CHAPTER 3—Refuge Complex Resources and Description

USFWS

The Bowdoin Refuge has one of only four nesting colonies of American white pelicans in Montana.

This chapter describes the characteristics and resources of the Bowdoin National Wildlife Refuge Complex, Montana, under these topic headings:

- 3.1 Physical Environment
- 3.2 Biological Resources
- 3.3 Salinity Background
- 3.4 State and Federal Listed Species
- 3.5 Cultural Resources
- 3.6 Special Management Areas
- 3.7 Visitor Services
- 3.8 Management Uses
- 3.9 Socioeconomic Environment
- 3.10 Partnerships
- 3.11 Operations

3.1 Physical Environment

The following sections describe the physical characteristics of the Bowdoin National Wildlife Refuge Complex. Physical characteristics include climate, climate change, physiography and geography, soils, water resources, and air quality.

Climate

The climate of the Bowdoin National Wildlife Refuge Complex is "semiarid continental," which is characterized by cold, dry winters and warm, dry summers. Average annual precipitation between 1905 and 2009 was 12.5 inches, most of which fell as rain from May to September, with June being the wettest month. The 10-year average, high temperature for January is 26 degrees Fahrenheit (°F) with a low of 2 °F. In July, the average high is 87 °F and the low is 56 °F. Temperature extremes range from 113 °F in the summer to –60 °F in the winter. The average growing season is 122 days.

Prevailing winds vary from southwest to northwest with periods of strong winds common throughout the year. Average annual pan evaporation (estimate of lake evaporation) is about 35–40 inches (Dunne and Leopold 1978). On refuge complex lakes, the average evaporation ranges from 26–30 inches (URS 2009). During the winter, warm Chinook winds can bring rapid temperature increases of 30–40 °F within a few hours.

Precipitation measurements from 1905 to 2008 show a slight downward trend in annual precipitation totals (figure 19). There is also a downward trend in the long-term precipitation totals for February, which is historically the driest month for the refuge complex, and for June, which is historically the wettest month (figures 20 and 21).

Average daily maximum temperatures and average daily minimum temperatures taken from 1969 to 2008 for February show a slight upward trend (figures 22 and 23.). The average daily maximum temperature for June from 1969 to 2008 showed a slight decrease while the average daily minimum temperature for June has slightly increased (figures 24 and 25).

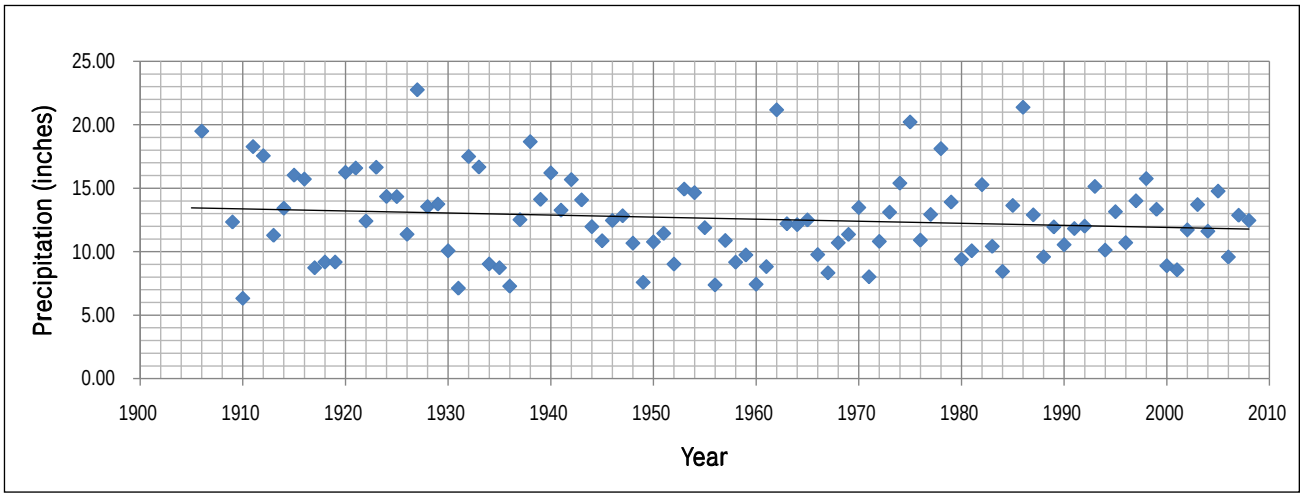

Figure 19. Graph of total annual precipitation at Bowdoin National Wildlife Refuge, Montana (1905–2008).

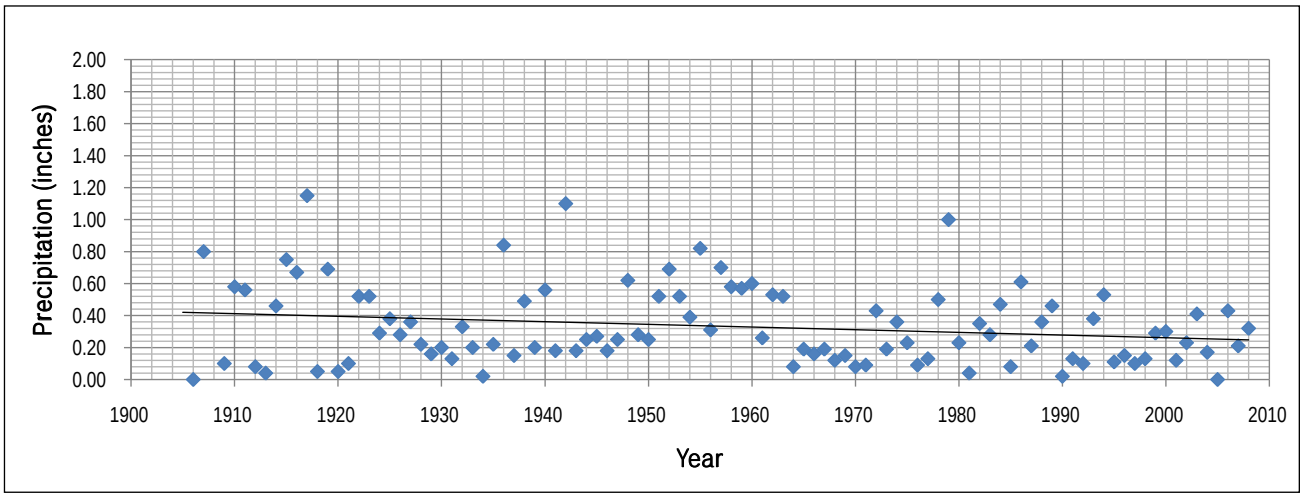

Figure 20. Graph of total February precipitation at Bowdoin National Wildlife Refuge, Montana (1905–2008).

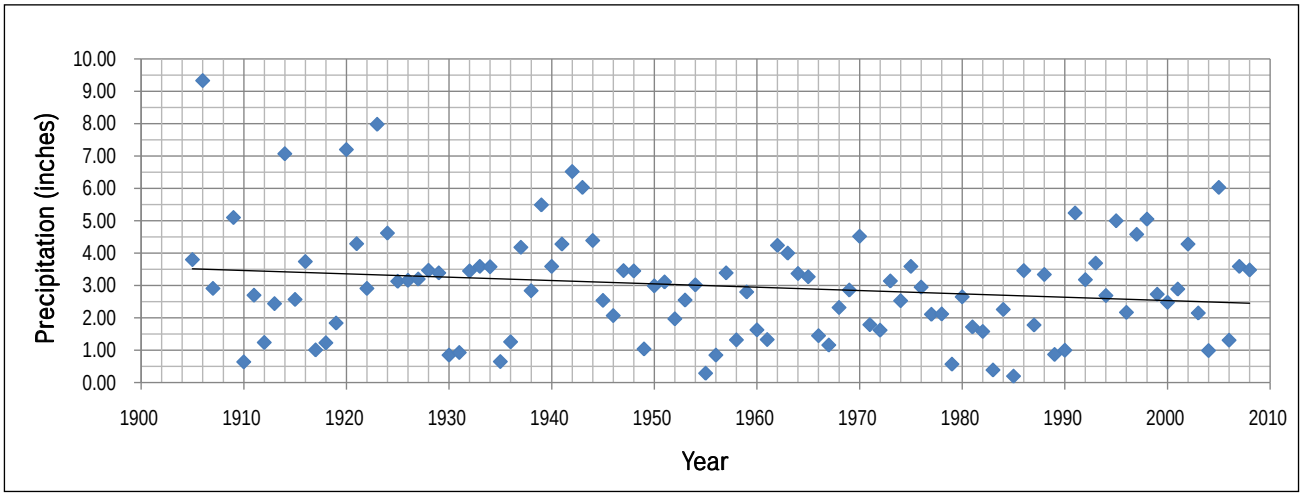

Figure 21. Graph of total June precipitation at Bowdoin National Wildlife Refuge, Montana (1905–2008).

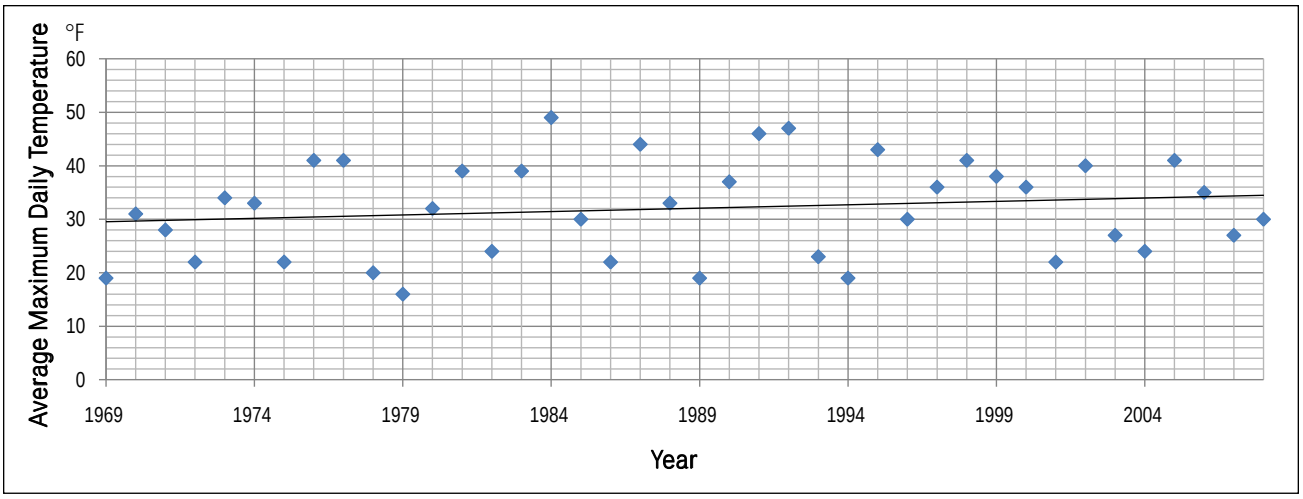

Figure 22. Graph of average maximum daily temperature for February at Bowdoin National Wildlife Refuge, Montana (1969–2008).

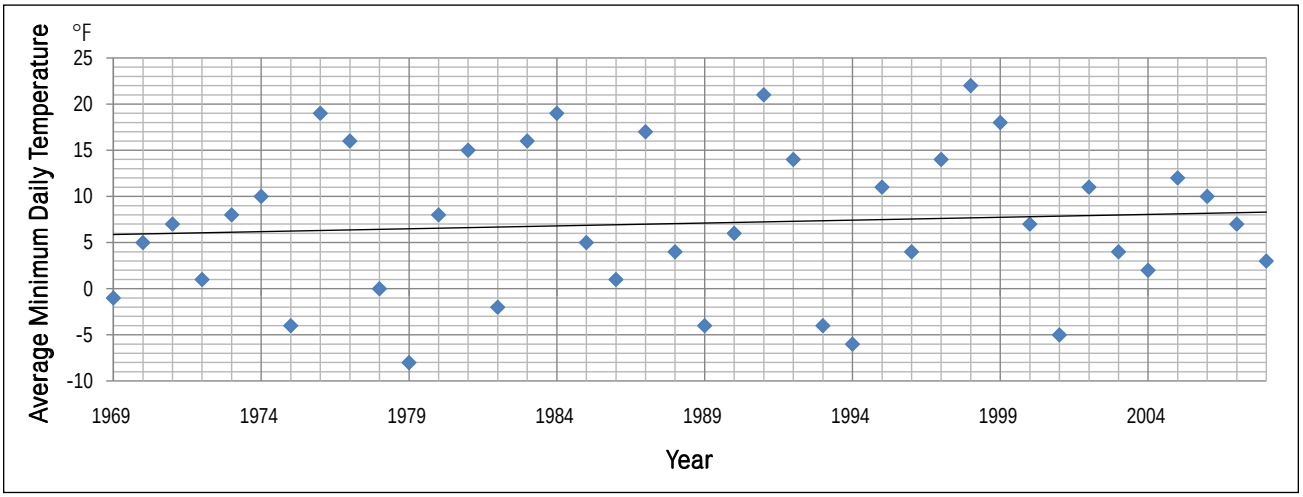

Figure 23. Graph of average minimum daily temperature for February at Bowdoin National Wildlife Refuge, Montana (1969–2008).

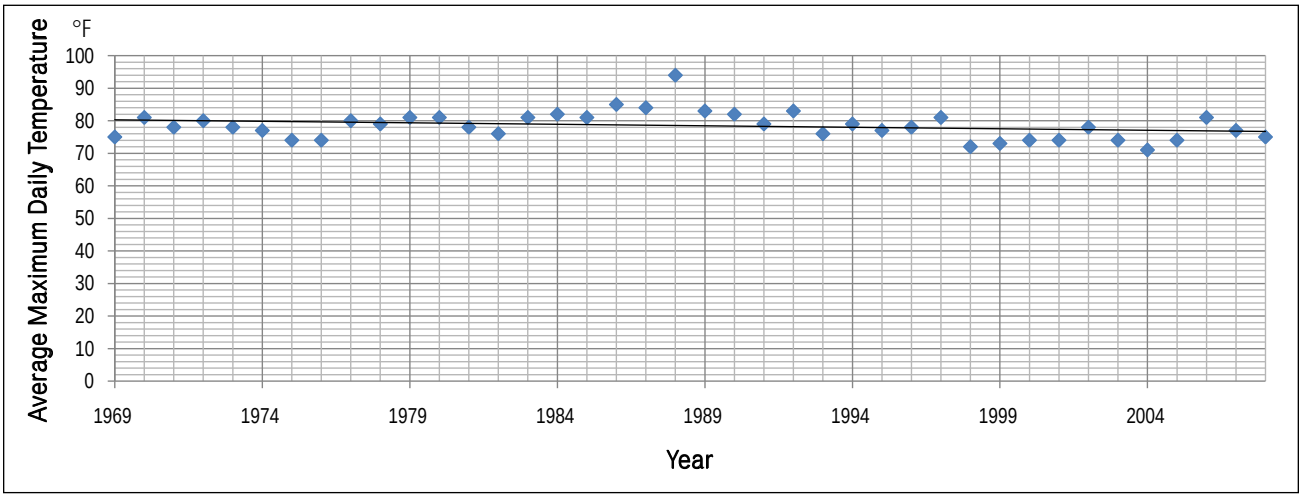

Figure 24. Graph of average maximum daily temperature for June at Bowdoin National Wildlife Refuge, Montana (1969–2008).

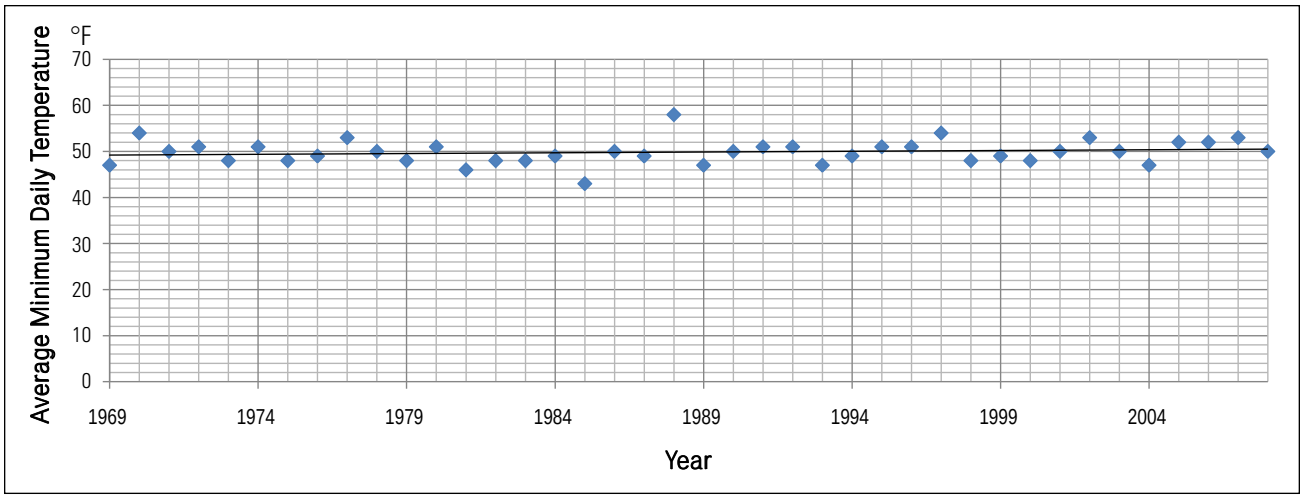

Figure 25. Graph of average minimum daily temperature for June at Bowdoin National Wildlife Refuge, Montana (1969–2008).

Climate Change

The U.S. Department of the Interior issued an order in January 2001 requiring Federal agencies under its direction that have land management responsibilities to consider potential climate change effects as part of long-range planning endeavors. The U.S. Department of Energy's report, Carbon Sequestration Research and Development (1999), concluded that ecosystem protection is important to carbon sequestration and may reduce or prevent loss of carbon currently stored in the terrestrial biosphere. The report defines carbon sequestration as "the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere" (1999).

The increase of carbon dioxide (CO_2) within the earth's atmosphere has been linked to the gradual rise in surface temperature commonly referred to as global warming. In relation to comprehensive conservation planning for Refuge System units, carbon sequestration constitutes the primary, climate-related effect to be considered in planning.

Vegetated land is a tremendous factor in carbon sequestration. Large, naturally occurring communities of plants and animals that occupy major habitats—grassland, forest, wetland, tundra, and desert—are effective both in preventing carbon emission and in acting as biological scrubbers of atmospheric CO_2.

One Service activity in particular—prescribed fire—releases CO_2 directly to the atmosphere from the biomass consumed during combustion. However, there is no net loss of carbon because new vegetation quickly germinates to replace the burned-up biomass. This vegetation sequesters an approximately equal amount of carbon as was lost to the air (Dai et al. 2006).

Climate data for this area does demonstrate a slight reduction in annual precipitation and increases in temperatures over the last 100 years. Although slight, in such an arid climate, this can have a significant effect on water resources, including decreasing the supply of water while demand for water increases. This change in climate could also alter vegetation patterns and species, possibly allowing for additional invasive species to become established. Invasive plants could spread more rapidly and would likely be able to survive the milder climates, thereby outcompeting the native plants.

Stronger and more frequent droughts associated with climate change could cause ducks and other waterfowl to lose breeding and migration habitat. In addition, changes in the timing of migration and nesting could put some birds out of synchronization with the life cycles of their prey. Natural food sources for wildlife, as well as the grain fields on which some migratory birds feed during the fall months, could be reduced or eliminated. Avian botulism outbreaks could be more frequent, and other wildlife diseases may increase.

As surface water supplies might decrease with climate change, the refuge complex could become more dependent on subsurface water sources; this would increase management costs due to the challenges of pursuing ground water that has also been depleted by increased demand. Less ground water recharge, along with a greater demand for human consumption and irrigation, could limit water available for wildlife purposes. There is the potential for managed wetlands dependent on runoff and delivered water to not receive adequate amounts of water for waterbird habitat. Lake Bowdoin might go dry more often and for possibly longer periods of time; as the lake dried, accumulated salts would be blown away during the

hot, dry summers. In addition, there could be the potential for more frequent heavy winds, creating dust storms and wind erosion.

Compatible public use activities may be affected on Service lands due to degraded habitats and less wildlife.

Physiography and Geology

Glaciation has been the predominant factor in the development of the soils and topography of the Prairie Pothole Region. The Bowdoin National Wildlife Refuge Complex area was glaciated about 15,000 years ago, but does not have the abundance of semipermanent and permanent wetlands found in the glaciated prairie to the east. Bedrock underlying the glacial materials consists of the Claggett Formation, Judith River Formation, and Bearpaw Shale, all of the Cretaceous age. These sedimentary rock formations consist mostly of nearly impermeable marine shale, alternating in places with sandstone beds. Topography of the area is typical of the glaciated plains, with flat to gently rolling terrain and elevations ranging from 2,205 feet to 2,300 feet above sea level.

Soils

A comprehensive soil survey of Bowdoin National Wildlife Refuge was completed in 1966; 11 soil types were identified, and 13 mapping units were delineated. The predominant soils on the refuge are clays and clay-loams. The most common clay-loam associations are Phillips–Elloam, Phillips–Kevin, Arvada–Bone, Scobey–Phillips, and Kevin–Sunburst. Soils are of a fine to loamy texture and have a montmorillonite component that commonly contains a substantial amount of selenium. Soluble calcium and sodium salts are dispersed in much of the profile and also tend to accumulate in subsoil horizons. The soils range from mildly to strongly alkaline.

The Bowdoin Wetland Management District falls primarily within the northern glaciated plains ecoregion. This ecoregion has gently undulating to rolling, continental, glacial till plains formed in the last ice age during the Pleistocene epoch about 15,000–30,000 years ago. The glacial till is largely underlain by Cretaceous shales of marine origin and Lower Tertiary nonmarine sedimentary rocks. Numerous wetlands characteristic of the Prairie Pothole Region of the north-central Great Plains are common throughout the district. Common soil series in the district are Elloam, Scobey, Phillips, and Kevin; these soils are largely deep and well-drained, consisting of glacial till parent material (Natural Resources Conservation Service 2008).

Water Resources

Water resources for Bowdoin National Wildlife Refuge consist of annual precipitation and runoff events, wells, established water rights, Milk River Project irrigation water, irrigation return flows, floodwater from Beaver Creek, and ground water seepage from off-refuge lands. Water resources for the other four refuges and the wetland management district consist of annual precipitation and runoff events, wells, established water rights, Milk River Project irrigation water, Beaver Creek and Milk River floodwaters, and ground water seepage from Nelson Reservoir.

Although spring and summer rains contribute to the water supply, most rain during this period is absorbed in the soil or lost through evapotranspiration. Significant runoff can occur if the soil is frozen or during an extremely heavy rainstorm.

Milk River Watershed

The Bowdoin National Wildlife Refuge Complex lies within the Milk River watershed (figure 26). The watershed originates in Glacier County, covers about 23,800 square miles, and crosses the Canadian border twice. The Milk River flows from the United States through Canada for about 215 miles before reentering the United States about 20 miles upstream of Fresno Reservoir. The watershed is used primarily for the production of livestock, alfalfa, native hay, oats, wheat, and barley.

Bowdoin National Wildlife Refuge lies between two natural tributaries: Milk River to the north and its Beaver Creek tributary to the south (figure 27). The Milk River is a 729-mile-long prairie stream with its headwaters in the Rocky Mountain Front, north of the town of Browning. It flows northward into Alberta, Canada, then curves eastward and south into Montana again, finally meandering its way to the Missouri River near the town of Fort Peck. The Milk River was given its name by Captain Meriwether Lewis of the Lewis and Clark Expedition, who described the river in his journal (DeVoto 1953):

> *"The water of this river possesses a peculiar whiteness, being about the colour of a cup of tea with the admixture of a tablespoonfull of milk. From the colour of its water we called it Milk river."*

The river's milky appearance results from fine sediment or glacial till picked up in the lower part of the Milk River watershed.

Beaver Creek is a major right bank tributary of the Milk River. The Beaver Creek rises in the Little Rocky Mountains south of Malta, Montana, between

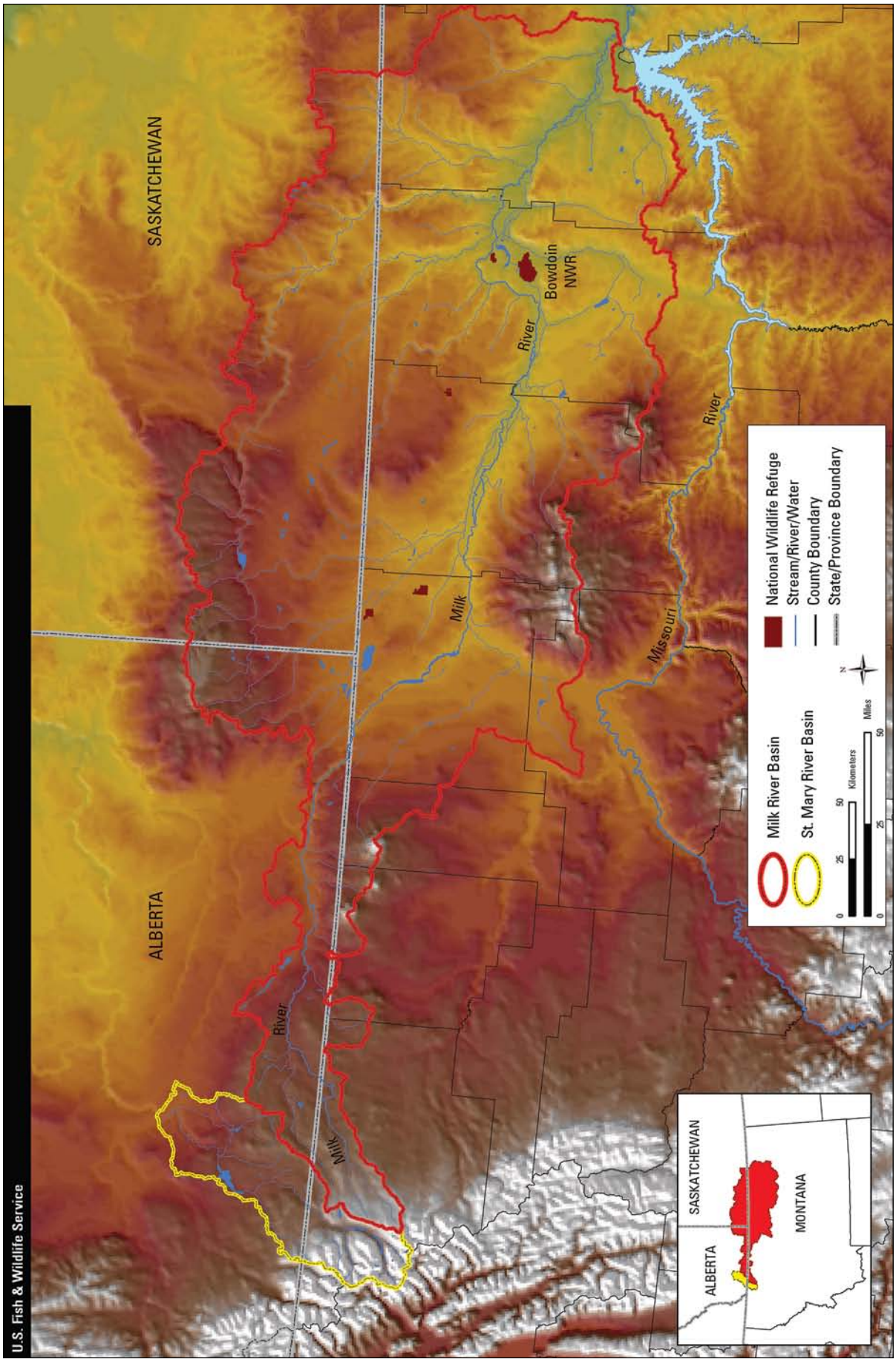

Figure 26. Map of Bowdoin National Wildlife Refuge Complex within the Milk River watershed.

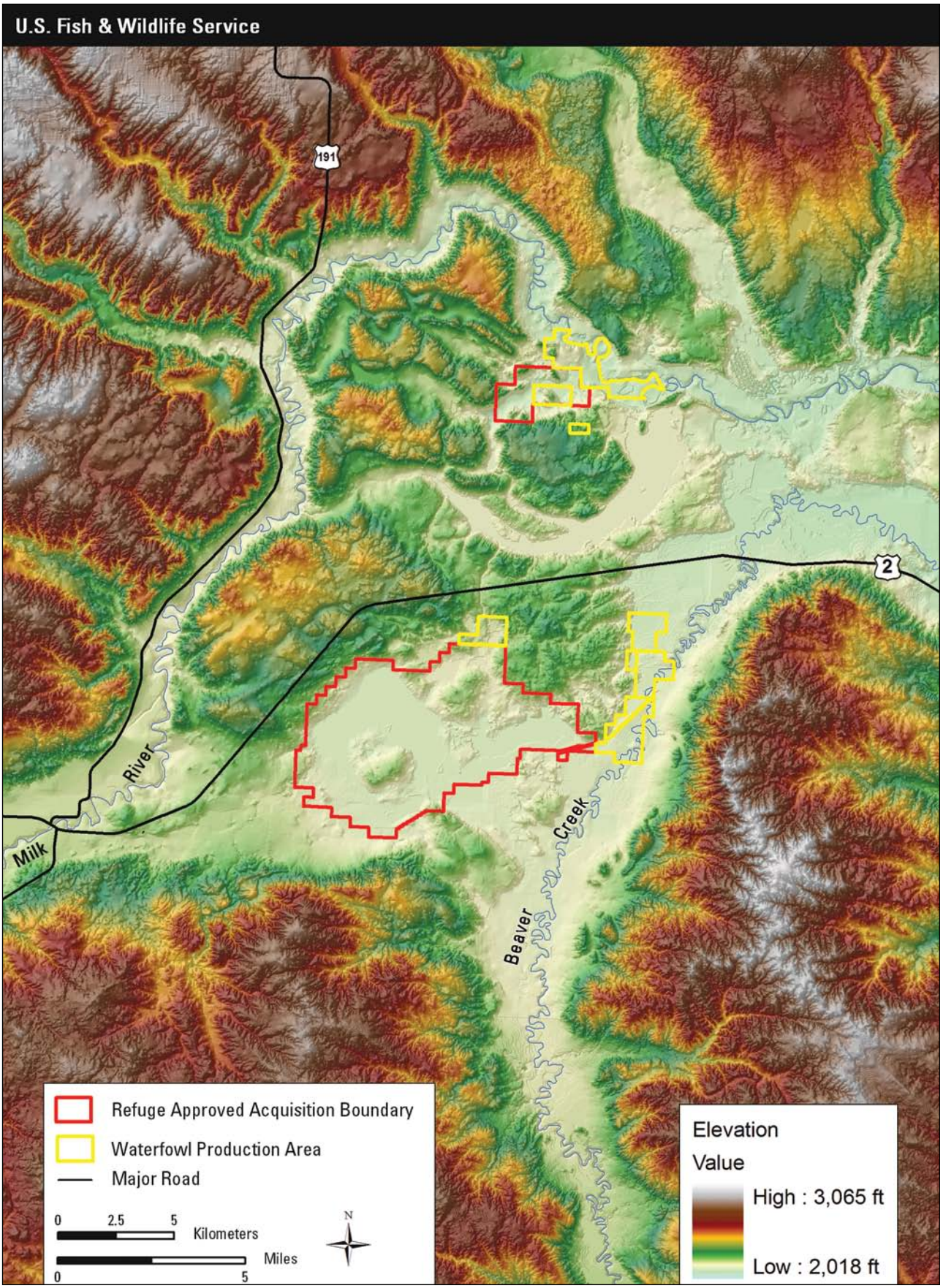

Figure 27. Map of Bowdoin National Wildlife Refuge Complex located between the Milk River and Beaver Creek watersheds.

