cokeville Meadows in Rich County, Utah and a preliminary interim soil map prepared by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) for the Bear River Valley in Lincoln County, Wyoming provide general description of soil types and their distribution (Figs. 4, 5). Apparently, about 12 major soil types/groups are present on, or adjacent to, Cokeville Meadows NWR (Fig. 4). The arrangement of soils on the NWR is complex and reflects the numerous channel migration events across this floodplain, introduction of mixed-erosion sediments from surrounding Quaternary and Tertiary terraces, and alluvial deposition of Bear River Valley parent materials. Most soils on the NWR are shallow, with thin veneers of loam, silt and clay overlying deeper sands and gravels.

Soils at Cokeville Meadows NWR can generally be categorized in three general groups. The largest geomorphic soil group occupies floodplains and low terraces and is of the Calciaquoll-Cryaquoll-Riverwash Association. This soil group is characterized by nearly level to strongly sloping (0-15% slopes) soils that are generally deep, variable in texture, and derived from alluvium. Test borings and wells indicate the maximum thickness of the alluvium including thin veneers of silt loams and underlying alluvial sands and gravel is about 150 feet thick (Robinove and Berry 1963). Silts that overlay gravel typically are < 6 feet below the surface. Wader loam comprise most soils immediately adjacent to the currently actively Bear River channel and Dogiecreek sandy loam occupies natural levees along the Bear River channel. Floodplain soils that overly former meander belts of the Bear River include Bear Lake silt loam, and Berenicteon silt loam. Abandoned channels and other meander belt depression in the Bear River floodplain have clay or silt-clay soils overlying sands and gravels of former river channel bottoms. The second soil group at Cokeville Meadows NWR occurs on alluvial fans and high terraces on the edges of the Bear River floodplain. These soils are found on nearly level to moderately steep slopes (0-30% slopes) and are generally well drained gravelly and cobble silty and sandy loams such as Nevka loam and Duckree gravelly loam. Alluvial fan deposits may reach a thickness of 75 feet locally. The third soil group is present on the foothills of the Overthrust Belt and is of the Calciorthrid-Haploxeroll-Torriothent Association. Geologic over-thrusting and resulting mixed parent materials have produced variable soil textures and complex soil/landform relationships.



. Soil map of the Cokeville Meadows region based on interim NRCS mapping. (incomplete)

Figure 4. Soil map of the Cokeville Meadows NWR based on interim NRCS mapping (incomplete).

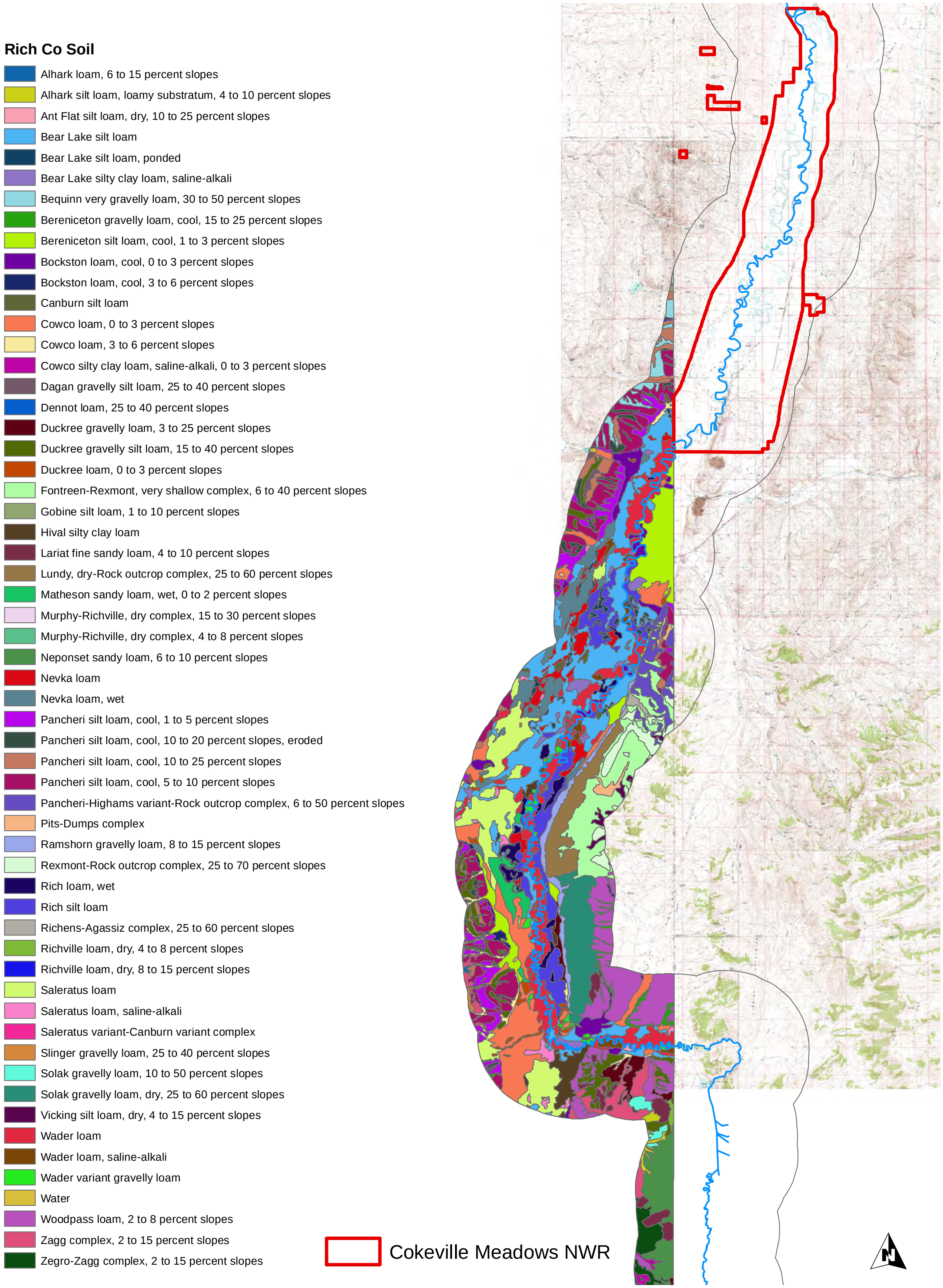


Figure 5. Rich County, Utah soils within 2 km of Bear River.

TOPOGRAPHY AND ELEVATION

Elevations on Cokeville NWR range from about 6,500 feet above mean sea level (amsl) on the bluffs at the south end to about 6,170 feet in floodplains on the north end where the Bear River exits the refuge (Fig. 6). Topographic heterogeneity on the refuge is related to historic Bear River channel and tributary channel migrations, minor within-floodplain channels, floodplain scouring, and alluvial deposition. Significant topographic features include the numerous abandoned channels of the Bear River, old alluvial and glacial terraces, and alluvial fans (Fig. 7).

