AN EVALUATION OF ECOSYSTEM RESTORATION AND MANAGEMENT OPTIONS FOR LEE METCALF NATIONAL WILDLIFE REFUGE

Prepared For:

U.S. FISH AND WILDLIFE SERVICE
REGION 6
DENVER, COLORADO

By:

Mickey E. Heitmeyer
Greenbrier Wetland Services
Advance, MO

Michael J. Artmann
U.S. Fish and Wildlife Service
Region 6 Division of Planning
Denver, CO

Leigh H. Fredrickson
Wetland Management and Education Services, Inc.
Puxico, MO

Greenbrier Wetland Services Report No. 10-02

May 2010

Mickey E. Heitmeyer, PhD
Greenbrier Wetland Services
Route 2, Box 2735
Advance, MO 63730
www.GreenbrierWetland.com

Publication No. 10-02

Suggested citation:

Heitmeyer, M. E., M. J. Artmann, L. H. Fredrickson. 2010. An evaluation of ecosystem restoration and management options for Lee Metcalf National Wildlife Refuge. Prepared for U. S. Fish and Wildlife Service, Region 6, Denver, CO. Greenbrier Wetland Services Report 10-02. Blue Heron Conservation Design and Printing LLC, Bloomfield, MO.

Photo credits:

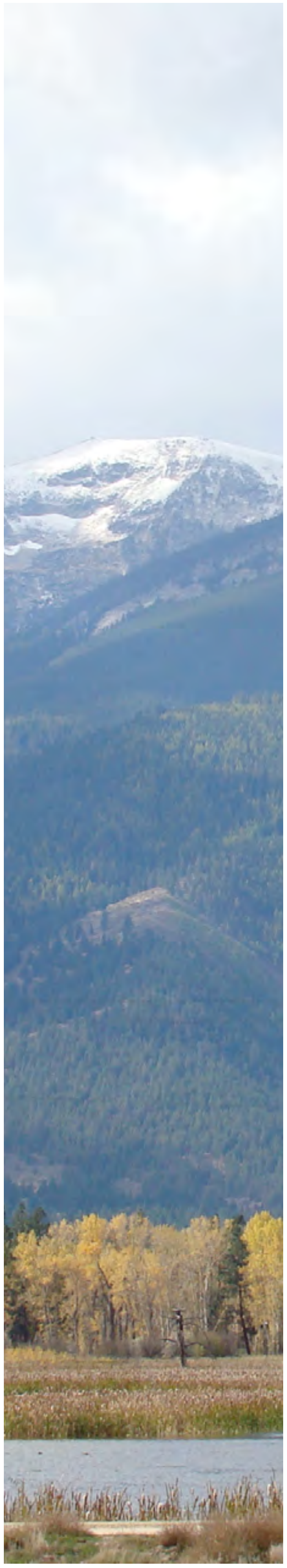
Cover photo by Karen Kyle

U. S. Fish & Wildlife Service (www.fws.gov/digital media) and Karen Kyle

This publication printed on recycled paper by

CONTENTS

Karen Kyle



EXECUTIVE SUMMARY

Lee Metcalf National Wildlife Refuge (NWR) is a relatively small (ca. 2,800 acre) refuge in the Bitterroot River Valley of southwest Montana. The refuge was authorized for management of migratory birds and incidental fish and wildlife-orient recreation, protection of natural resources, and conservation of endangered and threatened species. The historic ecosystem in the Bitterroot Valley contained diverse forest, wet meadow, grassland, and wetland communities. This ecosystem now is highly altered and degraded from construction of extensive roads, ditches, levees, dams, and water-control structures in the Bitterroot River floodplain; tile drainage and discharge from surrounding agricultural lands; water diversions and irrigation systems on and adjacent to the refuge, and expansion of invasive plant species. The channel of the Bitterroot River has been altered from levees, bank stabilization, and some channelization. Lee Metcalf NWR also is located in an area of rapid human population growth and residential development and is extensively used by the public.

In 2009, a Comprehensive Conservation Plan (CCP) was initiated for Lee Metcalf NWR. This CCP process is being facilitated by an evaluation of ecosystem restoration and management options using hydrogeomorphic methodology (HGM). This report provides HGM analyses for Lee Metcalf NWR with the following objectives:

1. Identify the pre-European ecosystem condition and ecological processes in the Bitterroot River floodplain near Lee Metcalf NWR.

2. Evaluate changes in the Lee Metcalf NWR ecosystem from the Presettlement period with specific reference to alterations in hydrology, vegetation community structure and distribution, and resource availability to key fish and wildlife species.

3. Identify restoration and management options and ecological attributes needed to successfully restore specific habitats and conditions within the area.

The Bitterroot River Valley extends about 120 miles from the confluence of the East and West Forks of the Bitterroot River south of Darby to its junction with the Missoula Valley and Clark Fork River five miles south of Missoula. The Valley is a structural trough formed during the late Cretaceous emplacement of the Idaho batholiths and is bounded by the Bitterroot Mountains on the west and the Sapphire Mountains on the east. Four geomorphic surface zones occur on or near Lee Metcalf NWR and include: 1) Holocene floodplain of the Bitterroot Valley, 2) low elevation alluvial fans that extend into the floodplain, 3) high elevation, mostly Quaternary-derived terraces adjacent to the floodplain on the west side of the valley, and 4) high elevation Tertiary-derived outcrop benches/terraces on the east side of the valley.

The Bitterroot River has inherent unstable hydraulic configuration and high channel instability. The river reach immediately upstream from Lee Metcalf NWR has a complex multi-strand channel pattern that is characterized by numerous braided channels that historically spread over a wide area of the valley bottom. The main channel system has widened and straightened since 1937 and bank erosion is common. Chutes and side channels facilitate overbank flooding and complex networks of minor floodplain drainage channels occur throughout the floodplain. Two major tributaries to the Bitterroot River (North Burnt Fork Creek and Three Mile Creek) flow through Lee Metcalf NWR.

Nearly 25 soil types are present on or adjacent to Lee Metcalf NWR and the juxtaposition of soils reflects the numerous channel migrations of the Bitterroot River across the floodplain. Most soils on the refuge are shallow, with thin veneers of silt and clay over deeper sand and gravel. Sandy subsoil layers outcrop in many places near the river.

The climate of the Bitterroot Valley is characterized by cool summers, low precipitation, and relatively mild winters. Annual precipitation averages about 13 inches, but is variable related to position in the valley. The growing season is about 103 days. Spring is the wettest period of the year, with about 25% of annual precipitation falling in May and June. Runoff in the Bitterroot River is highest in spring, with about 55% of annual river discharge occurring in May and June following snowmelt and local rainfall. Flows in the Bitterroot River decline throughout summer and remain relatively stable through winter. The river exceeds 1,050 cubic-feet/second (cfs) at a 50% annual recurrence interval and causes some water to back flood into floodplain depressions and drainages. Modest overbank flooding occurs at > 10,000 cfs and a > 50-year recurrence interval. The last major overbank flood event at Lee Metcalf NWR was in 1974.

Historic vegetation in the Bitterroot River floodplain at Lee Metcalf NWR included seven distinct habitat/community types: 1) Riparian/Riverfront-type Forest, 2) floodplain Gallery-type Forest, 3) Persistent Emergent, 4) Wet Meadow Herbaceous, 5) Floodplain and Terrace Grassland, 6) Saline Grassland, and 7) Grassland-Sagebrush. Riverfront Forest contains mainly cottonwood and willow on newly deposited and scoured gravelly-sand and fine sandy loam soils near the active channel of the Bitterroot River. Gallery Forest is dominated by cottonwood and ponderosa pine, has a shrub understory, and is present on higher floodplain elevations with veneers of Chamokane loam soil along natural levees and point bar terraces adjacent to minor floodplain tributaries. Low elevation oxbows, depressions, and off-channel areas historically supported Persistent Emergent wetland vegetation such as cattail. These habitats typically have poorly drained Slocum loam-clay soils. Some sites adjacent to Persistent

Emergent communities contained diverse Wet Meadow vegetation dominated by sedges, rushes, and water tolerant grasses. The majority of higher elevations within the Lee Metcalf NWR floodplain region were covered with grasses and some scattered shrubs. Sites that had occasional surface flooding contained wet Grassland communities with interspersed herbaceous plants such as smartweed and sedges, while higher floodplain terraces, slopes, and alluvial fans contained mixed grasses and shrubs such as rabbit brush, sage, needle and thread, and june grass. Certain sites on Lee Metcalf NWR have saline soils that historically supported more salt tolerant grassland species. A composite map of potential historic vegetation communities, based on HGM attributes, is presented.

The Bitterroot River floodplain at Lee Metcalf NWR historically supported a wide diversity of animal species associated with the interspersed riverine, floodplain, wetland, and grassland habitats. Migratory birds are especially abundant in the region. Resources historically used by animals were seasonally dynamic and annually variable. Most bird species exploited seasonal resources during spring migration and summer; few species overwintered in the area. Many waterbird likely stayed in the Valley during wet summers to breed when floodplain wetlands had more extensive and prolonged water regimes. In contrast, limited numbers of waterbirds probably bred in the region in dry years.

The first European settlement in Montana was established at the present day site of Stevensville, near the Lee Metcalf NWR, in 1841. Early land use of the valley was primarily cattle grazing. Discovery of gold in western Montana in the mid-1950s fueled immigration of settlers to the state and a short lived flurry of gold exploration and mining occurred in the Bitterroot Valley. By the 1870s, the economy of the area was almost solely based on local agricultural crops, cattle production and some timber harvest. The dry climate of the valley created annual variation in the availability of water to support crops, and water rights in the region were quickly appropriated and subsequent adjudication occurred. In the early 1900s, the Bitterroot Valley Irrigation

Company started construction of a major irrigation system including construction of Lake Como, a diversion dam on Rock Creek, many miles of conveyance canal, and associated siphons, distribution ditches, and water-control structures. Drought, insufficient water delivery for orchard crops, and Depression era economics exacerbated water problems in the valley and ultimately curtailed large scale agricultural development in the region in the mid 1900s. The Bureau of Reclamation assumed operation of the Irrigation Company in the early 1930s and has made extensive improvements and repair to the irrigation delivery system to its current condition.

Agricultural and irrigation developments and increasing human populations greatly altered the Bitterroot Valley by the time the Lee Metcalf NWR was established in 1963. Most Riparian and Gallery Forest and floodplain grassland was cut, cleared, and/or converted to alternate land uses by the mid 1900s. Irrigation ditches significantly altered floodplain drainage and hydrology. Numerous roads were built in the region and a rail line and bridge was constructed at the north boundary of Lee Metcalf NWR. By the early 1990s, Ravalli County had the fastest growing population and residential expansion in Montana, which now surrounds the refuge. Irrigation development and changed land uses significantly altered hydrology and channel morphology of the Bitterroot River and caused degradation and loss of wetlands in this ecosystem.

Following acquisition, the U.S. Fish and Wildlife Service began extensive physical developments on floodplain lands at Lee Metcalf NWR. By the late 1980's, over 1,000 acres had been partly or completely impounded in 14 ponds for managed wetland units. These impoundments have been subsequently managed by diverting irrigation and tile drain water, flows in minor channels and tributaries, and Three Mile Creek water into and through the impoundments. Lee Metcalf NWR has 24 water rights claims and one permit totaling 50,495 acre-feet/year. Since establishment, most wetland impoundments have been managed to promote waterfowl production by holding water through summer or year round. Otter Pond was stocked with warm-water fish in 1989. Level ditching, siphons, water-control structures, and sediment removal have been constructed in and near impoundments. Over 25 miles of road are present on the refuge. Certain upland areas were converted to warm-season grasses for dense nesting cover for waterfowl and predator exclusion fences were built around some fields. In the 1960s and early 1970s, some fields on the refuge were planted to small grains.