Zortman and Lodgepole. The watershed is 195 miles long and has a drainage area of 2,060 square miles. The area is used primarily for livestock production, and bottomlands are extensively irrigated for the production of hay (U.S. Army Corps of Engineers 1965).

Geologic history indicates that Lake Bowdoin was once an oxbow of the preglacial Missouri River channel. Today, the Missouri River is nearly 70 miles south of Bowdoin Refuge. Historically, Lake Bowdoin acted as a large catch basin for precipitation, Beaver Creek floods, and runoff events. Lake levels fluctuated a great deal from year to year, depending on runoff conditions and evaporation during the hot, dry summers.

The Milk River Project and St. Mary River Facilities

When Bowdoin National Wildlife Refuge was established, it was an overlay on Bureau of Reclamation lands. Before refuge establishment, Lake Bowdoin was managed as a sump for irrigation return flows from the Milk River Project. The Milk River Project, started in 1907, is one of the earliest Reclamation projects developed by the Federal Government (Cosens 2006). The project was designed to provide a reliable source of water for irrigating more than 100,000 acres of lands along the Milk River. Early settlers coming to the arid Milk River watershed had realized that a supplemental source of water would be necessary if they were to produce agricultural products and survive.

The Milk River rises from the plateau region just east of the St. Mary River watershed (figure 27); however, the river is cut off from the mountain water supply by a low divide separating the Milk River and St. Mary River watersheds. The best alternative to provide additional water for the Milk River watershed users was to divert water from the St. Mary River watershed in Glacier National Park by constructing a 29-mile canal and pipeline that emptied into the Milk River. From there, the water flows through Canada for 216 miles before returning to the United States. After reentering the United States, the water flows into two reservoirs where it is stored until needed by downstream irrigators: Fresno Reservoir (104 miles west of Bowdoin Refuge) and Nelson Reservoir (4.5 miles northeast of the refuge). Fresno Reservoir is owned and operated by Reclamation, and Nelson Reservoir is owned by Reclamation but operated by the Malta Irrigation District. The distribution systems are operated by the Malta, Glasgow, and Dodson irrigation districts, in which the refuge complex is located.

Along with irrigation benefits, the Milk River Project provides many recreational and wildlife benefits. Lake Sherburne, in Glacier National Park, is a popular spot for fishing and windsurfing. Boating and water skiing are popular activities at Fresno Reservoir, and fishing and camping are popular activities offered at Nelson Reservoir. Bowdoin National Wildlife Refuge provides protected habitat for migrating, breeding, and feeding migratory birds and other wildlife. In addition, the refuge provides public use activities such as waterfowl and upland game hunting, wildlife viewing and photography, and environmental education and interpretation facilities and programs.

Facilities on the St. Mary River have been in operation for more than 90 years. Most of the structures have exceeded their designed life and are in need of

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Ducks abound at Pearce Waterfowl Production Area.

major repairs or replacement. The economy of the Hi-Line Region (the northern tier of Montana counties) has been built around the stable water supply provided by these facilities. Without the needed rehabilitation, this aging system may soon suffer significant failure. Failure of these facilities would have a devastating effect to communities, agriculture, wildlife, and recreational opportunities throughout the Milk River watershed as well as for water-dependent migratory birds and other wildlife on the Bowdoin Refuge.

Wells

Only one well supplies domestic water to all the buildings at the Bowdoin Refuge headquarters. Another operating well supplies water to Display Pond, a wildlife observation area close to the headquarters. In addition, two wind-generated wells on the east end of the refuge have not been used since livestock grazing ended in the 1970s.

Water Quality

A significant amount of water provided to the Bowdoin Refuge and the Pearce WPA originates in the Milk River. The Milk River has good water quality upstream of Havre, Montana. Below Havre, it becomes progressively poorer downstream because of agricultural returns and municipal discharges over the summer (Montana Department of Natural Resources and Conservation 1977). Because the Milk River watershed is underlain by glacial till and shale containing high concentrations of soluble salts, the irrigation return flows and ground water seepage in the watershed are major sources of saline water.

The State water quality classification for the Milk River drainage from the International Boundary with Canada to the Missouri River ranges from B to D: (1) B means water supply for drinking, culinary, and food processing purposes; and (2) waters with a D classification are to be maintained suitable for agricultural purposes and secondary contact recreation (Montana Department of Environmental Quality 2006).

Lake Bowdoin, the primary water feature on Bowdoin Refuge, was first used as a sump by Reclamation after the completion of the Dodson South Canal in 1915 (before refuge establishment). The lake was used to capture irrigation return flows from the Milk River Project and seepage from adjacent irrigation activities. The Dodson South Canal was constructed along the north boundary of what is now Bowdoin National Wildlife Refuge. The canal conveys water from the Milk River at Dodson Dam for irrigated lands upstream of the refuge and transfers water to Nelson Reservoir for storage. This canal also conveys Milk River water to Bowdoin Refuge, but this water use is secondary to irrigation needs. The canal intercepts much of the local runoff, which limits the amount of water that would otherwise naturally flow into the refuge's lakes and wetlands. This canal water is normally higher in dissolved solids (salts) than seepage, which flows downhill through the naturally saline soils toward Lake Bowdoin. Over the years, large saline seeps have developed between the lake and the canal due to increased water infiltration rates and ground water seepage from agricultural lands north of the refuge. Rain and runoff events wash these deposits into the lake.

Saline lakes occur naturally throughout the western half of North America (Langbein 1961); however, geothermal energy development, irrigation return flows, and alterations in the hydrology of natural lake systems can unnaturally increase salts even in lakes that are not naturally saline. Hydrologic barriers such as roadbed construction can disrupt the natural flow and mixing, causing a lake to function as a hydrologic sump and concentrating salts at abnormal levels (Swanson et al. 1984).

The influx of saline water into Lake Bowdoin, combined with evapoconcentration (the concentration of chemical constituents in a liquid due to evaporative processes), has caused salt concentrations in the lake to increase exponentially (Kendy 1999). The total dissolved solids (salts) for Lake Bowdoin in September 2009 were about 10,500 milligrams of salt per liter (mg/L), which places the lake in the subsaline category (Gleason et al. 2009). In most years, surface water does not flow out of Lake Bowdoin because of a limited water supply.

Water quality in and near Bowdoin Refuge is monitored annually at 19 surface sites and 14 shallow, ground water wells. Sixteen additional surface sites off the refuge and 18 wells along the Dodson South Canal are also monitored (refer to figure 28). Water-quality monitoring begins in the spring when the ice thaws and ends in the fall when the water freezes. All sites are tested every 2 weeks for temperature, specific conductance, pH, and depth. Specific conductance is a measure of how well water can conduct an electrical current. This can be used to determine the presence of dissolved solids such as phosphate, magnesium, calcium, and sodium.

Past water management at Bowdoin National Wildlife Refuge was aimed at maintaining high water levels in all refuge wetlands. Due to an inadequate water supply, this philosophy did not provide for periodic drawdowns and flushing, except during the infrequent flooding by Beaver Creek. The long-term effect has been increased salinity, as measured by specific conductance, in not only Lake Bowdoin but in Dry Lake and Drumbo Pond.

Historically, the only means to remove these excessive concentrations of salts from lakes and wetlands was after a runoff and or flood event. The

excess water would drain away, and much of the remaining water would be lost to evaporation over the summer months and leave behind dissolved salts. These salts were naturally blown away by strong winds or partially flushed out of the lakes during the next heavy runoff or flood event.

Construction of water facilities during the 1980s significantly improved water management capabilities on Bowdoin Refuge. Present Service management emphasizes maintenance of freshwater conditions in smaller wetland units such as Lakeside, Lakeside Extension, Bootleg Marsh, Teal Ponds, and Farm Ponds. These wetlands and ponds are managed to mimic natural wetlands, allowing periodic drawdowns or dry periods. Current management also focuses on how to reduce salinity levels in Lake Bowdoin, Dry Lake Pond, Dry Lake, and Drumbo Pond to address the effects on wildlife and neighboring landowners.

The Service is trying to better understand how to use additional water supplies, when available, for effective dilution and flushing. Subsequently, the Service and the Montana Reserved Water Rights Compact Commission have spent more than 2 years evaluating methods to improve the water quality on Bowdoin Refuge. This salinity team developed five proposals, or alternatives, for addressing the increasing salinity levels (chapter 6 of the draft CCP and EA).

Water Supply and Rights

Water supply and rights are described in this section for the units of the Bowdoin National Wildlife Refuge Complex.

Bowdoin National Wildlife Refuge. Bowdoin Refuge has a complex system of dikes, canals, and water control structures for moving water between water units and for handling floodwaters entering from Beaver Creek (figure 28 shows the location of this infrastructure and the refuge wetlands). The Montana Water Court has identified the Beaver Creek watershed as basin 40M. Water right filings for Bowdoin Refuge (table 4) have a complicated history, involving agreements and coordination with Reclamation during construction of the Milk River Project. In the 1930s, the Service was able to negotiate an agreement with Reclamation for a perpetual delivery of its water right in return for the Service contributing $40,000 toward the construction of the Fresno Reservoir near Havre, Montana. During years the Milk River has normal runoff, Reclamation will furnish a maximum of 3,500 acre-feet of water to the refuge each calendar year for improvement and maintenance of the refuge. If runoff is below normal, the refuge is to receive that portion of 3,500 acre-feet that natural conditions and Federal Reclamation Law permits.

In the past, the refuge has been able to obtain water in excess of 3,500 acre-feet through deliveries

Table 4. Water rights for Bowdoin National Wildlife Refuge, Phillips County, Montana.

Owner	*Water right number*	*Source name / type*	*Priority date*	*Water right type*	*Purpose*
Bureau of Reclamation	40J–40937–00	Milk River / Surface water	11/02/1903	Statement of claim	Fish and wildlife
Fish and Wildlife Service	40J–189872–00	Milk River / Surface water	03/09/1937	Statement of claim	Fish and wildlife
Fish and Wildlife Service	40M–187361–00	Beaver Creek / Surface water	11/12/1940	Compact[1]	Fish and wildlife
Fish and Wildlife Service	40M–187362–00	Black Coulee / Surface water	11/12/1940	Reserved claim	Fish and wildlife
Fish and Wildlife Service	40M–187363–00	Spring, Unnamed tributary of Beaver Creek / Ground water	11/12/1940	Compact	Fish and wildlife
Fish and Wildlife Service	40M–187364–00	Ground water	11/12/1940	Compact	Wildlife
Fish and Wildlife Service	40M–187365–00	Ground water	11/12/1940	Compact	Wildlife
Fish and Wildlife Service	40M–189874–00	Ground water	11/12/1940	Compact	Institutional
Fish and Wildlife Service	40M–25539–00	Ground water	11/12/1940	Compact	Domestic

[1] *Compact (memorandum of agreement) with Montana Reserved Water Rights Compact Commission.*
[2] *Maximum flow measured in cfs=cubic feet per second; gpm=gallons per minute.*

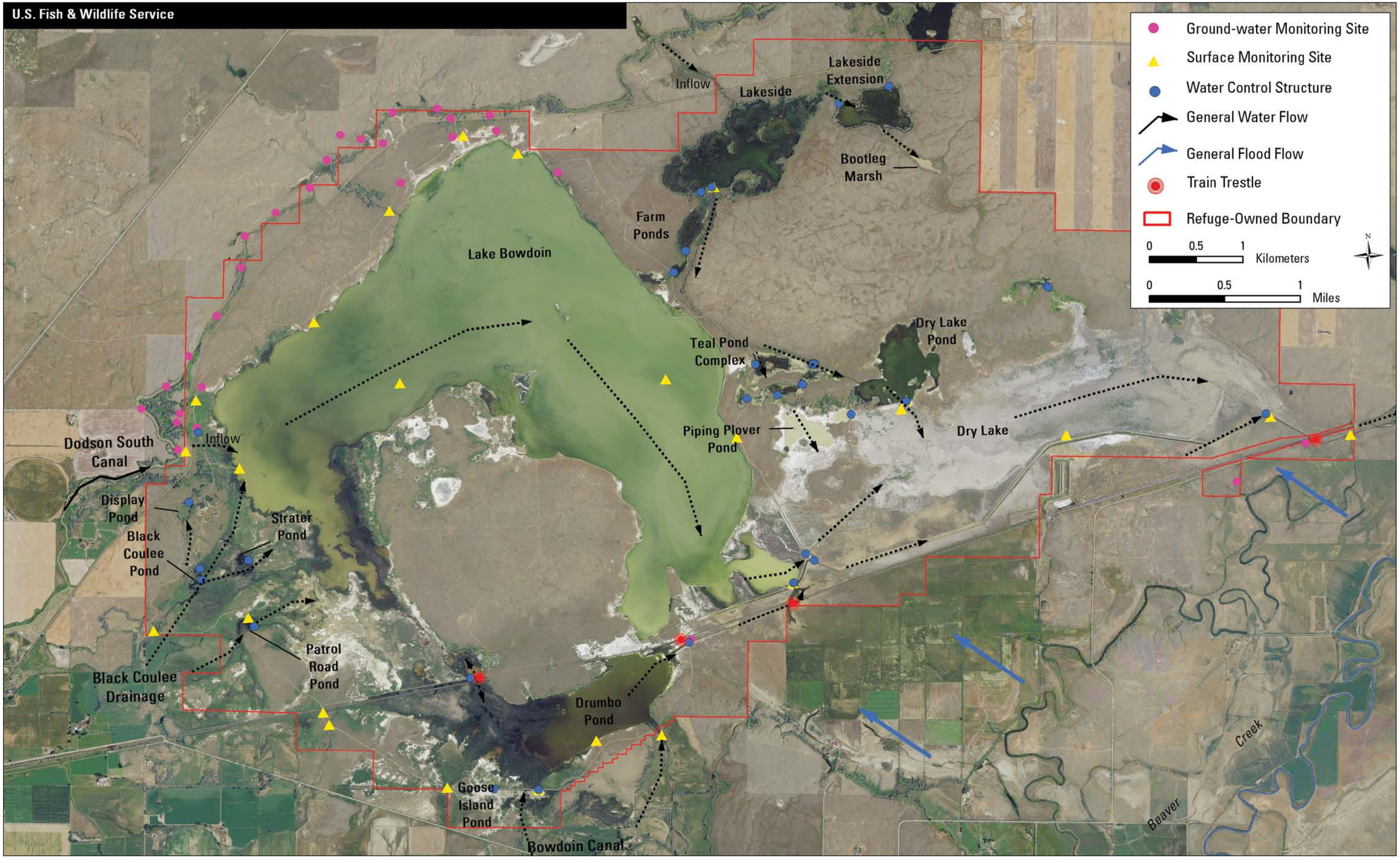

Figure 28. Map of wetlands, water management infrastructure, and monitoring sites on Bowdoin National Wildlife Refuge, Montana.

of water using the Malta Irrigation District facilities. This has averaged 4,877 acre-feet, when considering all recorded deliveries. The Service has had to pay a delivery fee to the irrigation district for this extra water. Based on the maximum delivery of water from the Milk River on record—11,540 acre-feet—the Service filed a historical use claim of 8,000 acre-feet at a delivery rate of 280 cubic feet per second.

Receiving this additional water was has been critical to the management of the refuge's wetland habitats. Nevertheless, in many years there is insufficient delivered water and runoff necessary to fill and manage all wetlands within the refuge.

Bowdoin Wetland Management District. All waterfowl production areas except Webb WPA have recorded water rights (table 5). Sources for these

Table 5. Water rights for the waterfowl production areas and satellite refuges of Bowdoin National Wildlife Refuge Complex, Montana.

Refuge complex unit[1]	*County*	*Water right number*	*Source name*	*Priority date*	*Water right type*	*Purpose*
Beaver Creek WPA	Phillips	40M–5987–00	Beaver Creek	09/08/1900	Statement of claim	Irrigation
	Phillips	40M–22930–00	Unnamed tributary of Beaver Creek	09/08/1900	Statement of claim	Irrigation
	Phillips	40M–169663–00	Beaver Creek	09/08/1900	Statement of claim	Irrigation
	Phillips	40M–22928–00	Unnamed tributary of Beaver Creek	07/11/1903	Statement of claim	Irrigation
	Phillips	40M–19581–00	Spring, Unnamed tributary of Beaver Creek	12/31/1930	Statement of claim	Stock
Dyrdahl WPA	Phillips	40J–167498–00	Natural pit, Unnamed tributary of interior drainage	12/31/1911	Statement of claim	Stock
	Phillips	40K–167499–00	Surface water	12/31/1911	Statement of claim	Stock
	Phillips	40J–167505–00	Unnamed tributary of interior drainage	01/30/1923	Statement of claim	Irrigation
	Phillips	40J–167516–00	Natural pit, Unnamed tributary of interior drainage	12/31/1923	Statement of claim	Stock
	Phillips	40J–167517–00	Natural pit, Unnamed tributary of interior drainage	12/31/1923	Statement of claim	Stock
	Phillips	40J–167518–00	Unnamed tributary of interior drainage	12/31/1923	Statement of claim	Stock
	Phillips	40J–167519–00	Natural pit, Unnamed tributary of interior drainage	12/31/1923	Statement of claim	Stock
	Phillips	40J–167521–00	Natural pit, Unnamed tributary of interior drainage	12/31/1923	Statement of claim	Stock
	Phillips	40J–167506–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock

[1] WPA=*waterfowl production area;* NWR=*national wildlife refuge.*
[2] *Maximum flow measured in cfs=cubic feet per second; gpm=gallons per minute.*
[3] *Compact (memorandum of agreement) with Montana Reserved Water Rights Compact Commission.*

Table 5. Water rights for the waterfowl production areas and satellite refuges of Bowdoin National Wildlife Refuge Complex, Montana.

Refuge complex unit[1]	*County*	*Water right number*	*Source name*	*Priority date*	*Water right type*	*Purpose*
Dyrdahl WPA (continued)	Phillips	40J–167507–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock
	Phillips	40J–167508–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock
	Phillips	40J–167509–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock
	Phillips	40J–167510–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock
	Phillips	40J–167511–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock
	Phillips	40J–167512–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock
	Phillips	40J–167513–00	Natural pit, Unnamed tributary of interior drainage	07/12/1928	Statement of claim	Stock
	Phillips	40K–167497–00	Unnamed tributary of closed basin	05/10/1940	Statement of claim	Stock
	Phillips	40J–167504–00	Natural pit, Unnamed tributary of interior drainage	12/31/1945	Statement of claim	Stock
	Phillips	40J–167522–00	Ground water	06/05/1964	Statement of claim	Stock
	Phillips	40J–34882–00	Ground water	08/23/1981	Ground water certificate	Stock
	Phillips	40J–47460–00	Ground water	12/07/1981	Ground water certificate	Domestic and Stock
Holm WPA	Blaine	40J 183201 00	Unnamed tributary of Hay Coulee	03/06/1942	Statement of claim	Stock
Korsbeck WPA	Phillips	40J–43760–00	Unnamed tributary of interior drainage	12/31/1905	Statement of claim	Stock
	Phillips	40J–43936–00	Constructed pit, Unnamed tributary of West Alkali Creek	12/31/1945	Statement of claim	Stock
	Phillips	40J–43940–00	Constructed pit, Unnamed tributary of West Alkali Creek	12/31/1954	Statement of claim	Stock
	Phillips	40J–102275–00	Ground water	10/06/1958	Statement of claim	Stock

[1] WPA=*waterfowl production area;* NWR=*national wildlife refuge.*
[2] *Maximum flow measured in cfs=cubic feet per second; gpm=gallons per minute.*
[3] *Compact (memorandum of agreement) with Montana Reserved Water Rights Compact Commission.*

Table 5. Water rights for the waterfowl production areas and satellite refuges of Bowdoin National Wildlife Refuge Complex, Montana.

Refuge complex unit[1]	*County*	*Water right number*	*Source name*	*Priority date*	*Water right type*	*Purpose*
McNeil Slough WPA	Phillips	40J–163022–00	Unnamed tributary of Milk River	06/21/1930	Statement of claim	Wetlands
Pearce WPA	Phillips	14–06–600–59081	—	10/17/1961	Statement of claim	—
Black Coulee NWR	Blaine	Compact[3]	Black Coulee	—	Compact[3]	—
Creedman Coulee NWR	Hill	40J–183197–00	Creedman Coulee	05/25/1937	Statement of claim	Fish and wildlife
Hewitt Lake NWR	Phillips	40J–183198–00	Unnamed Tributary to Spring Coulee	07/16/1902	Statement of claim	Fish and wildlife
Lake Thibadeau NWR	Hill	40J–187366–00	Unnamed Tributary to Redrock Coulee	10/25/1937	Statement of claim	Fish and wildlife
	Hill	40J–187367–00	Lohman Coulee	10/25/1937	Statement of claim	Fish and wildlife
	Hill	40J–188170–00	Martin Coulee	10/25/1937	Statement of claim	Fish and wildlife

[1] WPA=*waterfowl production area;* NWR=*national wildlife refuge.*
[2] *Maximum flow measured in cfs=cubic feet per second; gpm=gallons per minute.*
[3] *Compact (memorandum of agreement) with Montana Reserved Water Rights Compact Commission.*

rights include ground water wells, overland runoff, pumping from named watercourses, and created diversions. The Service uses these water rights to flood several wetland units on the waterfowl production areas to provide migration and brood habitat for migratory birds. Pearce WPA, located just downstream of Bowdoin Refuge on the Dodson South Canal, has a water right through Reclamation. When the Pearce WPA was purchased in 1976, the Service assumed responsibility of the contract for water that was previously held between the landowner and Reclamation; the contract was established in 1961 when the landowner requested water from the Milk River Project. The contract was for the irrigation of 50 acres of land and 100 acre-feet of water per full irrigation season. Reclamation granted the permanent contract with the requirement that the landowner pay a share of the construction cost of the irrigation project; semiannual payments were to be made against the $2,500 construction liability. The contract was amended in 1969, which reduced the construction repayment cost to $1,941 and set the semiannual payment amount at $23.03. When the Service acquired the property and assumed responsibility of the contract, there were 27 years left on the payment schedule; the construction payment was paid in full in 2003.

The Service still pays an annual operation and maintenance charge for the water and will continue to do so in perpetuity or until the contract is amended.

Satellite Refuges. The four satellite refuges in the refuge complex all have recorded water rights (see table 5). Each refuge has a dam built by the Government in the 1930s that impounds water, primarily on private land, for the purposes of water conservation, drought relief, and migratory bird and wildlife conservation. The Government obtained perpetual flowage easements from the original landowners; these easements grant the Service the right to manage the uses of structures and associated impoundments, lakes, streams, and rivers within easement boundaries. The flowage easements did not grant any rights for management or protection of other natural, shallow depressions except for control of hunting.

Air Quality

Air quality is a global concern. The U.S. Environmental Protection Agency (EPA) has lead responsibility for the quality of air in the United States; through the 1990 Clean Air Act, the agency sets limits on the amount of pollutants that can be discharged into the air. More than 170 million tons of pollution is emitted annually into the air within the United States, through either stationary sources (such as industrial and power plants) or mobile sources (such as automobiles, airplanes, trucks, buses, and trains). There are also natural sources of air pollution such as fires, dust

storms, volcanic activity, and other natural processes. The EPA has identified six principal pollutants that are the focus of its national regulatory program: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide.

Air quality problems in Montana are usually related to more urban areas and mountains or river valleys that are sensitive to temperature inversions. Carbon monoxide and particulate matter are the air pollutants that have the greatest adverse effect on Montana's air quality. Particulate matter is tiny liquid or solid particles in the air that are able to be breathed in through the lungs.

In the area of the refuge complex, air quality is considered to be exceptionally good; there are no nearby manufacturing sites or major sources of air pollution. At Bowdoin Refuge, however, salts on the east end of the refuge are sometimes blown into the air during high wind events. As water evaporates from Lake Bowdoin throughout the summer, the shoreline is left with the solids or salts that can be carried away by high winds. Most of the blowing salts historically came from Dry Lake after water transferred from Lake Bowdoin to create shallow wetlands for ducks and shorebirds eventually evaporated and left large concentrations of dried salts. In the past 10 years, no water has been transferred from Lake Bowdoin, and Dry Lake has remained dry except for some occasional, natural runoff. Any remaining salts in Dry Lake from past management activities are gone. Furthermore, much of Dry Lake has become vegetated, which has reduced the ability of salts to become airborne.

The refuge complex periodically uses prescribed fire to manage habitat and control invasive and nonnative species. Both prescribed fires and wildfires produce numerous gasses and particulate matter that affect air quality. Prescribed fires are conducted under strict smoke and air regulations as established by the Montana and Idaho Airshed Group—all prescribed fires conducted on the refuge complex have met permitted requirements. The Service is assessed an annual fee based on the previous year's tons of particulate matter produced from prescribed burning on a statewide basis. Each year, the refuge complex's fire management officer applies for and submits payment to Montana Department of Environmental Quality (DEQ).

3.2 Biological Resources

The following sections describe the biological resources that may be affected by the implementation of the CCP. The biological features detailed below are vegetative habitat types and the associated birds, mammals, amphibians, reptiles, fishes, and insects. The quality of these habitats varies throughout the refuge complex particularly due to water quality and quantity, the presence of invasive and nonnative species, impacts from surrounding land uses, and the Service's ability to properly manage and protect a particular area.

The major habitat types that occur on the refuge complex follow:

- *Uplands*—vast expanses comprised primarily of mixed-grass prairie and disturbed grasslands, including dense nesting cover
- *Wetlands*—natural and enhanced freshwater and saline wetlands and associated riparian areas, lakes, rivers, and ponds

Unless otherwise noted, most of the following information is from unpublished Service data located in files at the refuge complex headquarters.

Uplands

At least 50 percent of native grassland habitat has been converted to other uses in Montana's Prairie Pothole Region (Ducks Unlimited 2003). However, large, intact, native prairie communities can still be found throughout the Bowdoin Refuge Complex, with more than 10,400 acres of fee-title lands in the refuge complex in native prairie. In addition, grassland conservation easements on private lands are protecting almost 40,000 acres of native prairie and tamegrasses.

Native prairie is defined as areas of previously unbroken, unfarmed (virgin) sod where the soil composition is generally intact. Grasses in the prairie found in this area are a mixture of western wheatgrass, needlegrasses, blue grama, and upland sedges. Interspersed within the grasses are numerous species of forbs such as fringed sagewort, scarlet globemallow, coneflowers, and yarrow. Shrubs include winterfat, silver sage, and greasewood. In addition, clubmoss and prickly pear cactus are common.

While clubmoss is a natural component of native uplands, overgrazing, drought, and lack of fire have allowed it to increase as herbaceous cover decreased. It has been theorized that clubmoss outcompetes other vegetation by forming dense mats that intercept water and prevent seed germination (Majorowicz 1963, Heady 1952). Other studies have rejected these hypotheses and suggest that clubmoss does not affect water use by other plants (Colberg and Romo 2003) and that seed germination is more affected by the species of seeds in the seed banks (Romo and Bai 2004). Clubmoss may also reduce runoff, increase water infiltration, and prevent invasive plants from

becoming established in native grasslands that have been stressed by past overgrazing or drought.

In presettlement times, the frequency of wildfire across the northern Great Plains was highly variable depending on climate and soil type (Higgins 1986, Umbanhowar 1996). Other factors such as moisture, plant species composition, topography, and grazing by native animals also played a role in fire frequency, intensity, and duration (Askins et al. 2007, Madden et al. 2000). Fire-return intervals of 5–10 years have been estimated for the northern Great Plains (Frost 1998), and intervals averaging 6 years have been reported for studies in North Dakota (Madden et al. 1999). However, very little research has been conducted regarding fire in the drier prairies of north-central Montana. Askins et al. (2007) suggest that grazing and a lack of moisture maintained grass as the dominant vegetation with fire playing a lesser role and estimated a fire-return interval of 10–26 years for Montana. Historically, wildfires on the refuge complex were suppressed and prescribed fire was used sporadically. Since 2001, the Service has made a concerted effort to restore wildland fire to this prairie system, burning more than 13,000 acres throughout the refuge complex. Burning stimulates plant growth, returns nutrients to the soil, reduces residual cover, scarifies native seed, can reduce or increase competition from invasive plants, and restores upright structure. Following a prescribed fire, a more diverse native plant community returns, providing nesting and feeding habitat for migratory birds and other wildlife. To create a mosaic of habitat across the landscape, the Service staggers these prescribed fires, burning only 5–10 percent of the burnable acres in a single year.

Vast herds of bison once roamed throughout this area of north-central Montana. When the bison were eliminated, domestic cattle were brought to graze this expansive grassland habitat. The uplands may have been grazed even more heavily by livestock than other parts of the refuge complex because of the reliable water source in Lake Bowdoin. When Bowdoin Refuge was established in 1936, domestic cattle grazing went through several periods of use and nonuse until it was phased out between 1973 and 1977. In 2001, the Service began a prescriptive cattle grazing program to meet specific objectives for enhancing native grasslands and treating invasive plants.