CLIMATE AND HYDROLOGY

The climate of the Cokeville Meadows region is semi-arid, midcontinental (USFWS 1992). Most precipitation falling in the region is of Pacific origin; average annual precipitation is about 12 inches, with ranges from 9 to 18 inches annually, and the area is dry most of the year. About 38% of precipitation occurs as rainfall from April to June (Fig. 8). In winter, gusty winds can produce blizzards and drifting snow. The frost-free season is only 60-70 days. Days generally are clear and sunny (about 250 days/year) and evaporation rates are high in summer. Monthly average relative humidity ranges from 35% in July to about 75% in December. Mean monthly pan evaporation rates have a seasonal total of 31.3 inches, which is nearly three times annual precipitation. Temperatures are often below 0^{o} Fahrenheit in winter and can exceed 90^{o} Fahrenheit in midsummer. Annual mean temperature is 38^{o} Fahrenheit. The combined low precipitation, high evaporation, and high summer temperatures lead to scarce occurrence of natural

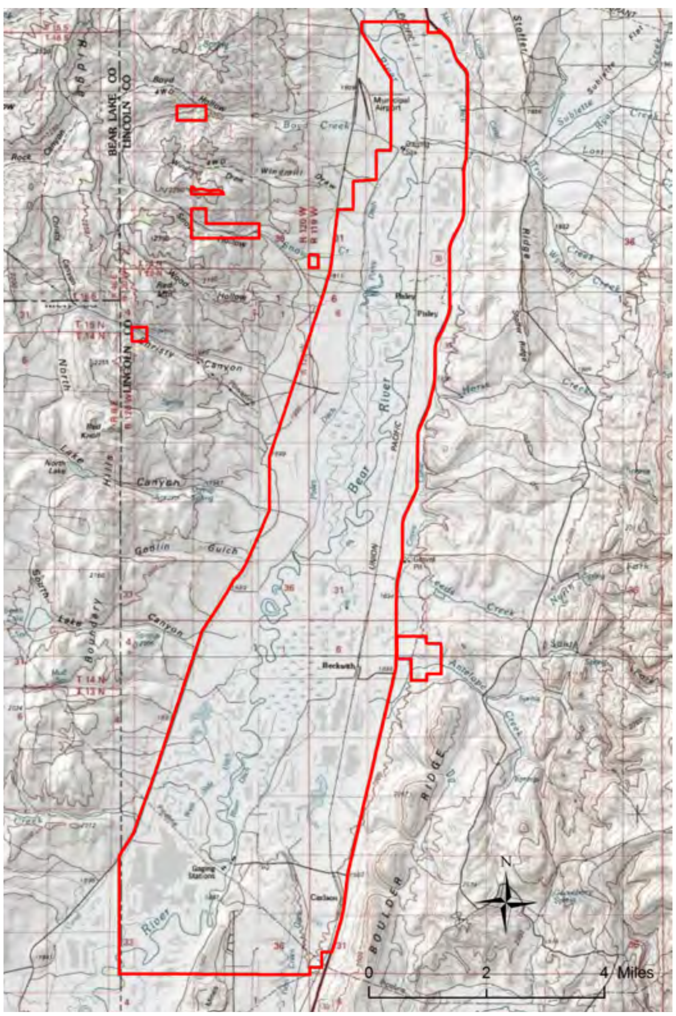


Figure 6. USGS topographic quadrangle map of the Cokeville Meadows region.

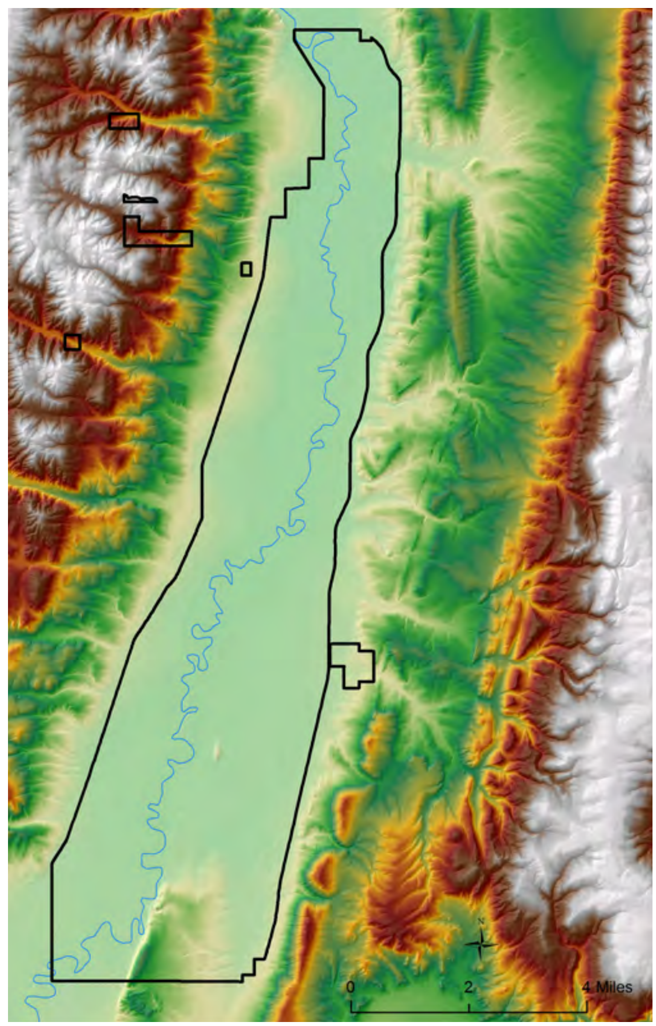


Figure 7. Shaded relief map of area surrounding Cokeville Meadows NWR. Elevations within the boundary range from 6,510 ft. on the south to about 6,165 ft. on the north.