Collectively, the many landscape and hydrological changes in the Bitterroot Valley have dramatically changed the ecosystem at Lee Metcalf NWR, which now has: 1) reduced area of Riparian and Gallery Forest, 2) Increased Persistent Emergent and Open Water habitat, 3) increased Herbaceous Wetland, 4) decreased native Grassland, 5) increased agricultural and tame grass fields, and 6) increased invasive and exotic plant species. These vegetation community changes also have caused changes, and declines, in abundance and distribution of native animal species. Many of the management developments at Lee Metcalf NWR have attempted to convert this semi-arid and inherently dynamic western river floodplain-terrace ecosystem into more of a Northern Great Plains wetland basin system that supported consistent and higher waterfowl production. In essence, management and development of Lee Metcalf NWR since the 1960s have not been consistent with the naturally occurring physical, biotic, and sustaining ecological features of the site.

This report identifies options to restore and manage natural ecosystem processes, functions, and values at Lee Metcalf NWR based on hydrogeomorphic characteristics of the historic and current system. Comprehensive restoration of native communities and sustaining processes will be difficult because of: 1) the small size of the refuge, 2) the insular nature of the refuge that increasingly is surrounded by urban/residential development, 3) highly modified landforms and communities on and adjacent to the refuge, 4) constraints on sustaining the inherently unstable morphology and hydrology of the Bitterroot River, and 5) high public use and competing demands for refuge management and access. Despite these challenges, future management of Lee Metcalf NWR should seek to:

1. Maintain the physical and hydrological character of the Bitterroot River and its floodplain on Lee Metcalf NWR.

2. Restore the natural topography, water regimes, and physical integrity of surface water flow patterns in and across the Bitterroot River floodplain and adjacent terraces and alluvial fans.

3. Restore and maintain the diversity, composition, distribution, and regenerating mechanisms of native vegetation communities in relationship to topographic landscape position.

Specific recommendations are provided to conduct restoration and management options for each of the above goals and to monitor and evaluate future management in an adaptive management framework.

Karen Kyle

Karen Kyle

INTRODUCTION

Lee Metcalf National Wildlife Refuge (NWR), owned and managed by the U.S. Fish and Wildlife Service (USFWS), is a relatively small (ca. 2,800 acre) refuge in Ravalli County in the Bitterroot Valley of southwest Montana about 20 miles south of Missoula (Fig. 1). The refuge was established in 1963 and was originally named the Ravalli NWR. The name was changed to Lee Metcalf NWR in 1978 in honor of long-time U.S. Senator Lee Metcalf who was instrumental in establishing the refuge and was involved in many other conservation initiatives. The authorizing purposes for the refuge were: 1) "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" (Migratory Bird Conservation Act, 16 USC 715d) and 2) "suitable for incidental fish and wildlife-oriented recreational development, the protection of natural resources, and the conservation of endangered species or threatened species" (16 USC 460k-2; Refuge Recreational Act 16 USC 460k, as amended).

Lee Metcalf NWR borders the Bitterroot River between the scenic Bitterroot and Sapphire Mountain ranges and is within a rapidly expanding human population area of Montana. This unique location includes a diverse mosaic of western mountain valley ecosystem types and provides many public use opportunities including recreation, education and discovery, and research activities. Currently, intensive agriculture, housing, strip malls, and other urban amenities in the Bitterroot Valley surround the refuge. A golf course is present at the refuge boundary and has a large number of daily visitors. The nearby Bitterroot National Forest is visited by several thousand people each year, and Lee Metcalf NWR has over 140,000 visitors and 2,000 hunters annually. The refuge has an active Friends Group and volunteer program.

The Lee Metcalf NWR ecosystem has been altered by extensive roads, ditches, levees, dams, and water-control structures in the Bitterroot River floodplain; tile drainage and discharge from surround agricultural lands; water diversions and irrigation systems adjacent to, and within, the refuge; and expansion of invasive plant species. A frontline levee

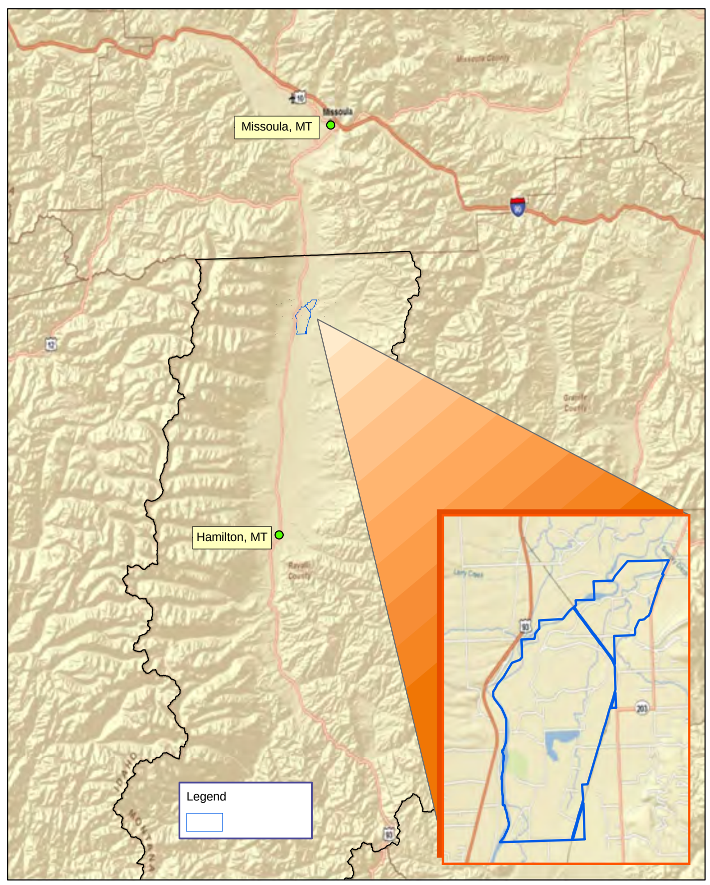


Figure 1. General location of Lee Metcalf National Wildlife Refuge.

along the Bitterroot River was constructed in the 1970s after a major flood event in 1974 and a complex network of water-control infrastructure was constructed for wetland management impoundments after the refuge was established. The refuge does not have senior water rights; but adjudication is an on-going process to be completed in 2015.

Three major irrigation ditches (McElhaney, Warburton, and Alleman Ditches) flow into and through the refuge. Additionally two primary tile drain ditches (Middle and South Drains) that originate on surround private farm lands provide year-round water flow into the refuge. Extensive bank erosion on the Bitterroot River is present in many locations, and in some places levees and other water-control structures in wetland impoundments or "ponds" are in danger of being compromised by this erosion. Extensive areas of the Bitterroot River channel are rip-rapped to control erosion and river channel migration. Part of the river also has been channelized immediately upstream from an old railroad bridge across the Bitterroot River.

Past management of Lee Metcalf NWR primarily has been directed at increasing waterfowl production, especially dabbling ducks. Consequently, a series of wetland impoundments were constructed to provide more annually stable and consistent water levels on the refuge. This more prolonged water regime gradually shifted plant communities to wetter types, including extensive monocultures of cattail in deeper areas. Other intensive waterfowl production management included establishment of dense nesting cover and construction of predator fences to enhance duck nesting success; construction of islands and level-ditch dredge and spoil areas within impoundments; and compartmentalization of wetland units.

In 2009, the USFWS initiated preparation of a Comprehensive Conservation Plan (CCP) for Lee Metcalf NWR. The CCP process seeks to articulate the management direction for the refuge for at least the next 15 years and it develops goals, objectives, and strategies to define the role of the refuge and its contribution to the overall mission of the National Wildlife Refuge system. At Lee Metcalf NWR, the CCP process is being facilitated by an evaluation of ecosystem restoration and management options using Hydrogeomorphological Methodology (HGM). HGM now is commonly used to evaluate ecosystems on National Wildlife Refuges (e.g., Heitmeyer and Fredrickson 2005, Heitmeyer et al. 2006, Heitmeyer and Westphall 2007, Heitmeyer et al. 2009) by obtaining and analyzing historic and current information about: 1) geology and geomorphology, 2) soils, 3) topography and elevation, 4) hydrology, 5) plant and animal communities, and 6) physical anthropogenic features of refuges and surrounding landscapes. Specifically, HGM analyses for Lee Metcalf NWR: 1) uses the above information to develop appropriate, realistic, and sustainable options for "habitat-based" objectives on the refuge; 2) seeks to emulate natural hydrological and vegetation/animal community patterns and dynamics within the Bitterroot River floodplain ecosystem; 3) understands, complements, and at least partly mitigates negative impacts and alterations to Lee Metcalf NWR and surrounding lands; 4) incorporates "state-of-the-art" scientific knowledge of ecological processes and requirements of key fish and wildlife species in the region; and 5) identifies important monitoring needs of abiotic and biotic features.

This report provides HGM analyses for Lee Metcalf NWR with the following objectives:

1. Identify the pre-European settlement (hereafter "Presettlement") ecosystem condition and ecological processes in the Bitterroot River floodplain near Lee Metcalf NWR.

2. Evaluate changes in the Lee Metcalf NWR ecosystem from the Presettlement period with specific reference to alterations in hydrology, vegetation community structure and distribution, and resource availability to key fish and wildlife species.

3. Identify restoration and management options and ecological attributes needed to successfully restore specific habitats and conditions within the area.

Bob Gress USFWS

THE HISTORIC LEE METCALF ECOSYSTEM

GEOLOGY, SOILS, TOPOGRAPHY

Geology

The Bitterroot Valley, where the Lee Metcalf NWR is located, is a north-trending basin bounded by the Bitterroot Mountains on the west and the Sapphire Mountains on the east. The origin of these mountains, and the rich montane Bitterroot Valley, date to nearly 90 million years before the present (Hodges and Applegate 1993). The Bitterroot Valley extends about 120 miles from the confluence of the East and West Forks of the Bitterroot River south of Darby to its junction with the Missoula Valley and Clark Fork River five miles south of Missoula. The elevation of the valley floor ranges from about 3,900 feet above mean sea level (amsl) in the south to about 3,200 feet amsl near Missoula. Summit elevations of surrounding mountains range from 6-8,000 feet amsl in the Sapphire Range and exceed 9,500 feet amsl in the Bitterroot Range. Four general geomorphologic zones occur in the Bitterroot Valley and include: 1) the Holocene (geologic timeframe is provided in Appendix A) floodplain of the Bitterroot River, 2) low elevation alluvial fans that extend into the floodplain, 3) high elevation, mostly Quaternary-derived, terraces adjacent to the floodplain on the west side of the valley, and 4) high elevation Tertiary-derived outcrop benches/terraces on the east side of the valley (Lonn and Sears 1998, 2001). The floodplain contains highly heterogeneous vertical and horizontal bands of mostly sandy and gravelly alluvium about 3 miles wide.

The Bitterroot Valley is a structural trough formed during the late Cretaceous emplacement of the Idaho batholiths (Ross 1950, McMurtrey et al. 1972, Hyndman et al. 1975). The Bitterroot Mountains are composed of granitic rocks, metamorphic materials, and remnants of pre-Cambrian sediments of the Belt series. The Idaho batholiths, predominantly gray quartz monzonite with small amounts of grandodiorite and anorthite, form the core of the Bitterroot Range. A veneer of gneissic metamorphic material about 2,000 feet thick drapes the range's eastern front (McMurtrey et al. 1972). The Sapphire Mountains are mostly Belt rocks with localized occurrences of granitic stocks. Outcrops of Belt rock include dark-gray quartzite and argillaceous limestone and limy argillites of the Newland formation.