Since the refuge complex was established, the Service has planted 4,477 acres of uplands to various grass species to create dense nesting cover. All of the 4,008 acres on the waterfowl production areas were prior cropland and 469 acres of native prairie on the Bowdoin Refuge were broken (tilled) to plant DNC. These areas are referred to as disturbed grasslands. All of the disturbed grasslands on the waterfowl production areas were once farmed; shortly after

Al Schneider / USDA–NRCS PLANTS Database

Blue grama is a common prairie grass.

Larry Allain / USDA–NRCS PLANTS Database

Fringed sagewort is one of the many forbs on the Bowdoin Refuge Complex.

Service acquisition, these acres were seeded to herbaceous cover consisting of a cool-season vegetation mix of wheatgrasses and legumes. The predominant grass species used were intermediate wheatgrass, tall wheatgrass, slender wheatgrass, pubescent wheatgrass, and western wheatgrass; the legumes were alfalfa and sweetclover. These species, commonly referred to as dense nesting cover, were chosen based on research that showed they are highly attractive and beneficial to waterfowl (Duebbert 1969). The remaining 469 acres of disturbed grasslands, located on Bowdoin National Wildlife Refuge, were planted into broken native prairie in the 1970s specifically to provide ducks a denser nesting cover than the surrounding upland. Rationale for this type of management action was likely based on research conducted in the late 1960s and 1970s, which indicated ducks were experiencing higher nesting success in DNC than in surrounding upland habitats (Duebbert 1969, Duebbert and Lokemoen 1976, Kaiser et al. 1979). Many of the DNC fields are in poor condition with respect to plant diversity. The lifespan of a DNC seeding is about 15 years (Higgins and Barker 1982, Lokemoen 1984), and most of the DNC fields on the refuge complex are well past this lifespan.

Invasive and Nonnative Species in Uplands

North-central Montana does not have many new invasive plant species when compared to other parts of the State; however, refuge complex lands will be constantly monitored for new nonnative species that can occur in this area including Russian knapweed, hoary alyssum, and baby's breath. Although most of the native prairie is free from invasive and nonnative plants, there is encroachment of crested wheatgrass, Russian olive, and Japanese brome. Leafy spurge, spotted knapweed, and Canada thistle can be found in disturbed uplands including along roadsides and railroad tracks.

Crested Wheatgrass. Crested wheatgrass has been the most commonly planted exotic grass in western North America since the early 1900s. Invasion of this species into native rangeland can have a negative effect on plant and wildlife diversity (Reynolds and Trost 1981, Christian and Wilson 1999, Davis and Duncan 1999). When it invades native prairie, crested wheatgrass often eliminates its native competitors and can form vast monocultures that create ecological traps for nesting grassland birds (Lloyd 2005). According to Lloyd (2005), nests in native prairie were depredated 17 percent less often than nests in a field of crested wheatgrass. Survey data for grassland birds nesting on Bowdoin Refuge indicates fewer nests in the crested wheatgrass areas adjacent to the native grassland fields. Crested wheatgrass was used

Cassondra Skinner / USDA–NRCS PLANTS Database

Crested wheatgrass is a nonnative species that can have a negative effect on plant and wildlife diversity.

to landscape areas around the refuge headquarters area in the 1930s and to replace the small plots of wildlife food crops on the west end of the Bowdoin Refuge as they were phased out. Throughout the refuge complex, scattered monocultures of crested wheatgrass are slowly spreading and are overtaking native grasslands. It is difficult to effectively treat and eradicate this invasive grass.

Russian Olive. This species is adaptable to semiarid and saline environments and has been promoted as a source of food and cover for some wildlife species (Natural Resources Conservation Service 2002), particularly ring-necked pheasant. With this in mind, refuge staff planted Russian olive trees on Bowdoin National Wildlife Refuge in the 1950s until the 1970s. Over the years, the trees have encroached into native prairie, fragmenting grassland habitats throughout the refuge complex, but particularly on Bowdoin Refuge. Research has proven that fragmentation causes avoidance of these areas by some nesting grassland birds and increased predation of nests, adults, and juvenile grassland-dependent birds (Delisle and Savidge 1996, Gazda et al. 2002, Helzer 1996, Johnson and Temple 1990).

In Bowdoin Wetland Management District, Pearce WPA has the greatest infestation of Russian olive

trees; the McNeil Slough, Beaver Creek, and Korsbeck WPAs have a few Russian olive trees as well. The greatest infestation of Russian olive is on Bowdoin Refuge, which has more than 140 acres of this species scattered throughout the refuge. The eastern end of the refuge has relatively pristine, native prairie, and Russian olive trees were encroaching into this area. Control of Russian olive on the refuge began in 2000 with tree cutting and treating the stumps with an herbicide (Arsenal® or Garlon® 3A); in some treated areas, the remaining tree stumps sprouted and readily propagated, becoming difficult for the refuge staff to control. The Service began by removing these single, scattered trees, and then turned its attention to larger, older infestations. Labor-intensive control methods, combined with a lack of staff, has slowed progress in reducing the infestation.

In September 2010, the State reclassified Russian olive as a priority 3 regulated plant. Regulated plants are not listed as noxious weeds but have the potential to have significant impacts. This plant species may no longer be intentionally spread or sold.

Japanese Brome. This grass has been present in the refuge complex for many years with almost no attention given to estimating the size of the infestations or treating them. Japanese brome is an early invader and spreads quickly, particularly in disturbed sites. Not only does this plant compete for the resources needed by desirable native plants, it provides poor cover for grassland birds and decreases in nutritive content and digestibility as it matures.

Leafy Spurge. Leafy spurge is an aggressive perennial species that is known to displace desirable grasses and forbs. The plant's ability to spread rapidly by seed and vegetative reproduction and its extensive deep-root system are factors that can make eradication of this species extremely difficult.

Leafy spurge was first discovered growing on Bowdoin Refuge during the summer of 1989. There is a 0.7-acre patch on both sides of the railroad tracks on Big Island that has been treated with mowing and spraying since it was discovered. McNeil Slough WPA (Bowdoin District) was infested with leafy spurge when it was purchased in 1991; the infestation is extensive but sparse and has been treated sporadically with spraying. In 1996, about 2,000 *Aphthona lacertosa* flea beetles were released in this infestation at McNeil Slough WPA, with no apparent effect. The Service's Montana Strike Team has been surveying, treating and monitoring this species on McNeil Slough for the last 3 years, and evidence suggests that infestations are decreasing. There was a small patch (25 feet square) discovered in 2004 at Korsbeck WPA, which has been treated annually with chemicals.

Spotted Knapweed. In 2004, a few spotted knapweed plants were discovered along the auto tour road to the main boat ramp near the Bowdoin Refuge office. The infestation has been treated by pulling and spraying.

Elaine Haug / USDA–NRCS PLANTS Database

Spotted Knapweed

Canada Thistle. Canada thistle has been prevalent for many years on Bowdoin Refuge, Pearce WPA, and McNeil WPA; thistle patches are found near many roads and other disturbed areas. Some dense stands have been treated with success, but most areas go untreated.

Yellow Toadflax. On Bowdoin Refuge, a small stand of yellow toadflax was discovered growing along the railroad tracks on Big Island (near the leafy spurge patch) in 1993 and has been hand-pulled sporadically over the years.

Upland-Associated Wildlife

There are 119 species of birds that have been documented breeding and nesting on the refuge complex. About 29 species use upland habitats, particularly native grassland, for nesting. From 1995 to 2008, the most abundant breeding and nesting passerines using the native grasslands were chestnut-collared longspur, Savannah sparrow, grasshopper sparrow, Baird's sparrow, Sprague's pipit, and western meadowlark. Also documented were clay-colored sparrow, lark bunting, and vesper sparrow.

The importance of this area to breeding and migrating waterfowl and shorebirds has long been recognized, serving as a catalyst for establishment of Bowdoin National Wildlife Refuge and the remaining refuge complex. The most common upland-nesting ducks are mallard, gadwall, northern pintail, northern shoveler, and blue-winged teal. Several upland-nesting shorebirds are also found in native prairie habitats including marbled godwit, willet, upland sandpiper, long-billed curlew, and Wilson's phalarope.

Sharp-tailed grouse are one of the few native prairie birds that are year-round residents. During the early 1980s, Bowdoin Refuge had up to seven leks that were used each spring by 50–100 sharp-tailed grouse. The number of leks and birds per lek have decreased dramatically since that time. By 1999, there was only one active lek on the refuge and it had less than 20 birds. Despite this decline on the refuge, sharp-tailed grouse are observed on lands around the refuge throughout the year; many of these grouse move onto Bowdoin Refuge in the fall and stay through the winter months.

Although not abundant, sage-grouse, a federal candidate species, has been documented on Beaver Creek, McNeil Slough, Hewitt Lake, and Korsbeck WPAs. Other bird species include raptors such as northern harrier, ferruginous hawk, burrowing owl, and short-eared owl, which are commonly seen hunting or nesting in the uplands. The nonnative ring-necked pheasant is also common on most of the refuge complex. Introduced to the area in the 1930s primarily for hunting, pheasant have become a permanent part of the upland wildlife, nesting and feeding in grassland habitat.

Native grazers such as pronghorn, white-tailed deer, and mule deer browse and graze the uplands. Some of the other mammals found in native grasslands on the refuge complex are coyote, white-tailed jackrabbit, badger, and Richardson's ground squirrel. In 2000, a small mammal-trapping study on Bowdoin Refuge found deer mouse, meadow vole, western harvest mouse, house mouse, and least weasel. Other species observed included masked shrew, northern pocket gopher, white-footed mouse, and western jumping mouse.

There have been no formal amphibian or reptile surveys on the refuge complex. Some of the documented reptiles are gopher snake, prairie rattlesnake, yellow-bellied racer, plains garter snake, and common garter snake.

The diversity of insects in the refuge complex has not been quantified, but prairie and tame grassland produce large numbers of grasshoppers, leafhoppers, butterflies, beetles, and spiders.

Target Upland Birds

The Service has identified a diverse group of target bird species for uplands in the refuge complex: Baird's sparrow, chestnut-collared longspur, greater sage-grouse, long-billed curlew, Sprague's pipit, and marbled godwit. The life history needs of these species are described below, excepting the godwit—an upland-nesting shorebird that is a target species for both uplands and wetlands and is described under "Target Waterbirds."

Baird's Sparrow. The Baird's sparrow is a true grassland specialist, requiring grasslands on both its breeding and wintering grounds. This sparrow breeds exclusively in the northern mixed-grass prairie from southeastern Alberta and southern Saskatchewan (Canada) through North Dakota and eastern Montana. Populations of many grassland birds including Baird's sparrows have declined due to habitat loss from conversion to cropland, overgrazing, and poor rangeland management (Dechant et al. 2003).

Baird's sparrows nest in idle to lightly grazed native prairie that has some residual litter cover and few shrubs. In wetter, eastern portions of their range frequent fires may be required to prevent shrub invasion. Drier, western grasslands do not require the same frequency (Dechant et al. 2003). In Alberta, the highest densities of Baird's sparrows were found in sites not burned for 5–15 years (Green et al. 2002), and a fire-return interval of up to 25 years has been recommended for dry mixed-grass prairie (Askins et al. 2007, Dechant et al. 2003). On Bowdoin Refuge, Baird's sparrows were common in prairie that had not burned for at least 70 years. Although they prefer native prairie, the sparrows will use tamegrass pastures and some exotic grass species that are structurally similar to native prairie.

Baird's sparrows arrive at Bowdoin Refuge around mid-May and begin nesting in late May (Jones et al. 2010). A long-term grassland bird study at the refuge compared vegetation measurements taken at nest sites to measurements taken at random sites throughout four study plots (445 acres total). The sparrows preferred nesting habitat with greater litter depth (averaging 8 inches) and taller vegetation (averaging 14 inches) than that found at random sites (Dieni and Jones 2003). In addition, they have been found to select sites devoid of clubmoss (Dieni and Jones 2003) and bare ground (Dieni and Jones 2003, Green et al. 2002). Dechant et al. (2003) made the following management recommendations for Baird's sparrow:

- Protect native grasslands that support breeding populations of Baird's sparrow
- Prevent encroachment of woody vegetation
- Encourage vegetative diversity within grasslands
- Provide large tracts of grassland
- Use fire-return intervals appropriate for the area
- Prevent overgrazing in pastures used by Baird's sparrows

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Baird's Sparrow

© Michael Forsberg

The chestnut-collared longspur is a Montana species of concern that nests on Bowdoin Refuge.

Chestnut-collared Longspur. Chestnut-collared longspurs breed only in short- and mixed-grass prairie of the western and northern Great Plains and are the most abundant grassland songbird species that breeds at Bowdoin Refuge (Jones et al. 2010). Their breeding range extends from southern Alberta to southern Manitoba in Canada, south through eastern Montana and Wyoming, and east through North Dakota and South Dakota to western Minnesota.

Longspurs nest in open prairie with minimal shrubs and litter. They prefer native grasslands that have been recently disturbed by fire, grazing, or mowing (Hill and Gould 1997). Optimal grazing intensity is dependent on soil productivity, geographic area, and climate. In dry, sparse, mixed-grass prairie, light to moderate grazing is more appropriate, and heavy grazing or overgrazing may be detrimental (Dechant et al. 2003). Longspurs will nest in tame-grass pastures but in lower abundance than in native prairie, and they do not nest in cropland (Hill and Gould 1997).

Chestnut-collared longspurs arrive at Bowdoin Refuge in mid-April and begin nesting in early to mid-May (Jones et al. 2010). A long-term study of grassland birds at the refuge found that longspurs nest in sparser areas than Sprague's pipits or Baird's sparrows, with less grass and litter cover and more clubmoss cover than the other two species (Dieni and Jones 2003).

Dechant et al. (2003) made the following management recommendations for chestnut-collared longspurs:

- Protect native prairie from plowing and cultivation
- Avoid managing for idle, dense vegetation, as longspur densities decrease with increased vertical density, diversity, and litter depth
- Graze at light to moderate intensity in dry, mixed-grass prairie and avoid overgrazing
- Use mowing to improve habitat by decreasing vegetation height and density

Greater Sage-Grouse. The historical range for sage-grouse covered portions of 16 states and three Canadian provinces (MSGWG 2005). The species presently occurs in 11 western states and two provinces, having disappeared from scattered areas around the periphery of its original range due to alteration or elimination of sagebrush habitat. In March 2010, the greater sage-grouse was listed as a candidate species, meaning it warrants protection under the Endangered Species Act but is precluded by higher priority species.

Greater sage-grouse require different habitat conditions, often across broad landscapes, to meet yearlong needs for breeding, nesting, brood-rearing, and wintering habitat. Regardless of the season, they require large expanses of sagebrush habitats with healthy, diverse understories of grasses and forbs. In the spring, displaying males require relatively

open areas as lek sites, or dancing grounds, where breeding takes place. Females nest in a variety of cover types, but the most suitable nesting habitat is a mosaic of sagebrush with horizontal and vertical structural diversity (Dechant 2003b). Shrub height of sagebrush most commonly used by nesting sage-grouse ranges from 11.5 to 31 inches, with a grass-canopy height greater than 7.2 inches and a diversity of forbs (MSGWG 2005).

Brood-rearing habitats for sage-grouse are typically mosaics of upland sagebrush and other habitats such as wet meadows and riparian areas that, together, provide abundant insects and forbs for hens and chicks (Dechant 2003). Succulent forbs, a preferred food source for sage-grouse broods, are a key component of summer habitat (MSGWG 2005). While sage-grouse are associated with sagebrush throughout the year, it is essential during winter when the birds mostly occupy sagebrush habitats with greater than 20-percent canopy cover (MSGWG 2005).

Conserving sagebrush habitats on private and public lands is by far the most effective approach to assuring long-term maintenance of sage-grouse abundance and distribution (MSGWG 2005). Other management recommendations (Dechant et al. 2003) follow:

- Maintain, conserve, and restore large blocks of intact sagebrush with a healthy understory of native grasses and forbs
- Protect from alteration lek sites and adjacent habitat (up to 11 miles from the lek)
- Manage breeding habitats to maintain sagebrush canopy cover of 15–25 percent and perennial herbaceous cover of at least 15-percent grasses or at least 10-percent forbs, with grasses and forbs at least 7.1 inches tall
- Eliminate or control invasive, nonnative plants in sagebrush-steppe
- Use prescribed fire in sagebrush-steppe with caution, especially in the more arid portions of sage-grouse range, and attempt to maintain a mosaic of habitats following the burn
- Manage livestock grazing through stocking rates and season of use on all seasonal ranges of sage-grouse to avoid habitat degradation
- Minimize human disturbance in sage-grouse habitats, especially around leks and nesting habitat, for example: reduce or avoid development of mining and other resource extraction industries such as coal-bed methane, and avoid construction of power lines especially within 1.86 miles of seasonal habitats

Dr. Thomas G. Barnes / USFWS

A greater sage-grouse male on a lek, or dancing ground, in sagebrush-steppe habitat.

Long-billed Curlew. The long-billed curlew, or "sickle-bill," is the largest shorebird in North America. There is no accurate estimate of the current population size, but the species is considered vulnerable throughout its range. Continued loss of grassland breeding habitats is thought to be the greatest threat to population stability (Poole 2005).

Standing 16 inches tall, this curlew has an extremely long, down-curved bill (5–6 inches for males and 6.5–8 inches for females) and long legs. Their long bills and legs are feeding adaptations for walking and probing for food in deep mud and for probing in soft soil and animal burrows. They feed on insects, marine and freshwater invertebrates, mollusks, amphibians, and wild fruits. When foraging in uplands they feed on grasshoppers, beetles, and other invertebrates in low-growing grassy areas (Montana Bird Distribution Committee 1996).

Curlews breed in the shortgrass and mixed-grass prairie habitats of the Great Plains, the Great Basin, and the intermontane valleys of southwestern Canada and the United States including Montana, except the Rocky Mountain region (Montana Bird Distribution Committee 1996). Curlews rely on the cover and openness of native-prairie grasslands and pastures to nest and rear their young. Adequate, short-growth grassland for nesting habitat may be the single most important factor in sustaining long-billed curlew populations (Allen 1980, Cochrane and Anderson 1987, King 1978). In the northern Great Plains, the highest curlew densities were in lightly grazed grasslands

Lee Karney / USFWS

Long-billed Curlew

on dry soils and in heavily grazed areas on moister soils (Kantrud and Kologiski 1982). Grazing generally has a positive effect on breeding densities because grazing produces the short grass and open ground favored for predator detection and chick mobility (Jenni et al. 1981, King 1978, Pampush 1980). The best rotation system should include grazing through early spring, so vegetation height and density are low during courtship and egg laying (Jenni et al. 1981). Overgrazing in drier, shortgrass habitats may be a threat to long-billed curlews and should be avoided (Bock et al. 1993, Strong 1971). Timing and intensity of grazing treatments should be adjusted according to local climate and habitat characteristics (Bicak et al. 1982, Bock et al. 1993). In addition, prescribed fire can improve habitat for curlews by removing shrubs and increasing habitat openness (Pampush and Anthony 1993).

Accounts of spring arrival dates for long-billed curlews in Montana are from early to mid-April. Habitat requirements for breeding curlews are grassland vegetation less than 12 inches tall, which enables curlews to forage without restricting the maneuverability of their long bills. They also prefer a range of 35–120 acres of suitable breeding and nesting habitat depending on the topographic and vegetative diversity of an area. Curlews nest in shortgrass prairie, grazed mixed-grass uplands and pastures, wet and dry meadows, grassy floodplains, alkali flats, and occasionally in hayfields, cropland, and fallow or stubble fields 3–9 inches high. Nests are usually formed in a shallow depression that is lined with grasses or weeds to protect the eggs. Curlew nests are often located close to standing water, within 100–450 yards, and near conspicuous objects including livestock dung piles, rocks, and dirt mounds (Allen 1980, Cochrane and Anderson 1987, King 1978). Individuals may intentionally place nests near these objects, possibly to provide shade, increase camouflage, or facilitate nest location by a breeding pair.

Nesting usually takes place in May and June (Gillihan and Hutchings 2000). The female lays four eggs, which are incubated by both birds for 27–29 days. The young are precocial (covered with down and capable of moving about) and, once hatched, are ready to leave the nest almost immediately; most young birds leave their nests during the months of June and July. After hatching, the adults move the chicks to areas of taller grasses and scattered forbs and shrubs, apparently for protection from predators and weather extremes. However, the adults avoid dense vegetation, possibly due to low visibility and difficulty of travel for chicks (Dechant et al. 1999). The female typically abandons the brood 2–3 weeks after hatching and leaves brood care to the male. The remaining groups of birds leave their breeding grounds by the end of August (Dechant et al. 1999). Curlews typically depart Montana in late August to early September.

Sprague's Pipit. Sprague's pipit breeds only in the northern mixed-grass prairie, and its range is similar to that of Baird's sparrow. However, while Baird's sparrow numbers have been stable since the 1980s, Sprague's pipit numbers have continued to decline, causing it to be listed in 2010 as a candidate species in the United States.

Pipits nest in native prairie with high plant species diversity and few shrubs. They prefer lightly to moderately grazed pastures throughout much of their breeding range (Jones 2010); however, grazing can have a dramatic negative effect in drier, less densely vegetated, mixed-grass prairie (Robbins et al. 1999).

Burning can have short-term, adverse effects on the abundance of Sprague's pipit; however, burning may have long-term benefits through improved habitat quality if it occurs at an appropriate frequency (Jones 2010). In drier portions of their range, pipits were common on native grassland that had not been burned for more than 15–32 years (Jones 2010, Robbins et al. 1999). Unlike Baird's sparrows, Sprague's pipits are uncommon in tame pasture and have not been documented to nest in cropland, Conservation Reserve Program land, or in dense nesting cover planted for waterfowl habitat (Jones 2010).

Sprague's pipits arrive at Bowdoin Refuge in late April and begin nesting in mid-May (Jones et al. 2010). A long-term study of grassland birds at the refuge found that pipits used nest sites with intermediately tall (averaging 12 inches), vertically dense, vegetation and nest patches (16-foot-radius plot around the nest) with greater litter cover and depth, while avoiding areas with prickly pear cactus (Dieni

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Sprague's Pipit

and Jones 2003). This is similar to what has been reported in other published studies such as that by Sutter (1997). The pipits selected areas with less than 20-percent clubmoss cover, few shrubs, and little bare ground (Dieni and Jones 2003).

According to the Sprague's Pipit Conservation Plan (Jones 2010), management should consist of the following:

- Keep large native prairie grasslands intact
- Remove woody vegetation from the interior of grassland patches
- Increase patch size and minimize the amount of edge habitat
- Remove exotic plant species from native prairie
- Apply prescribed fire (with frequency highly dependent on soil productivity, geographic area, and climate, particularly in the drier portions of their range)
- Use low-intensity or no grazing in the semiarid mixed-grass prairie

Wetlands

Wetlands are classified using several attributes—vegetation, water regimes (the length of time water occupies a specific area), and water chemistry. Wetland vegetation refers to plants that grow in water or in soils that are saturated for most of the growing season. Emergent plants are those rooted in the substrate and having foliage that grows partially or entirely above the water surface. Some emergent plants found on the refuge complex are broadleaf cattail, alkali bulrush, hardstem bulrush, common three-square, and smartweed. Other notable species that occur along the shores of lakes and marshes include pickleweed and saltgrass. Submergent plants are those having roots in the substrate but do not emerge above the surface of the water, except some that have floating leaves. Submergent plants found in refuge complex wetlands include northern watermilfoil, widgeongrass, sago pondweed, and flatstem pondweed. Many wetland plants have broad salt tolerances and can be found in freshwater and saline wetlands; however, species richness for both emergents and submergents decreases as salinity increases (Johnson 1990). In a study conducted on Bowdoin Refuge in 1987 and 1988, five species of emergent plants and six species of submergent plants were found in freshwater wetlands, but only one emergent species and four submergent species were found in saline wetlands (Johnson 1990).

In 1971, Stewart and Kantrud developed a wetland classification system to differentiate and describe natural and modified wetland basins (or ponds) and lakes in the Prairie Pothole Region and also reflects seasonal, regional, and local variations in the environment. Stewart and Kantrud's (1971) investigations indicated that the use of prairie ponds and lakes by waterfowl is strongly influenced by water permanence, depth, and chemistry and by land use. They also stated any marked variations in wetlands are usually reflected in differences in life form, cover interspersion, species composition, and species dominance. Differences in vegetation are easily discernible in the field and are the principle criteria for the Stewart and Kantrud (1971) classification system.

Seven major classes of wetlands of natural basins are recognized based on ecological differentiation. Each class is distinguished by the vegetation zone occurring in the central or deepest part and occupying 5 percent or more of the total wetland area (Stewart and Kantrud 1971). Four wetland classes are found on the refuge complex: temporary, seasonal, semipermanent, and permanent.

- The primary function of temporary wetland basins is to provide isolation for breeding pairs of waterfowl and supply invertebrate foods early in

the nesting period (Kantrud et al. 1989). The rapid warming of these shallow wetlands in the spring results in early development of invertebrate populations (Swanson et al. 1974).

- Seasonal wetland basins are a major source of invertebrate protein for laying female ducks early in the breeding season, and these basins provide isolation for paired waterfowl and sites for overwater nests (Kantrud et al. 1989). During wet years, seasonal wetlands are also highly attractive as breeding habitat (Talent et al. 1982) and molting areas. They usually receive considerable use by spring-migrating waterfowl and shorebirds but normally are dry by fall.

- Semipermanent wetland basins supply most of the needs of common prairie-nesting waterfowl and their broods. Use of semipermanent wetlands by breeding waterfowl seems to be greatest when amounts of emergent cover and open water are approximately equal (Weller and Spatcher 1965). They are the last to become ice-free in the spring and, therefore, are not an early source of invertebrate foods for waterfowl and shorebirds. In addition, semipermanent wetlands are the main habitat for staging and fall-migrating waterfowl (Kantrud et al. 1989).

- Permanent wetlands remain flooded throughout the year. Due to year-round flooding, permanent wetlands support a diverse, but usually not abundant, population of invertebrates. Submerged aquatic vegetation may occur if adequate water clarity exists. These wetlands are important in mid- to late summer when other wetlands may dry up and when ducks are molting their flight feathers; the deep water and dense cover provide protection from predators.

Across the entire Bowdoin Refuge Complex, wetlands are diverse in size and type including the following: permanent wetlands (4,544 acres); semipermanent wetlands (1,016 acres); and seasonal or temporary wetlands (1,900 acres). Most of these wetlands are found on Bowdoin Refuge including the largest, Lake Bowdoin (refer to figure 28).

Many of the wetlands on Bowdoin Refuge have been sampled and fall into the following salinity classes defined by Stewart and Kantrud (1971):

- *Slightly brackish (320–1,280 mg/L salinity)*—Black Coulee Pond, Display Pond, Farm Ponds, and Lakeside

- *Moderately brackish (1,280–3,200 mg/L)*—Goose Island Pond, Patrol Road Pond, and Strater Pond

- *Brackish (3,200–9,600 mg/L)*—Dry Lake Pond, Piping Plover Pond, and Drumbo Pond

- *Subsaline (9,600–28,800 mg/L)*—Lake Bowdoin

These wetlands have a diverse distribution of sizes, types, locations, and associations; according to Service data, there are more than 10,000 acres of wetlands in the refuge complex. The chemistry of surface waters in these wetlands tends to be dynamic because of interactions among numerous factors, such as the position of the wetland in relation to ground water flow systems, chemical composition of ground water, surrounding land uses, and climate (LaBalugh et al. 2004, Swanson et al. 1988).

Invasive and Nonnative Species in Wetlands

The refuge complex has several invasive, wetland-loving, plant species such as *Phragmites* (reed), Russian olive, perennial pepperweed, saltcedar, and reed canarygrass. Although the Service has been working to control these invaders through an integrated pest management program, these species are very hardy, spread rapidly, and easily outcompete the more vulnerable, native, wetland plant species.

Phragmites. Samples of *Phragmites* plants were collected from Bowdoin Refuge and Beaver Creek WPA in 2005 and sent to Cornell University for identification. The refuge sample was identified as a native species. However, the sample from the waterfowl production area was identified as an introduced species; the Service is currently conducting control methods to stop the spread of this small, 1-acre infestation.

Russian Olive. Russian olive trees were planted on Bowdoin National Wildlife Refuge in the 1950s until the 1970s, under the belief that they were beneficial to the landscape and wildlife. Over the years, the trees have encroached into wetland edges and along canals and ditches, making it difficult for refuge staff to maintain these water delivery systems. Russian olive grows well in wet-saline environments and is shade tolerant; as a result, Russian olive trees have become established in the understory of the native cottonwood trees that surround several refuge wetlands and saline areas throughout the refuge complex. Russian olive trees were encroaching into the eastern end of Bowdoin Refuge, in drainages and around small wetlands. Control of Russian olive on the refuge began in 2000 with tree cutting and treating the stumps with an herbicide (Arsenal® or Garlon® 3A); in some treated areas, the remaining tree stumps sprouted and readily propagated, becoming difficult for the refuge staff to control. The Service began by removing these single, scattered trees, and then turned its attention to larger, older infesta-

tions. Labor-intensive, but effective, control methods combined with a lack of staff has slowed progress in reducing the infestation.

Perennial Pepperweed. In 2004, an infestation of perennial pepperweed was discovered on the Big Island dike road at Bowdoin Refuge. The pepperweed has spread into the surrounding wetlands, and the size of the infestation varies depending on water levels. The infestation has been mapped and chemically treated every year.

Saltcedar. One saltcedar tree was discovered growing on the east end of Bowdoin Refuge in 2007 and was cut down and treated with herbicide. In 2009, an infestation was discovered in the northern wetlands of Beaver Creek WPA; the area was surveyed and all saltcedar plants found were documented using Global Positioning System (GPS) and sprayed with herbicide. No saltcedar was found in 2010. Constant monitoring and repeated treatments will be needed to prevent further spread.

Reed Canarygrass. This grass has been present in the refuge complex for many years with almost no attention given to estimating the size of canarygrass infestations or treating them.