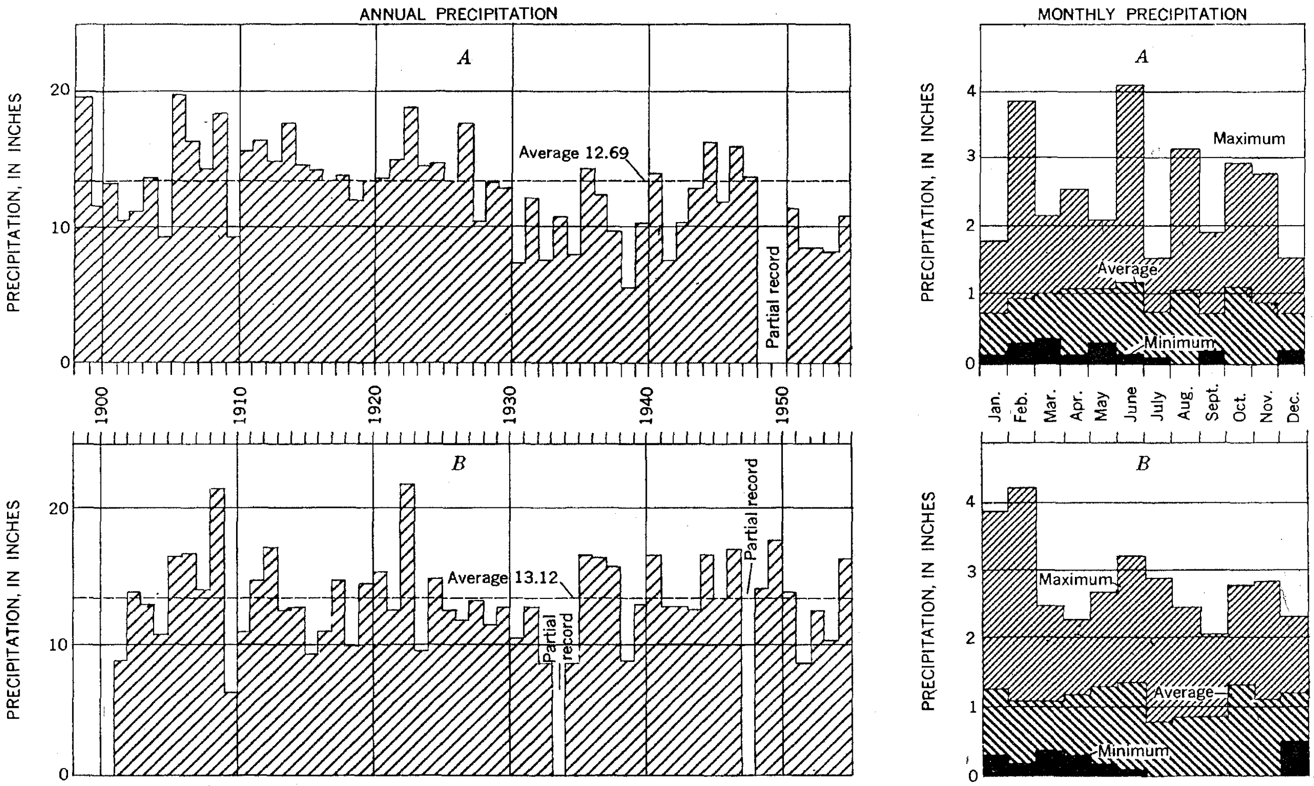


Figure 8. Mean annual precipitation and long-term trends for Cokeville, WY area (U. S. Weather Bureau).

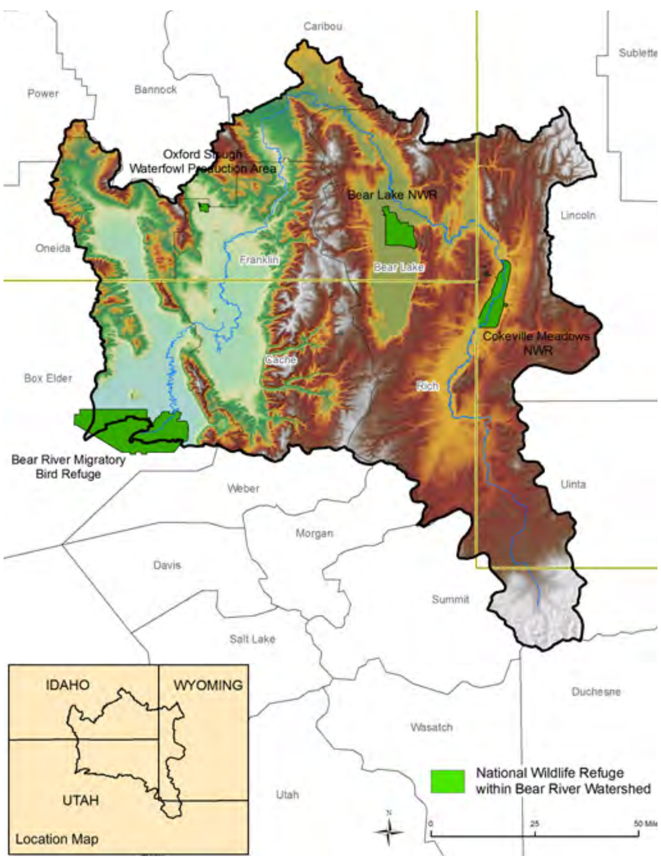


Figure 9. Shaded relief map of the Bear River Watershed.

free-standing surface water from summer through winter.

Cokeville Meadows NWR is within the Bear River Basin, which has a drainage area of about 4.8 million acres in three states (Fig. 9). Water flow into the Bear River comes from onsite regional precipitation, snowmelt, and groundwater discharge. Major tributaries to the Bear River near Cokeville Meadows NWR are the Smith's Fork River and Sublette, Twin, Spring, Brunner, Muddy, and Coral creeks. Water in the Bear River is fresh, but shallow depressions and larger lakes in the system can be highly saline. The Bear River at Cokeville Meadows NWR has little gradient, or fall, with the channel slope approximately 1.5-2.0 feet/mile. The flat relief and low stream gradient have caused the Bear River to frequently meander across the floodplain and has created many abandoned river channels and entrenched meanders. The majority of the acquisition boundary of Cokeville Meadows NWR is within the 100-year floodplain.

Historically, the Bear River had a strongly unimodal discharge/river stage pattern with peak discharges above 400 cubic-feet/second (cfs) in June and relatively sustained low discharges near 100 cfs from August through February (Fig. 10). Water from the Bear River begins to enter many off-channel

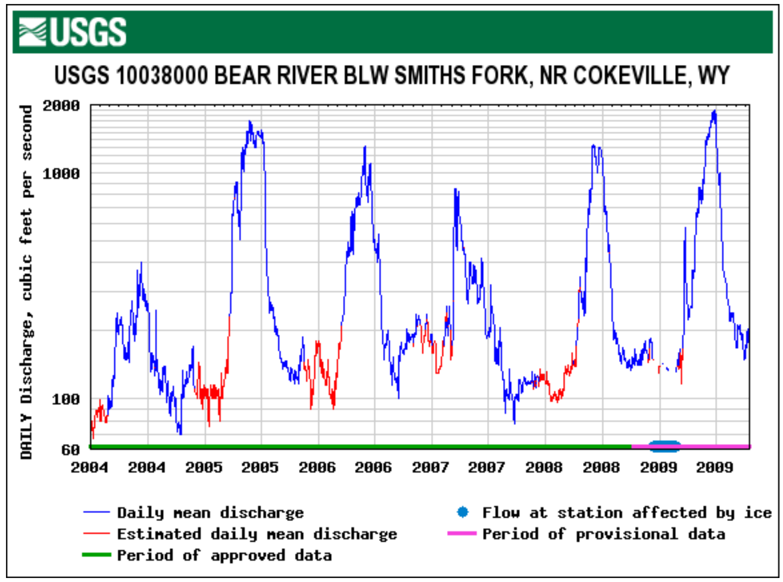


Figure 10. Mean daily discharge of Bear River near Cokeville, WY.

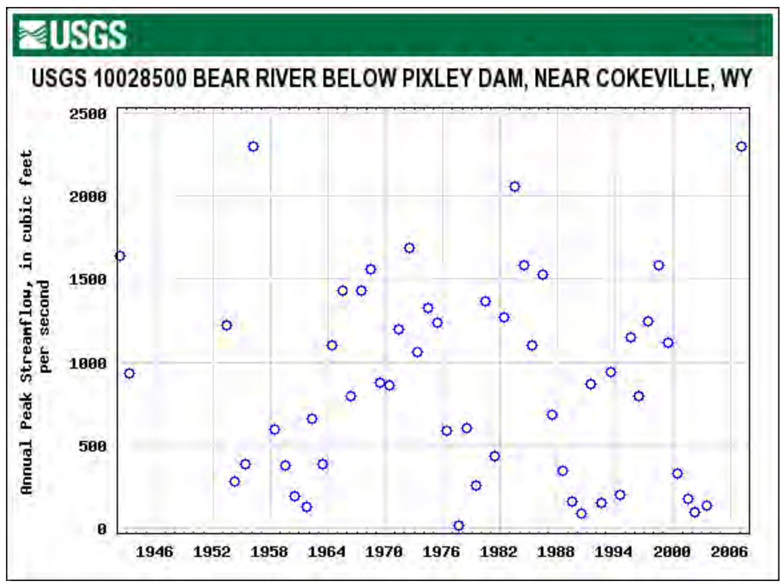


Figure 11. Peak annual discharge of Bear River at Pixley Dam near Cokeville, WY.

oxbows and depressions at about 300 cfs, and much of the floodplain is inundated at discharges of > 1,000 cfs. Consequently, historic flow data suggest overbank and backwater flooding from the Bear River into the Cokeville Meadows floodplain ecosystem typically occurred for short time periods in late May through mid-June in most years. While being of short duration, this seasonal flooding recharged floodplain wetlands to their highest levels in spring and thereafter wetlands gradually dried from evapotranspiration to low maintenance levels in winter.