The unusually straight front of the Bitterroot Range is a zone of large-scale faulting (Langton 1935, Pardee 1950); however, the Bitterroot Valley shows little sign of recent tectonic activity (Hyndman et al. 1975). Undisturbed valley fill indicates that tectonic movement since the early Pliocene has been slight or that the entire valley floor has moved as a single unit. The structural basin of the Bitterroot Valley has accumulated a considerable thickness of Tertiary sediments capped in most places by a layer of Quaternary materials. Surficial geology evidence suggests Tertiary fill in the Bitterroot Valley may be up to 4,000 feet thick in some locations (Lankston 1975). This fill is highly variable in context with mostly Six-Mile gravelly formation and finer-grain Renova formation (Noble et al. 1982, Uthman 1988). Sediment is coarse colluviums near the fronts of mountains with finer-grain alluvial fill deposits that interfinger with floodplain silts and clays. Channel deposits of the ancestral Bitterroot River lie beneath the valley center. Tertiary sediments outcrop only on the high terraces of the east side of the valley. Average thickness of Quaternary sediments is about 40 feet of alluvium over the Tertiary strata. The ends of the high Tertiary terraces on the east and most of the west-side terrace surfaces are capped by early to mid-Pleistocene alluvium, while the low terraces and current floodplain are composed of late Pleistocene and Holocene alluvium.

Quaternary alluvium on high terraces in the valley is mostly unconsolidated sediments of fluvial, glaciofluvial, and glaciolacustrine origin. Low terrace alluvium occurs as outwash, or "alluvial fans", below the mouths of tributaries on both sides of the valley (Lonn and Sears 2001). Floodplain alluvium is mostly well-rounded gravel and sand with a minor amount of silt and clay derived from the edges of the adjacent terraces and fans. Most of Lee Metcalf NWR is mapped as "Qal" alluvial deposits of recently active channels and floodplains (Fig. 2). These deposits are well-rounded, and sorted gravel and sand with a minor amount of silt and clay. Clast lithologies represent rock types of the entire drainage including granitic, volcanic, metamorphic, and sedimentary rocks. Minor amounts of "Qaty" (younger alluvial outwash terrace and fan complex deposits from the late Pleistocene) occur adjacent to the Bitterroot Valley alluvium on the north end of the Lee Metcalf NWR. These surfaces are late Pleistocene alluvium of the Riverside and Hamilton terraces and rise 10-20 feet above the present floodplain and are approximately 10-30 feet thick. Materials in these terraces are well-rounded and sorted gravel of predominantly granitic, gneissic, and Belt sedimentary origin (Lonn and Sears 2001). "Qafy" surfaces extend along the Bitterroot Valley on both sides of Lee Metcalf NWR. These surfaces are younger (late Pleistocene) alluvial outwash terrace and fan complexes of well-rounded cobbles and boulders in a matrix of sand and gravel deposited in braided-stream environments that formed between and below the dissected remnants of older fans. These surfaces appear to have been at least partly shaped by glacial Lake Missoula that reached a maximum height at an elevation of 4,200 feet and covered the Bitterroot Valley near Lee Metcalf during the last glacial advance 15-20,000 years before the present (Weber 1972). Surfaces of these deposits are 5-25 feet above active channels. Some alluvial fans coalesce with younger alluvial terrace deposits; average thickness of fans is about 40 feet.

The Bitterroot River has an inherently unstable hydraulic configuration and high channel instability, particularly between the towns of Hamilton and Stevensville (Cartier 1984, Gaeuman 1997). The river reach immediately upstream from Lee Metcalf NWR has a complex multi-strand channel pattern that is characterized by numerous braided, or anastomosing, channels that spread over a wide area of the valley bottom. The zone of non-vegetated gravels associated with main braided channel system has widened and straightened since 1937 (Gaeuman 1997). In addition to this widening, severe bank erosion is common but numerous cut-off chutes counteract some lateral bend displacement. Chutes and other avenues of river overflow are encouraged by low river banks and natural levees, which were never highly accreted because of active river movements and a braided river channel configuration. Complex networks of minor channels occur in

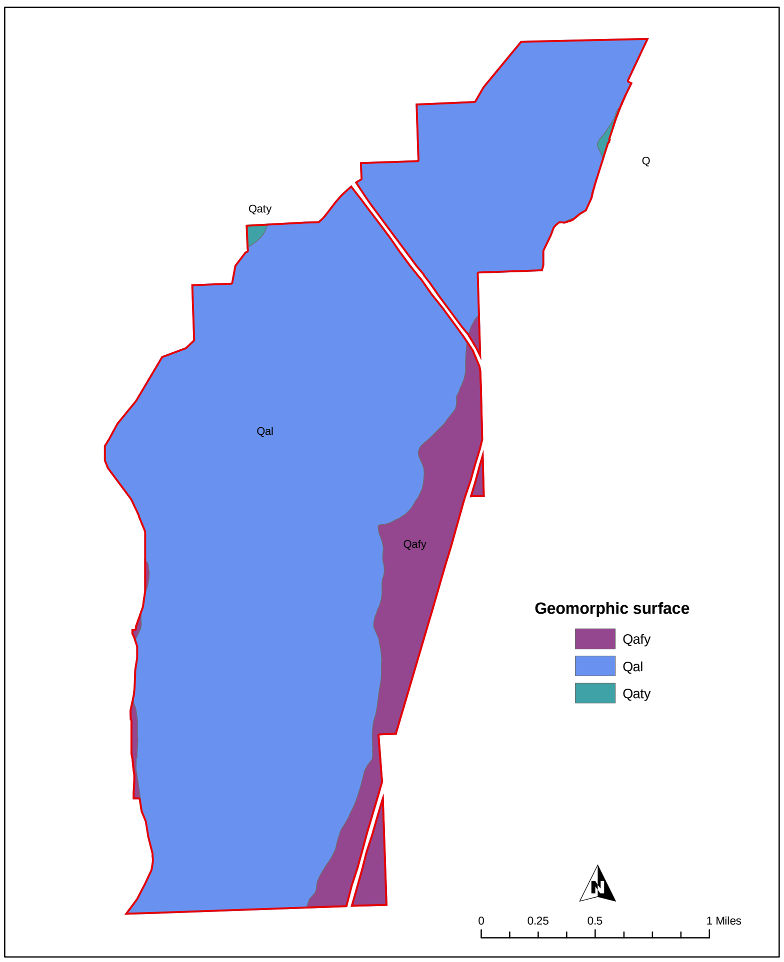


Figure 2. Geomorphic surfaces on Lee Metcalf National Wildlife Refuge (from Lonn and Sears 2001). "Qal" – Quaternary alluvial deposits. "Qafy" – Holocene alluvial outwash terraces and fan complexes. "Qaty" – Pleistocene alluvium of late Riverside and Hamilton terraces.

the valley floor including the floodplain lands on Lee Metcalf NWR (Fig. 3). These minor channels appear to have their genesis from groundwater discharge, which promotes basal sapping and headwater retreat of small channel head cuts on the floodplain. Channel multiplicity appears to be controlled by irregularities in the respective elevation gradients of the valley.

From Stevensville north about 10-15 miles, the Bitterroot River channel is more confined, compared to a highly braided form further south. Despite some river morphology change north of Stevensville, the river stretch along the Lee Metcalf NWR has maintained a highly dynamic, instable channel form due to its geological, topographic, and hydraulic position. The historic floodplain at Lee Metcalf NWR was characterized by: 1) multiple abandoned channels (e.g. Barn and Francois sloughs) that were connected with the main river channel during high flow events; 2) small "minor" within-floodplain channels (e.g., Rogmans and Spring Creek) that received water from groundwater discharge and occasional overbank backwater flooding during high flow events; 3) entry of two mountain/terrace derived major tributaries to the Bitterroot River (e.g. North Burnt Fork Creek and Three Mile Creek); 4) slightly higher elevation inter-drainage point bars, natural levees, and terraces; and 5) alluvial fans (Figs. 4,5).

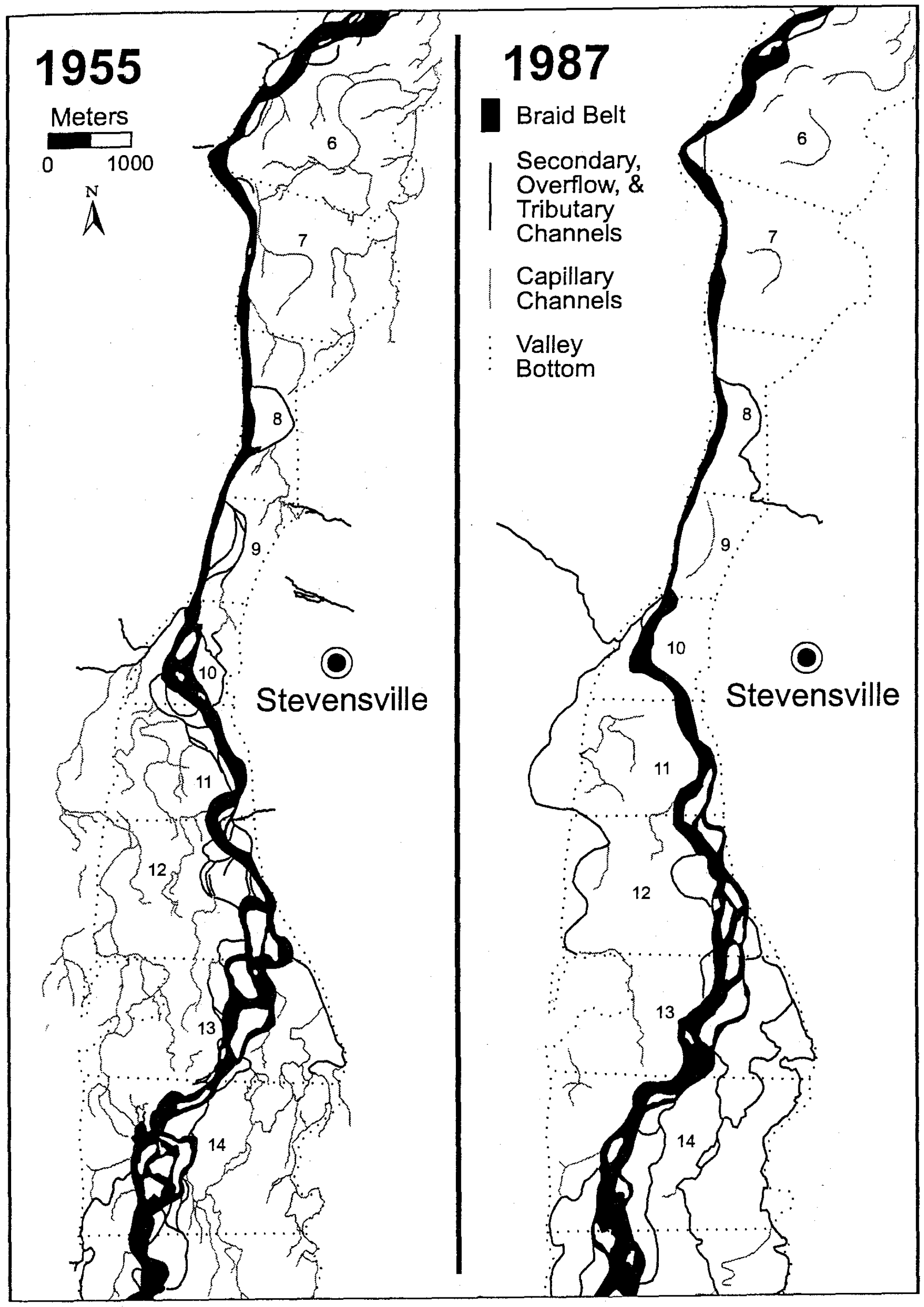


Figure 3. Bitterroot River floodplain channels and tributaries in the Lee Metcalf National Wildlife Refuge region, 1955 and 1987 (from Gaeuman 1997).