Wetlands within Bowdoin Refuge

Lake Bowdoin at full pool is a 4,470-acre natural, subsaline, permanent wetland that, during the early history of Bowdoin Refuge, was modified to create additional wetland habitat for migratory birds and to prevent outbreaks of avian botulism. With Montana's hot, dry climate, the lake has an evaporation loss of more than 2 feet annually. Most of the water in Lake Bowdoin evaporates during the summer, leaving a small pool of water in the deepest portion of the lake or drying completely in some years. In years when only a small pool of water was left, there would be an outbreak of avian botulism, killing thousands of waterfowl and other migratory birds in one season. Modifications to the lake consisted of installing two water control structures and a dike system or auto tour road (which acts as a dike) around the southern portion of the lake, and two low water or "Texas crossings." This infrastructure holds delivered water and captures runoff and Beaver Creek floodwaters.

Lake Bowdoin attracts thousands of ducks, swans, and geese during the spring and fall migrations. The lake provides breeding and nesting habitat for overwater nesters such as white-faced ibis, Franklin's gull, black tern, eared grebe, lesser scaup, and redhead. The islands in the lake as well as its shoreline provide breeding and nesting habitat for American white pelican, great blue heron, northern pintail, mallard, Wilson's phalarope, marbled godwit, and willet. In late summer and early fall, Lake Bowdoin affords quality roosting habitat for thousands of migrant Canada geese, ducks, and sandhill cranes.

All of the wetlands can be manipulated by water deliveries and or water control structures to produce valuable migration, breeding, feeding, and nesting habitat for migratory birds. The corresponding bird use is generally quite diverse.

Dry Lake is a large natural wetland; the 1,019-acre lake is a brackish (somewhat salty), shallow, and seasonal wetland. Dry Lake was modified to create additional wetland habitat for migratory birds by installing one water control structure, a 4-mile dike along the lake's entire length, and two low water or "Texas crossings." Being a shallow seasonal wetland, Dry Lake goes dry most years. The infrastructure was constructed to hold as much delivered water as possible and to capture as much runoff and Beaver Creek floodwaters as possible. When at least 50-percent full, Dry Lake attracts a tremendous diversity of shorebirds and waterfowl, particularly during spring migration. It can also be significant wetland habitat for shorebirds and waterfowl during fall migration when delivered water is available from the Malta Irrigation District.

When Piping Plover Pond is at least half full, it attracts a diversity of shorebirds, particularly during May and from July through September. These shorebird species have included the threatened piping plover, which was last documented nesting along the shoreline in 1999.

Patrol Road Pond (4 acres) and Strater Pond (17 acres) are permanent, moderately brackish wetlands, because they are difficult to manage for migratory birds due to ground-water seepage and irrigation return flows from neighboring private lands. These wetlands have been modified by levees and water control structures to capture water and provide habitat for migratory birds. These wetlands act as deepwater impoundments with emergent vegetation such as bulrush and cattails and are important nesting, brood-

Mike Artmann / USFWS

This "Texas crossing" on the eastern end of Dry Lake is a water control structure that also serves as a road.

Mike Artmann / USFWS

This bay structure allows water into Dry Lake from Lake Bowdoin via the conveyance channel.

rearing, and feeding sites for diving duck species such as canvasback, redhead, and lesser scaup. The emergent vegetation provides escape cover, shelter, and nesting sites for these species as well as marsh wren, blackbirds, coot, eared grebe, and sora rail.

Black Coulee Pond (8 acres), Lakeside Extension (46 acres), Lakeside Pond (296 acres), Lower Farm Pond (5 acres), and Upper Farm Pond (15 acres) are slightly brackish, semipermanent wetlands. Water levels in these wetlands can be manipulated with timely water deliveries and water control structures to mimic natural wetland conditions. These conditions provide important, diverse wetland habitat for breeding, feeding, roosting, and brood rearing by waterfowl species such as northern pintail, mallard, lesser scaup, and eared grebe. In addition, the ponds' emergent vegetation is cover for nesting black terns, blackbirds, marsh wrens, and white-faced ibises. The shoreline can provide important foraging habitat for shorebirds during spring and fall migrations and during the breeding and nesting seasons.

George F. Russell / USDA–NRCS PLANTS Database

Broadleaf cattail is an emergent plant species in wetland habitat.

Drumbo Pond is a 207-acre natural, brackish, semipermanent wetland. Water levels in this unit can be manipulated with timely water deliveries and by two water control structures to mimic natural wetland conditions and to provide diverse wetland habitat for migratory birds. This wetland is also affected by the uncontrolled entry of irrigation return flows from neighboring private lands. Although the Service cannot control this flow of water into the pond, the Service can manipulate the water control structures to accomplish its wetland habitat management goal. Aquatic vegetation such as sago pondweed and widgeongrass grows profusely and provides valuable food for tundra swans, coots, and waterfowl such as canvasbacks and wigeons. Drumbo Pond provides important spring and fall migration habitat for waterfowl such as northern pintail and tundra swan, as well as shorebirds such as Wilson's phalarope and marbled godwit. Waterfowl species such as mallard and lesser scaup find important breeding, feeding,

Mike Artmann / USFWS

Clumps of Baltic rush (middleground) and bulrush (background) grow on the southern tip of Lakeside unit, an area that floods when the refuge pumps water in the spring.

roosting, and brood-rearing habitat at the pond. In addition, the pond's emergent vegetation is cover for nesting black terns, blackbirds, marsh wrens, and white-faced ibises.

Wetlands within Bowdoin District

Wetlands habitat in the Bowdoin Wetland Management District are predominantly seasonal wetland basins. The Service manages some of these basins by delivering water and manipulating the levels by using water control structures and dams. Riparian habitat and intermittent prairie streams are also found on the district. There are 1,391 acres of wetlands on Service-owned land in the district including the following:

- 45 acres of permanent wetlands
- 449 acres of semipermanent wetlands
- 881 acres of seasonal or temporary wetlands
- 16 acres of riverine or intermittent wetlands

Some of these wetlands are created and others have been enhanced by the construction of an earthen dam. Wetlands that can receive delivered water—by either pumping or gravity flows or whose water levels are influenced by water control structures—are considered managed wetlands. There are currently 928 acres of managed wetlands.

Temporary wetlands at the wetland management district are areas where the wet meadow zone dominates the deepest part of the wetland area. A peripheral low-prairie zone is usually present. Wet meadow vegetation occupies the central areas of many of the shallower pond basins and commonly occurs as a peripheral band in most of the deeper ponds and lakes. Most of the more numerous plant species in the normal emergent phase are fine-textured grasses, rushes, and sedges of relatively low stature. Wet meadow zones in the central areas of shallow pond basins are restricted to fresh or slightly brackish wetlands. Examples of temporary wetlands that the Service manages are Pearce WPA (basins P11 and P12), McNeil Slough WPA (Jack's Pond and Pintail Pond), and Beaver Creek WPA (Bergum Ponds).

Seasonal ponds are the shallow-marsh zones that dominate the deepest part of the wetlands. Peripheral wet meadow and low-prairie zones are usually present. Shallow-marsh vegetation dominates the central areas of pond basins that normally maintain surface water for an extended period in spring and early summer but frequently are dry during late summer and fall. In shallow alkali ponds, it may occur as a band between wet meadow and intermittent alkali zones. Examples of seasonal managed wetlands in the wetland management district are Pearce WPA (P4), Beaver Creek WPA (Beaver Creek oxbow and the North Cell and South Cell wetlands), and McNeil Slough WPA (Bruce's, Dowitcher, Woodduck, and Fidelity Ponds).

Semipermanent ponds are where the deep-marsh zone dominates the deepest part of the wetland area. Shallow-marsh, wet meadow, and low-prairie zones are usually present, and isolated marginal pockets of fen zones (bog zones) occasionally occur. Deep-marsh vegetation dominates the central areas of pond basins that ordinarily maintain surface water throughout the spring and summer and frequently maintain surface

water into fall and winter. Occasionally in deeper ponds with other zones, a narrow border of surrounding low prairie is inundated during unusually high water. Examples of semipermanent managed wetlands in the wetland management district are Pearce WPA (Upper Slough and Big wetland), Beaver Creek (Masters Oxbow and unnamed tributary), and McNeil Slough WPA (Turtle Pond and Bureau of Reclamation Ponds).

R.A. Howard / USDA–NRCS PLANTS Database

Widgeongrass is a submergent plant species, which grows completely under water.

Wetland-Associated Wildlife

Many mammals use wetlands and surrounding vegetation for water and cover but muskrats, mink, raccoon, and beaver are those most commonly associated with the lakes and wetlands in the refuge complex.

There have been no formal amphibian or reptile surveys in the refuge complex, but wetland species that have been recorded on Bowdoin Refuge include leopard frog, chorus frog, and painted turtle.

Due to the shallow nature of prairie lakes and wetlands, they may be dry for several months to several years. As a result, many refuge complex wetlands do not support fish. In 2002 and 2003, a fish-trapping study was conducted on Bowdoin Refuge on several small wetlands (Display Pond, Bowdoin Intake Canal, and Black Coulee Pond); carp, fathead minnow, spottail shiner, white sucker, yellow perch, brassy minnow, and brook stickleback were documented.

Wetlands normally carry high insect (invertebrate) populations. Nesting waterfowl, waterfowl broods, marsh birds, waterbirds, and shorebirds are highly dependent on these protein food sources for healthy, vigorous growth. Common aquatic macroinvertebrates documented on the Bowdoin Refuge are midges, scuds, water boatman, snails, damselflies, mayflies, and water fleas (Johnson 1990). The same insect species may be found in fresh and saline wetlands, but the total diversity decreases with increased salinity (Johnson 1990).

Concentrations of thousands of migrating shorebirds are found throughout most of the refuge complex, particularly in drier years when low water levels leave large areas of exposed shoreline. Thirty-seven species of shorebirds have been observed in the refuge complex; of these, 13 species including the spotted sandpiper and threatened piping plover will breed in the refuge complex (refer to "Appendix H–Species Lists"). In 2002, Bowdoin National Wildlife Refuge was designated as a site of regional importance by the Western Hemisphere Shorebird Reserve Network. It was given this distinction for documenting at least 20,000 shorebirds using the refuge annually or at least 1 percent of the biogeographic population for a species (Western Hemisphere Shorebird Reserve Network 2009).

As part of the central flyway, wetlands in the refuge complex are used by many waterfowl species as important stopover sites on migration routes (refer to "Appendix H–Species Lists"). Other bird species are common around the wetlands, such as sora rail, black-necked stilt, American avocet, yellow-headed blackbird, and marsh wren. Lake Bowdoin provides habitat for colonial-nesting and overwater-nesting waterbirds including western grebe, eared grebe, American coot, white-faced ibis, black-crown night-heron, American bittern, ring-billed gull, double-crested cormorant, great blue heron, and American white pelican.

Target Waterbirds

The Service has identified a diverse group of target waterbird species for wetlands: northern pintail, mallard, redhead, tundra swan, marbled godwit, Wilson's phalarope, white-faced ibis, and Franklin's gull. The life history needs of these species are described below.

Northern Pintail. The northern pintail is the most widely distributed dabbling duck (surface feeder) in the Northern Hemisphere. It frequents lakes, rivers, marshes, and ponds in grasslands, and areas where water is lined with trees are avoided (DeGraaf et al. 1991, Johnsgard 1979, Madge and Burn 1988).

Pintails have a tendency to avoid areas that are flooded too deeply if shallow sites are also present. These ducks feed in shallow waters of marshes, ponds, and wet meadows or in grain fields, consuming seeds, roots, and leaves of aquatic plants, emergents, and many terrestrial plants (Belrose 1980, DeGraaf et al. 1991). Specifically, plants commonly eaten by pintails include pondweeds, sedges, smartweed, fall panicum, brownseed paspalum, panic grass, bulrush, widgeongrass, chufa, and saltgrass (Belrose 1980, DeGraaf et al. 1991). Many well-managed wetlands have the potential to provide an abundant supply of high-energy and nutritionally complete foods for pintails when water depths are less than 18 inches and preferably less than 6 inches. Optimal foraging depth is less than or equal to 18 inches. Water more than 18 inches can still provide important roost sites and give security from predators (Fredrickson 1991).

Pintails regularly breed in the shortgrass prairies of the northern United States and southern Canada and are especially attracted to large expanses of shallow open water where visibility is good and small seeds and invertebrates are readily available (Fredrickson 1991). These ducks migrate early in spring and move northward as soon as wetlands become ice-free (Fredrickson 1991). On the Bowdoin Refuge Complex, pintails typically arrive in early March, and they normally initiate nesting earlier in the spring and summer than other dabblers. The first nests appear in early April during normal years, and nesting activity peaks during the first 2 weeks of May. The preferred nesting habitat is short grass where temporary ponds are abundant nearby. The highest nesting densities occur in open habitats where vegetation is low and sparse such as areas dominated by prairie grasses, whitetop, nettle, spikerush, rushes, and buckbrush or snowberry (Fredrickson 1991). The northern pintail builds its nest in a hollow on dry ground, generally within 300 feet of water (Madge and Burn 1988, Musgrove and Musgrove 1943). Grazing programs that leave good residue ground cover but remove robust growth can enhance nesting cover for pintails (Fredrickson 1991).

Mallard. Another dabbler, the mallard is one of the most familiar of ducks found throughout North America. Mallards use all wetland habitat types and depend on wetland areas and the associated upland habitats to survive. They feed on insects and larvae, aquatic invertebrates, seeds, acorns, aquatic vegetation, and grain. They are well adapted to eating both natural and domestic foods such as waste grain from crop harvests. Most of their diet is made up of wetland plants and grains such as wheat, barley, rice and oats (Montana Field Guide (no date(b)).

Mallards tend to leave their wintering areas early to reach the breeding grounds, usually departing in February and March. Migration periods in the Bozeman, Montana, area occur from February 25 to April 20 and from October 15 to January 1, with peaks on March 20 and December 1 (Skaar 1969). On the Bowdoin Refuge Complex, mallards typically arrive the first week in March. Among dabbling ducks, the mallard is one of the latest fall migrants. In the northern tier of States (like Montana), local breeding populations of mallards are not appreciably augmented by more northerly birds until early October. Peak population numbers are reached in early November and begin to gradually decline as the season changes and waters begin to freeze.

Mallard hens prefer to nest in dense vegetation about 24 inches high, regardless of other cover qualities. The mallard begins to nest between April 10 and April 30 over vast reaches of its breeding range (Belrose 1980). Each spring, the female mallard's diet switches from plants to aquatic invertebrates. This diet provides her with the nutrition and energy she needs to lay and incubate a clutch of eggs. Mallard duck eggs usually hatch from late April to late May. As soon as the ducklings are dry, within the first 12 hours of hatching, the hen mallard leads them to water (Belrose 1980).

Redhead. The redhead is a diving duck found in shallow freshwater lakes, ponds, and marshes (Belrose 1980). The redhead is a breeding bird of the northern prairies and associated parklands and the intermountain marshes of western Montana (Belrose 1980). The largest populations of breeding birds are found in South Dakota and western Montana as well as Canada (Belrose 1980). They prefer semipermanent to permanently flooded wetlands that support persistent emergent vegetation.

Redheads obtain their food by diving in water 3.3–9.8 feet deep, but they can dive as deep as 45.9 feet. They feed in shallow waters by tipping up so they can reach the bottom from the surface. Ninety percent of their diet is plants and the other 10 percent are animals. The redhead's diet consists of pondweed seeds, tubers, leaves, muskgrass, bulrush seeds, wild celery, duckweeds, water lily seeds, sedges, grasses, wild rice, widgeongrass, and coontail. During spring migration and the breeding season, adult redheads are opportunistic and omnivorous. In the spring in North Dakota and Canada, redheads forage in large, deep, open areas (more than 1 acre) with submersed aquatic vegetation; they feed primarily on protein-rich invertebrates, including *Diptera* larvae and *Trichoptera* (more than 50 percent by volume). Much of their remaining diet consists of bulrush seeds and

sago pondweed buds (less than or equal to 15 percent by volume) (Custer 1993). In fall and winter, they primarily eat leaves, stems, seeds, and tubers of aquatic plants, mostly submergents, with smaller amounts of aquatic insects (Custer 1993).

Most redheads depart wintering areas in the Laguna Madre of Texas within 2 weeks in early March and from the Atlantic Coast in mid-March. They are considered midseason migrants, because they migrate later than species such as mallard and northern pintail (Custer 1993). They reach breeding areas in the northern prairies of the United States in early April and numbers rapidly increase through the month (Belrose 1980); however, they typically arrive on the Bowdoin Refuge Complex as early as the second week in March. Redheads begin to appear on migration areas adjacent to their breeding grounds in September, reach peak numbers by mid-October, and are largely gone by mid-November (Belrose 1980).

The redhead uses smaller, shallower permanent to semipermanent wetlands with blocks of dense emergent vegetation for nesting—laying and incubating eggs (Custer 1993). Many nest studies reveal that redheads have a strong preference for hardstem bulrush beds over other types of vegetation, with cattails a second choice and sedges third (Belrose 1980). Deeper water with invertebrates or shallow water with moist-soil plants should be made available during the prelaying period. Water levels should be kept constant during the laying and incubation periods to reduce losses of clutches from flooding or from predators if the area becomes too dry. Recently flooded areas with high invertebrate populations should be available during the first few weeks of the brood period and should be followed by access to deeper water with ample pondweeds (Custer 1993).

Tundra Swan. The tundra swan, once known as the whistling swan in North America, is the most numerous and widespread of the two swan species native to this continent. Tundra swans are attracted to large open wetlands for roosting and foraging (Earnst 1994). Its long neck allows it to feed in water up to 3.3 feet deep as it forages in shallow ponds, lakes, and riverine marshes. The swan will also feed in harvested agricultural fields and fields growing winter cereal grain. Tundra swans prefer wetlands containing sago pondweed regardless of wetland size or extent of open water (Limpert and Earnst 1994). Tubers and seed of the sago pondweed were the exclusive diet of swans collected in the Great Salt Lake marshes (Sherwood 1960).

Tundra swans migrate in flocks comprised of family groups or in small flocks comprised of several families and some nonbreeders. The swans begin to leave their wintering grounds and push northward with the first spring thaw in March. Tundra swans arrive on Bowdoin Refuge in the spring as early as mid-March and are gone by the end of the month. A large portion of the eastern population of tundra swans migrates through the central flyway in fall and spring, primarily through the province of Saskatchewan and the States of Montana, North Dakota, and South Dakota. Staging areas are confined to southern Saskatchewan,

John and Karen Hollingsworth / USFWS

Northern Pintail

Gene Nieminen / USFWS

Mallard Pair

Donna Dewhurst / USFWS

Redheads feed in large, open areas.

Mike Artmann / USFWS

Tundra swan, Canada goose, and other waterfowl species at Lake Bowdoin.

northeastern Montana, large portions of North Dakota, and northeastern South Dakota (Vrtiska et al. 1999). They leave their major breeding grounds in Alaska in late September and early October (Belrose 1980). They appear again on Bowdoin Refuge in the fall, around the last week in September and depart by mid- to late November. Censuses of tundra swans at Freezeout Lake, Montana, made by Dale Witt from 1963 to 1969 revealed that the swans start arriving early October, build up to peak numbers by the end of the month or early November, and depart rapidly thereafter.

Marbled Godwit. The marbled godwit is a large shorebird with a long, upturned bill. Most nest in prairies of north-central United States and south-central Canada (midcontinental population). Within these grasslands, godwits require complexes of wetlands that represent a broad diversity of sizes and types—ranging from temporary to permanent (Melcher et al. 2006, Ryan et al. 1984). Godwits feed at water depths of 2–5 inches and in dry years, when temporary wetlands are limiting, the birds will shift to semipermanent wetlands. Such shifts underscore the need for conserving wetland complexes as opposed to single wetlands (Melcher et al. 2006).

Northbound migration for the midcontinental population peaks from late April to mid-May, with later peaks generally occurring at more northern latitudes. Godwits typically arrive on the Bowdoin Refuge Complex the third week in April. Typical of most shorebirds, the marbled godwit's southbound migration is quite drawn out. Suspected nonbreeders and unsuccessful breeders begin to form large flocks at staging sites within core areas of the breeding range as early as the first week of June. By late June and early July, successful breeders and, later, juveniles join staging flocks. Godwits may continue moving southward into November, although southbound migration peaks in mid-July to mid-September (Melcher et al. 2006).

The godwit breeds in the center of North America and winters along the coasts (Gratto-Trevor 2000). It is not well-known whether, or how, godwit breeding distributions are affected by annual changes in climatic or other conditions. Bowdoin Refuge data shows that banded individuals come back to the same location in subsequent breeding seasons. They will nest on occasion in tamegrass habitats, including hayfields and idle pastures (Ryan et al. 1984), especially if the vegetative structure is similar to that of native, shortgrass habitats. Typically, nesting birds avoid dense grass cover and rarely nest in croplands or stubble fields (Dechant et al. 2003). Adults with broods, however, are often found near taller grass (6–24 inches) than that used for nesting, which provides escape cover and protection from exposure (Ryan et al. 1984). Godwits in the midcontinental breeding range appear to prefer large, contiguous blocks of habitat (Melcher et al. 2006). They nest on the ground in native prairie areas, a considerable distance from water (Montana Field Guide (no date (c)). Most authorities agree that marbled godwits in the midcontinental breeding range nest preferentially in sparse (less than 75-percent canopy coverage) to moderately (more than 75-percent canopy coverage) vegetated, native shortgrass (less than 6 inches) habitats—often grazed or recently idled from grazing (Melcher et al. 2006).

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Marbled Godwit

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Wilson's phalarope is a small "wader."

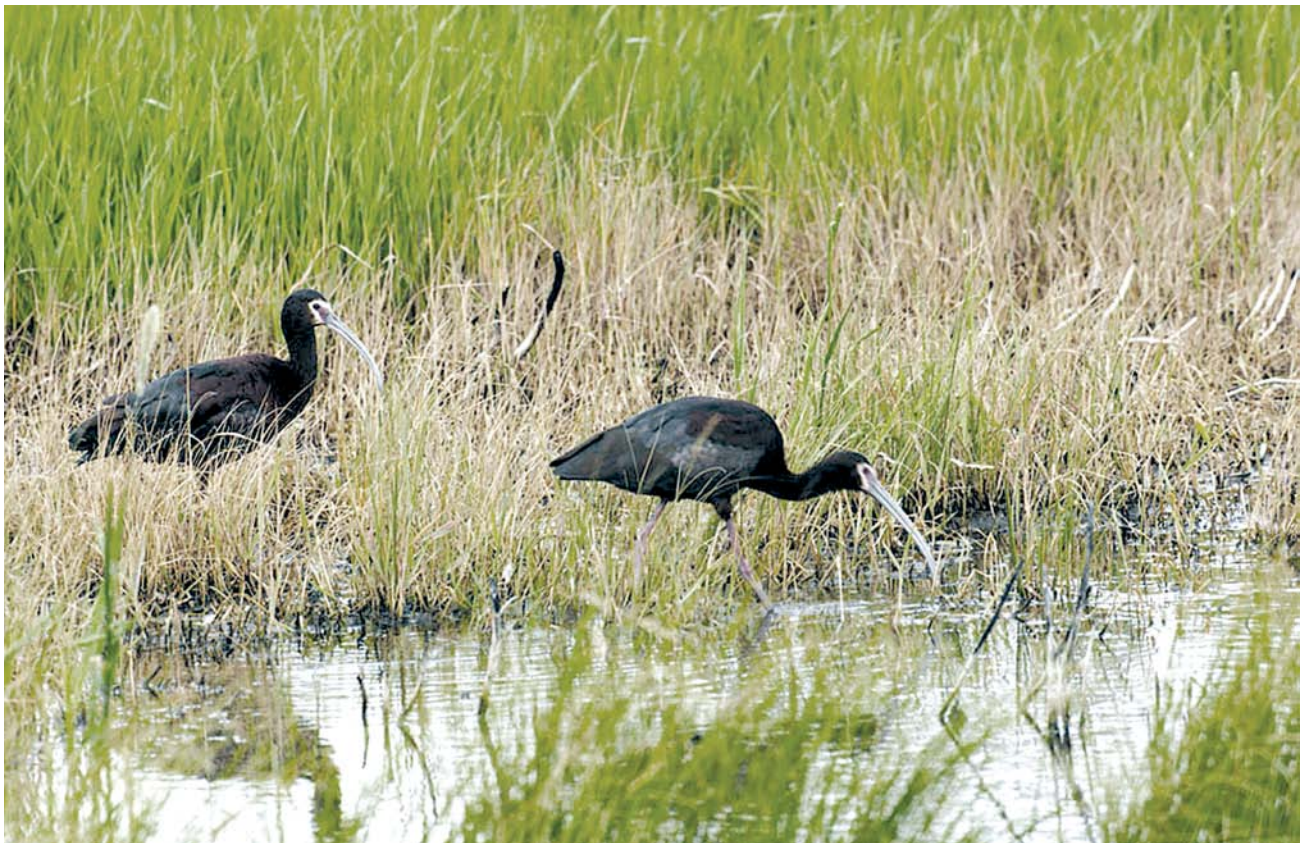
Wilson's Phalarope. Wilson's phalaropes are small wading birds that use both fresh and alkali wetlands with three characteristics: open water, emergent vegetation, and open shoreline (Hohn 1967, Naugle 1997, Prescott et al. 1995, Saunders 1914, Stewart 1975, Stewart and Kantrud 1965). Phalarope need protected wetland complexes with both seasonal and semipermanent wetlands to provide suitable habitat during both wet and dry years (Colwell and Oring 1988b, Kantrud and Stewart 1984). The phalarope feeds by swimming or "spinning" or walking along the shoreline of shallow grassy ponds or lakes and picking insects and crustaceans from the surface (Johns 1969). On its breeding grounds, Wilson's phalarope forages on open water and flooded meadows, less frequently in upland habitats and along beaches (Colwell and Jehl 1994).

Wilson's phalarope usually appears on the breeding grounds of Montana during the first week of May. In the central and northern Great Plains (Minnesota, Nebraska, and North Dakota), Wilson's phalaropes arrive on the breeding grounds from mid-April to early May and depart from mid-August to early September (Howe 1972, Johnsgard 1980, Murray 1983, Roberts 1932). Females arrive on the breeding grounds earlier than males (Colwell 1987, Reynolds et al. 1986) and commonly depart from breeding areas earlier than males, usually from early June to early July (Colwell 1987; Colwell and Oring 1988a,c; Dechant et al. 2003; Hohn 1967; Howe 1972). Typically, phalaropes begin arriving on the Bowdoin Refuge Complex the last week in April.

Wilson's phalarope begins nesting in June in sparse to dense vegetation. Its nest is a grass-lined depression. Nesting habitat varies widely and includes wetlands, wet meadows, upland grasslands, and road rights-of-way (Bent 1962, Bomberger 1984, Colwell 1987, Colwell and Oring 1990, Dinsmore and Schuster 1997, Einemann 1991, Faanes and Lingle 1995, Hohn 1967, Murray 1983, Roberts 1932, Stewart 1975). Phalarope need wet meadows near deeper wetlands during the breeding season (Colwell and Oring 1988b). This may make it easier for adults to move young from nests to wetlands by decreasing overland travel distance. Nest site selection varies seasonally—the birds nest in upland vegetation early in the breeding season and in wet meadow vegetation later in the season (Colwell and Oring 1990). They usually nest no more than 328 feet from shorelines (Colwell and Oring 1990, Eldridge 1992, Hatch 1971, Hohn 1967). Burning can be used to improve nesting habitat (Eldridge 1992). In pastures that contain wetlands important to breeding Wilson's phalaropes, grazing should be deferred until after July 15 (Prescott et al. 1993). Idle grasslands and previously grazed areas provide habitat for nesting, but areas with cattle present during the breeding season are less suitable (Kantrud and Higgins 1992, Renken 1983, Renken and Dinsmore 1987).

White-faced Ibis. Much larger than the phalarope, the white-faced ibis is a wader that probes deep in the mud with its long bill and feeds in shallow water or on the water surface (Cogswell 1977). Ibises typically feed on crayfish, frogs, fishes, insects, newts, earthworms, and crustaceans in freshwater marshes (Terres 1980). In the Central Valley of California they preferentially selected foraging sites with biomass that is significantly higher for midges (Chironomidae) and significantly lower for earthworms (Safran et al. 2000).

Most white-faced ibis arrive in Montana in May (Montana Bird Distribution 2002); however, they typically arrive on the Bowdoin Refuge Complex the third week in April. In late summer they disperse throughout the State before beginning the fall migration to their wintering habitat (Ryder and Manry 1994). Most begin their southern movement in August, and by September they are usually gone from the State (Montana Bird Distribution 2002).



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White-faced ibis are large wading birds.

Breeding habitat is typically freshwater wetlands including ponds and marshes with pockets of emergent vegetation. The white-faced ibis also uses flooded hay meadows and agricultural fields as feeding locations. Ibises nest in areas where water surrounds emergent vegetation, bushes, shrubs, or low trees. In Montana, they use old stems in cattails, hardstem bulrush or alkali bulrush over shallow water as their nesting habitat (DuBois 1989). Water conditions usually determine whether nesting occurs in a particular area; therefore, ibis nesting sites can often move around from year to year. White-faced ibis is a fairly adaptable species but does require colony and roosting site isolation. Nesting colonies are often shared with black-crowned night-herons and Franklin's gulls.

Franklin's Gull. A small gull found in the wetlands of the interior of North America, the Franklin's gull is listed in Montana as a species of concern. It prefers large, relatively permanent, prairie marsh complexes. The gulls feed on insects, earthworms, fish, mice, and seeds. It forages while walking in fields, swimming, or in dense flocks in fields being cultivated by a plow. It is also very adept at catching flying insects on the wing (Burger and Gochfeld 1994). At Freezeout Lake, Montana, stomach contents of Franklin's gulls included insects, earthworms, spiders, unidentified vertebrates, and plant material believed to be taken incidentally to consuming animals (Montana Field Guide (no date (a)).

Franklin's gulls return to Montana, including the Bowdoin Refuge Complex, in mid-April and are gone by early to mid-October. In Montana, the extreme migration dates for this species are April 4, (recorded in 1971 at Benton Lake Refuge (Casey 2000) and October 11, recorded in 1955 at Medicine Lake Refuge (Montana Field Guide (no date (a), Reichel 1996).