In addition to the strong seasonal pattern of river discharge, stage data from the Bear River below Pixley Dam, near Cokeville, WY indicate a long term pattern of peak discharges about every 12-15 years when the river exceeds 1,500 cfs (Fig. 11). In contrast, intervening dry years did not have river discharges > 500 cfs. During the ca. 60 year period of record below Pixley Dam, the Bear River exceeded 1,500 cfs in 9 years and was below 500 cfs in 15 years. This long term pattern of river discharge suggests a highly dynamic flooding environment for floodplain wetlands in the Cokeville Meadows NWR region, with occasional years when extensive overbank flooding punctuating more regularly occurring moderate flows and frequent dry years (Wyoming Water Development Commission 2001). The Central Division of the Bear River in Wyoming, where Cokeville Meadows NWR sets, has about 500,000 acre-feet of water flow in wet years, about 190,000 acre-feet in average years and essentially no flow in extreme dry years (Fig. 12). In average and wet years available water flow occurs during the non-irrigation season (August-March) on both the Smith's Fork and Bear River mainstem channels. The long-term alternating wet-dry pattern of water flow in the Bear River and related variable annual recharge of floodplain wetlands, probably caused long-term regularly fluctuating patterns of wetness-dryness in these wetlands at about 10-15 year intervals (Fig. 11).

Ground water in the Cokeville Meadows area is present in the Bear River Valley alluvium, alluvial fan deposits, and older geologic formations that underlie the area. The alluvial aquifer underlying the Cokeville Meadows NWR is bounded laterally and vertically by relatively impermeable shale (Glover 1990). This shale layer effectively prevents groundwater movement between the alluvial aquifer and other deeper formations. The potentiometric surface of the alluvial aquifer (Fig. 13) indicates that water enters the aquifer as underflow from the Bear River at the upstream part of Cokeville Meadows and then this water discharges downstream into the Bear River (Berry 1955). A second source of water recharge into the alluvium is leakage from tributary streams. Generally, groundwater levels in

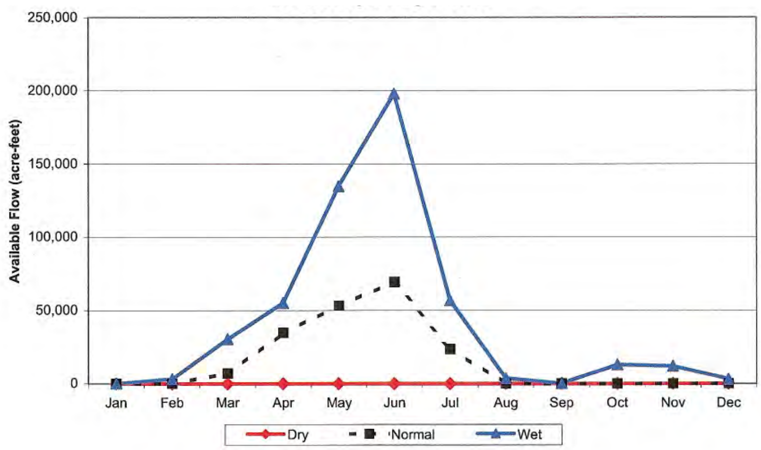


Figure 12. Available discharge in the Bear River in wet vs. dry years.

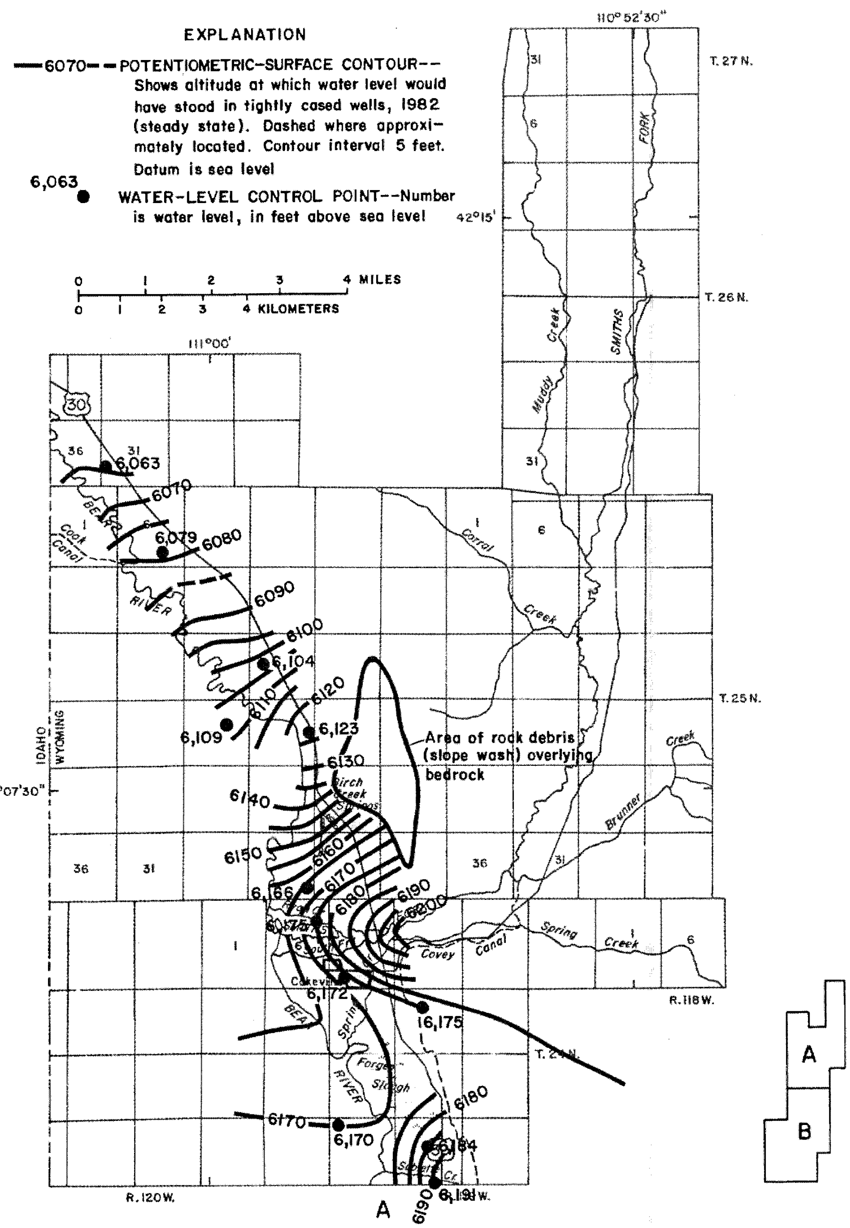


Figure 13. Potentiometric surface of groundwater.

the alluvium mirror seasonal precipitation and Bear River discharge patterns (Fig. 14). Alluvial fan deposits also yield large quantities of water where they overlie the alluvium, but the amount of groundwater gradually decreases away from the Bear River as the saturated thickness decreases (Berry 1955). The recharge for alluvial fans is derived mainly from infiltration of surface runoff. Older geologic formations that underlie the area include the Madison limestone, Amsden Formation, Tensleep sandstone, Bear River Formation and the Wasatch Formation that yield moderate quantities of groundwater to wells. Water from these formations generally is under artesian head and often moves to the land surface as low elevations dip from outcrop areas of these formations. Up to 100 gallons of water/minute occurs in artesian wells derived from the Madison limestone and Tensleep sandstone outcrops.