Soils

Nearly 25 soil types/groups currently identified by the U.S. Department of Agriculture SSURGO data bases are present on or adjacent to Lee Metcalf NWR (Fig. 6). The most extensive soils are Riverrun-Curlew-Gash complex, Ambrosecreek sandy loams, and Riverside-Tiechute-Curlew complexes. Current soil maps of Lee Metcalf NWR are constrained

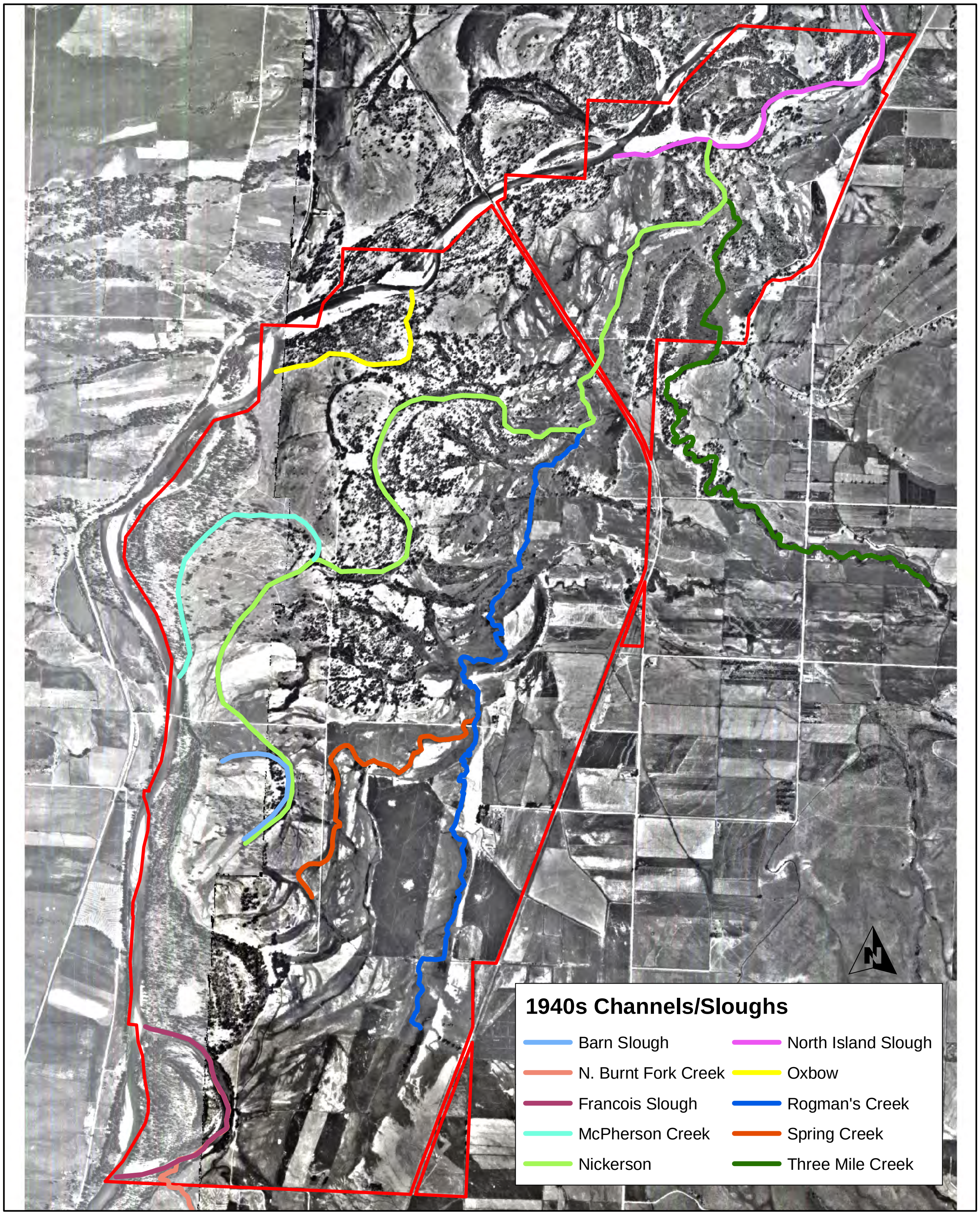


Figure 4. Aerial photograph of the Lee Metcalf National Wildlife Refuge region in 1940 showing major floodplain drainages and abandoned channels of the Bitterroot River.

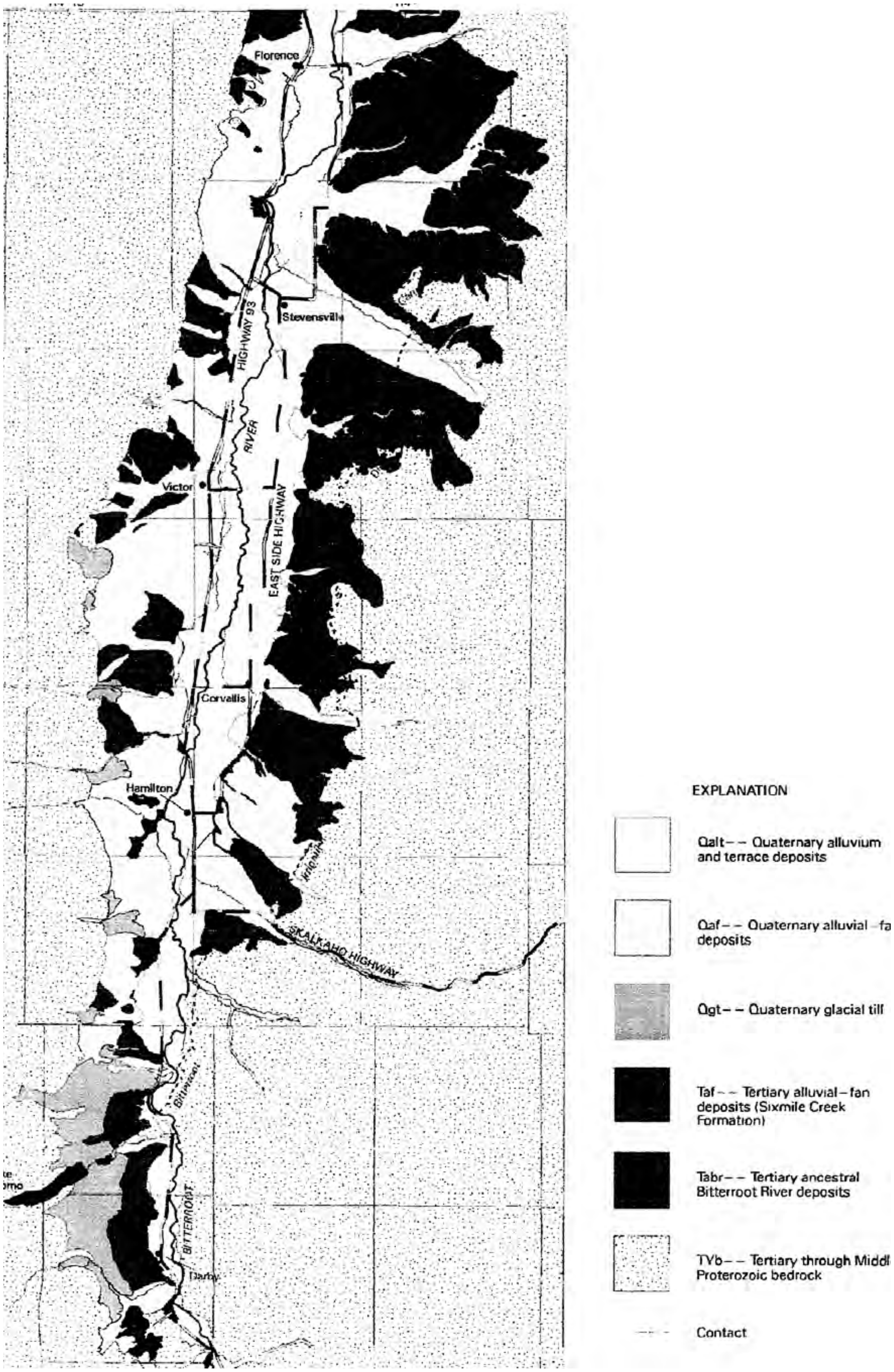


Figure 5. Location of major alluvial fans along the Bitterroot River Valley (modified from Lonn and Sears 1998).

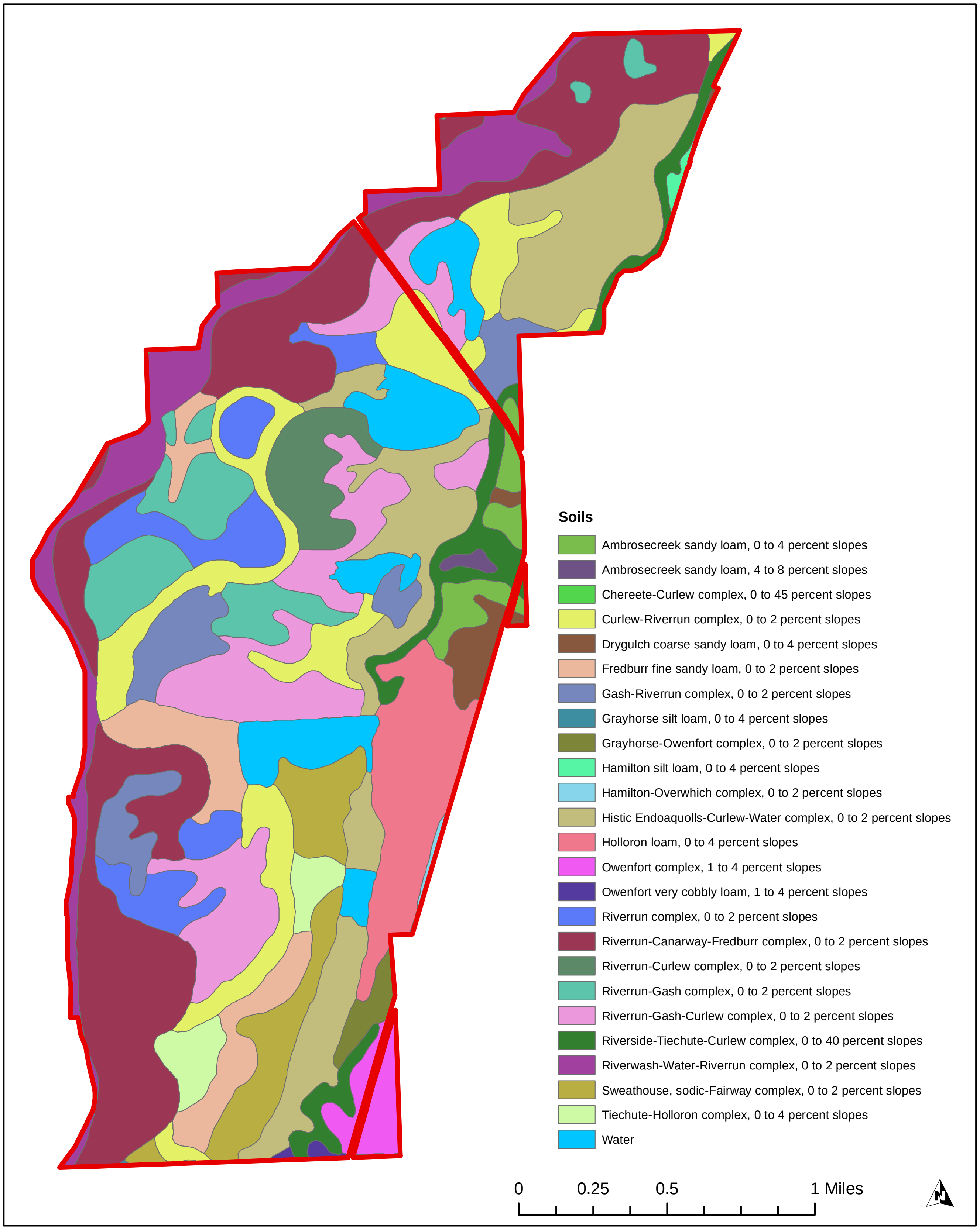


Figure 6. Soils on Lee Metcalf National Wildlife Refuge (from U.S. Department of Agriculture SSURGO data bases).

by numerous water impoundments where no soil type is identified and the impoundment areas are listed as "water." Consequently, older soil surveys (e.g., Bourne et al. 1959), despite using different soil taxonomy names, are more useful to understand soil types and distribution on the refuge prior to major floodplain developments and impoundment construction and are used in this report to construct HGM matrices of historic distribution of plant communities. The juxtaposition of soils on the NWR is complex, highly interspersed, and reflects the numerous channel migration events across this floodplain, introduction of mixed-erosion sediments from surrounding Quaternary and Tertiary terraces, and alluvial deposition of Bitterroot Valley parent materials. Most soils on the NWR are shallow, with thin veneers of silts and clays overlying deeper sands and gravels. In many places sandy outcrops occur, especially near the Bitterroot River.