The gull nests in colonies and builds its nests over water on a supporting structure of emergent vegetation including cattails and bulrushes (Burger and Gochfeld 1994). Typical water depth is 12–24 inches. One key feature of selected nesting sites is water levels that remain high enough throughout the nesting period, or at least until the young can fledge, to provide protection from predators (Casey 2000, Montana Field Guide (no date(a)). Breeding is localized and occurs mainly in the northern portion of States in the plains region (Montana, North Dakota, South Dakota, and western Minnesota), prairie region of Canada, and in the Southwest (Nevada). According to the Western Colonial Waterbird Survey, from 2009 to 2011, Franklin's gulls were known to nest in five locations in Montana, averaging 8,097 breeding pairs, with 8,100 documented in 2011 (Wightman et al. 2011). Median colony size during the survey period was estimated at 1,200 breeding pairs while colony

size ranged from 16 to 4,833 breeding pairs (Wightman and Tilly 2011). Between 2009 and 2011, it is estimated that Bowdoin Refuge contained an average of 1,765 breeding pairs (ranging 1,025–2,450) or about 21.8 percent of Montana's breeding population (Wightman et al. 2011).

Avian Disease

The Bowdoin Refuge has a history of botulism outbreaks dating back to pre-refuge establishment, but efforts to document the severity and exact location of die-offs were not recorded until the 1940s. Botulism has been documented in Lake Bowdoin, Drumbo Pond, Lakeside, Dry Lake, and the Dry Lake Canal. Outbreaks generally begin in early to mid-July and may last into September. The numbers of waterfowl affected has varied greatly from year to year, while the location of disease hotspots—areas with the highest mortalities—has changed little. These hotspots are in the southwestern and southeastern bays of Lake Bowdoin, the northeast shore of Big Island in Lake Bowdoin, and the northwest portion of Drumbo Pond.

The first confirmed cases of West Nile virus in Phillips County, Montana, were documented in 2003. A small number of horses and humans became ill and unknown numbers were exposed to the virus. Many people reported finding dead birds of various species throughout the area. In early August 2003, a sudden die-off of pelicans was observed on Lake Bowdoin; sample carcasses sent in to the National Wildlife Health Center tested positive for West Nile virus. The disease has been documented in the area every year since this time, but the number of cases have varied greatly. Outbreaks have begun as early as mid-July and can last into fall when colder nighttime temperatures control the mosquito population.

Highly pathogenic avian influenza has not yet been documented in North America but, because of the serious health risks to humans and domestic fowl, the Service has entered into an interagency agreement to develop an early detection system should this influenza migrate to the continent.

The refuge complex staff completed a Disease Contingency Plan in 2006 for the Bowdoin National Wildlife Refuge Complex. This plan will be reviewed annually and updated as new information becomes available.

Riparian Areas

According to Montana's Comprehensive Fish and Wildlife Conservation Strategy, riparian areas support the greatest concentration of plants and animals yet only constitute 4 percent of Montana's land cover (Montana Fish, Wildlife & Parks 2005). Plant species composition in riparian areas is influenced largely by water quality, water permanence, and soils.

The Bowdoin National Wildlife Refuge Complex manages two waterfowl production areas that are either bordered or crossed by riparian habitat: Beaver Creek WPA and McNeil Slough WPA. Beaver Creek, which flows through portions of Beaver Creek WPA, can be classified as a mixed riparian area—"riparian areas dominated by a mix of shrub and herbaceous species, with codominance of shrub and grass species present and tree cover is less than 15 percent" (Montana Fish, Wildlife & Parks 2005). Western wheatgrass, bluejoint reedgrass, rose, willow, silver sage, and snowberry are common plants along Beaver Creek. The Milk River, which borders McNeil Slough WPA, is classified as a broadleaf riparian area "dominated by broadleaf (cottonwood) forest, with total tree cover from 20 to 100 percent" (Montana Fish, Wildlife & Parks 2005). Associated shrub species are alder, bunchberry, serviceberry, thimbleberry, common chokecherry, and willow. Some of the more common invasive and nonnative plants found in riparian areas are Russian olive, Canada thistle, and leafy spurge.

Riparian Area–Associated Wildlife

Across the State, there are 149 bird species, 22 mammal species, 16 amphibian species, and 6 reptile species that depend on riparian and wetland habitat for breeding and survival. An additional 72 species of wildlife regularly use these habitats and benefit from riparian and wetland conservation (Sullivan 2008).

Birds observed on and near McNeil Slough WPA include raptors such as golden eagle, red-tailed hawk, northern goshawk, American kestrel, snowy owl, and western screech-owl. A great variety of passerines (perching birds and songbirds) use riparian habitat, including northern flicker, western wood-pewee, gray catbird, brown thrasher, cedar waxwing, loggerhead shrike, yellow warbler, and Baltimore oriole.

Although assessments of the refuge complex's riparian areas have not been completed, a small mammal-trapping survey was conducted in 2004 on a State-owned wildlife management area near McNeil Slough WPA. The study found little brown myotis, silver-haired bat, deer mouse, northern grasshopper mouse, western jumping mouse, striped skunk, and three species of vole (Carson et al. 2004). Other mammals that use riparian areas are white-tailed deer, beaver, raccoon, porcupine, and red fox.

In 2000 and 2001, fish surveys in Beaver Creek on Beaver Creek WPA documented the presence of fathead minnow, black bullhead, carp, yellow perch, brook stickleback, pumpkinseed, white sucker, brassy minnow, black crappie, spottail shiner, and smallmouth bass.

3.3 Salinity Background

This section contains basic information about salts, quantification and classification of salinity, and principal salts at Bowdoin Refuge. Background about the salt balance covers the historical and current situations.

Salt Basics

The salt balance concept refers to the balance between the amount of salt entering a waterbody, in this case, Lake Bowdoin, and the amount of salt exiting. Over time, this salt inflow and outflow should be roughly equal to ensure the stability and resiliency of the lake system. A stable system increases the probability that plant and animal communities, which have adapted to this localized and sometimes highly variable system, remain within tolerable ranges and, thus, remain healthy and productive. If the system is not in balance, the concentration of salts is either increasing or decreasing depending on the direction of the imbalance. The magnitude of the salt imbalance is ultimately reflected in the diversity of (or lack of) plant and animal communities that are supported, as well as the number of viable management options to restore balance to the system.

Except for pure distilled water, all water has dissolved minerals or trace elements present in varying concentrations. These minerals (or salts) and trace elements are present within all landscapes in the underlying geology and soils as well as in precipitation that falls over an area. In many areas where precipitation does not exceed evaporation—which includes the arid climate of eastern Montana—the process of evaporation is a leading natural cause of concentrating salts in a system.

Donna Dewhurst / USFWS

Salinity can decrease the diversity of the wetland vegetation and the invertebrates that ducks like mallards rely on.

Evapoconcentration is the process of concentrating salts or trace elements (solids) in a liquid due to evaporation. When water evaporates during the hot, dry summer months, the solids remain in the water. As the volume of water is reduced by evaporation, the concentrations of these solids increase. In general, salinity concentrations are at their lowest during the spring after snowmelt and at their highest at summer's end. Salts that precipitate out of water during the evaporative process are often seen on the soil surface as white salt residues or crystals. When these salts fully dry and are exposed to strong winds,

Mike Artmann / USFWS

Salt residue accumulates at the southeastern outflow area of Lake Bowdoin.

some particles become airborne and are transported out of the system by the wind. At Bowdoin Refuge, these conditions create the blowing salts events. The process of salts blowing out of a system is natural and is one way that a salt balance was maintained historically, especially during times of significant drought. Salts that do not blow away are re-dissolved when precipitation returns and water levels rise.

In wetland systems that are "closed basins"—which means there is no natural outflow due to topographic features or some other barrier—the evapoconcentration process greatly affects the overall water chemistry and resulting water quality. For example, the Great Salt Lake, located in an arid landscape in northern Utah, is the largest natural lake west of the Mississippi River and is a closed basin. It is naturally salty due to evapoconcentration. There is no outflow, thus salts are only removed from the system through wind or through artificial removal activities. As a result, salt concentrations are two to eight times greater than the world's oceans.

In comparison, a "flow-through system" is not closed—the water moves through the system before evaporation can accumulate the salts carried in the water to elevated concentrations. The Milk River, like all streams and rivers, is a flow-through system. Although salts do not accumulate like those in a closed system, salt concentrations vary depending on where the stream sits in relation to its overall watershed. Typically, salt concentrations are higher farther down in the watershed. In the case of the Milk River, concentrations are considerably higher where the Milk River empties into the Missouri River east of Nashua, Montana, compared with the headwaters area north of Browning, Montana. This is from the continual addition of salts and other minerals to the river as the water moves downstream in the watershed.

Quantification of Salinity

The concentration of salts present in the water and the underlying soils of Lake Bowdoin can be measured, quantified, and described. Typically, the concentration of salt in water is expressed as a measure of "total dissolved solids," which comprise inorganic salts—principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates—and small amounts of organic matter present in water. The measure of total dissolved solids, or TDS, is often reported as parts per thousand (ppt), percent, milligrams per liter, or total mass in grams. One way to measure the TDS is to take a water sample, evaporate the water, and weigh the remaining solids. This is the most accurate method to obtain TDS, but it is very time-consuming, expensive, and requires laboratory-type equipment; thus, this method's utility for field testing and monitoring is limited.

Another way to measure TDS, which is quicker and less expensive and currently used by refuge staff, is to find out the electrical conductivity (or specific conductance) of water. The electrical conductivity (EC) is directly related to the concentration of dissolved ionized solids in the water. Ions from the dissolved solids enable water to conduct an electrical current, which can be measured with a conductivity meter. EC is reported in microSiemens per centimeter (µS/cm), milliSiemens (mS), or millimhos (mmhos). The relationship between EC and TDS is largely linear, thus conversion factors between EC and TDS are well understood. The following equation makes the conversion between EC and TDS (Tchobanoglous and Burton 1991):

$$(\mu S/cm)\times(0.64 \text{ of EC})=mg/L \text{ of TDS}$$

Salts in a waterbody are described by total weight, typically in tons. The total weight of salts is calculated by multiplying the concentration of salts in the water by the weight of the water. Weight of 1 acre-foot of water is approximately 1,360 tons.

$$(mg/L)\times(\text{weight of water})/1{,}000{,}000=\text{tons of salts}$$

Therefore, the water delivered by the Malta Irrigation District to Bowdoin Refuge averages about 500 mg/L TDS. Subsequently, for every 1,000 acre-feet of water delivered at that concentration, approximately 680 tons of salts are added to Lake Bowdoin.

$$(500 \text{ mg/L}\times1{,}360{,}000 \text{ tons})/1{,}000{,}000=680 \text{ tons of salts}$$

Describing the salts by weight is useful, because the concentration of salts can vary considerably since concentrations depend on both the total amount of salts and the total amount of water. The total amount of water can fluctuate widely in a single year due to evaporation and water deliveries, which causes the salt concentrations to fluctuate. By evaluating only the total weight of salts, the seasonal variations shown in concentrations are removed, and general trends such as the salt removal rate are easier to evaluate.

Throughout this chapter, mg/L is used in reference to TDS to represent the salinity concentration. However, for the modeling conducted to analyze which alternative would be most effective at balancing salt, the total weight in tons was used as the measure to describe the amount of salts entering and exiting the refuge.

Classification of Salinity

Lake Bowdoin, like all of the wetlands on the refuge, can be described and classified in terms of its average

salinity concentration. It is helpful to classify wetlands based on their salinity, because there has been considerable research describing the effect of varying salinity concentrations in terms of plant and animal communities and their tolerances to changing salinity. Entirely different plant and invertebrate communities thrive at varying salinity concentrations. In general, the higher the salinity concentration, the less diverse the communities tend to be (Gleason et al. 2009).

Refuge staff and others have been monitoring water quality in the wetlands since the late 1970s. A lot of information has been collected on salinity and how concentrations change with varying climatic conditions at the refuge. In 2009, Lake Bowdoin had an average salinity concentration of 10,500 mg/L. Following the salinity classification scheme displayed in table 6 (Stewart and Kantrud 1972), this concentration places the lake in the subsaline (second most concentrated) class.

Interestingly, monitoring data shows that even within Lake Bowdoin, considerable variation in salinity concentrations exists. For example, the east side of the lake is typically more salty (1,000–2,000 mg/L more concentrated) than the west side. This is due almost entirely to the inflows of fresher water from the Black Coulee drainage and the Dodson South Canal on the west side of the lake.

Figure 28 shows the locations of the monitoring sites on and off the refuge, along with the infrastructure for water management in and between the refuge wetlands. Flow-through wetlands like Black Coulee Pond on the west side of the refuge and Lakeside and the Farm Ponds on the east side, rarely exceed 1,250 mg/L as water and salt pass through to Lake Bowdoin or Dry Lake, respectively. In addition, monitoring data shows that salinity concentrations tend to be lowest in the spring and highest in the late summer due to the evapoconcentration process.

Most of the refuge wetlands are less saline than Lake Bowdoin and fall into other salinity classes according to Stewart and Kantrud (1971), as follows:

- *Slightly Brackish*—Black Coulee Pond, Display Pond, Farm Ponds, and Lakeside
- *Moderately Brackish*—Goose Island Pond, Patrol Road Pond, Teal Pond Complex, and Strater Pond
- *Brackish*—Dry Lake Pond, Piping Plover Pond, and Drumbo Pond
- *Subsaline*—Lake Bowdoin

Mike Artmann / USFWS

With the fresher water it receives, Black Coulee Pond supports a greater amount of cattail than in more saline wetlands.

Table 6. Salinity categories and the corresponding ranges of specific conductance values.

Salinity category	*Conductance*[1] *(µS/cm⁻¹)*	*Concentrations of dissolved solids—salts*[2] *(mg/L⁻¹)*	*(ppt)*
Fresh	0–500	0–320	0–0.3
Slightly brackish	500–2,000	320–1,280	0.3–1.3
Moderately brackish	2,000–5,000	1,280–3,200	1.3–3.2
Brackish	5,000–15,000	3,200–9,600	3.2–9.6
Subsaline	15,000–45,000	9,600–28,800	9.6–28.8
Saline	>45,000	>28,800	>28.8

Principal Salts at Bowdoin Refuge

The principal salts at Bowdoin Refuge are sodium sulfate, sodium bicarbonate, calcium carbonate, calcium sulfate, and magnesium sulfate; minor amounts of chloride and fluoride salts are also present (Bauder et al. 2007, Gleason et al. 2009). These salts are largely derived from the soils and underlying geology that compose this area of Montana. Geologic history indicates that Lake Bowdoin is an old oxbow of the Missouri River channel that was pushed far to the south during the advancement of the last glaciers, about 15,000 years ago (Alden 1932).

The predominant soils on the refuge are clays and clay–loams. The most common clay-loam associations are Phillips–Elloam, Phillips–Kevin, Arvada–Bone, Scobey–Phillips, and Kevin–Sunburst. These soils range from mildly to strongly alkaline; soluble calcium and sodium salts are dispersed in much of the soil profile. The presence of these soluble salts contributes to the alkaline nature of refuge wetlands, in particular Lake Bowdoin. Delivered water from the Milk River via the Dodson South Canal also contains these primary salts. Although these salts occur in relatively low concentrations in the delivered water (typically less than 500 mg/L), the total volume of water is high; therefore, the total tons of salts is high. In addition, saline seeps occur as water moves through the soil profile and exits at the surface near and along the west and north shoreline of Lake Bowdoin.

Mike Artmann / USFWS

Open water in the southern bay of Lake Bowdoin in spring (May 2007).

Mike Artmann / USFWS

The (same) southern bay of Lake Bowdoin in fall (October 2007). Concentrated salt crystallized on top of very shallow water and was susceptible to blowing.

Presettlement Salt Balance

To understand how the salt balance has been lost or altered over time, it is important to look at how it was maintained in the past. For the salt load to balance over time, incoming salts must be removed (or moved through the lake system) in roughly equal proportions, either by flushing or by the wind when water levels are low and salts precipitate out. There is little doubt that Lake Bowdoin functioned as a flow-through system during spring runoff and high-precipitation events. The flow-through nature of the system was essential to maintaining the lake's salt balance, as was the removal of salts by the wind during times of drought.

Historical evidence, in the form of a General Land Office (GLO) survey, helps shed light on how the system functioned in the past (figure 29). The GLO survey, which divided the landscape into 1-square-mile sections, was completed in 1892 and approved in 1893 for the area near Malta including the refuge. This survey included the Great Northern Railway, which

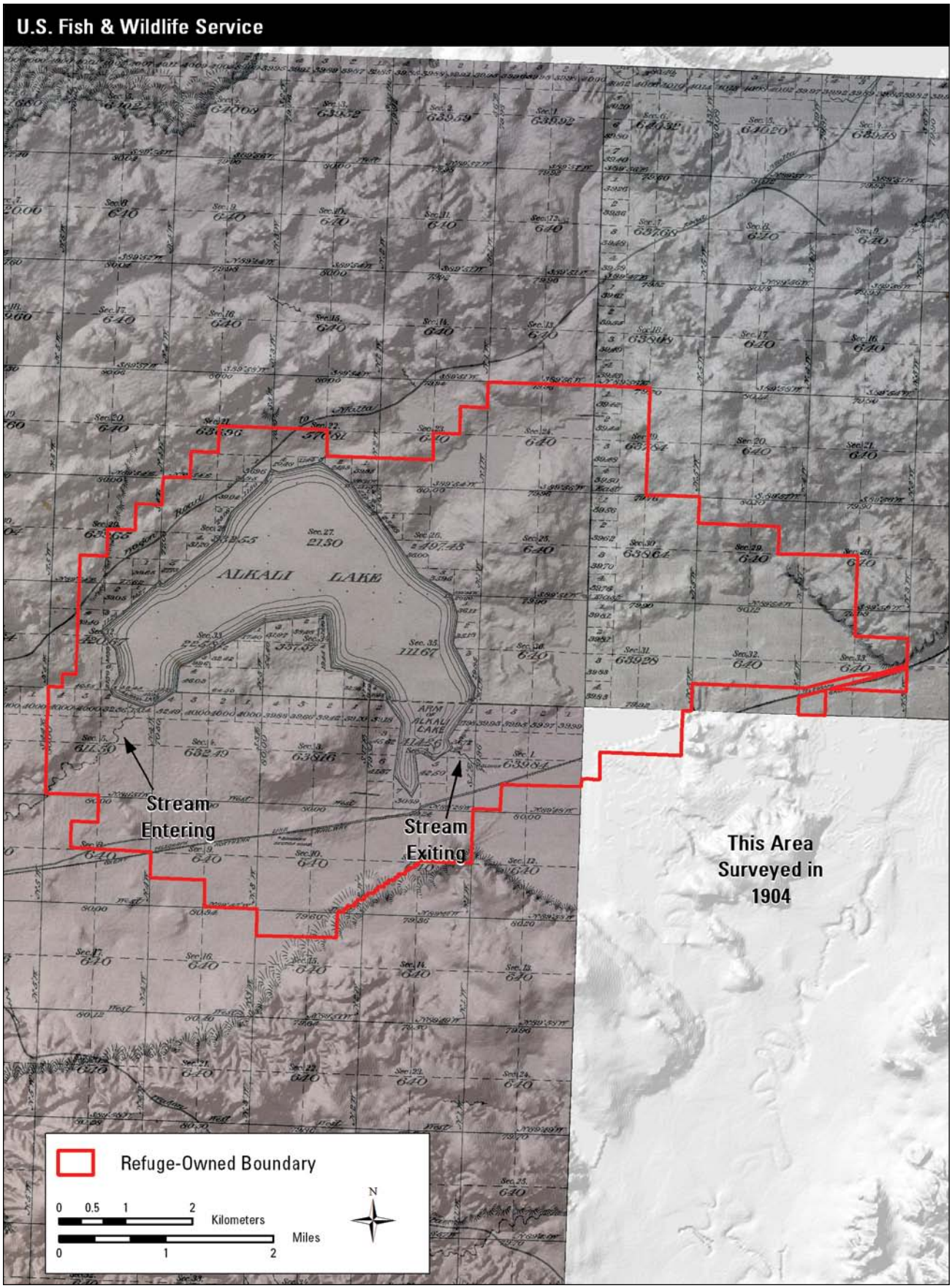

Figure 29. Map of a historical survey showing the location of Bowdoin Refuge on the topographic features of the landscape. *Source: General Land Office, 1892.*

was constructed just a couple years prior in 1887. In addition, the survey shows that Lake Bowdoin was originally called "Alkali Lake" (figure 29), undoubtedly in direct reference to the alkaline characteristics of the water and soils of the lake. Interestingly, there is no mention or depiction of marsh or lake habitat in the current locations of Dry Lake or Drumbo Pond.

The GLO survey shows a stream entering Alkali Lake (Lake Bowdoin) on the west side in the general location where the Black Coulee drainage enters today. It is drawn on the map as a dashed line, suggesting the stream was intermittent. This makes sense given the arid climate of the area (less than 12.5 inches in precipitation per year). The volume of water entering the lake through this stream is, of course, unknown. However, the drainage area does span to a low divide near the Milk River to the west and includes many smaller coulees coming from the hills to the south. It is likely that, during heavy rainstorms or deep snow years, this stream carried a considerable flow into the lake. Likewise, a stream is depicted exiting the lake in the southeast side near the present-day southeast arm of the lake. Based on local topography downstream of this outflow point, any outflow would have flowed into Beaver Creek following a relatively similar path as occurs today.

As mapped in 1892, the overall size of Lake Bowdoin was about 40 percent smaller than it is today; surface acres were approximately 2,885 acres. At a smaller surface area, and with a smaller volume, historically the lake would have exited at a lower elevation than it does today. In addition to spilling at a lower elevation, even small floods from Beaver Creek would have likely entered and exited the lake (from the east) and, in doing so, removed salts with it as a flood moved downstream. During very large flood events, like the one in 1986, water entered the lake from several directions and extensively flushed salts downstream. Following large floods, the lake may have remained in a fresher state longer than normal, because the large influx of fresh water would have removed large quantities of salts.

Historically, the inputs of water and salts have come from precipitation, local runoff, Black Coulee drainage inflows, and Beaver Creek floods (likely the largest water inputs). The flow-through nature of Lake Bowdoin was critical to maintaining the salt balance. Wind also likely played an important role in removing salts when water levels were very low during droughts. Over time, this cyclical input and removal of water and salts from Lake Bowdoin maintained a brackish lake system, which supported a greater diversity of plant and animal communities than exists today.

Postsettlement Salt Balance

Why are salts "out-of-balance" at Lake Bowdoin? Simply put, significant development and changes in the last 100 years have altered the inputs and outputs of water and salts that maintain the lake's salt balance. Many of these changes occurred decades before the Milk River Project (described below) and subsequent establishment of Bowdoin National Wildlife Refuge in 1936. The combination of a modified landscape and reduced flooding continues to contribute to increased salinity levels. Below is a summary of the major changes that affected the processes controlling the salt balance in Lake Bowdoin:

- *Hydrologic Barriers*: The Great Northern Railway (1887) and early roads and dikes (1900) altered water flow into and out of the lakes.

- *Irrigation Inputs*: Starting in 1915, increased water from the Milk River Project (described below) west and south of the refuge added more water and salts to the lake. Without a consistent outflow mechanism, salts continue to increase.

- *Refuge Management*: Following refuge establishment, there was an emphasis on water conservation for wildlife during the 1930s. The Service built higher dikes, retained water longer to benefit wildlife, and developed new sources of water.

- *Beaver Creek Development*: Also during the 1930s, increased water development in the Beaver Creek watershed lowered the frequency of flooding, which greatly reduced the primary mechanism for removing salts.

Railroad and Early Settlers

This area of northeastern Montana is commonly referred to as the "Hi-Line" of Montana, which includes the northern tier of counties. The Milk River watershed was largely unsettled by Europeans settlers before completion of the Great Northern Railway in the late 1880s and early 1890s. The railroad passed through Malta around 1887, reaching Havre in 1890 and its final destination, the west coast of the United States, in 1893. Regional industry and trade centers quickly grew around the railroad as goods, services, and people could now be moved quickly between locations. A post office was established in Malta in 1890. The 1892 GLO survey helped in the distribution of lands to homesteaders.

The railroad was a tremendously successful tool that propelled the area into full homesteading and economic development in the 1890s. However, the

Mike Artmann / USFWS

This railroad trestle over a wetland south of Lake Bowdoin creates a constricted waterway.

railroad effectively functioned as a hydrologic barrier to the natural movement of surface water between Lake Bowdoin and Beaver Creek. Instead of water flowing unimpeded during floods as it had previously, water now funneled through a series of railroad trestles, bridges, and culverts to flow in and out of the lake. It is very likely that smaller floods, which would have entered Lake Bowdoin unimpeded from the east, were deflected downstream by the railroad, thereby reducing the volume of water entering the lake.

In addition to the railroad, the Brady–Bateman–Switzer Company previously owned the lands within Bowdoin Refuge. The company was a partnership between three men from Helena and Great Falls, Montana, who started a cattle and hay ranch on Beaver Creek near the town of Ashfield. The company took up 19 desert and homestead entries along Beaver Creek and attempted to irrigate the land by diverting water from Beaver Creek and Lake Bowdoin. As early as 1900, the company constructed levees and ditches between Lake Bowdoin and Dry Lake and at the outflow of Dry Lake. These structures helped to increase water storage capacity and increase capabilities for water movement between Lake Bowdoin and Dry Lake (John Simpson, hydrologist, USFWS Region 6; personal communication, 2011). The Brady ditch and structure increased the storage capacity of Dry Lake and Lake Bowdoin by effectively halting the natural flow-through nature of the system; it could also capture floodwaters from Beaver Creek for later irrigation use. GLO surveys conducted in 1904 east of the refuge delineate extensive irrigation ditches and levees built to improve water distribution along Beaver Creek for pasture and grazing lands. It is clear that Lake Bowdoin and Dry Lake were part of an active irrigation system as early as 1900, more than a decade before construction of the main infrastructure associated with the Milk River Project.

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The Brady ditch and structure changed the flow-through lake system to increase the water storage for irrigation uses.

Milk River Project

With the completion of the railroad, farmers and ranchers continued to arrive and settle throughout the Milk River watershed. Early settlers of the Milk River watershed soon realized that, in this arid climate, water was limited and often came in sporadic deluges that were not conducive to growing crops and raising livestock consistently. Dryland farming was the only means available in the absence of irrigation sources, which at the time were only available near streams and rivers. It soon became evident that a supplemental, stable supply of water was necessary if these settlers were to produce agricultural products and make a living on the landscape.

At the turn of the century, new Federal laws such as the Reclamation Act in 1902 committed the Federal Government to fund the construction and management of irrigation projects for arid lands of 20 States in the American West. To fund the construction and maintenance of irrigation projects, the act set aside money from the sale of semiarid public lands. In addition, the act established the U.S. Reclamation Service, the predecessor to the Bureau of Reclamation, to oversee the development of all irrigation projects in the West.

On March 4, 1903, the Secretary of the Interior conditionally authorized the Milk River Project, one of the first irrigation projects initiated under the Reclamation Act. The Milk River Project was one of many projects initiated during in the early 1900s to secure stable and reliable sources of water in Montana. The Milk River Project is a federally owned project that today supplies irrigation water to more than 110,300 acres in eight irrigation districts and to

approximately 200 irrigation pump contracts along the Milk River (figure 30). The authorized purpose for the Milk River Project is for irrigation; all other uses are secondary. Most of the Milk River flows used by irrigators and municipalities and for recreational and wildlife benefits comes from the Milk River Project.

Completion of the Milk River Project meant supplemental water from the St. Mary River was be available to irrigators in the Milk River watershed, which otherwise would have flowed north into Canada, and ultimately into Hudson Bay. The idea behind the Milk River Project was relatively simple: move water east across a low divide separating the St. Mary River and the Milk River watersheds (USRS 1920). A 29-mile-long facility diverts water from the St. Mary River watershed near Glacier National Park into the North Fork of the Milk River. From there, the river flows into Canada for 216 miles before returning to the United States. After reentering the United States, the water flows into two primary reservoirs for storage until needed by downstream irrigators: (1) Fresno Reservoir is 104 miles west of Bowdoin Refuge; and (2) Nelson Reservoir is 4.5 miles northeast of the refuge. The St. Mary facilities are located on the Blackfeet Reservation in Glacier County; Reclamation owns and operates the diversion facilities.

Although authorized in 1903, it took another 40 years to complete the primary infrastructure of the Milk River Project. The construction of facilities began in earnest in July 1906 with the St. Mary Storage Unit along the St. Mary River. Because both the Milk River and the St. Mary River flow from the United States into Canada, a treaty was needed for water issues related to the Milk River Project. A treaty with Great Britain (for Canada) was signed in January 1909 and proclaimed in May 1910. It took several years to complete the canal and St. Mary Storage Unit, but in 1916 water from the St. Mary River was finally diverted into the North Fork of the Milk River; however, water for irrigation became available as early as 1911 in areas along the Milk River (USBR 1920). Other early infrastructure and facilities included the following:

- Dodson Diversion Dam (January 1910)
- Dodson North Canal (1914), built on the north side of the river
- Dodson South Canal (1915), supplied by the Dodson Diversion Dam, provided water to fill Nelson Reservoir and irrigate areas south of the river and east of Dodson
- Nelson dikes (1915), enlarged starting in 1921
- Swift Current dikes (1915)
- Vandalia Diversion Dam (1917)
- Bowdoin Canal (1917)
- Lake Sherburne Dam (1921)
- Fresno Dam (1939)

Nelson Reservoir's current storage capacity is approximately 79,200 acre-feet, and Fresno Reservoir's is approximately 103,000 acre-feet. While Reclamation manages the water storage facilities, eight irrigation districts manage distribution of the water to irrigators (farmers and ranchers); the Malta, Glasgow, and Dodson districts are closest to the refuge.

At one time during the early construction history of the Milk River Project, Reclamation considered Lake Bowdoin as a potential reservoir for downstream irrigation. An early project document (1902–11) by Reclamation states:

> *"The use of Bowdoin Lake as a reservoir site in connection with the Milk River project was considered by the employees of the Geological Survey before the Reclamation Act was passed. During the fall of 1902 a survey of the lake and adjacent territory was made and for several years thereafter the plans contemplated the construction of a reservoir that would utilize the lake for storage."*

Two items had to be considered before going forward with the reservoir plan for Lake Bowdoin: (1) moving the Great Northern Railway from south of Lake Bowdoin to north of the lake, from a point near Ashfield to a point near Strater; and (2) acquiring more than 5,000 acres of land "occupied and controlled by the Brady–Bateman–Switzer Company of Great Falls." The cost of these items made the development a reservoir prohibitive. Eventually, Reclamation acquired most of the lands and the lake, and plans for using the lake as a reservoir were abandoned. Instead, plans were considered to use Lake Bowdoin "as some plan for the control of the waters of Beaver Creek." Reclamation also abandoned this plan, and instead the lake was primarily used as a sump for irrigation return flows and excess runoff from the Milk River Project.