Evapotranspiration, primarily from willows (*Salix* sp.), persistent emergent wetland plants, and wet meadow grasses and sedges/rushes that obtain water directly from the water table, is a significant type of groundwater discharge during summer (Glover 1990). The amount of water that discharges as evapotranspiration depends on the consumptive-use requirements of various plant species and the depth to water. Evapotranspiration is higher when the water table is close to the land surface (such as in wetter years), but decreases as depth to groundwater increases. Essentially no evapotranspiration discharge of groundwater occurs to depths of greater than 10 feet.

Groundwater from the northern part of the Bear River Valley, including the Cokeville Meadows NWR area, is a calcium bicarbonate type, but constituents vary by geological source (Robinove and Berry 1963). Total mineral content of alluvial groundwater is 285-510 ppm dissolved solids (Table 1). Groundwater seepage from the Smith's Fork River influences local groundwater quality and apparently reduces local sodium and chloride levels. Generally, wells tapping alluvium up-gradient and away from return flow into the Bear River have water that is lower in dissolved solids and with lower sodium and chloride content than sites close to the river channel. Terrace deposits and alluvial fans contain magnesium-calcium bicarbonate type ground water with moderate amounts of sulfate. Deeper artesian groundwater contains predominantly sodium-calcium sulfate and bicarbonate types.

Surface water quality in the Bear River and floodplain wetlands reflects source of water and drainage in the area underlain by Precambrian metamorphic rocks on the north slopes of the Uinta Mountains of northeastern Utah and flows through the area underlain by Tertiary formations and through Tertiary and Cretaceous rocks in Wyoming. Seasonal fluctuations in discharge of the Bear River are accompanied by relatively minor changes in total mineral content of water; the effects of high flows in spring are mainly dilution of major constituents. Bear River water generally has a progressive increase in mineral content to the B-Q Dam and then a decrease in mineral content to Cokeville, WY (Table 1). Part of this latter decrease in mineral content apparently is due to the dilution effect of lower mineral water entering the Bear River from the Smith's Fork River (Robinove and Berry 1963).

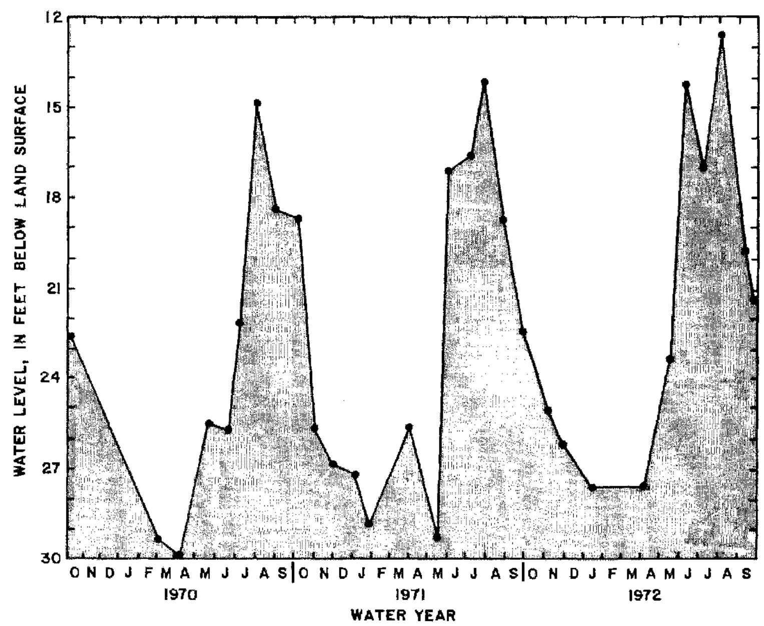


Figure 14. Water levels in wells near or on Cokeville NWR.

LAND COVER AND VEGETATION COMMUNITIES

Cokeville Meadows is a riverine floodplain vegetation complex within the cold northern shrub steppe landscape of the Great Basin Floristic Province (Cronquist et al. 1972, West 1988, Welsh et al. 1993). Historic vegetation communities at Cokeville Meadows NWR included: 1) narrow riparian/riverfront-type forest corridors, 2) semi permanently flooded floodplain wetland depressions, 3) "wet meadow" sedge and grass communities, and 4) upland sagebrush/grassland communities (Nuttall 1834, Hironaka et al. 1983, Youngblood et al. 1985). Numerous accounts of vegetation within the Bear River Valley and adjacent uplands were made by early explorers and travelers (e.g., Nuttall 1834, Townsend 1839, Fremont 1845, Johnson and Winter 1846, Young 1899, Hafen and Hafen 1955).

Riparian communities historically were present along the Bear River, and some areas along major tributaries, and contained relatively narrow bands of early succession "riverfront" forest species, mainly black cottonwood (*Populus trichocarpa*) and willow (Youngblood et al. 1985). These wooded habitats were present on newly deposited and scoured sand-silt and gravelly soils on natural levee deposits near the active channel of the Bear and Smith's Fork rivers (Table 2). Consequently, soils in these areas are well drained but saturated for much of the year and usually have some surface flooding in most years (Auble et al. 2005). Riparian communities generally comprise < 1% of the total land area in the Wyoming Basin, but are among the productive communities in biomass of plants and animals and are essential habitats for meeting specific life history requirements of many species, especially Neotropical migrant songbirds (Nicholoff 2003). The extent and continuity of these riparian forest areas along the Bear River in the Cokeville Meadows NWR region in Presettlement times is unknown, but they probably were present in most river stretches (Fig. 15).

Low elevation abandoned channels of the Bear River (oxbows), floodplain depressions, and tributary off-channel areas contained wetland-obligate vegetation communities that graded from persistent robust

Table 1. Water quality data from Bear River.

[All values are expressed in or computed from equivalents per million]

Well	Geologic source	Percent of total cations			Percent of total anions			Total ions (epm)
		Ca	Mg	Na	HCO_3	SO_4	Cl-F-NO_3	
GROUND WATER								
Southern part								
13-120-25bb	Tertiary deposits	65	30	5	88	8	4	13.15
15-120- 8dd	Alluvium	42	29	29	71	16	13	17.75
21bdd	do	54	22	24	83	7	10	15.08
16-121-11ac	Terrace deposits and Tertiary deposits.	30	42	28	51	13	36	16.49
13bd	Alluvium	25	39	36	65	16	19	18.23
24ad	do	24	41	35	25	48	27	60.74
24bc	do	50	30	20	75	10	15	11.68
17-120- 6ac2		10	8	82	11	15	74	53.44
8db	Alluvium	22	38	40	62	9	29	21.51
19db	Tertiary deposits	23	64	13	68	18	14	22.35
32db	Alluvium and Tertiary deposits.	35	32	33	55	10	35	20.49
Northern part								
22-119- 5cc	Alluvium	46	29	25	52	22	26	18.34
23-119- 6ad	Alluvium and alluvial-fan deposits.	62	22	16	70	11	19	10.78
32bd	Alluvium	55	38	7	71	23	6	11.37
23-120-26ab	Nugget sandstone	29	24	47	42	48	10	27.83
24-119- 9bd	Terrace deposits	41	43	16	69	16	15	15.59
33ac	Slope wash	31	37	32	64	28	8	19.35
25-119-33dac	Alluvium	75	19	6	74	20	6	10.93