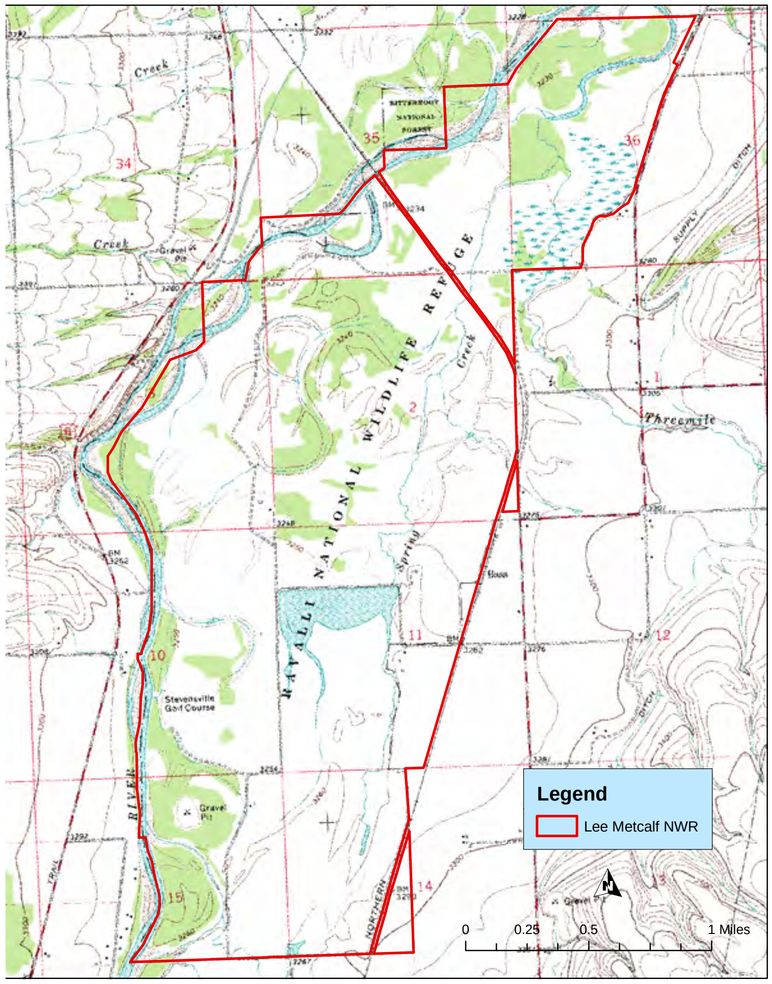


Figure 7. U.S. Geological Survey 7.5-minute topographic quadrangle map of the Lee Metcalf National Wildlife Refuge region.

Topography and Elevation

Elevations on Lee Metcalf NWR range from about 3,230 on the north end to about 3,260 on the south end of the refuge (Figs. 7, 8). Much topographic heterogeneity occurs within the refuge related to historic Bitterroot River channel and tributary channel migrations, scouring and natural levee deposition along minor floodplain channels, and alluvial deposition. A large portion of the southeast part of the refuge contains higher, more uniform, elevations while north and west parts of the refuge have lower, more diverse, elevations. Alluvial fans are present in many locations along the "Qafy" geomorphic surfaces on the east side of the refuge. A larger "tributary fan" is present where North Burnt Fort Creek enters the Bitterroot River floodplain and is much larger than the alluvial fans along the floodplain margin that grade into the Sapphire Mountain Range (Fig. 5).

CLIMATE AND HYDROLOGY

The climate of the Bitterroot Valley is characterized by cool summers, generally light precipitation, little wind, and relatively mild winters. Annual precipitation averages about 13 inches but is variable related to position in the valley (Fig. 9). Precipitation increases with elevation along the valley margins and ranges from < 13 inches in the Bitterroot Valley floor to nearly 60 inches near Bitterroot Mountain summits on the west side of the valley. In contrast, precipitation along the crest of the Sapphire Mountains on the eastern margin of the Valley is about 25-35 inches/year. The growing season in the Valley averages about 103 days; the average last occurrence of freezing temperatures is 30 May and average first frost is 10 September. Spring is the wettest period of the year, with about 25% of annual precipitation falling in May and June (Fig. 10). Runoff in the Bitterroot River is highest in spring, with about 55% of the river's discharge occurring in May and June following snowmelt and local rainfall (McMurtrey et al. 1972). Natural flows in the Bitterroot River

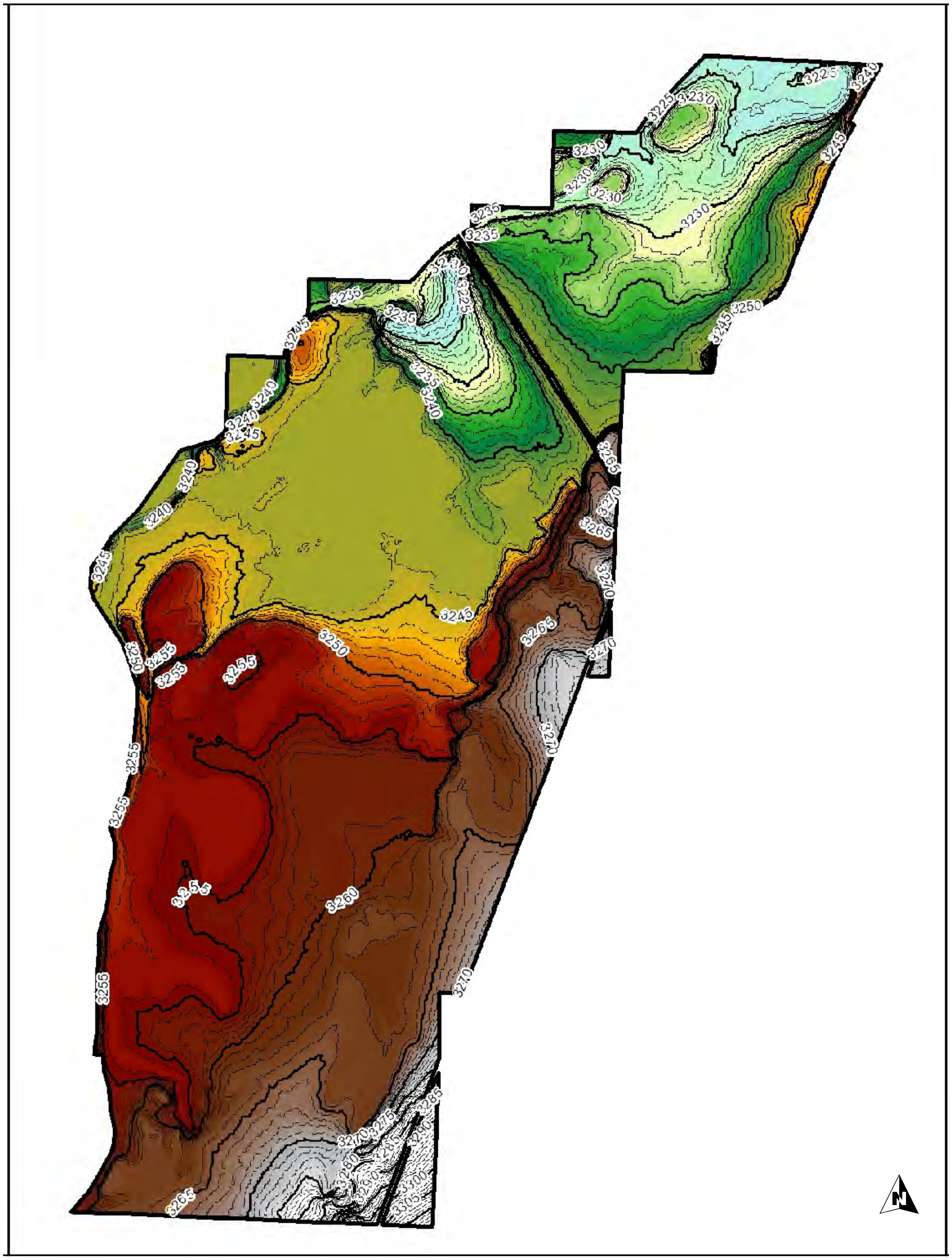


Figure 8. Digital elevation (10 m) model of Lee Metcalf National Wildlife Refuge, showing one-foot contour intervals.

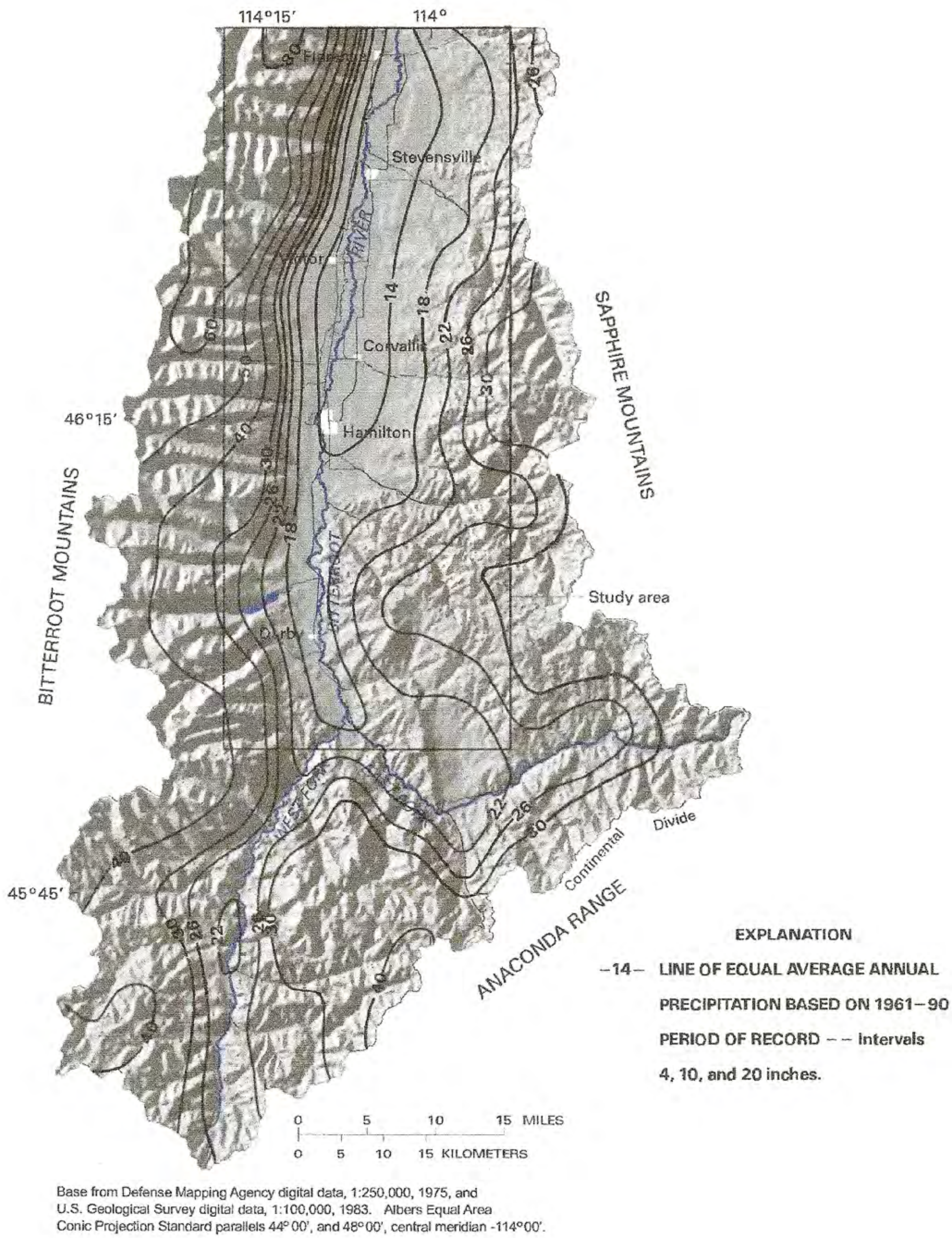


Figure 9. Average annual precipitation in Ravalli County, Montana (from Briar and Dutton 2000).