The Milk River Project was very successful in bringing additional water, and with it economic viability and stability to lands all along the Milk River. Additional structures have been constructed, enlarged, and repaired over the last 80–90 years to improve the distribution of irrigation water and expand capabilities within the project.

In 1936, the Bowdoin National Wildlife Refuge was established as an overlay on lands owned and operated by Reclamation, with both agencies having jurisdiction. It was not until 1972 that the Service received primary jurisdiction over these lands. Bowdoin Refuge receives Milk River water through both the Dodson South Canal and the Bowdoin Canal. The Dodson South Canal provides water to lands immediately west of the refuge and is the feeder canal to Nelson Reservoir. This canal delivers water to Lake Bowdoin through the terms of a 1937 agreement between the Service and Reclamation. A sluice-type structure on the west side of the lake delivers the water; the structure was built more than two decades before the establishment of the refuge to divert irrigation return flows and excessive runoff in the canal into the lake. Unfortunately, construction of this canal intercepted the natural flow of surface water from the hills north of Lake Bowdoin. Additionally, seepage from the canal likely expanded saline seeps on the north and west shores of the lake.

The Black Coulee drainage, which drains into Lake Bowdoin, provides spring runoff and receives Milk River water as irrigation return flow supplied by the Dodson South Canal. Irrigation return flow comprises about 2,500 acre-feet annually to the refuge. The salt concentration of irrigation return flows is relatively fresh, about 500–700 mg/L. As such, the Black Coulee drainage is an important source of water for refuge habitats, especially wetlands on the west end of the refuge. However, the increased flow of water from increased irrigation capabilities brings in more salts than would likely have naturally occurred. Similarly, the Bowdoin Canal is an offshoot of the Dodson South Canal and provides irrigation water to lands south and east of the refuge, before emptying into Beaver Creek. The refuge can also receive water directly from the Bowdoin Canal into Drumbo and Goose Island Ponds. In addition, the refuge receives irrigation return flows from lands immediately adjacent to the refuge on the south side. These sources of irrigation return flow are important for the refuge. However, absent a flow-through system, they add more salts than otherwise would have been added to Lake Bowdoin, contributing to the salinity problem.

Refuge Establishment

The Bowdoin National Wildlife Refuge was established in 1936 to help restore declining waterfowl populations, which had been devastated by the loss of grassland and wetland habitats during the 1930s' Dust Bowl. It was one of many national wildlife refuges established throughout the northern Great Plains during the 1930s for migratory birds.

The Bureau of Biological Survey (a precursor to the U.S. Fish and Wildlife Service) correctly recognized the significance of Lake Bowdoin to protecting and restoring waterfowl populations in eastern Montana. The Bureau of Biological Survey began studying ways to increase the lake's water-holding capacity to provide valuable wetland habitat along with looking for ways to secure a more stable source of water for the newly formed refuge. To this end, the Secretary of the Interior (for Reclamation) and the Secretary of Agriculture (for the Bureau of Biological Survey) signed an MOA on March 9, 1937, to provide a refuge water supply from the Milk River of up to 3,500 acre-feet per year.

However, the 3,500 acre-feet was never enough water to manage Lake Bowdoin as a flow-through system. Based on the combination of the arid climate, the unpredictable water supply year to year, and the need to keep Lake Bowdoin from going dry, the Service needed to retain as much delivered water and floodwater as possible. This additional water needed to last through the summer and into the fall to provide wetland habitat for waterfowl and to prevent an outbreak of avian botulism. Except during flood years on the refuge, which allowed the flushing of salts from the lakes, Lake Bowdoin and Dry Lake were converted from a flow-through wetland system to a closed-wetland system.

During the 1930s and 1940s, the refuge received help from work crews employed through the Works Progress Administration, a Depression Era program that provided jobs on public works projects. These crews were instrumental in constructing refuge buildings and enhancing existing dikes, levees, roads, and

Mike Artmann / USFWS

Salt residue covers Dry Lake's northern bay, which supports salt-tolerant plants like bulrush and the low-growing saltgrass.

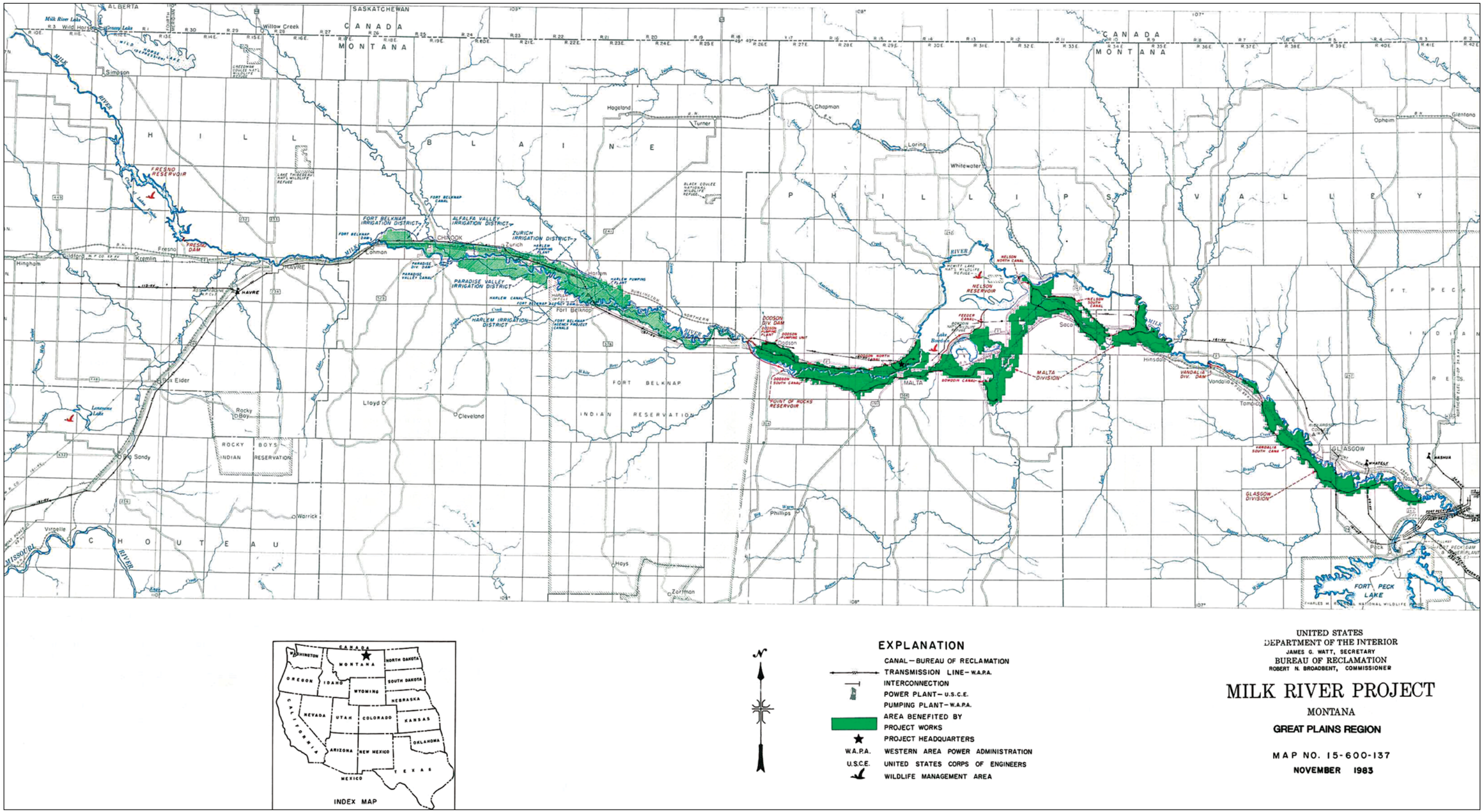

Figure 30. Map of the Milk River Project, Montana. *Source: Bureau of Reclamation, 1983.*

water control structures to impound more water. The result was improved capabilities for water storage and management on Lake Bowdoin and Dry Lake.

While there is no question that changes to increase water storage capacity and manage water levels have provided tremendous benefits to waterfowl and wetland-dependent wildlife, these changes also have been some of the many factors contributing to salt accumulation in Lake Bowdoin.

Beaver Creek Watershed

Beaver Creek has its origin in the Little Rocky Mountains south of Malta, between Zortman and Lodgepole, Montana. The watershed is 195 miles long and has a drainage area of 2,060 square miles. Floods along Beaver Creek played a significant role in flushing salts from Lake Bowdoin and, over time, helped maintain the salt balance; however, water-related developments in the watershed have significantly reduced the frequency of natural floods.

Refuge data, starting in 1937, indicates that the historical, average, flood frequency was once every 3–4 years. However, observations by refuge staff suggest that the frequency of floods since 1970 has decreased to once every 7–10 years. Only four floods have been recorded entering the refuge since 1970, the last being in 1996. It is likely that the establishment of numerous small impoundments and irrigation diversions in the Beaver Creek watershed has reduced the flood frequency on the refuge. The irrigation diversions and reservoir retention have reduced, by an estimated 45 percent, the average annual runoff in the Beaver Creek watershed upstream of Lake Bowdoin (Rodney and Mohrman 2006). Furthermore, the gradual but significant improvements in land management practices within the watershed might have contributed to the diminished magnitude and frequency of floods. Improved grazing, minimum-tillage farming, conversion of dry cropland to grass, and other innovations designed to retain rain and snowfall and use it more efficiently have reduced the runoff to Beaver Creek. The combined effect of these evolving land management practices is to reduce flood frequency, thereby inhibiting the primary mechanism for removing salts from the refuge.

Current Salt Balance

Inputs and outputs of salt affect and create the current salt balance.

Inputs of Salts

The sources of salts into Bowdoin Refuge are primarily from irrigation return flow, canal deliveries, ground water seepage, Beaver Creek floods, and rainfall. Figure 31 shows the sources of salts into the refuge and the average weight in tons per year; nearly half of the salts are from irrigation return flow. These input amounts have been developed from historical monitoring data as well as modeling to recreate the salt and water balance at the refuge.

Figure 32 shows the results from the model that estimated the total weight of salt on the refuge as a whole (Lake Bowdoin, Dry Lake, Dry Lake Pond, Drumbo Pond, and Lakeside) and Lake Bowdoin individually. There was a general increase of salts on the refuge, with Dry Lake seeing the most dramatic increase in salts. This was due to the 1990s' management practice of placing saline water on Dry Lake, which helped keep Lake Bowdoin in relative balance (figure 32). This management practice stopped in 1999, and Dry Lake has remained dry from 2000 to present except for spring runoff and rain events. Salts on the refuge decreased in the early 2000s due to the gradual loss of accumulated salts in Dry Lake from blowing away and from the onset of a drought that reduced the salt inputs. However, the salts began increasing once again since refuge managers no longer used this method to remove salts, with most concentrating in Lake Bowdoin. Under the current management plan of preventing releases into Dry Lake, the salts in Lake Bowdoin will continue to increase.

Outputs of Salts

Management actions as well as natural processes remove salts from the refuge.

Managed Removal of Salts. Past managers understood the salt imbalance and dealt with it in various ways. As shown in figure 33, various water sources add approximately 7,000 tons of salts to Lake Bowdoin in a typical year. Refuge managers have used two primary management methods to improve Lake Bowdoin's water quality and to reduce salinity concentrations:

- Discharge water into Beaver Creek (flow-through system)
- Manage Dry Lake as an evaporation basin for Lake Bowdoin (salts carried away by wind)

When water was plentiful and there were high spring flows in the Milk River and Beaver Creek drainages, past refuge managers occasionally managed Lake Bowdoin and Dry Lake as flow-through basins, flushing salts into Beaver Creek to improve water quality on the refuge. Managers made controlled releases to Beaver Creek in cooperation with downstream landowners. The releases, although rare, generally

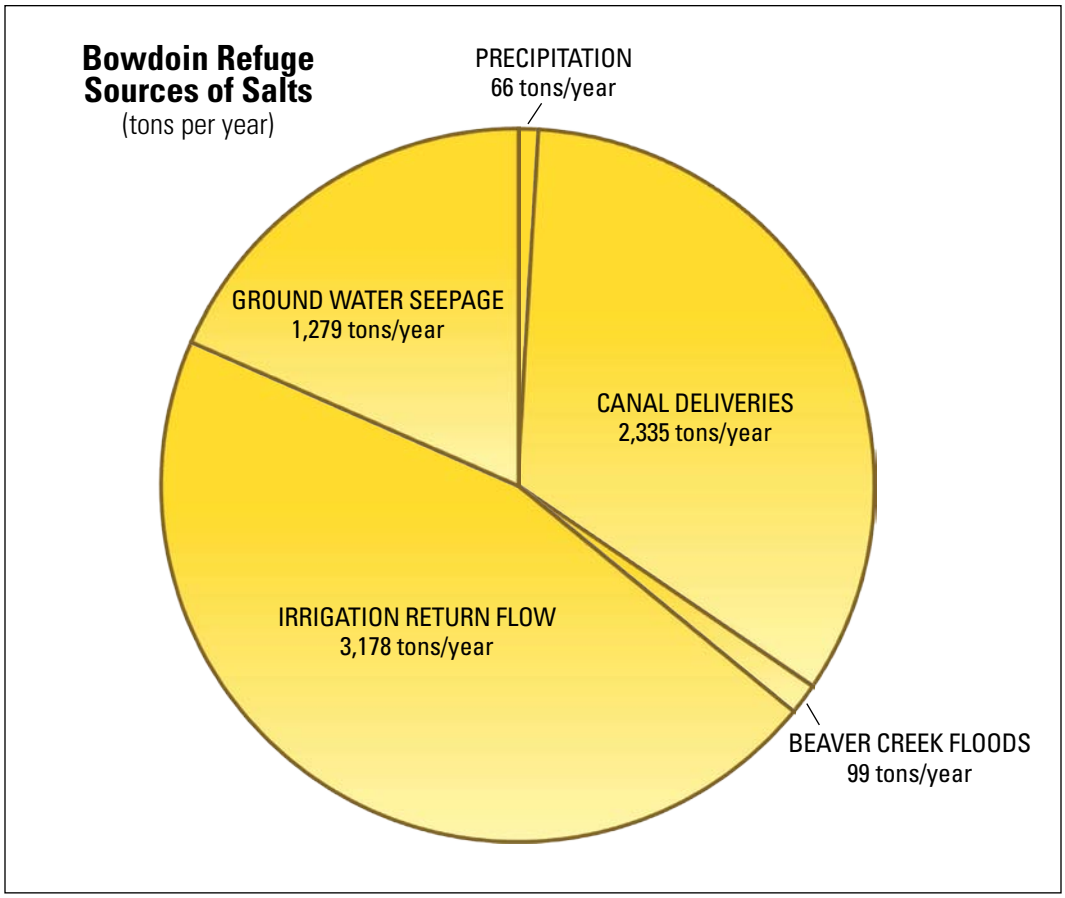

Figure 31. Chart of sources of salts into Bowdoin National Wildlife Refuge, Montana.

occurred before the start of the irrigation season to coincide with high stream flows in Beaver Creek during the spring. These high flows increased the dilution effect and discharges were within allowable limits, which minimized impacts to downstream irrigators.

However, in 1976, an accidental spill from the refuge into Beaver Creek due to failure of a water control structure occurred during the irrigation season. The Service settled the resulting lawsuit from downstream landowners claiming salts from the refuge impacted their lands. Consequently, this incident effectively stopped the Service from making future water releases into Beaver Creek; refuge staff has not intentionally released surface water from Lake Bowdoin into Beaver Creek since the late 1970s. As a result, managers needed to find another solution to deal with the increasing salinity concentrations on the refuge.

Droughts and floods in the 1980s provided a natural means of removing salts from the refuge. However, by the late 1980s and early 1990s, the Service needed to find other solutions. The solution at that time was to move salt-laden water from Lake Bowdoin to Dry Lake under the ice during the winter. This method was effective because, in the winter, the highly concentrated saltwater stays in solution (salt lowers the freezing point of water), while the fresher water separates and forms an ice layer on top. As water freezes, salts precipitate out into the water and the remaining ice contains very little salt. Refuge and State staffs recorded recent measurements of salt concentrations exceeding 30,000 mg/L under the ice. After transferring this salty water to Dry Lake, the water remained throughout the spring and summer until it finally evaporated and left behind the salt residue. High winds transported the salt particles, which eventually settled downwind on the refuge uplands or the neighboring lands to the east and southeast of the refuge. During periods of high winds, the large salt "clouds" were very visible as the salts blew away from Dry Lake. Several factors created ideal conditions for the transport of salts from Dry Lake: (1) the lake's west–east geographic orientation; (2) the length of the lake; and (3) the surrounding topography (hilly on the east side) in relation to the prevailing westerly winds. The transfer of water into Dry Lake removed salts from Lake Bowdoin—approximately 5,000 tons of salt per year, or enough to roughly balance the annual salt inputs.

Although monitoring data clearly shows that this combination of moving water to Dry Lake and blowing salts was effective in maintaining relative salt

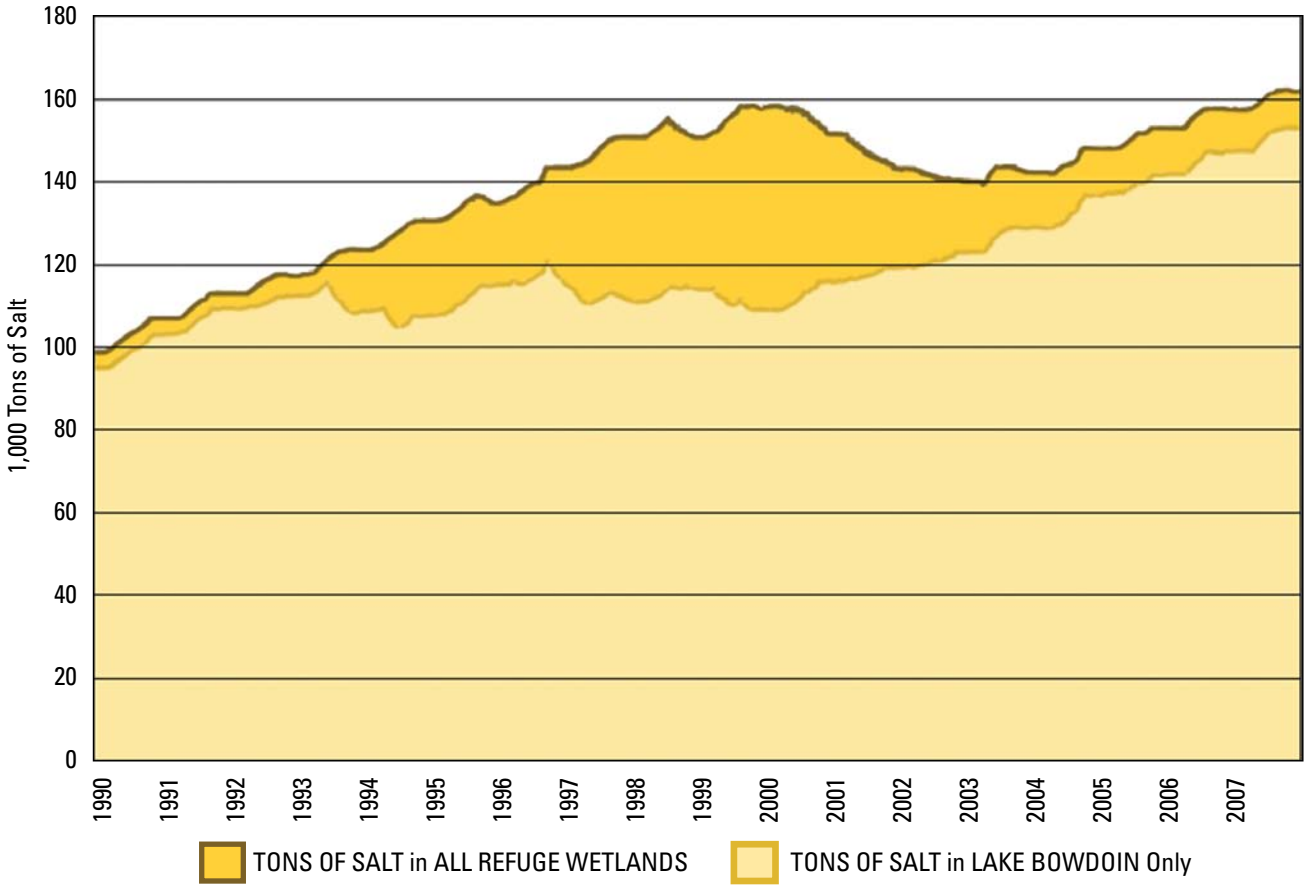

Figure 32. Graph of tons of salt in the lakes and wetlands at Bowdoin National Wildlife Refuge, Montana (1990–2007).

loads in Lake Bowdoin, Service managers no longer find it a viable option due to the effects on neighboring landowners and the effects on habitat in Dry Lake. Continually placing highly concentrated saltwater in Dry Lake for many years changed the value of the area's vegetation and habitat for wildlife. Where once sedges, rushes, and wetland grasses grew, today there are mostly weedy species such as kochia and large areas of bare soil. These effects occur across the 1,200-acre Dry Lake basin even though salty water has not been placed there since 1999.

However, it is inaccurate to say Dry Lake currently has no wildlife value, because a variety of invertebrates and birds are adapted to saline environments. For example, when the Service managed Dry Lake as a wetland unit, or transported water to the lake, and food was available, large numbers of migrating and breeding waterfowl and shorebirds used Dry Lake. Even today, a variety of wetland-dependent birds and other wildlife use Dry Lake when there is water in the lake from runoff or precipitation. During years of abundant water supply, refuge staff manages Dry Lake as a separate wetland unit without the transfer of water from Lake Bowdoin. While water transfer may be a means to provide valuable wetland habitat, managers are not willing to accept the negative effects of transferring water to Dry Lake and the resulting blowing salts.

Natural Removal of Salts. The removal of salts due to natural climatic variables such as major drought and flooding still occurs on occasion, with the most recent in the mid-1980s. These natural events are important to keeping salinity concentrations from becoming even more extreme.

For example, a significant drought from 1983 through 1985 reduced Lake Bowdoin's water level nearly in half (figure 34). Salt concentrations in the lake eventually exceeded 30,000 mg/L, some of the highest concentrations ever recorded. Because of the smaller lake size, large areas of exposed shoreline were subject to drying and the forces of the wind; there was considerable wind removal of salts during the summers of 1984 and 1985. In fall 1985, the rains returned and Lake Bowdoin began to fill up again. This combination of concentrating the salts and transporting them away by wind, followed by an influx of water, created a dramatic decrease in salt concentrations from 30,000 mg/L to approximately 2,500 mg/L in spring 1986. This natural process continued into the next year starting in spring 1986, which saw above-normal precipitation, and having high water levels all summer. In late September, a massive, widespread

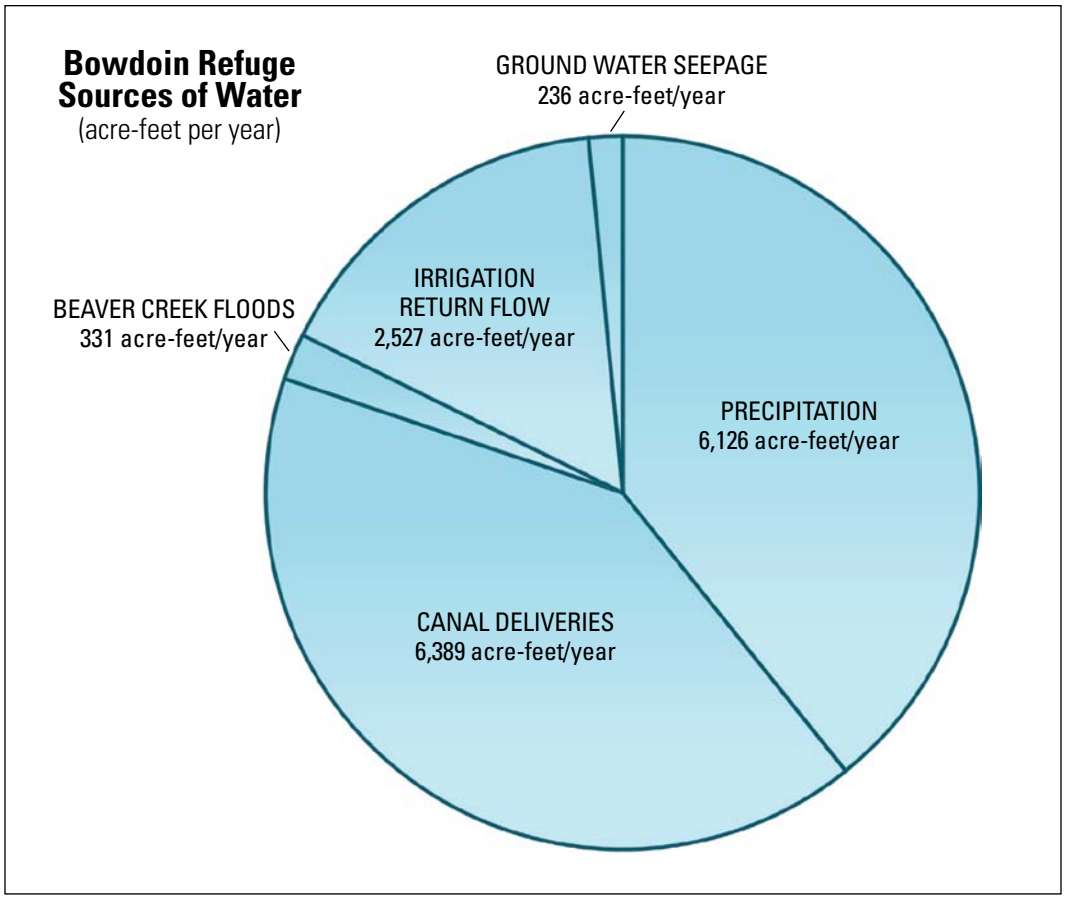

Figure 33. Chart of sources of water into Bowdoin National Wildlife Refuge, Montana.

rainstorm led to a 200-year flood episode in the Beaver Creek drainage, subsequently flooding the refuge and surrounding landscape (figure 34). This historic flood moved downstream a large amount of the salts stored in the lake and effectively lowered the salinity concentration for several years thereafter.

The natural processes of drought and flooding have a role in moving salt out of the system; however, their occurrences are unpredictable (in the case of major floods) and likely do not occur at frequencies to sustain the salt balance in the lake system.

Water Supply

The sources of water into the Bowdoin Refuge are primarily from irrigation return flow, canal deliveries, ground water seepage, Beaver Creek floods, and rainfall. As shown previously, figure 33 shows these sources and the average quantity in acre-feet by year. These input amounts have been developed from historical monitoring data as well as modeling to recreate the salt and water balance at the refuge.

Currently, the primary water right for the refuge is a right for "flood flows" from Beaver Creek. The Service can exercise this water right only during periods of high flows, which typically occur during spring runoff or after the irrigation season is over. In addition, the refuge is entitled to continue receiving all surface flows that originate in the Beaver Creek watershed and drain naturally into the refuge. However, these Beaver Creek water rights are ineffective in supplying adequate water to the refuge and in maintaining acceptable water quality because of the following: (1) senior water users downstream have priority over the refuge; and (2) there is increased development, primarily exempt stock ponds, in the upstream portion of the watershed. Consequently, the refuge is highly dependent on deliveries from the Milk River Project to meet its water needs for achieving the refuge purposes.

In addition to the Beaver Creek floodwater right, the Service's 1937 MOA with Reclamation provides for delivery of up to 3,500 acre-feet per year from the Milk River Project. In exchange for the water supply, the Service (then the Bureau of Biological Survey) agreed to contribute $40,000 toward the construction of Fresno Reservoir, which was completed in 1939. The MOA is still in effect and specifies that, during years of normal runoff, Reclamation will provide up to 3,500 acre-feet of water to the refuge each calendar year for improvement and maintenance of the refuge.

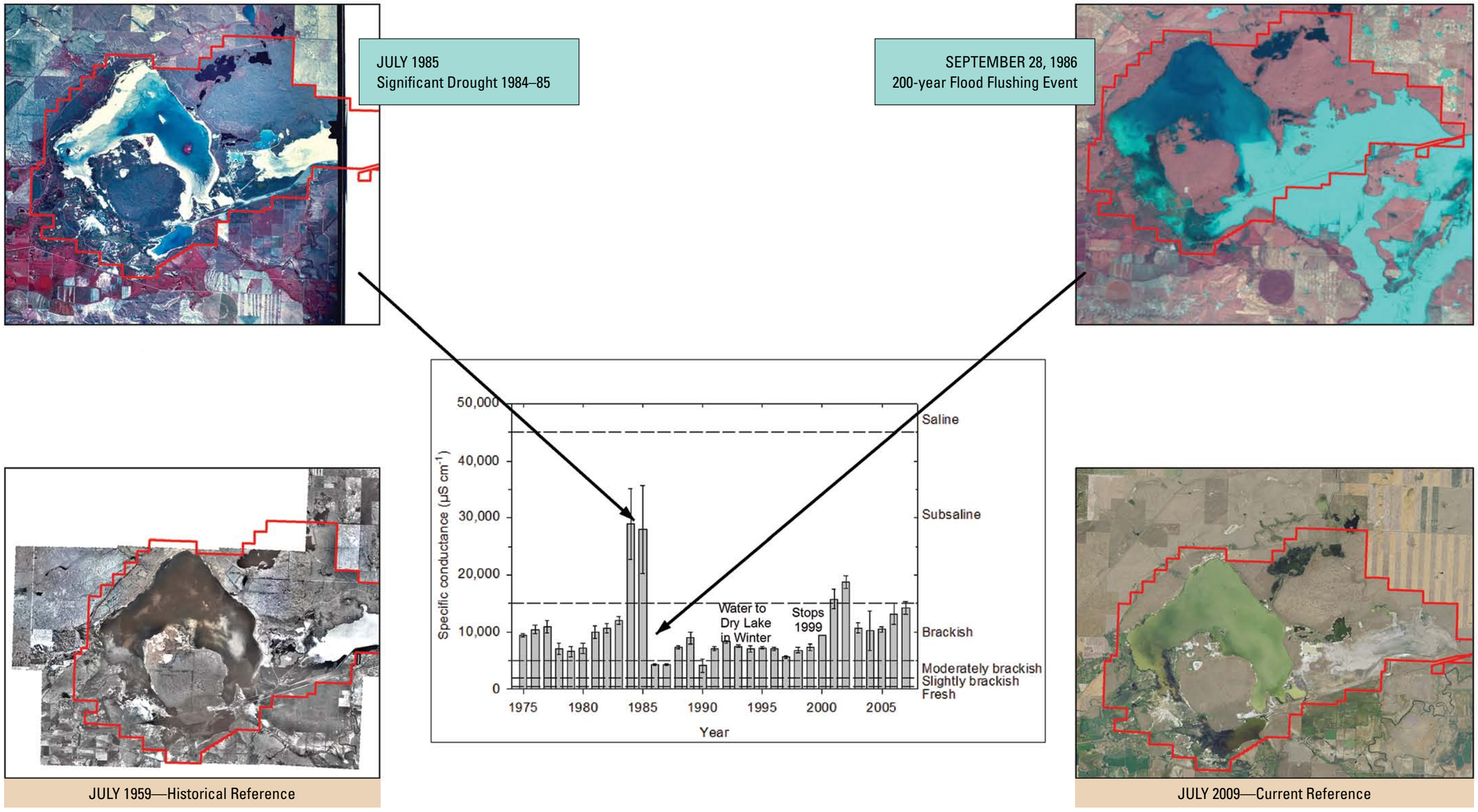

Figure 34. Map of water levels and salinity for Lake Bowdoin, Montana (1975–2007).