SURFACE WATER

Southern part

Location	Date	Ca	Mg	Na	HCO_3	SO_4	Cl-F-NO_3	Total ions (epm)
Mill Creek, east branch	4-18-56			5	86	10	4	7.50
Mill Creek, west branch	4-18-56			4	90	7	3	8.81
Bear River above Sulphur Creek south of Evanston	4-18-56	64	29	7	89	7	4	6.71
Do	6-21-56	65	32	3	89	9	2	3.61
Do	9- 4-56			4	89	9	2	6.60
Yellow Creek, near mouth, west of Evanston	4-18-56			14	74	12	14	15.61
Bear River, 10 miles north of Evanston	4-17-56			12	77	14	9	10.32
Do	6-22-56	56	35	9	84	8	8	7.03
Do	9- 4-56			31	56	28	16	17.33
Northern part								
Bear River, at Beckwith Dam	4-13-56			22	66	18	16	15.54
Do	6-22-56	50	24	26	73	11	16	17.32
Do	9- 4-56			26	56	25	19	20.21
Sublette Creek, near mouth	4-13-56			12	66	25	9	14.75
Bear River, at Cokeville, above Smiths Fork	4-13-56	44	34	22	64	20	12	15.16
Do	6-22-56	35	38	27	67	16	17	15.89
Do	9- 3-56			19	59	27	14	16.10
Smiths Fork, at Cokeville	4-13-56			8	74	20	6	9.51

Table 2. Hydrogeomorphic (HGM) matrix of potential historic distribution of major vegetation/habitat types on Cokeville Meadows National Wildlife Refuge. Relationships were determined from historic land cover maps, aerial photographs, geomorphology maps (Reheis 2005), soil maps prepared by the USDA Natural Resource Conservation Service, hydrological data (various USGS, NOAA, and USFWS data from the Bear River and Cokeville Meadows floodplain areas), and various naturalist/botanical/explorer accounts and publications from the early and mid 1800s.

Habitat type	Geomorphic surface	Soil type	Flood frequency[a]
Riparian/Woodland	Natural levee	Gravelly, Sand-silt	A-SFE
Persistent Emergent	Abandoned channel, Tributary off-channel Depressions	Clay, silt-clay	A-PSMF
Meadow	Alluvial floodplain	Silt-loam	A-SF
Sagebrush-Grassland	Alluvial fans, terrace	well-drained Sandy loam, Erosional gravel	R

[a] A-SFE = annually flooded for seasonal periods, with extended soil saturation; A-PSMF = annually flooded with permanent or semipermanent water regimes; A-SF = annually flooded with short seasonal flooding in most years; R = rarely if ever flooded, but with seasonal surface sheetflow or groundwater infiltration.

emergent plants such as cattail (*Typha latifolia)* and hardstem bulrush (*Schoenoplectus acutus*) in deeper elevations with more prolonged annual flooding to diverse annual and perennial sedges, rushes, and grasses in seasonally flooded depressions and margins of abandoned and minor channels that had semi-permanent and seasonal flooding regimes (Cronquist et al. 1972, see also Cowardin et al. 1979 and Hansen et al. 1995) Soils in these depressions typically have clay and silt-clay veneers over varied alluvial deposits (Table 2). Water levels and extent of flooding in these floodplain depressions were both seasonally and annually dynamic because of the ecological "driving" effect of annually variable precipitation, runoff, and flooding from the Bear River. Deeper water areas that had more permanent water regimes contained stands of submerged aquatic plants such as coontail (*Ceratophyllum demersum*), naiads (*Najas* sp.), pondweed (*Potamogeton* sp.), and marsh buttercup (*Ranunculus* aquatilis) and dense accumulations of algae. Semipermanently flooded wetland edges contained bands of persistent emergent vegetation such as cattail and hardstem bulrush. Seasonally flooded margins of these wetlands had mostly non-persistent emergent plants such as arrowhead (*Sagittaria latiifolia*), sedges, and rushes. In wet years with higher Bear River discharge, more area of floodplains likely was flooded at a deeper depth and stands of persistent emergent vegetation probably expanded from the margins to the interior of floodplain depressions (see e.g., van der Valk and Davis 1978, Van der Valk 1989). In contrast, during drier years, less water was present for shorter durations and more sedge-rush and less robust emergent vegetation probably was present. The National Wetland Inventory conducted in the late 1970s and early 1980s classified wetlands in the Cokeville Meadows area as 3% permanently flooded, 7% semi-permanently flooded, 21% temporarily flooded, 60% seasonally flooded, and ca. 10% intermittently flooded or saturated soils (Fig. 16, Table 3). These proportions may have been slightly different prior to developments in the area, and more area may have been seasonally or temporarily flooded during historic periods.

The majority of the relatively flat higher elevations (i.e., non-depressional) within the Cokeville Meadows NWR floodplain region were covered with "wet meadow" vegetation that ranged from meadow foxtail (*Alopecurus partensis*), arrowhead, sedges, and rushes in lower elevation seasonally flooded areas to wheat grass (*Apropyron* sp.), saltgrass (*Distichlis stricta*) , basin wild rye (*Elymus cinereus*), and greasewood (*Sarcobatus vermiculatus*) in higher elevations on the edges of floodplains with intermittently flooded water regimes (Cronquist et al. 1972, Dorn 1986). Nuttall alkali grass (*Puccinellia airoides*), saltgrass, alkali sacaton (*Sporobolus airoides*), and alkali cordgrass (*Spartina* gracilis) and a few forbs generally were associated with greasewood communities because of the higher salinity levels of