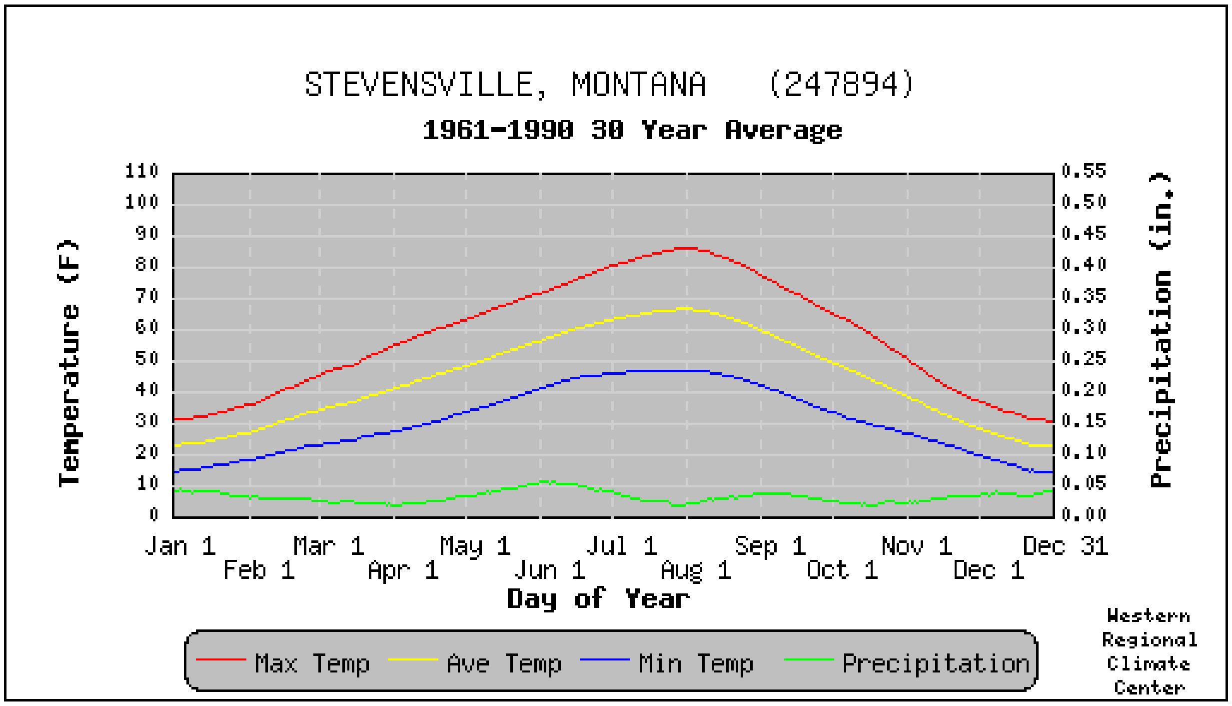


Figure 10. Mean annual temperature and precipitation at Stevensville, Montana 1961-1998.

Figure 11. Aerial photograph of flooding on Lee Metcalf National Wildlife Refuge in summer 1974.

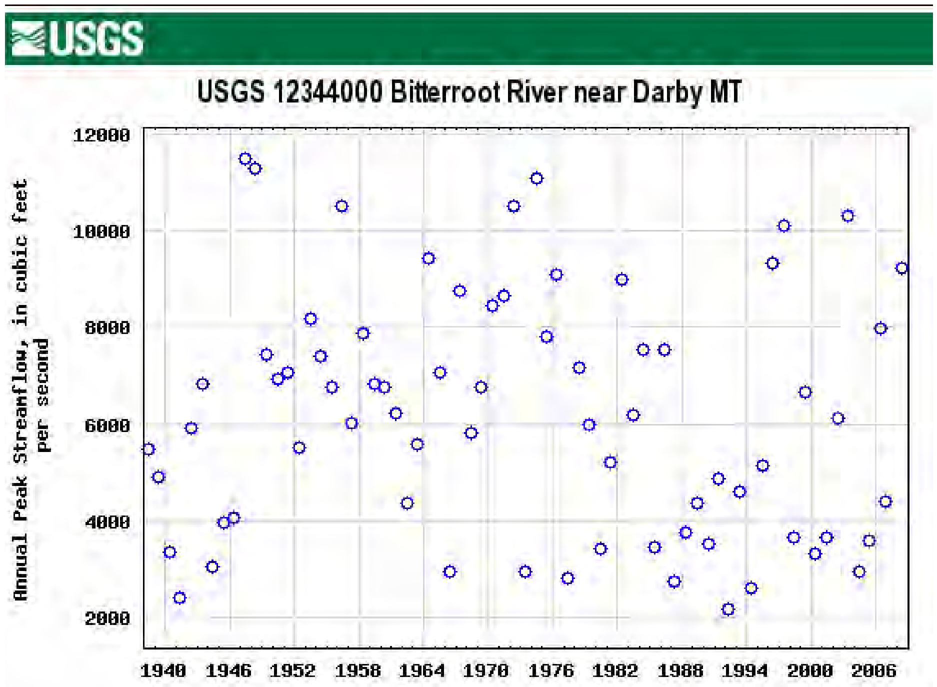


Figure 12. Peak discharge (cfs) of the Bitterroot River near Darby, Montana 1940-2007.

decline from spring peaks throughout summer and remain relatively stable through winter. On average about 1.772 million acre-feet of water flows into the Bitterroot basin via the Bitterroot River each year. Of this total entry, 52% is from the west, 37% is from the south, and 11% is from the east (Briar and Dutton 2000).

Numerous tributaries enter the Bitterroot Valley from mountain canyons. North Burnt Fork Creek and Three-mile Creek are major tributaries flowing across Lee Metcalf NWR into Francois Slough and North Island Slough, respectively (Fig. 4). Other minor, within flood-plain, drainages that historically crossed Lee Metcalf and ultimately emptied into the Bitterroot River included Spring Creek, Rogmans Creek, and the currently modified McPherson and Nickerson creeks (now called "ditches"). Valley-wide, about four times as many tributaries join the river from the Bitterroot Mountains on the west compared to the drier Sapphire Mountains on the east.

Flow and flood frequency relationships are available for the Bitterroot River near Florence since 1950 (Table 1). For this period of record, the river exceeded 1,050 cubic feet/second (cfs) at a 50% recurrence interval, or every other year frequency. Bankfull discharge at Florence is about 13,000 cfs; some modest backwater flooding on Lee Metcalf NWR occurs at > 10,000 cfs with a > seven-foot stage height (USFWS 1974). This high flooding discharge occurs very infrequently at a > 50-year recurrence interval, yet it causes extensive flooding throughout higher floodplain areas (e.g., Fig. 11). In contrast, spring backwater flooding into connected floodplain sloughs and oxbows occurs regularly, at a 5-10 year recurrence interval. The Darby gauge station, upstream from Lee Metcalf NWR, has the longest period of record for discharge on the Bitterroot River. Discharges on the Bitterroot River at Darby have less influence from irrigation return flow, so this gauge station represents the best location to evaluate relatively natural long-term patterns in river flow. Peak discharge at Darby, dating to the 1940s suggests periodic high discharge (> 10,000 cfs) at about 20-25 year intervals with intervening years of moderate to low flows (Fig. 12). During the period of record, more very low flow (< 4,000 cfs) years (20) occurred than did high flow (> 8,000) years (16). In summary, river gauge data suggest the floodplain at Lee Metcalf was seldom extensively flooded historically (e.g., 1974, Fig. 11), but that some backwater flooding into primary sloughs and tributaries occurred at a > 50% recurrence interval in spring.

Many of the morphological characteristics of "capillary" or "secondary" channels of the Bitterroot River floodplain, including those at Lee Metcalf NWR (such as Three-Mile, Rogmans, McPherson, and Nickerson creeks and Francois Slough) are indicative of an intimate connection with ground-water discharge (Gaeuman 1997). Lack of connectivity within secondary channel networks, large upstream and downstream variations in discharge within individual channels, and observed springs along the margins of floodplain terraces indicate a substantial subsurface flow. Many of these channels are probably remnants of formerly large channels (including past abandoned channels of the Bitterroot River) that have filled incompletely, perhaps because of the maintenance of a base groundwater flow. In other cases, groundwater discharge may be actively

Table 1. Flow duration record for the Bitterroot River near Florence, Montana, 1950-79 (from Cartier 1984).

BITTERROOT RIVER NEAR FLORENCE
(USGS 123512.00)

FLOW DURATION RECORD
1950-1979*

PERCENT EXCEEDENCE	DISCHARGE (CMS)	DISCHARGE (CFS)
0.1	546	19300
0.2	521	18400
0.5	464	16400
1.0	416	14700
2.0	362	12800
5.0	275	9700
10.0	184	6500
15.0	126	4450
20.0	87.8	3100
25.0	65.1	2300
30.0	51.2	1810
35.0	43.9	1550
40.0	38.2	1350
45.0	34.0	1200
50.0	29.7	1050
55.0	27.7	980
60.0	25.2	890
65.0	23.2	820
70.0	21.8	770
75.0	20.4	720
80.0	19.3	680
85.0	17.8	630
90.0	16.7	590
95.0	15.0	530

excavating channels that seem to be growing by head cuts.

Alluvial aquifers in the Bitterroot Valley are generally unconfined and interconnected, although the configuration of water-bearing layers in the heterogeneous valley fill is highly variable (Briar and Dutton 2000). Permeability is highest in alluvium of the low Quaternary terraces and floodplain and hydraulic conductivity of up to 75 feet/day has been calculated in low terrace alluvium. Groundwater circulation is predominantly away from the valley margins toward the Bitterroot River. The basin-fill aquifers are recharged by infiltration of tributary streams into coarse terrace alluvium, subsurface inflow from bedrock, and direct infiltration of precipitation and snowmelt. High amounts of precipitation on the western side of the valley cause greater recharge there than on the east side of the valley. Groundwater recharge is by seepage to springs and streams, evapotranspiration, and now by withdrawals from wells. Water in basin-fill aquifers is primarily a calcium bicarbonate type. Median specific conductance is about 250 microsiemens/centimeter at 25o C and median nitrate concentration is relatively low (0.63 mg/L) within the aquifer. Nitrate concentration in surface waters may reach 6 mg/L (Briar and Dutton 2000).