If runoff is below normal, the refuge is to receive that portion of the 3,500 acre-feet that natural conditions and Federal reclamation laws permit, because the primary purpose of the Milk River Project is for irrigation. Therefore, the primary source of water for the refuge under normal conditions is Milk River water delivered to the refuge via the Dodson South Canal.

In the past, the refuge has obtained water in excess of 3,500 acre-feet through deliveries using the Malta Irrigation District facilities; the Service pays a fee to the irrigation district for all delivered water. Recorded deliveries have averaged 4,877 acre-feet of water. Figure 35 shows the historical deliveries of water supplied to the refuge—with the greatest quantities coming from canal deliveries and rainfall. Still, the current water supply does not meet resource needs at Bowdoin Refuge; consequently, the Service entered negotiations with the State of Montana for a reserved water rights compact.

Water Rights Compact

To address water supply issues at Bowdoin Refuge, the Service chose to negotiate a reserved water rights compact with the State of Montana. The following sections summarize the pertinent Montana water history and water rights issues, as they relate to the refuge, along with a description of the water rights compact for Bowdoin Refuge.

Montana Water History and Water Rights. The Montana Water Use Act of 1973 changed water rights administration in the State significantly. The act required that all water rights existing before July 1, 1973, be finalized through a statewide adjudication process in State courts. Furthermore, the act provided for the following: (1) the establishment of a permit system for all new water rights; (2) an authorization system for changing water rights; (3) a centralized records system; and (4) a system to reserve water for future consumptive uses and to maintain minimum instream flows for water quality, fish, and wildlife.

In 1979, the Montana legislature passed a bill amending the adjudication procedures for water rights. Rather than adjudicating water rights one watershed ("basin" in State terminology) at a time, all water rights existing before July 1, 1973, are to be adjudicated statewide in all 85 basins. The State established the Montana Reserved Water Rights Compact Commission (Compact Commission) for negotiating compacts with Federal agencies and Indian tribes to quantify their reserved water rights. Thereafter, these compacts are included in adjudications.

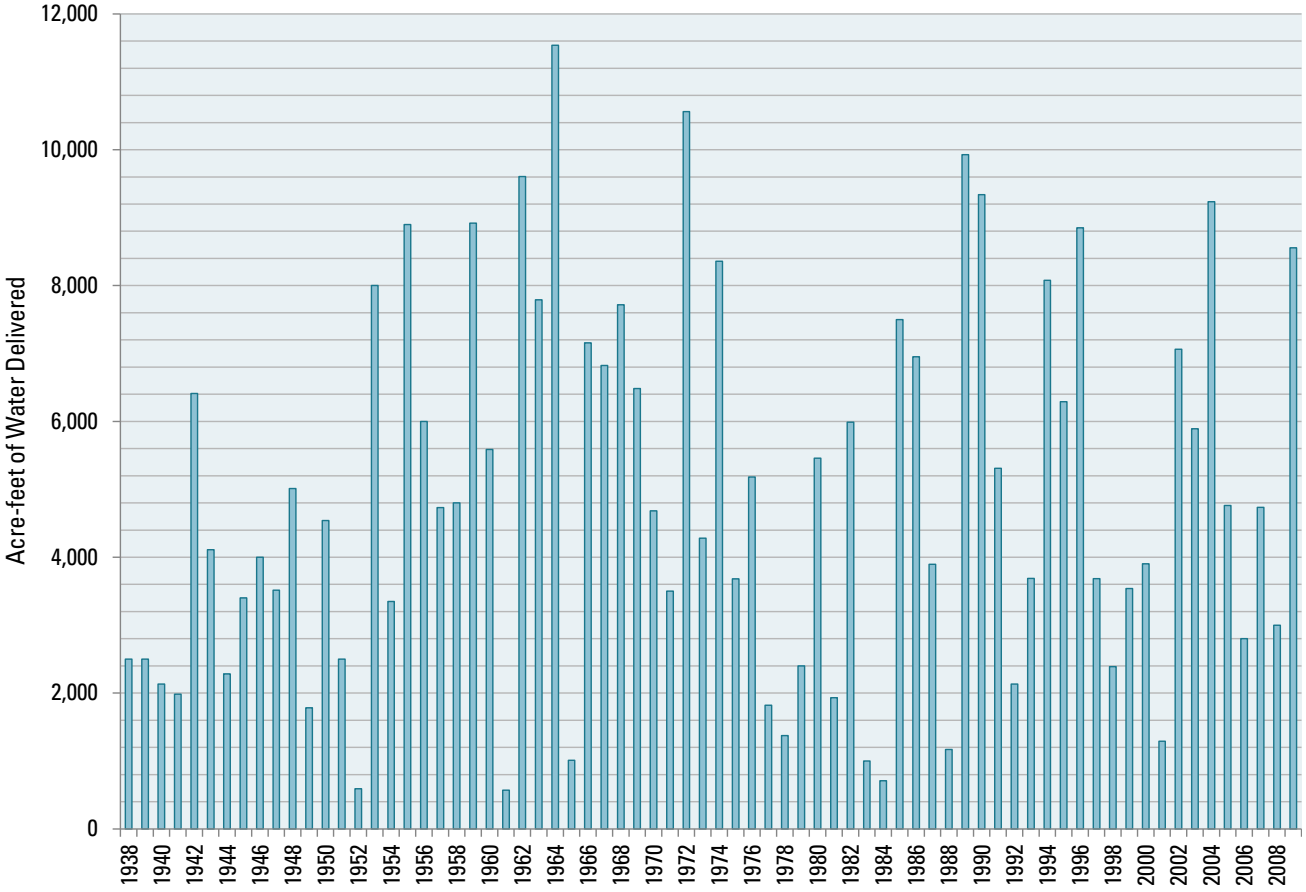

Figure 35. Graph of water deliveries to Bowdoin National Wildlife Refuge, Montana (1938–2008).

The Montana Supreme Court issued an order requiring everyone who believed they had existing water rights to file statements of claim with Montana Department of Natural Resources and Conservation (DNRC) by January 1, 1982. DNRC provides technical assistance to the Montana Water Court by examining each claim for completeness, accuracy, and reasonableness. These examinations frequently result in the development of "issue remarks" if there are problems identified with the claim. A claimant must deal with these issue remarks before the court will develop a decree for the basin. Following resolution of the issue remarks and development of a report by DNRC, the Montana Water Court will issue temporary preliminary decrees or preliminary decrees. An objective period follows issuance of the decrees, during which parties can request up to two 90-day extensions. At the close of the objection period, anyone whose claims have objections must be notified, which triggers a 60-day counter-objection period. After all objections are resolved for a claim, the water judge issues a final decree. Subsequently, DNRC issues each water right holder a "certificate of water right" based on that decree.

The DNRC designated the Beaver Creek watershed as "basin 40M" and the Milk River watershed as "basin 40J." The water rights for Bowdoin Refuge consist of two major components: (1) water rights for water supplied within the Beaver Creek watershed; and (2) water from the Milk River watershed.

Water Rights Compact. Since 1995, the Service and the Compact Commission have been in negotiations about the Service's assertion of Federal reserved water rights in the Beaver Creek watershed for Bowdoin National Wildlife Refuge. The two parties reached a settlement in January 2007, and the Compact Commission's attorney developed a draft compact with input from the Solicitor's Office (Department of the Interior) and Service staff. This compact was presented to the Montana legislature twice and was passed in House bill 717, "Bill to Ratify Water Rights Compact between the State of Montana and the U.S. Fish and Wildlife Service for the Bowdoin National Wildlife Refuge."

The compact recognizes water rights from two sources: surface flows from the Beaver Creek watershed and ground water from existing wells within the refuge boundary. In addition, the Service has the right to develop up to 5,300 acre-feet of deep ground water. In negotiating the compact, the Service agreed to subordinate all of the water rights on Beaver Creek to valid, existing junior uses. In other words, the Service will not attempt to assert seniority in placing a "call" on any junior user after the date that the compact is finalized. A "call" is a request by an appropriator for water that a user is entitled to under its decree; such a call would force users with junior decrees to cease or diminish their diversions and pass the requested amount of water to the downstream senior making the call.

The Beaver Creek watershed is closed to all, large, future development as a result of the water right compact negotiated with the Fort Belknap Indian Reservation, which is in the same watershed as the refuge. Excluded from the closure are as follows: (1) exempt wells of 35 gallons per minute (gpm) that pump less than 10 acre-feet of water per year; and (2) stock ponds of 15 acre-feet or less that can fill and refill once each year. In return for agreeing to subordinate to existing valid junior uses, Bowdoin Refuge received a water right for 24,714 acre-feet per year from Beaver Creek and can continue to use 223 acre-feet of ground water from any source within the refuge boundary. The refuge can also develop 5,300 acre-feet of deep ground water from geologic formations dating at least back to the Jurassic Period.

The water rights compact is conditioned on the Service executing a memorandum of understanding (MOU) with the State (DNRC) within 5 years of passage of the previously mentioned House bill 717 that ensures the Service's use of these water rights will not continue or increase the issues associated with salinity and blowing salts. If the Service and DNRC cannot agree on an MOU, the water rights compact will be nullified; the Service would have to litigate its water rights in the Montana Water Court. The preferred alternative of the final CCP will be the basis for negotiating the MOU with the State.

3.4 State and Federal Listed Species

The Service has not documented any species listed as endangered under the Endangered Species Act using any lands or water within the Bowdoin National Wildlife Refuge Complex. The Great Plains population of the piping plover, federally listed as threatened in 1985, has been found on Bowdoin Refuge.

Many species found in the refuge complex have been designated as species of concern by Montana Fish, Wildlife & Parks and the Montana Natural Heritage Program (2009a, 2009b) or as birds of conservation concern by the Service (2008a).

Two bird species on the refuge complex are designated as Federal candidate species under the Endangered Species Act—greater sage-grouse and Sprague's pipit. The Service has determined that both of these species warrant protection, but that listing is precluded by the need to address other listing actions of a higher priority. Both will remain classified as candidate species until listing proposals can be prepared.

Until listed as threatened or endangered, candidate species do not receive statutory protection under the Endangered Species Act.

The mountain plover, which is found on Hewitt Lake National Wildlife Refuge within the refuge complex, is proposed for listing as a threatened species. The Service is still developing scientific information regarding the mountain plover's life history, ecology, and habitat use to determine its status and eligibility for listing.

Piping Plover

Piping plovers occur in three distinct populations: Atlantic Coast, Great Lakes, and northern Great Plains. Of the roughly 6,000 piping plovers left in the world, about half breed in the northern Great Plains. Unlike the Atlantic Coast and Great Lakes populations, the northern Great Plains population is declining, somewhere between 6 percent and 12 percent annually (Larson et al. 2002, Plissner and Haig 2000, Ryan et al. 1993). This population is expected to go extinct in 50–100 years unless significant conservation activities are started. The decline and poor prognosis led to the listing of this population in the mid-1980s as threatened under the Endangered Species Act in the United States and endangered in Canada.

The first recorded sighting for piping plovers in Montana was in 1967 in Phillips County (Prellwitz et al. 1989). Bowdoin National Wildlife Refuge is located on the extreme western edge of the breeding range for the northern Great Plains population. Piping plovers nest on wide, sparsely vegetated sand or gravel beaches and on islands in rivers. In the northern Great Plains, flooding of nests and chicks from precipitation or untimely discharges of water from dams has been a major cause of reproductive failure. The refuge has suitable breeding and nesting habitat for piping plovers; nevertheless, use has been very sporadic and in low numbers (nesting was last documented in 1999). Because of its history of piping plover use, 3,325 acres of Bowdoin Refuge has been designated as critical habitat for the piping plover.

Gene Nieminen / USFWS

The Bowdoin Refuge has critical habitat for piping plover.

The Bowdoin Refuge participates in the International Piping Plover Breeding Census every 5 years and is a member of the Montana Piping Plover Recovery Committee. In addition, refuge staff conducts annual surveys for piping plover on Bowdoin and Hewitt Lake refuges and at nearby Nelson Reservoir. The reservoir lies approximately 4.5 miles, as the plover flies, northeast of Bowdoin Refuge and is administered by the Bureau of Reclamation. This 4,559-acre irrigation reservoir has approximately 34 miles of primarily gravel shoreline at a normal pool elevation of 2,221 feet. This extensive shoreline often supports several nesting pairs of piping plover. Since the nearest Reclamation office is 200 miles away in Billings, Montana, the Service entered into an agreement with Reclamation to have the nearby refuge staff monitor plover use of the reservoir during the migration, breeding, and nesting seasons. Reclamation has provided the funding, and refuge staff has been responsible for the monitoring. In 2009, the Service no longer had the staff to continue this monitoring program. Future agreements to continue this partnership are contingent on the addition of a biologist or permanent biological technician to the refuge complex staff to carry out this additional work.

In cooperation with Reclamation, the refuge staff has improved nesting habitat on Nelson Reservoir by adding gravel to historical nesting areas and by periodically removing vegetation from those sites as needed. The Service has also collaborated with Reclamation and Ducks Unlimited to create Piping Plover Pond on the west end of Dry Lake. In addition, portions of the alkali beach on the pond have been enhanced with gravel to improve nesting habitat.

Plant Species

No federally listed plant species are known to occur at Bowdoin Refuge or within the Bowdoin Wetland Management District; however, comprehensive vegetation inventories have not been done for most of the district.

Animal Species of Concern

Species of concern are native animals breeding in Montana that are considered to be at risk due to their declining population trends, threats to their

habitats, or restricted distribution (Montana Natural Heritage Program 2009a, 2009b). The Service identifies birds of conservation concern as migratory and nonmigratory birds of the United States and its territories that have declining populations, naturally or human-caused small ranges or population sizes, threats to habitat, or other factors. This designation helps stimulate coordinated and proactive conservation actions among Federal, State, tribal, and private partners. Bird species considered for inclusion on this list include nongamebirds, gamebirds without hunting seasons, subsistence-hunted nongamebirds in Alaska, birds that are candidates or proposed as threatened or endangered under the Endangered Species Act, and birds that recently have been removed from a Federal listing (USFWS 2008a).

The refuge complex has documented more than 80 wildlife species that are listed as State species of concern or Federal birds of conservation concern, or both (refer to "Appendix H–Species Lists"). In particular, many grassland-nesting birds such as Baird's sparrow, Sprague's pipit, and McCown's longspur use the refuge complex for nesting and migration habitat each year. These birds, along with many others using the refuge complex, are identified on both the State and Federal lists as species that require special attention to prevent them from becoming threatened or endangered.

3.5 Cultural Resources

Based on radiocarbon dating, evidence of human occupation within the northwestern plains of the greater Missouri River drainage extends back at least 11,000 years (Brumley 2006). Excavations from this area indicate that prehistoric inhabitants evolved significantly over time by adopting new methods of hunting, gathering, and preparing food. Cultural phases can be identified by the types or styles of projectile points used, means of food preparation, and presence or absence of certain items such as ceramics.

Prehistoric Occupation

The cultural sequence for prehistoric occupation in this area is often split into three major subdivisions based on these phases—early, middle, and late prehistoric.

Early Prehistoric

Dating back 11,000–7,700 years ago, early prehistoric or paleo-Indian peoples appear to have used heavy throwing or stabbing spears to hunt primarily big game such as mammoth and early bison. Evidence from this period in northern and central Montana is limited and most finds have been found on the surface.

Middle Prehistoric

Middle prehistoric humans occupied the area 8,000–1,300 years ago and may have hunted a larger variety of animal species as well as gathered and processed wild plant foods. Projectile points from this period were presumably designed for a spear thrower, known as an atlatl. Evidence also shows that the bow may have coexisted and eventually replaced the atlatl. Signs of stone boiling and the appearance of pottery indicate changes in food processing and storage.

Carmen Luna / USFWS

Rocks define a tipi ring at the Bowdoin Refuge.

Late Prehistoric

Dating from 100 A.D. to historical times, this period is characterized by projectile points used with the bow and arrow. Bison were still the primary game, but communal kills that involved driving animals over a cliff, into corrals, or into natural traps were more common. There is also significant evidence of the use of pottery and ceramics.

Protohistoric and Historic Native Americans

The protohistoric period is the period of time between the arrival of horses and manufactured goods in the area and before the arrival of white traders and explorers. This time period lasted only about 100 years in this area due to the arrival of the Lewis and Clark expedition in the early 1800s.

On arrival of the early white explorers, northern Montana was occupied primarily by three tribal groups: the Gros Ventres or Atsina, the Piegan of the Blackfoot Confederacy, and the Assiniboine. As a result of warfare and migration of Euro-Americans, the Sioux (Fort Peck Reservation), Chippewa, and Cree (Rocky Boy's Reservation) had also moved into northern Montana by the late 1800s (Wolfgram and Nemeth 1998). Cultural remnants from these groups can be found scattered over most undisturbed areas within the Bowdoin National Wildlife Refuge Complex. Lodges, tipi rings, and rock cairns are the most common remains encountered.

Historic Euro-Americans

The post-Lewis and Clark historic period in central and northern Montana can be divided into three generalized periods based on the major type of economic activity—fur trade era, ranching and railroad era, and homestead era (Wolfgram and Nemeth 1998).

Fur Trade Era

The fur trade era began in Montana a year after the Lewis and Clark Expedition returned to St. Louis. By the 1840s, trading posts were established along the Missouri River and most of its major tributaries including the Milk, Marias, Musselshell, and Yellowstone Rivers. Most of these posts were small, independent ventures and lasted little more than a year. In addition, a network of military posts was established throughout central and northern Montana.

By the mid-1880s, much of the Plains Region of northern Montana was ceded by the Native American tribes present there, and these peoples were moved to smaller reserves with boundaries similar to those found today. The fur trade era came to an end at the same time, and most of the trade and military posts were closed.

Unreserved public domain in northern Montana was opened to settlement in 1887, and that same year the Great Northern Railway was built along the Milk River valley. Large cattle and sheep operations quickly moved into the area.

Ranching and Railroad Era

The ranching and railroad era in northern Montana coincided with a major boom in the market for beef cattle. The slaughter of the once-vast herds of bison and the considerable increase in the human population after the Civil War created an almost insatiable market for beef. The railroad development across northern Montana meant that large numbers of cattle could be shipped throughout the United States. Many of the branch lines that extended from what is now called the Burlington–Northern Railroad have since been abandoned, but many of the towns that were established along those branches as well as along the main railway remain today. These communities were service points for the coal-fired locomotives or as sidings for freight (railway sections where one section is lowered to allow two trains on the same rail to pass). These towns became important to the farmers who came to the region during the homestead era. One siding town that experienced the rapid boom and just as rapid bust of the railroad era was Bowdoin, for which the refuge was named. The old town site is located on the southeast boundary of Bowdoin National Wildlife Refuge.

Homestead Era

The homestead era in northern Montana lasted only 18 years between 1900 and 1918. Before 1900, farmers considered the region to be much too dry, and the open, rolling grasslands were not conducive to the farming techniques of the time. As dryland farming techniques improved—and with the passing of the Enlarged Homestead Act of 1909 and the Three Year Homestead Act of 1912—the stage was set for a major land rush in Montana. Individuals were provided with a free 320-acre homestead and, after only 3 years, could lay full claim to the land even if they only lived on it for 5 months of the year.

In 1902, the Newlands Reclamation Act committed the Federal Government to develop and manage irrigation systems along the major rivers in Montana. Also in 1902, the Bureau of Reclamation came into existence with funding from the sale of public lands. Since there was a lack of reliable, stable water in the

Milk River system, a plan was developed to divert spring and floodwaters from the St. Mary River in western Montana into the Milk River system and store it for later use in downstream reservoirs. The Milk River Project would irrigate and reclaim more than 250,000 acres of agricultural land along the Milk River valley and was one of the first projects of this type in the United States interior.

The period between 1909 and 1916 was wetter than normal and individuals were able to exist off their 320-acre farms. However, by the mid-1920s the situation had changed, and it became clear that farms had to be significantly larger to provide a living. Many homesteaders went broke and their lands were purchased by those who had been able to persevere.

History of Bowdoin Refuge Complex

The establishment and early history of the Bowdoin National Wildlife Complex is tied to the Emergency Relief Act and the Works Progress Administration program. Created by President Franklin D. Roosevelt during the Great Depression and the Dust Bowl era of the mid-1930s, these programs were developed to employ the maximum number of people to work on public lands. The Civilian Conservation Corps was never assigned to work on any areas of the refuge complex (Speulda and Lewis 2003).

Works Progress Administration crews performed construction on the refuges in the refuge complex between 1936 and 1941. Their activities focused not only on buildings, roads, and other facilities, but also on the construction of dams and levees to impound water. Recognizing the importance of the Milk River system to the Lake Bowdoin Migratory Waterfowl Refuge (now Bowdoin National Wildlife Refuge), the Bureau of Biological Survey (now U.S. Fish and Wildlife Service) contributed funds for the construction of the Fresno Reservoir Dam near Havre, Montana, in exchange for a 3,500 acre-foot water right. This agreement was signed on March 7, 1937, and the Milk River Project still serves as the main source of water for Bowdoin National Wildlife Refuge.

Construction projects completed by the Works Progress Administration at the Bowdoin Refuge headquarters were a residence for the manager, an office, a shop and service building, vehicle storage, an observation tower, and a road to the headquarters area. The office building and residence were unique for the time—instead of the concrete block buildings common in this era, the crews built wood structures due to the availability of salvaged wood from dismantled farmsteads on other refuges. The shop building burned down soon after being built, and a new structure was built on the concrete foundation. Crews also landscaped the headquarters area, constructed the two stone pillars that still stand at the refuge entrance driveway, put in flagstone walks, developed a 10-acre garden and orchard, and installed overhead electric lines from Malta to the new headquarters.

Early habitat projects completed by Works Progress Administration crews on Bowdoin Refuge included planting trees, shrubs, and aquatic vegetation,

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Crews from the Works Progress Administration constructed several buildings for the Bowdoin Refuge headquarters (1961).

collecting rock, constructing nesting islands on Lake Bowdoin, and constructing water delivery and control systems. Many other refuge projects were also accomplished by the Works Progress Administration "boys" when refuge managers were able to get funding and workers, which was often difficult according to refuge narratives. While none of the buildings or bridges constructed by the Works Progress Administration crews survived, most of the dams, dikes, ditches, and a few water control structures still exist. In addition, a small National Youth Administration crew was employed in 1937 to conduct a nest and brood count throughout Bowdoin Refuge.

The Works Progress Administration was pivotal to the establishment of all four satellite refuges. During this Dust Bowl era, the country and the Government were very focused on capturing and conserving water for wildlife, particularly waterfowl, and agricultural operations. Water impoundments were popularized when the connection was made to employing out-of-work citizens to build the structures needed to impound and manage limited water resources. Most of this work was completed on public lands, except for the privately owned easement refuges, known today as limited-interest refuges. These limited-interest refuges are encumbered by a refuge or flowage easement, or both, and the Service has acquired less than 10 percent of the refuge acquisition boundary. By definition, only Lake Thibadeau is considered a limited-interest refuge, but the remaining satellite refuges (Black Coulee, Creedman Coulee, and Hewitt Lake) have their origins in this program. These types of refuges are found not only in Montana, but also in North Dakota and South Dakota. Most of the land within these refuges is still in private ownership and the refuges do not fully function as fee-title refuges, hence the name, limited interest. The Works Progress Administration constructed dams, spillways and water control structures on the private lands of what was to become Black Coulee, Greedman Coulee (now Creedman Coulee), Hewitt Lake, and Lake Thibadeau National Wildlife Refuges. Willing landowners signed perpetual refuge and flowage easements granting the Government the right to construct and maintain these structures; control the uses that occur on these impoundments and other lakes, rivers, and streams; and control hunting and trapping. The real benefit to these landowners was a more reliable water source; as an added benefit, some of these landowners were also employed by the Government to build these impoundments. Most of the structures are still functioning, but due to development in the watershed, much of the water that once flowed into these impoundments is captured before it ever reaches some refuges. Some habitat work was conducted by the Works Progress Administration crews including planting seed balls of sago pondweed (a desirable aquatic plant) in Hewitt Lake and constructing a nesting island at Black Coulee.

3.6 Special Management Areas

Areas with official designations are managed to retain the special features that led to their designation. While not suitable for wilderness, the Bowdoin National Wildlife Refuge has been identified as an important bird area.

Wilderness Review

A wilderness review is the process used for determining whether to recommend Service lands or waters to Congress for designation as wilderness. The Service is required to conduct a wilderness review for each refuge as part of the CCP process. Lands or waters that meet the minimum criteria for wilderness are identified in a CCP and further evaluated to determine whether they merit recommendation for inclusion in the Wilderness System. To be designated a wilderness, lands must meet certain criteria as outlined in the Wilderness Act of 1964:

- Generally appears to have been affected primarily by the forces of nature, with the imprint of human work substantially unnoticeable
- Has outstanding opportunities for solitude or a primitive and unconfined type of recreation
- Has at least 5,000 acres of land or is of sufficient size to make practicable its preservation and use in an unimpaired condition
- May also contain ecological, geological, or other features of scientific, educational, scenic, or historical value

Bowdoin Refuge is the only unit in the refuge complex that meets the wilderness criteria for size and for scientific, scenic, and ecological value. In 1973, the refuge was evaluated for inclusion in the Wilderness System by the Bureau of Sport Fisheries and Wildlife (now the U.S. Fish and Wildlife Service). The report concluded that Bowdoin Refuge was not suitable for this designation due to the extensive development and intensive management needed to meet refuge objectives (Bureau of Sport Fisheries and Wildlife 1973). This still holds true today. The refuge landscape has been altered by roads, fences, and extensive human effects from livestock grazing

and wetland modifications that preclude it from being designated a wilderness.

Important Bird Area

Bowdoin National Wildlife Refuge has been designated as an important bird area through a program administered by the National Audubon Society. This program is a global effort to identify and conserve areas that are vital to birds and for biodiversity. Important bird areas are sites that provide essential habitat for one or more species of birds. These areas include sites for breeding, wintering, or migrating birds. Important bird areas may be a few acres or thousands of acres, but usually they are discrete sites that stand out from the surrounding landscape. Important bird areas may include public or private lands, or both, and they may be protected or unprotected (National Audubon Society 2010). To qualify as an important bird area, sites must satisfy at least one of the following criteria to support the following types of bird species groups:

- Species of conservation concern (for example, threatened and endangered species)
- Restricted-range species (species vulnerable because they are not widely distributed)
- Species that are vulnerable because their populations are concentrated in one general habitat type or biome
- Species or groups of similar species (such as waterfowl or shorebirds) that are vulnerable because they occur at high densities due to their behavior of congregating in groups

More than 260 species of birds have been documented on the Bowdoin National Wildlife Refuge. According to the National Audubon Society, the list of species breeding on the refuge has 19 species of global and continental conservation concern.

- *Global Concern*—ferruginous hawk, piping plover, long-billed curlew, red-headed woodpecker, Sprague's pipit, Brewer's sparrow, chestnut-collared longspur
- *Continental Concern*—northern harrier, Swainson's hawk, upland sandpiper, marbled godwit, Wilson's phalarope, common tern, burrowing owl, short-eared owl, willow flycatcher, loggerhead shrike, Baird's sparrow, McCown's longspur

© Michael Forsberg

The upland sandpiper uses habitats on the refuge complex. In Montana, it has been declining in range and abundance.

The Bowdoin Refuge has one of only four nesting colonies of American white pelicans and one of only five nesting colonies of Franklin's gulls in Montana.

Western Hemisphere Shorebird Reserve Network

Because of the concentrations of migrating shorebirds, the Western Hemisphere Shorebird Reserve Network recognizes Lake Bowdoin as a site of regional importance.

3.7 Visitor Services

Visitors to the Bowdoin Refuge Complex enjoy a variety of wildlife-dependent, public use activities such as hunting, fishing, wildlife observation, photography, environmental education, and interpretation. Most visitors use the Bowdoin Refuge's 15-mile auto tour route. Brochures containing area maps, public use regulations, bird species, and general information are available for the units in the refuge complex.

The Bowdoin National Wildlife Refuge office is open Monday–Friday, 7:30 a.m.–4:00 p.m. The auto tour route and remainder of the refuge are open from dawn to dusk, except during hunting season when hunters are allowed reasonable time to access hunt-

ing areas when arriving before dawn and leaving after dusk. The report Banking on Nature 2004—The Economic Benefits to Local Communities of National Wildlife Refuge Visitation shows that in 2004, 7,147 individuals made 5,217 recreational visits to Bowdoin National Wildlife Refuge (Caudill and Henderson 2005). About 83 percent of these visits were by nonresidents. Hunting accounted for about 23 percent of the visits while the remainder of the outings is attributed to other activities such as wildlife observation, photography, and hiking. Hunters are required to register at a kiosk located in front of the headquarters building so these numbers are fairly accurate. Visitors are asked to sign the guest register at the headquarters entrance, but registration is not mandatory. Nonhunting use is estimated each year based on the guest register and head-counts of education and interpretation groups.