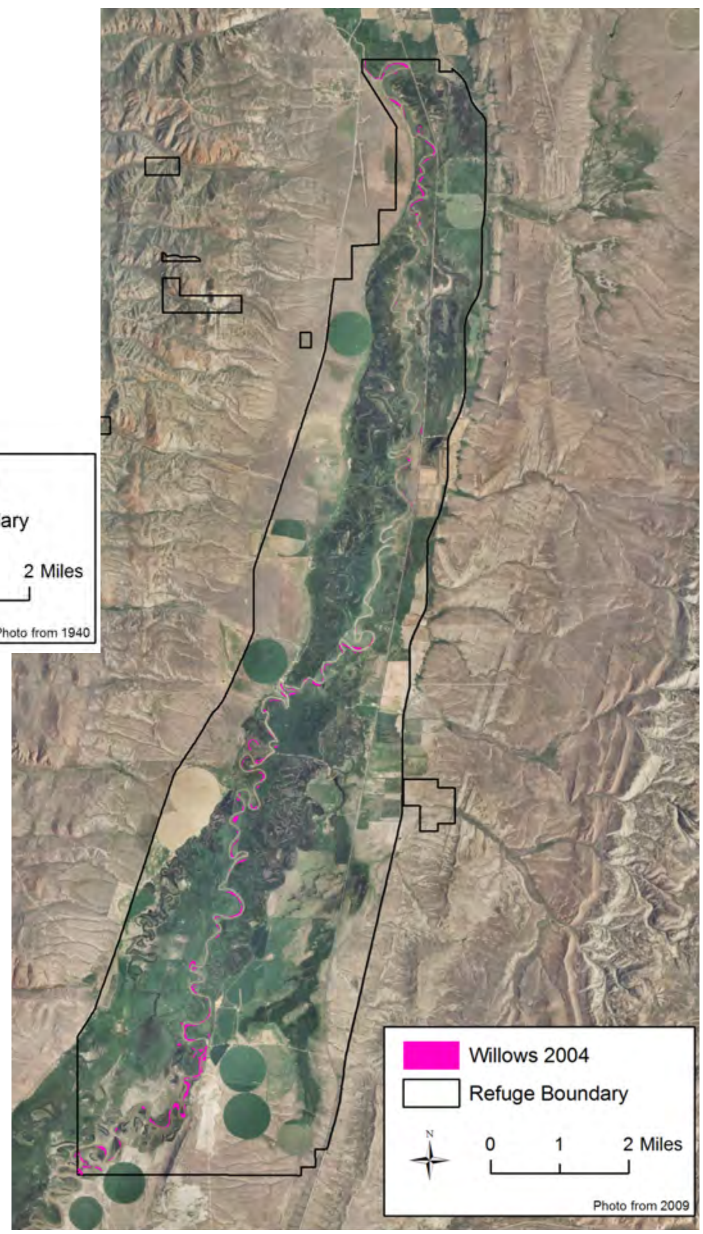


Figure 15. Comparison of willow/riparian forest in 1940 vs. 2004.

these sites. Soils in meadow communities were predominantly silt-loam types (Table 2). This extensive meadow community at Cokeville Meadows NWR was sustained because of the high floodplain water table, a tendency for alkaline soils, and short duration pulses of river flooding that followed snow melt and rises in the Bear River in spring and early summer. Meadow vegetation way seasonally grazed by bison, elk, and mule deer and small rodents also consumed and processed meadow plants. Fire occasionally ranged through meadows. Collectively, herbivory and fire recycled nutrients in meadows and provided germination and regeneration sites for grass, sedge, and rush species.

Table 3. Summary of wetland types related to water permanence on the Cokeville Meadows National Wildlife Refuge acquisition boundary area in 1984 as determined by the U.S. Fish and Wildlife Service National Wetlands Inventory.

Wetland water regime	Acres	Percentage Total
Permanently flooded	738	3.0
Semipermanently flooded	1,704	7.0
Seasonally flooded	13,773	60.0
Temporarily flooded	4,748	21.0
Intermittently flooded	187	< 1.0
Saturated	1,918	8.0

Upland-type vegetation communities, dominated by shrub steppe communities, were present on the higher elevation alluvial fans and older terraces that adjoined the Bear River floodplain (Hironaka et al. 1983). Wyoming and big sagebrush (*Artemisia tridentate*) were the dominant species in these communities; other common species included thickspike wheatgrass (*Agropyron dasystachyum*), western wheatgrass (*Agropyron smithii*), needle and thread (*Stipa comate*), rabbit-brush (*Chrysothamnus nauseosus*), galletta grass (*Hilaria rigida*), bottlebrush squirreltail (*Sitanion* hystrix*),* and bluegrasses (*Poa* sp.). Soils under these communities were loams or sandy loams and depth of soil and moisture penetration probably set the limits of plant distribution.

A HGM matrix of relationships of the above major plant communities to geomorphic surface, soils, hydrology and elevation (Table 2) was developed to map potential distribution of historic communities on Cokeville Meadows and the surrounding landscape (Fig. 17). Generally, historic communities were distributed as relatively parallel bands or zones as water-elevation gradients move from the Bear River upslope to valley terraces and alluvial fans. Persistent emergent wetland communities were imbedded within Holocene floodplains in abandoned channels and other depressions created by meandering of the ancestral Bear River.

KEY ANIMAL COMMUNITIES

The combined riverine, riparian forest, floodplain wetland, wet meadow, and upland habitats at Cokeville Meadows NWR historically provided important resources that supported annual cycle events for a wide diversity of animal species, and

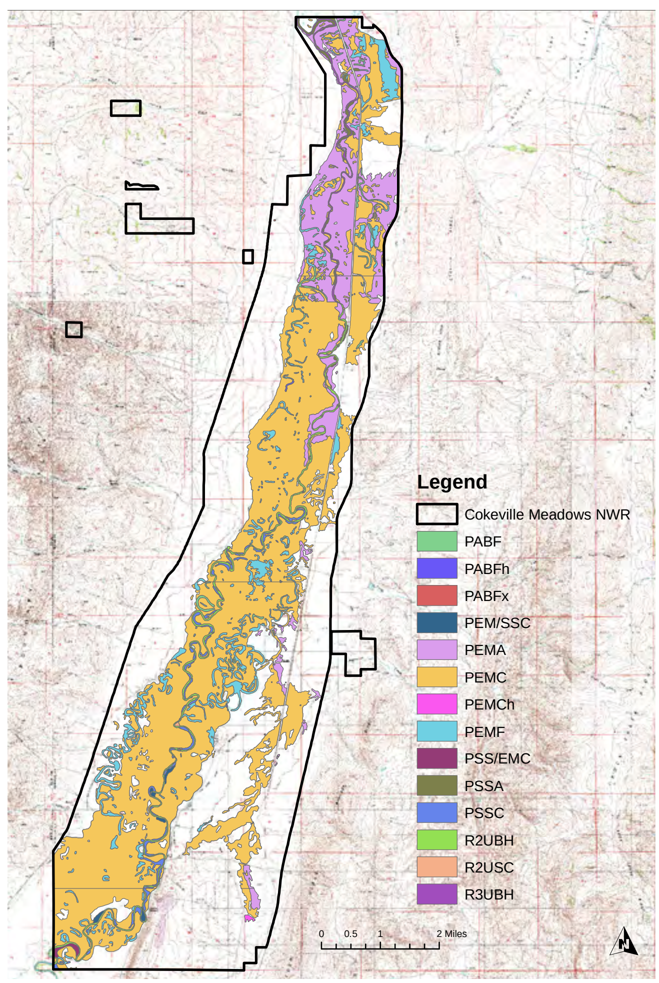


Figure 16. National Wetland Inventory data for Cokeville NWR, WY.

contributed to the sustainability of populations, throughout the Intermountain West region (USFWS 1992). Because of the short growing season and cold winters, most animal species that used the area were seasonal visitors from spring through fall (Laubhan and Fredrickson 1997). Migratory birds, both terrestrial and wetland species, were especially abundant in this floodplain system (Bellrose 1980, Jones et al. 2003, Nicholoff 2003). About 100 species of birds, including 65 species of waterbirds have been recorded at Cokeville Meadows NWR (USFWS 1992). The first nesting record of a least bittern (*Lxobrychus* exilis) in Wyoming occurred in the wetlands south of Cokeville in the late 1980s (Grove and Henry 1990). Key species groups include grebes, bitterns, herons, ibis, egrets, waterfowl, raptors, sandpipers, curlews, terns, flycatchers, swallows, chickadees, warblers, wrens, sparrows, and blackbirds. Over 30 species of waterbirds regularly breed in the region and many other species also nest in forest, wetland, and grassland areas; the most common species are dabbling and diving ducks, sandhill cranes (*Grus canadensis*), Canada geese (*Branta canadensis*), long-billed curlew (*Numenius americanus*), snowy egret (*Egretta caerulea*), black tern (*Sterna nigra*), great blue heron (*Ardea herodias*), American bittern (*Botaurus lentiginosus*), black-crowned night heron (*Nycticorax nycticorax*), white-faced ibis (*Plegadis chihi*), warblers, flycatchers, swallows, blackbirds, sparrows, and raptors. Bald eagles (*Haliaeetus leucocephalus*) commonly use the area in spring and fall, whooping cranes (*Grus Americana*) are occasional visitors during summer, and peregrine falcons (*Falco peregrines*) commonly stop in the area during migration.