LAND COVER AND VEGETATION COMMUNITIES

Historic vegetation in the Bitterroot River floodplain near Lee Metcalf NWR included seven distinct habitat/community types: 1) Riparian/Riverfront-type Forest, 2) floodplain "Gallery-type" forest, 3) Persistent Emergent wetland, 4) Wet Meadow Herbaceous, 5) floodplain and terrace Grassland, 6) Saline Grassland, and 7) Grassland-Sagebrush (Table 2). The relatively low precipitation in the Bitterroot Valley prohibits the establishment of expansive areas of densely wooded or herbaceous wetland vegetation communities that require larger amounts of water each year. Consequently, the distribution of woody or wetland-type species is restricted to areas of greater soil moisture – primarily sites adjacent to the Bitterroot River and in floodplain drainages/depressions (Hansen et al. 1995 and indirect observations in various historical accounts including Leiberg 1899, Browman 1989, Cappious 1939, Clary et al. 2005, Stevensville Historical Society 1971, Chaffin 1971, Popham 1998, Losensky 1993).

Riverfront Forest includes early succession tree species such as cottonwood and willow (Appendix B) that are present on newly deposited and scoured gravelly-sand, sand, and fine sandy-loams near the active channel of the Bitterroot River and in sand-outcrop sites adjacent to floodplain drainages (Table 2). These sites have high water tables for most of the year and are inundated for short periods during high spring river flows almost annually. Regularly scoured soils provide bare soil sites for seed deposition and subsequent germination and growth of willow and cottonwood (e.g., Cooper et al. 1999).

Gallery Forest at Lee Metcalf NWR is dominated by cottonwood and ponderosa pine and is present on higher floodplain elevations with veneers of Chamokane loams over underlying sands along natural levees and point bar terraces adjacent to

Table 2. Hydrogeomorphic (HGM) matrix of historic distribution of vegetation communities/habitat types on Lee Metcalf National Wildlife Refuge. Relationships were determined from old aerial photographs, geomorphology maps (Lonn and Sears 2001), soil maps and survey publications (Eckmann and Harrington 1917, Bourne et al. 1959), U.S. Geological Survey 7.5-minute quadrangle topographic maps, river gauge data from the Bitterroot River (from Cartier 1984), various historical accounts of the region (e.g., Stevensville Historical Society 1971), botanical relationships (Hansen et al. 1995), and land cover maps prepared by the U.S. Fish and Wildlife Service.

Habitat type	Geomorphic surface[a]	Soil Type	Flood frequency[b]
Riverfront Forest	Qal, Qaty	Riverside, Riverwash, Chamokane gravelly-sand, sand, fine sand-loam	1YR-I
Gallery Forest	Qal	Chamokane loam and loamy sand	2-5YR
Persistent Emergent	Qal	Slocum poorly drained loam	1YR-P
Wet Meadow	Qal	Slocum deep loams	2-5YR
Grassland	Qal, Qafy	Corvallis, Hamilton, Grantsdale silt loam	> 5YR
Grassland-saline	Qal	Corvallis saline silt loam	> 5YR
Grassland-sage	Qafy	Lone Rock mixed erosional alluvial fan	> 10YR

[a] Qal – Quaternary alluvial deposits, Qafy – Quaternary younger alluvial fan and outwash terrace complex, Qaty – late Riverside and Hamilton terraces.
[b] 1YR-I – annually flooded for intermittent periods, primarily during high water periods of the Bitterroot River, 2-5YR – surface inundation at a 2-5 year recurrence interval, 1YR-P – annually flooded primarily for most of the year, > 5YR – surface inundation at a greater than 5 year recurrence interval, > 10YR – surface inundation rare except for lower elevations during extreme flood events.

minor floodplain tributaries. Gallery Forest areas often have woody shrubs such as alder, hawthorn, dogwood and wood's rose in the understory and mixed grass species such as bluebunch wheatgrass and Idaho fescue under and between trees and shrubs. Gallery Forests historically were flooded occasionally by overbank or high backwater floods from the Bitterroot River and secondary floodplain channels, but when flooding did occur, it was for short durations during spring. Fire and grazing by native ungulates probably sustained the savanna nature of these sites and encouraged a mix of grass, shrubs, and overstory trees (Fischer and Bradley 1987, Burkhardt 1996).

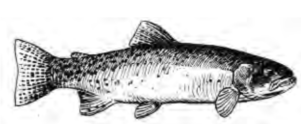
Low elevation oxbows, depressions, and tributary off-channel areas contained more permanent water regimes and supported water tolerant wetland vegetation species dominated by Persistent Emergent species such as cattail. Certain of these low elevation sites with extended water regimes may have been periodically created, and then abandoned during dry periods, by beaver activity (Kudrey and Schemm 2008). Sites immediately adjacent to Persistent Emergent communities grade into diverse Wet Meadow communities dominated by annual and perennial sedges, rushes, herbaceous species, and water tolerant grasses. Historic Persistent Emergent habitats appear to have had predominantly poorly drained Slocum loams, while historic Wet Meadow areas had deeper, better drained, loam-type soils.

The majority of higher elevations within the Lee Metcalf NWR floodplain region were covered with grasses and some scattered shrubs (Eckmann and Harrington 1917, Cappious 1939, Chaffin 1971, Popham 1998). Sites that had occasional surface flooding contained more wet Grassland communities with interspersed herbaceous plants such as smartweed and sedges while higher floodplain terraces, slopes and alluvial fans included mixed wet- and upland-type grasses and shrubs such as rabbit brush, sage, needle and thread, and june grass. Most floodplain grassland areas have Corvallis, Hamilton, and Grantsdale silt loam and loam soils. Certain sites in the Lee Metcalf NWR region have saline soils that supported more salt tolerant species. Larger alluvial fans, such as near Three Mile Creek, are present on "Qafy" surfaces with Lone Rock mixed erosion soils, and these sites historically had a mixed Grassland-Sagebrush community (e.g., Browman 1989, Clary et al. 2005). A composite model of potential historic vegetation communities, based on HGM attributes (Table 2); present on Lee Metcalf NWR prior to significant alteration and development beginning in the late 1800s is presented in Fig. 13.

KEY ANIMAL COMMUNITIES

The Bitterroot River floodplain at Lee Metcalf NWR historically supported a wide diversity of vertebrate and invertebrate animal species associated with the interspersed riverine, riparian, floodplain wetland, and grassland habitats Appendices C, D). Migratory birds are especially abundant at Lee Metcalf during fall and spring migration. About 267 native species of birds are present in the Bitterroot River watershed and 242 species have been documented at Lee Metcalf NWR (USFWS, unpublished refuge files). Key species groups include grebes, bitterns, herons, egrets, waterfowl, raptors, shorebirds, flycatchers, swallows, chickadees, warblers, wrens, sparrows, and blackbirds. Additionally, many bird species nest in forest, wetland, and grassland areas; the most common species are dabbling ducks, warblers, flycatchers, swallows, blackbirds, sparrows, wading birds, and raptors. Over 40 mammal species also are present in the region; the most common species are marmots, chipmunks, northern pocket gopher, woodrat, voles, silver-haired bat, red squirrel, striped skunk, mule deer, moose, and elk in upland and riparian areas and muskrat, otter, mink, and raccoon in wetland and riverine areas. At least twelve species of reptiles and amphibians apparently used the area including 6 snakes, 3 turtles, and 3 frogs. Several species of native fish historically were present in the Bitterroot River and many moved into floodplain drainages, oxbows, and wetlands during high flow periods. Native species included bull trout, mountain whitefish, northern pikeminnow, large scale sucker, longnose sucker, redside shiner, and mottled sculpin. The bull trout, a federally listed threatened species, was native to North Burnt Fork Creek.

Resources used by animal species within the Bitterroot River floodplain were seasonally dynamic and also annually variable depending on long-term climate and river flow/flooding patterns. Most bird species exploited seasonal resources during migration and summer in the Lee Metcalf region, but a few species overwintered in the area. Many waterbirds likely stayed in the Bitterroot Valley during wet summers to breed when floodplain wetlands had more extensive and prolonged water regimes. In contrast, limited numbers of species and individuals probably bred in the Valley during dry years. Similarly, wet springs and carryover water to fall likely encouraged larger numbers of waterbirds to stopover in the Valley during fall migration in these years. In average or dry years, however, little wetland habitat would have been available in fall. Cold winter temperatures freeze most wetlands in the floodplain, but the river remains open throughout winter in most years and provides refuge, loafing, and some foraging resources for some species. Amphibian and reptile annual emergence and life cycle events coincide with spring thaw and flooding and the availability of key arthropod and other prey species. Larger mammals move in and out of the floodplain to forage and take advantage of cover during winter and in other seasons when nutritious grassland forage and carnivorous prey are present.



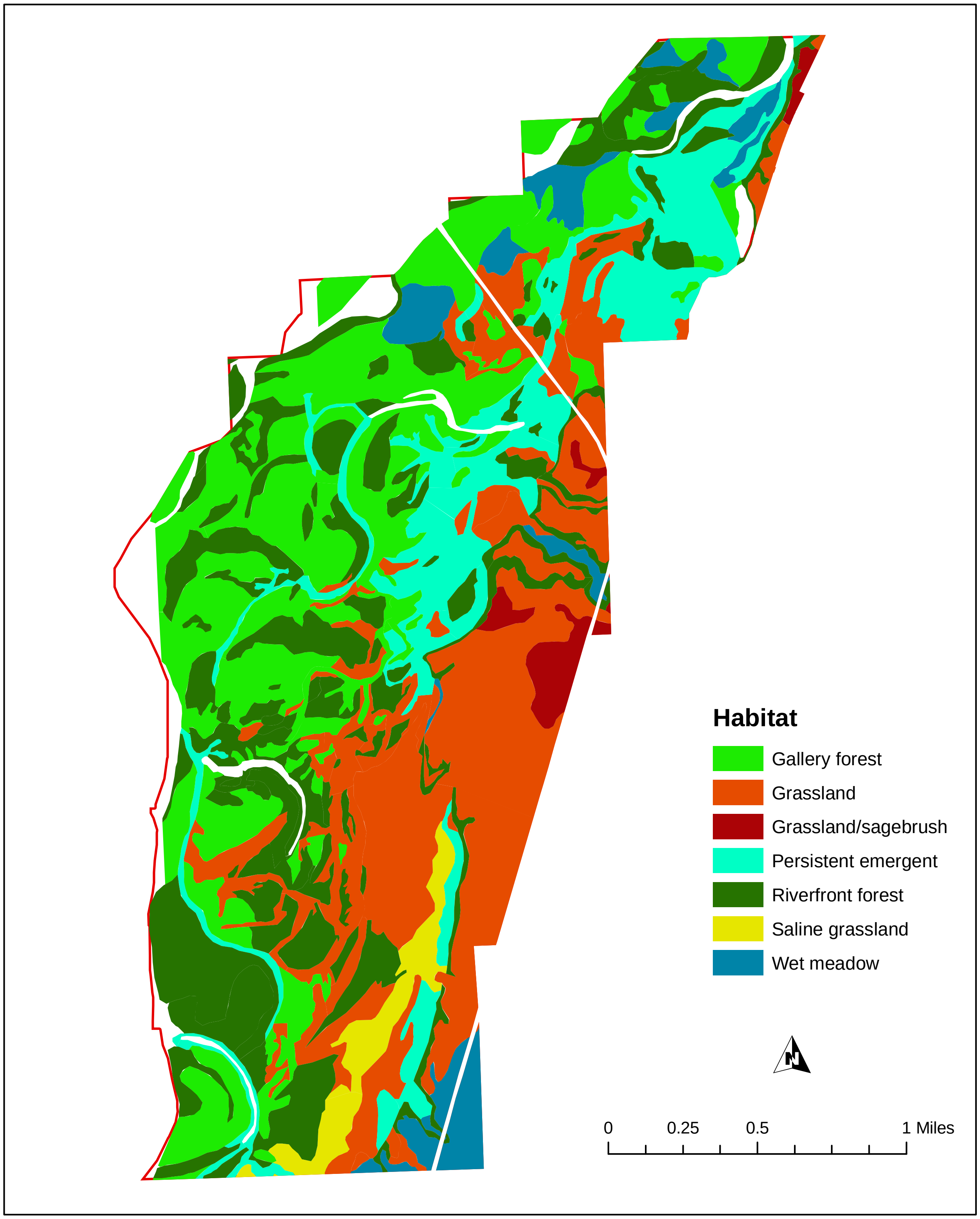


Figure 13. HGM-derived model map of potential vegetation communities present on Lee Metcalf National Wildlife Refuge prior to European settlement in the mid 1800s (mapped from data in Table 2).