No documented visitation data is available for the rest of the refuge complex; nevertheless, the Service estimates that current visitor use throughout the refuge complex is approximately 25,000 annually.

Hunting

In addition to the site-specific regulations mentioned below, all State of Montana hunting regulations apply to Service lands in the refuge complex. Shotgun hunters may only possess and use nontoxic shot on lands within the refuge complex, and vehicle travel and parking is restricted to roads, pullouts, and parking areas.

Bowdoin National Wildlife Refuge

Public hunting of migratory gamebirds (ducks, geese, coot, swan, sandhill crane, and mourning dove), upland gamebirds (pheasant, sharp-tailed grouse, greater sage-grouse, gray partridge), fox, and coyote is permitted in the designated portions (about 40 percent) of Bowdoin Refuge (figure 36). An accessible boat dock, pier, and parking area are available at the west boat launch on Lake Bowdoin. Boating is only allowed on the refuge during the hunting season and only in those areas open to hunting. A 25-horsepower boat motor limit protects submerged aquatic vegetation in the refuge's shallow wetlands. Big game hunting is not allowed at the refuge and predator hunting (fox and coyote) requires a special use permit approved by the refuge manager.

Since 2002, the eastern portion of the refuge that is normally closed to hunting has been opened to upland gamebird hunting throughout December. The first 2 days of the special opening are limited to only young hunters. Waterfowl generally remain on Bowdoin Refuge until freezeup. To avoid disturbance to these migratory birds, the opening of the late-season hunt for upland gamebirds is contingent on waterfowl being gone by November 30.

Black Coulee National Wildlife Refuge

Black Coulee comprises fee-title refuge lands and waterfowl production areas, which are surrounded by private lands encumbered by Service easements. The hunters wanting access to these private lands must get permission from the landowner. Another portion of the refuge was acquired as Black Coulee WPA; hunting here can be challenging, because public use regulations for refuges are different from those for waterfowl production areas. Hunting is open to the general public on the waterfowl production area. Hunting on the refuge is open but requires landowner permission to access private lands. The refuge is otherwise open to hunting for big game, migratory gamebirds (ducks, geese, coot, swan, sandhill crane, and mourning dove), and upland game (pheasant, sharp-tailed grouse, greater sage-grouse, gray partridge, fox, and coyote). Hunters must follow State game laws including seasons and limits when hunting on this refuge.

Creedman Coulee National Wildlife Refuge

Most of the land within the refuge boundary is private land and hunters wanting access must get permission from the landowner. The refuge is otherwise open to hunting for big game, migratory gamebirds (ducks, geese, coot, swan, sandhill crane, and mourning dove), and upland game (pheasant, sharp-tailed grouse, greater sage-grouse, gray partridge, fox, and coyote). Hunters must follow State game laws including seasons and limits when hunting on this refuge.

Hewitt Lake National Wildlife Refuge

A portion of the land within the refuge boundary is private land and hunters wanting access to this inholding must get permission from the landowner. A portion of the land within the Executive boundary was acquired as Hewitt Lake WPA. The refuge is otherwise open to hunting for big game, migratory gamebirds (ducks, geese, coot, swan, sandhill crane, and mourning dove), and upland game (pheasant, sharp-tailed grouse, greater sage-grouse, gray partridge, fox, and coyote). Hunters must follow State game laws including seasons and limits when hunting on this refuge.

Lake Thibadeau National Wildlife Refuge

Most of the land within the refuge boundary is private land and hunters wanting access must get per-

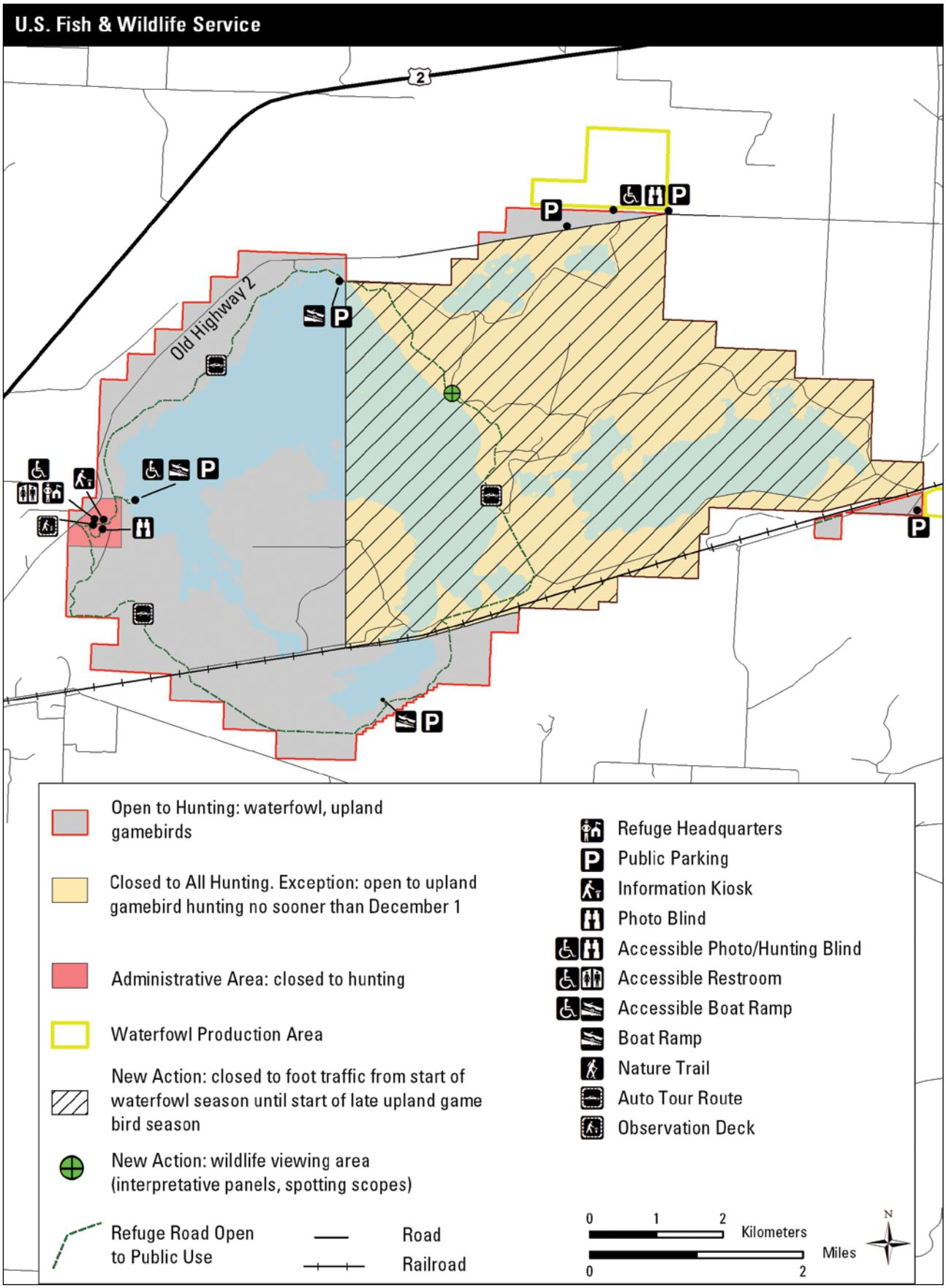

Figure 36. Map of current and planned public use sites and activities at Bowdoin National Wildlife Refuge, Montana.

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Carmen Luna / USFWS

Waterfowl hunting continues to be popular at the Bowdoin Refuge Complex (top photo—1940; bottom photo—2009).

mission from the landowner. The refuge is otherwise open to hunting for big game, migratory gamebirds (ducks, geese, coot, swan, sandhill crane, and mourning dove), and upland game (pheasant, sharp-tailed grouse, greater sage-grouse, gray partridge, fox, and coyote). Hunters must follow State game laws including seasons and limits when hunting on this refuge.

Waterfowl Production Areas

Except for Holm WPA, all waterfowl production areas within the Bowdoin Wetland Management District are open to hunting big game, migratory birds, upland game, and furbearers according to State game laws and regulations. Big game hunting on McNeil Slough WPA is restricted to archery, muzzleloader, and shotgun only. The Pearce WPA has an accessible hunting and photography blind and a parking area.

Fishing

Although recreational fishing opportunities are available on McNeil Slough WPA (Milk River) and Beaver Creek WPA (Beaver Creek), the Service does not actively manage sport fisheries within the Bowdoin Wetland Management District. The remaining wetlands within the refuge complex have only minimal habitat or high salinity levels, or both, and do not support a game fishery. Bowdoin Refuge is closed to fishing to provide a refuge for migratory birds and due to the poor fish habitat as a result of high salinity levels.

Anglers have many quality fishing opportunities on other public lands around the refuge complex including Nelson Reservoir, Cole Ponds, Milk River, Missouri River, Fort Peck Lake, and stocked ponds on both public and private lands (Missouri River Country 2007).

Wildlife Observation and Photography

Opportunities for wildlife observation and photography are abundant within the Bowdoin National Wildlife Refuge Complex, and more than 25,000 people visit annually for these purposes.

The Bowdoin Refuge's bird list can be used across the entire refuge complex. The Bowdoin Refuge's 15-mile auto tour route guides visitors through a variety of wildlife habitats. The auto tour route is graveled and is maintained throughout the year but may be closed periodically due to impassable or hazardous conditions. Binoculars and field guides can be checked out at the refuge headquarters. Near the headquarters office, the 0.4-mile Display Pond Trail (walking) features a photography blind for visitors including those with disabilities. The refuge is also a designated stop on the Northeastern Montana Birding Trail. Walk-in access is allowed anywhere on the refuge except for the closed area surrounding the shop, equipment storage, and residential areas. Boating is only allowed on the refuge during the hunting season and only in those areas open to hunting. A 25-horsepower boat motor limit protects submerged aquatic vegetation in the refuge's shallow wetlands.

Parking and walk-in access is allowed on the satellite refuges and the waterfowl production areas in Bowdoin Wetland Management District. People wishing to access the easement portions of the satellite refuges must gain permission from the affected landowners. The Pearce WPA has an accessible photography blind.

Commercial filmmakers and still photographers must acquire a special use permit to work on Service

David Brezinski / USFWS

Birdwatchers look for the Baltimore oriole in riparian areas, this bird's habitat.

lands. The permit specifies regulations and conditions that the permittee must follow to protect the wildlife and habitats they have come to capture on film and to prevent unreasonable disruption of other visitors enjoyment of the refuge complex. Commercial filming and photography on Service lands must also demonstrate a means (1) to generate the public's appreciation and understanding of the refuge's wildlife and their habitats and the value and mission of the National Wildlife Refuge System, or (2) to facilitate the outreach and education goals of the refuge complex.

Environmental Education

The diversity of habitats and wildlife found throughout the Bowdoin Refuge Complex make it an ideal "classroom" for the area's environmental education needs. The refuge complex staff has instituted educational programs—such as the wildlife poetry, wildlife art, and centennial quilt contests—to promote an appreciation and understanding of the wildlife and habitats the refuge complex was established to protect. Teacher workshops have been offered at Bowdoin Refuge in cooperation with Montana State University–Northern (Havre, Montana). Unfortunately, limited staff and resources are making environmental education programs increasingly rare and opportunistic, except for annual events such as the following:

- Migratory Bird Day
- Enrichment Days (a 2-day educational event in conjunction with the local schools, area businesses, organizations, and other agencies)
- National Wildlife Refuge Week

A variety of elementary and high school science classes have used the refuge as an outdoor classroom. School groups can check out the wetland teaching trunk, bat teaching trunk, binoculars, birding field guides, and a variety of wildlife videos to use on or off the refuge. Slide presentations about local birds and bats are also available and can be taken to the classroom or used for onsite programs.

Interpretation

Most of the public brochures and interpretive panels have been updated following Service guidelines. Brochures containing area maps, public use regulations, and general information are available for the refuge complex and include the following:

- Auto tour interpretive guide highlighting the numbered stops
- General brochure for Bowdoin Refuge
- Bird list for Bowdoin Refuge
- Public use regulations for Bowdoin Refuge
- Public use regulations for Bowdoin Wetland Management District, including the satellite refuges

These brochures are available at the refuge complex headquarters and at the main kiosk. The kiosk has three interpretive panels displaying a location map, general refuge information, wetland facts, and information about habitat management techniques. In addition, the refuge complex's Web site provides information about programs and regulations.

The Service has provided local newspapers with periodic news articles on refuge complex activities and informative articles on the values and protection of the area's natural resources. Monthly updates on refuge complex activities are also prepared for the Malta Chamber of Commerce.

3.8 Management Uses

The Service manipulates habitat through several management uses that are carried out under specific, prescribed conditions to meet the needs of wildlife

and habitat management and to reduce hazardous fuel loading—cooperative farming, prescribed burning and haying, and prescriptive grazing.

Cooperative Farming

Restoration of cropland and DNC fields back to native species is quite time and labor intensive. Therefore, the refuge complex addresses this habitat need by working with cooperative farmers to gradually convert disturbed grasslands to native grasses, forbs, and shrubs, which have the greatest potential to survive and outcompete invasive species while providing habitat to grassland-dependent migratory birds.

Cooperative farming of Service lands is usually done on a share basis where the Service and the cooperator each receive a share of the crop. The Service may retain its share (1) as standing cover for wildlife forage, (2) in exchange for additional work from the cooperator such as invasive plant control and grass seeding, or (3) in exchange for supplies from the cooperator such as herbicides and fence materials for habitat protection and improvement. Any fees or cash income received by the Service are deposited in the Refuge Revenue Sharing Account. The refuge manager issues farming cooperators a cooperative farming agreement or a special use permit. Subsequently, cooperators are allowed to (1) till, seed, and harvest small grain, (2) control invasive plants, or (3) harvest hay on the restoration site until native seed can be planted and becomes established. These agreements are generally issued for a 2- to 4-year management prescription but in some cases may extend longer to allow time for establishment of native plants.

Prescribed Burning, Haying, and Grazing

Scientific and management communities largely agree that continuous idling of grassland is a poor management choice in comparison to periodic treatment to rejuvenate grasslands. Continuous idling (for example, more than 10 years) without periodic treatment as a conscious management decision fails to address long-term grassland health (Naugle et al. 2000). Methods used by managers to rejuvenate grasslands are prescribed burning, haying, and grazing. Periodic rejuvenation of vegetation is necessary to maintain optimum plant vigor, remove excessive litter, and stimulate plant height and density. Litter accumulations not only negatively affect the health of stands of vegetation but also negatively affect duck production (Naugle et al. 2000) as well as other wildlife that depend on grassland habitats.

Methods used by managers to rejuvenate grassland are haying (predominantly in seeded grasslands) and burning and grazing (predominantly in native prairie).

Prescribed Burning

Prescribed fire is recommended as a primary grassland management treatment whenever possible, because fire provides the fastest and most effective means of litter removal (Naugle et al. 2000). Most grasses and forbs respond positively to burning in the grassland of the northern Great Plains. Nonetheless, care must be taken when using fire to manage grasslands in drier climates, such as in eastern Montana. The use of fire may have a negative vegetation response due to longer recovery periods attributed to reduced litter and soil moisture, increased evapotranspiration rates and solar radiation, less snow retention, and poorer water infiltration (Henderson 1982, Hulbert 1986, Old 1969, Wright and Bailey 1980).

Bird species native to northern mixed-grass prairie are well adapted to defoliation by fire (Murphy et al. 2005). In general, decreases in species abundance and nesting density during the first growing season after prescribed burning are offset by increases in following years compared to pre-burn levels; nest survival appears unaffected. The short-term unavailability of breeding habitat probably is outweighed by the long-term benefits from using prescribed fire to restore and maintain vegetation structure and to manage the fuel load by reducing accumulated litter and woody vegetation. Data collected by Murphy et al. (2005) in the plains of North Dakota indicates that occurrence and survival of nests of some bird species is negatively associated with the extent of trees and tall shrubs in the landscape. Efforts to reduce these fuels via prescribed fire seem warranted for improving the productivity of grassland birds as well as addressing other prairie restoration objectives.

In presettlement times, the frequency of wildfire was variable, occurring every 5–10 years (Frost 1998, Wright and Bailey 1980). However, very little research has been conducted regarding fire in the drier prairies of north-central Montana. Askins et al. (2007) suggest that grazing and the lack of moisture maintained grass as the dominant vegetation with fire playing a lesser role; they estimated a fire-return interval of 10–26 years for eastern Montana. Wildfires have been greatly suppressed since settlement by Europeans, and the use of prescribed fire by the Service and other groups or agencies has been sporadic.

Based on information regarding vegetation recovery intervals and bird-nesting studies, Naugle et al. (2000), recommends 3- to 10-year fire intervals in the wetter regions of the northern Great Plains and 10-

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The Service uses prescribed fire to rejuvenate grasses and reduce vegetative litter.

year or greater intervals in the drier mixed-grass and shortgrass zones. Since 2000, the Bowdoin Refuge Complex has increased the use of prescribed fire as a habitat management tool to improve plant diversity and structure and to improve grassland habitat for upland-nesting birds and other wildlife. However, before an extensive prescribed fire program can occur, a greater understanding of fire frequency in this arid climate is needed.

Haying

About 4,478 acres of Service-owned uplands had been cultivated by the previous landowner. Since Service acquisition, most of these previously farmed areas have been converted to dense nesting cover or native grasses. The restoration of cropland to seeded grassland such as DNC is relatively easier to establish, less expensive than native prairie restoration, and provides valuable wildlife habitat. In the 1970s, 200 acres of native prairie habitat on Bowdoin Refuge was "broken" to plant DNC to enhance nesting habitat for waterfowl (Duebbert 1969). Of the remaining 4,278 acres, 465 acres have been restored to native grasses. Seeded grasslands such as DNC fields must be periodically rejuvenated to maintain optimal nesting cover for migratory birds and optimal plant vigor. Nesting waterfowl using DNC fields require vigorous stands of vegetation with the tallest, most dense cover form that is possible under prevailing soil and climate conditions (Duebbert et al. 1981).

Restoration of previous cropland areas to DNC or native grasses is initially very time-intensive. It requires seedbed preparation by tilling, use of control measures to reduce or eliminate undesirable plants or weeds, planting of a protective annual crop for 1–2 years, and finally planting of grasses into the remaining crop stubble. Once established, DNC fields require periodic disturbance (mainly haying) every 4–10 years to maintain plant vigor. An exact schedule for disturbance of these fields is not possible because of other contributing variables such as the accumulation of vegetative litter, soil, and climate conditions. The average life expectancy of a DNC field is approximately 15 years, before plant diversity has declined and it becomes necessary to reestablish it. DNC fields in the refuge complex have been established for 20 or more years and are in need of replanting. Given the intensive management requirements along with the limited lifespan of DNC fields, the refuge complex has been gradually working to reseed DNC fields to native grasses. The only fields that will remain as DNC will be parcels of land regarded as highly erodible.

Native grass restoration initially is as intensive as the planting of DNC fields but once established it should never require further restoration other than invasive plant management and periodic disturbance by prescribed fire, haying or grazing. Restoration of fields to native grasses depends on the availability of funds as well as climate conditions and the establishment of native grasses.

Grazing

Historically, vast herds of bison ranged throughout north-central Montana. The mixed-grass prairie evolved and depended on these native grazers for its diversity and productivity. As bison were eradicated, cattle were brought in to graze on the large, expansive grasslands—most of the area that is now the Bowdoin National Wildlife Refuge Complex was extensively grazed by domestic livestock. Bowdoin Refuge uplands were grazed more heavily than other areas because of the presence of a reliable source of water in Lake Bowdoin. Today, native grazers such as pronghorn, white-tailed deer, and mule deer continue to browse and graze the uplands. Their grazing habits are different from that of bison or cattle, but

it is not certain what effects these native big game grazers have had on upland vegetation communities, particularly at Bowdoin Refuge. Observations have shown that pronghorn and other native ungulates may be overharvesting plant species that they prefer to eat such as winterfat, resulting in overbrowsing this native plant.

After Bowdoin Refuge was established, grazing continued until it was gradually phased out between 1973 and 1977. The plan at that time was to rest areas indefinitely, and then to resume grazing on a periodic basis as needed, anticipating intervals of 6–10 years. In 1986, a short-duration, high-intensity grazing experiment was conducted on Bowdoin Refuge with an objective to break up large mats of clubmoss. Prescriptive grazing was not used again on the refuge complex until 2001. The objectives of the limited grazing program started in 2001 are to promote a diversity of native species and to control invasive plants by mimicking bison grazing and subsequently benefitting the mixed-grass prairie through control of vegetative litter and increased plant production and diversity.

The right to graze the lands encumbered by refuge and flowage easements in the four satellite refuges is maintained by the private landowners.

Mike Artmann / USFWS

Winterfat

3.9 Socioeconomic Environment

Most of the Bowdoin National Wildlife Refuge Complex is open to public use including the compatible, wildlife-dependent uses of hunting, fishing, wildlife observation, and photography. These recreational opportunities attract outside visitors and bring in dollars to the community. Associated visitor activity—such as spending on food, gasoline, and overnight lodging in the area—provides local businesses with supplemental income and increases the local tax base. Management decisions for the refuge complex about public use, expansion of services, and habitat improvement may either increase or decrease visitation to the refuge complex and, thus, affect the amount of visitor spending in the local economy.

As part of the CCP process, the Service had a contractor prepare an socioeconomic study for the Bowdoin Refuge Complex (BBC Consulting 2010), which is the basis for the following sections described below: population and employment, public use of the refuge complex, and baseline economic activity.

Population and Employment

The refuge complex is located throughout Valley, Phillips and Blaine Counties; a portion of the refuge complex is also located within Hill County. The entireties of these four counties comprised the socioeconomic study area.

Population and Demographics

The population of the four-county study area was estimated to be 33,741 in 2008. Hill County has the largest population (16,500) among the included counties while Phillips County has the smallest population (3,900) as well as the most refuges and waterfowl production areas in the refuge complex. Blaine and Valley Counties have similarly sized populations (6,500 and 6,900 respectively). The population of the study area declined by 5 percent between 1990 and 2000, from 37,800 to 36,000. The population of Montana grew by 13 percent from 800,000 to 900,000 over the same period. Future population projections for the study area and the State overall are expected to follow historical trends: the study area population is expected to decline slowly, and the State population will increase slowly.

In 1990, about 18 percent of the population was between 45 and 64 years old; that same demographic constituted 22 percent of the population in 2000 and 27 percent in 2008. All other age groups are holding steady or have declined except for young adults whose population has grown slightly since 1990.

Employment

Employment in the four-county study area grew slowly between 2001 and 2007 from 19,700 to 21,000, an increase of 7 percent. Hill County had the largest workforce with 10,414 employees, followed by Valley County (4,820), Blaine County (3,144), and Phillips County (2,687). As of December 2009, the un-

employment rate for Blaine County was 5.3 percent, Hill County was 4.9 percent, Phillips County was 6.5 percent, and Valley County was 5.2 percent. These compared favorably with a statewide unemployment level of 6.8 percent (U.S. Bureau of Labor Statistics 2009).

The study area primarily employs individuals in government, farm employment, retail trade, accommodations, food services, and construction. Government establishments employed 22 percent of the workforce while farm employment accounted for 15 percent of the workforce. Retail trade was the largest private, nonfarm source of employment (12 percent).

Public Use of the Refuge Complex

Public use and visitation levels are described below.

Public Use

Wildlife observation, photography, and hiking (nonconsumptive activity) account for 77 percent of visits to the refuge complex (Caudill and Henderson 2005). Most wildlife observers visit in the spring and summer, when the greatest numbers of migratory birds inhabit the area.

Hunting accounts for the remaining 23 percent of visitation to the refuge complex. Public hunting of migratory gamebirds and upland gamebirds are most popular. Predator hunting (fox and coyote) is allowed throughout the refuge complex. Big game hunting is allowed throughout the refuge complex except at Bowdoin Refuge and Holm WPA.

Fishing is permitted only on McNeil Slough WPA and Beaver Creek WPA. Most wetlands within the refuge complex have minimal habitat for fish or high salinity levels that cannot support a game fishery. In 2004, there were no fishing recreation visits to the refuge complex (Caudill and Henderson 2005).

Occasionally, Bowdoin Refuge offers environmental education opportunities including school group tours, Migratory Bird Day, Enrichment Days, and National Wildlife Refuge Week.

Camping and fires are not allowed on the refuge complex; however, the Bureau of Land Management oversees land around the refuge complex, which is open for camping. There are also several motels located in the town of Malta as well as two recreational vehicle campgrounds.

Visitation Levels

Annual visitation to the entire Bowdoin National Wildlife Refuge Complex is an estimated 25,000 people according to Service staff. Visitation is most heavily concentrated during wildlife-viewing seasons in the fall and spring and hunting season in the fall. Bowdoin Refuge staff estimates that 90 percent or 22,500 of all visitor days at the refuge complex are from outside the four-county study area. Of the total visitors to the refuge complex, the visitation breakdown follows:

- 12,680 visitor days are for wildlife viewing
- 6,646 visitor days are for hiking and walking
- 5,674 visitor days are for hunting of big game, predators, upland gamebirds, and migratory birds

Baseline Economic Activity

The refuge complex affects the economy through the nonresident visitor spending it generates and the employment it supports. Combining the effects of Service employment and visitor spending, the total economic activity generated by the refuge complex in the four-county study area is approximately $910,000 annually.

U.S. Fish and Wildlife Service Employment

The refuge complex employs five full-time equivalent employees and has a payroll of $398,553, or about $80,000 per employee. Using the Bureau of Labor Statistics Consumer Expenditure Survey data for individuals in these income categories, roughly 79 percent of annual income is spent locally. Under this assumption, the refuge complex contributes $316,000 to the local economy in employee spending.

Pasqueflower
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Visitor Spending

The refuges and waterfowl production areas in the refuge complex currently experience total visitation of about 22,500 nonresident visitor days per year. Of these, roughly 17,400 visitor days are for nonconsumptive recreational activities and 5,100 are for hunting. Combining these visitation numbers with nonresident spending averages from the Banking on Nature study, total visitor expenditure generated by the refuge complex is estimated to be $594,000 per year. Of this total, about $313,000 comes from nonconsumptive recreational activity and $281,000 comes from hunting.

3.10 Partnerships

The Bowdoin National Wildlife Refuge Complex has a history of fostering partnerships that help accomplish its vision and goals. These organizations and individuals with whom a common goal is shared include county, State, and Federal agencies; nongovernmental organizations and conservation groups; schools, colleges, and universities; and local landowners and private citizens. These partners have assisted in wildlife and habitat management, visitor services and recreational activities, land protection and acquisition, fire protection, law enforcement, and community outreach. Several of these relationships have developed into formalized partnerships with written agreements or memoranda of understanding while others remain more informal.

Private lands and significant acreages of Federal and State lands surround the refuge complex. Activities on and uses of these lands have a tremendous effect on the adjacent Service lands. These neighboring landowners and agencies have been and will continue to be partners in achieving the refuge complex's vision while sharing ideas and resources.

3.11 Operations

Service operations consist of the staff, facilities, equipment, and supplies needed to administer resource management and public use programs throughout the Bowdoin National Wildlife Refuge Complex, which is located across a four-county area totaling 17,183 square miles. Within this area, the Service is responsible for the protection of 85,713 acres of lands and waters including 17,009 acres of refuge lands, 10,635 acres of wetland easements, 39,767 acres of grassland easements, and 9,504 acres of fee-title waterfowl production areas.

Staff

Currently, the Bowdoin National Wildlife Refuge Complex staff comprises five permanent full-time employees (table 7). Since 1998, the refuge complex has lost two positions—one permanent biological science technician and a permanent maintenance worker. The current staffing level remains well below the minimum prescribed in the June 2008 Final Report—Staffing Model for Field Stations (USFWS 2008c), which recommended 6.5 additional staff including a GS–13 refuge manager, GS–12 wildlife refuge specialist, GS–9 park ranger (visitor services specialist), GS–9 park ranger (law enforcement), GS–12 wildlife biologist, WG–8 maintenance worker, and GS–6 biological science technician (0.5 full-time equivalent employee).

Table 7. Base staff funded in fiscal year 2011 at Bowdoin National Wildlife Refuge Complex, Montana.

Staff group	*Position*
Management	GS–12 refuge manager GS–9 wildlife refuge specialist (assistant refuge manager and collateral-duty law enforcement officer)
Biology	GS–11 wildlife biologist
Administration	GS–7 administrative support assistant
Maintenance	WG–8 maintenance worker

Facilities

Facilities are used to support habitat and wildlife management programs and wildlife-dependent public use activities for visitation estimated at 25,000 visitors annually. The refuge complex has one full-time maintenance worker to maintain buildings, fences, and roads.

Facilities have remained fairly updated over the years. The refuge headquarters and shop were built in 1980 and have been maintained in good condition. The headquarters was expanded in 2003, adding five new offices and a mailroom. Two new houses were constructed in 2001 to provide housing for refuge employees. In addition, the apartment building used for seasonal housing was remodeled in 2004 but still does not have sufficient space for the number of volunteers and seasonal employees needed to accomplish field projects. A new cold storage building with five parking bays was constructed in 2009.

Bowdoin Refuge Facilities

- 5,241-square-foot headquarters office building
- 0.25-mile asphalt entrance road and parking area
- 15-mile, self-guided auto tour route (graveled)
- Solar-powered entrance gate with a timer
- Two kiosks including interpretive signs
- 0.4-mile hiking trail (paved) with one photo blind, bench, and overlook

Carmen Luna / USFWS

- Two 2,700-square-foot, three-bedroom houses for staff; two unattached two-car garages with houses (684 and 672 square feet)
- 2,184-square-foot, two-bedroom bunkhouse apartment for seasonal staff with three parking bays
  - 3,472-square-foot maintenance shop and storage facility
  - 3,600-square-foot cold storage building with five parking bays
  - 600-square-foot storage shed for the airboat
  - 700-square-foot storage shed for all-terrain vehicles and field equipment
  - 348-square-foot seed storage shed
  - Two aboveground fuel tanks

Bowdoin Refuge Complex Facilities

- 62 miles of road (40 miles are Service-only roads and 22 miles are open to the public)
- 34 pullouts and parking areas
- 10 bridges (2 are Service-only bridges and 8 are open to the public)
- 90 miles of boundary fence
- Eight entrance signs
- 137 water control structures
- 32 miles of canals and dikes