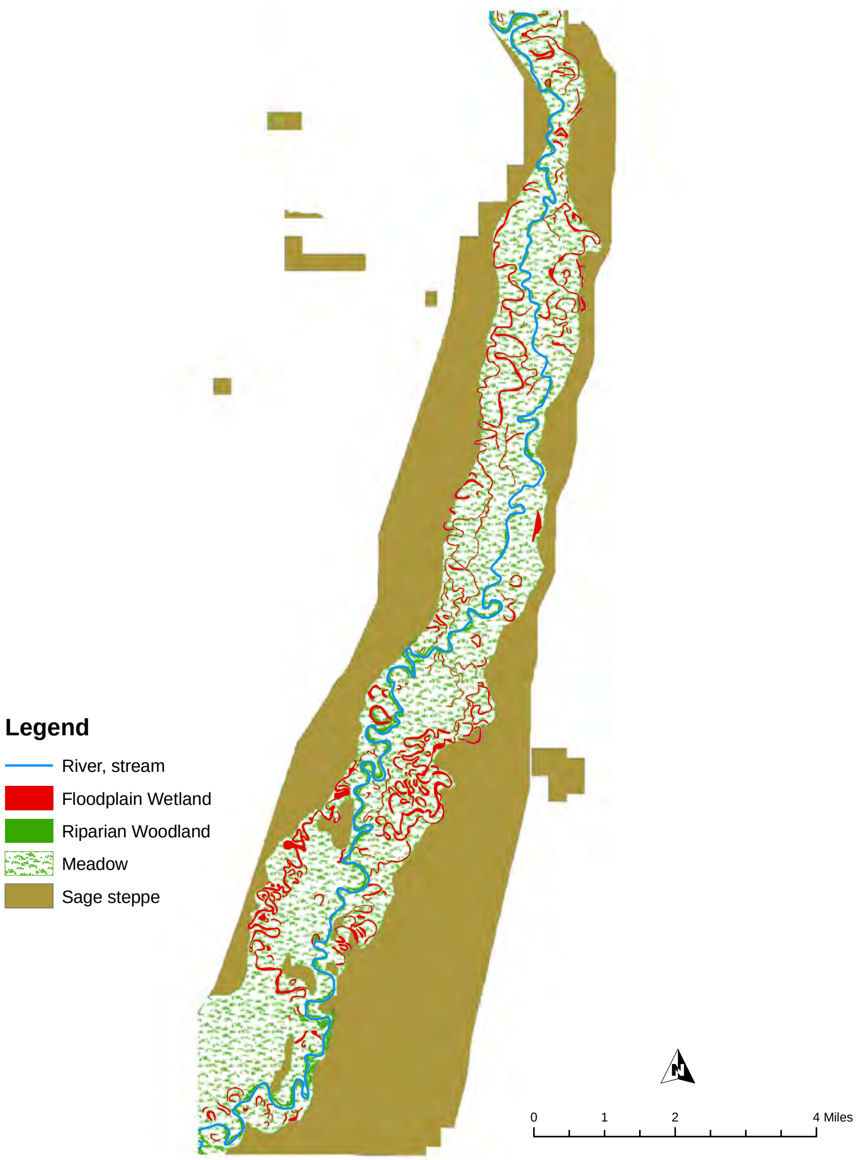


Figure 17. HGM map of potential historic community types.

Many mammal species historically were present in the Cokeville Meadows NWR region. The most common mammal species included marmots, chipmunks, northern pocket gopher (*Thomomys talpoides*), woodrat (*Neotoma cinera*), voles (*Microtus* sp.), silver-haired bat (*Lasionycteris noctivagans*), red squirrel (*Tamiasciurus hudsonicus*), striped skunk (*Mephitis mephitis*), mule deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocarpa americana*) moose (*Alces alces*), and elk (*Cervus elaphus*) in upland and riparian areas and muskrat (*Ondatra zibethicus*), otter (*Lutra canadensis*), mink (*Mustela vison*), and raccoon (*Procyon lotor*) in wetland and riverine areas. The black-footed ferret (*Mustela nigripes*) historically ranged throughout the area (USFWS 1992).

Nearly 20 species of reptiles and amphibians apparently historically were present in the Cokeville Meadows NWR region (USFWS 1992). Northern leopard frogs (*Rana pipiens*), a species of concern, are abundant in Cokeville Meadows wet meadows and wetlands. A small number of native fish were present in the Bear River and some species apparently moved into floodplain drainages, oxbows, and wetlands during high flow periods. These fish included the Bonneville cutthroat trout (*Oncorhynchus clarki Utah*), mountain whitefish (*Prosopium williansoni*), longnose sucker (*Catostomus catostomus*), longnose dace (*Rhinichthys cataractae*), speckled dace (*Rhinichthys osculus*), redside shiner (*Richardsonius baltcatus*), and mottled sculpin (*Cottus bairdii*).

Resources used by animal species within the Bear River floodplain were seasonally dynamic moderated by long-term climatic variation and river flow/flooding patterns. Most bird species exploited seasonal resources during migration and summer, and only a few species overwintered in the region (Laubhan and Fredrickson 1997). Cold winter temperatures froze most wetlands in the floodplain, but the river remained open throughout winter in most years and provided refuge, loafing, and some foraging resources for some species. Amphibians and reptiles timed annual emergence and life cycle events to coincide with spring thaw and flooding and availability of key arthropod and other prey species. Larger mammals often moved into the floodplain to escape cold and to find food and cover during winter and also used the area extensively in other seasons when nutritious grassland forage and carnivorous prey were present.

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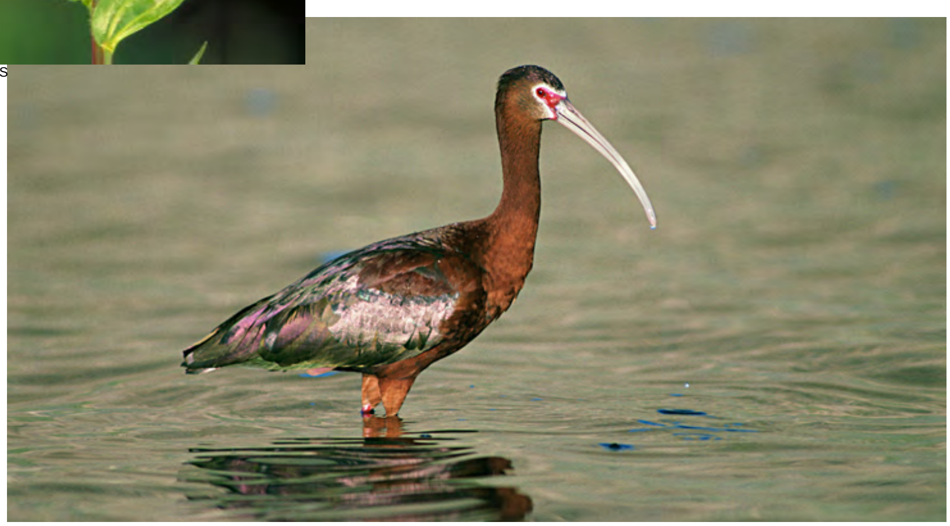
Ryan Hagerty/USFWS



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