http://etc.usf.edu/clipart

Left:
Old Bill Williams ca 1839, Rocky Mountain trapper

Below:
Salish men, 1903

Wikipedia.org

CHANGES TO THE LEE METCALF ECOSYSTEM

SETTLEMENT AND LAND USE CHANGES

The Bitterroot Valley was a route used by native people moving from Idaho and eastern Washington/Oregon to the plains of eastern Montana where they hunted buffalo and obtained other seasonal resources. The earliest occupation of the Bitterroot Valley by native people is unknown but apparently dates to nearly 12,000 BP (Ward 1973). The Salish Indian people occupied the area immediately prior to European settlement; these people were somewhat nomadic and likely used the area for hunting, fishing, and gathering native plants and for overwintering. The Bitterroot Valley was used by the first European explorers to the western U.S., including Lewis and Clark. Following the Lewis and Clark expedition, fur traders from the Hudson's Bay Company entered the Bitterroot Valley to secure furs from the Indians, and forts and missions were established. The oldest community in Montana was initially established at the present day site of Stevensville by Catholic missionaries in 1841 (Stevensville Historical Society 1971). Father Pierre De Smet came to the Valley at the request of four separate Indian delegations from the Salish tribe to St. Louis in the late 1830s. De Smet and other priests were eventually joined by Father Anthony Ravalli in 1845. Named St. Mary's Mission, this community kindled additional settlement in the region. St. Mary's Mission was closed in 1850, and the community was renamed Fort Owen, and then later Stevensville. The primary early use of land by settlers in the Bitterroot Valley was for cattle grazing; by 1841 extensive areas of the valley were grazed and used for winter range as cattle were moved from summer grazing and calving locations in mountain slopes and foothills back into the valley in the fall (Clary et al. 2005).

In the mid 1850s, the discovery of gold in western Montana fueled immigration of settlers to the state and a short flurry of gold exploration and mining occurred in the Bitterroot Valley. Early workers in the gold camps subsisted on wild meat and the importation of produce, meat, and dairy products. At this time some local residents began growing vegetable crops to feed the miners and this demand stimulated the first agricultural development in the Bitterroot Valley. Subsequently, the Bitterroot Valley became the "breadbasket" that nourished Montana's genesis and Fort Owen was the nucleus of the first European settlement. Gold exploration was short lived in the Bitterroot region, however, and by the 1870s, the economy of the area was almost solely based on local agricultural crops and cattle production. Ravalli County was created in 1893 and by 1914 extensive settlement had occurred in the region. Timber harvest and grazing were the predominant economic uses of the area at that time (Browman et al. 1989, Clary et al. 2005).

The dry climate of the Bitterroot Valley created annual variation in the availability of water to support agricultural crops. As early as 1842, priests at St. Mary's Mission successfully planted and irrigated crops of wheat, potatoes, and oats (Stevensville Historical Society 1971), and thus by appropriation, the first water right in Montana was established. A water right on the North Burnt Fork Creek was filed in 1852 by Major John Owen, who used creek water to operate a grist mill and sawmill. Two methods of water appropriation occur in Montana. The first (used by early settlers, miners, and mill operators) applies the "relation back" rule of law. That means that the right is dated to the time when first construction began to build a ditch or means to use the water in a "beneficial" (sic) way. The second method involves posting a point of diversion on a creek or other drainage and filing notices in the courthouse. A stream inevitably becomes over-appropriated when many people and industries make demands on it. Over-appropriation usually ends in "quick frozen" or "decreed" action and adjudication of a stream becomes necessary when rights are conflicting. For example, water in North Burnt Fork Creek was adjudicated in 1905.

In the early 1900s, the Bitterroot Valley Irrigation Company began construction of a major irrigation system for the Bitterroot Valley (U.S. Bureau of Reclamation 1939, 1982; Stevensville Historical Society 1971). The Irrigation Company developed an extensive irrigation network of water storage and conveyance facilities along the Bitterroot River and its tributaries including constructing several reservoirs, including Lake Como west of Darby, and a diversion dam on Rock Creek. In 1905 the existing dam at Lake Como was raised 50 feet and by winter 1906, 17 miles of canal were built to convey water from Lake Como north in the Bitterroot Valley. Eventually, a channel was built from Lake Como to the Bitterroot River, at which point it was siphoned under the river bed and into a 24 foot wide canal, capable of carrying water six feet deep. Water was then flumed across several small gulches and Sleeping Child Valley and around the foothills for 75 miles to the Eight Mile country east of Florence. By 1909, 56 miles of canal had been built northward to North Burnt Fork Creek. Subsequently about 14,000 acres of cropland were sold and irrigation water was delivered to the acreage. The main Supply Canal originally was constructed to primarily deliver water to apple orchards. The canal, however, was only able to supply about ½ inch of water/acre, which was barely enough to support fruit trees and only about half enough for other crops. The land was bought by local farmers and then resold in promotional schemes to eastern families for mainly apple production. Limited water and poor yields collapsed orchard production and by 1918 the "Big Ditch Company" (i.e., the Bitterroot Valley Irrigation Company) went bankrupt.

In 1920, a reorganized Bitterroot Irrigation District was formed and the newly formed district issued bonds to purchase water rights and to develop water storage/distribution works. Drought conditions in the late 1920 and 1930s coupled with the Depression era economics, further exacerbated water problems in the valley and curtailed agricultural expansion in the region during this period (Cappious 1939, Stevensville Historical Society 1971). Following further financial difficulty, in 1930 Congress authorized the Bureau of Reclamation to liquidate private indebtedness and rehabilitate the Bitterroot Irrigation District (U.S. Bureau of Reclamation 1939). Extensive rehabilitation to the main "Supply Canal" and its distribution system was conducted from 1963 to 1967. Flood damage occurred in 1974 and extensive repairs were made on many structures. Currently the Bitterroot Irrigation District provides water to about 16,665 acres on the east side of the Bitterroot River (U.S. Bureau of Reclamation 1982). The Main Supply Canal for the Bitterroot Irrigation District runs ca. one-mile east of the Lee Metcalf NWR and primary distribution ditches on the refuge include the McElhaney, Warburton, and Alleman ditches (Fig. 14).

The majority of the Bitterroot Valley was unfenced in the early era of settlement from 1850 to 1910. However, in the early 1900s, the "apple boomers" that bought much land in the Valley began fencing most of the area. By the mid 1930s, more than 50,000 sheep and 30,000 cattle were present in the Bitterroot Valley; only about 22% of the valley was harvested cropland (Richey 1998). Generally wet conditions in the late 1940s and early 1950s stimulated agricultural production in the Bitterroot Valley and large scale cattle grazing and haying operations, and some small grain farming, expanded in and near the Lee Metcalf NWR area. Most native riparian forest and grassland in the Lee Metcalf NWR region had been cut, cleared, and/or converted to alternate land uses by the mid 1900s (Fig. 15). Two of the larger minor floodplain channels, Nickerson and McPherson creeks (now called ditches), were partly ditched in the mid 1900s and some minor impoundment of low elevation depressions and drainages occurred. By the 1960s, lands that became part of Lee Metcalf NWR were controlled by about 13 ownerships that heavily cropped and grazed the area (Fig. 16). Much of the site was irrigated crop and pastureland using the extensive ditch and irrigation diversion system constructed across the floodplain (Fig. 14). These impounded "ponds" probably were created for water sources for livestock. Another interesting development, a golf course, was established on the southwest side of Lee Metcalf in 1933.

Numerous roads have been built in the Bitterroot Valley starting with a stage coach road in 1867 (Stevensville Historical Society 1971). This route eventually became U.S. Highway 93. Other early roads in area were constructed from 1870 to 1900. These roads skirted higher ground and avoided the river, but eventually bridges were built across the Bitterroot River beginning in the late 1800s. These bridges often were destroyed by high water levels and floods. The Bitterroot Branch of the Northern Pacific Railroad was constructed from Missoula to Grantsdale in 1889 and soon thereafter was extended to Darby. This rail line was built primarily to transport timber from the slopes of the Bitterroot Mountains and sawmills sprang up all along the west side of the valley. Rail spurs connected mills and eventually logging and mills expanded to the east side of the valley. Transporting lumber from the east side of the Valley eventually led to the construction of rail bridge crossings over the Bitterroot River including the bridge and line at the northern boundary of Lee Metcalf NWR. In 1927 and 1928, the railroad was relocated from south of Florence to the east side of the river

By the late 1970s, farm sizes in the Bitterroot Valley increased greatly, but agricultural economies prevented more extensive small grain farming in the valley and landowners began subdividing holdings for residential development (Richey 1998). By the early 1990s, Ravalli County had the fastest growing population and residential expansion in Montana, expanding from about 25,000 residents in 1990 to > 38,000 in 2007 (U.S. Bureau of the Census, issued annually). Most of the residents of Ravalli County live on the Bitterroot Valley floor within a few miles of the river. Much of the increase in population occurred outside of established towns and became concentrated in areas where each dwelling or subdivision has its own well and septic systems. Several hundred residential structures now essentially surround Lee Metcalf NWR (Fig. 17).

HYDRO-GEOMORPHOLOGIC CHANGES

The Bitterroot River stretch at Lee Metcalf NWR lies near the geomorphic threshold between a highly braided river channel pattern from Hamilton to Stevensville and a straight or sinuous channel pattern immediately downstream (Fig. 3). Consequently, the river channel pattern for the area is metastable and highly sensitive to perturbation (Gaeuman 1997). The combination of irrigation development and land use changes, mainly in the 1900s, significantly altered hydrology and river channel morphology and movement in the Bitterroot Valley and its floodplains and facilitated degradation and loss of wetlands in this ecosystem (e.g., Kudray and Schemm 2008). The extensive irrigation network of the Bitterroot Irrigation District led to construction of reservoirs, ditches, water diversion structures, and modified natural drainage routes (Fig. 14, Table 2). Stream channel networks, common in the Bitterroot Valley near Lee Metcalf NWR, were altered by culvert and bridge crossings, railroad levees and beds, and extensive channelization of tributaries. Many stream channels, including sections of the Bitterroot River, were lined with rip-rap rock and car bodies to slow stream migration and in-channel bank erosion (Fig. 18). In addition to local physical disruptions to topography and hydraulics, the larger-scale entire fluvial system of the Bitterroot River has been altered by historic land use changes. The valleys and lower hill slopes have been grazed and farmed, while the upper valleys and mountains have been partly deforested. Overgrazing was common on many valley terraces and, when coupled with deforestation in adjacent mountains and slope areas, led to erosion and increased sediment loading in the Bitterroot River (Briar and Dutton 2000). Subsequently, extensive sedimentation has occurred in drainages

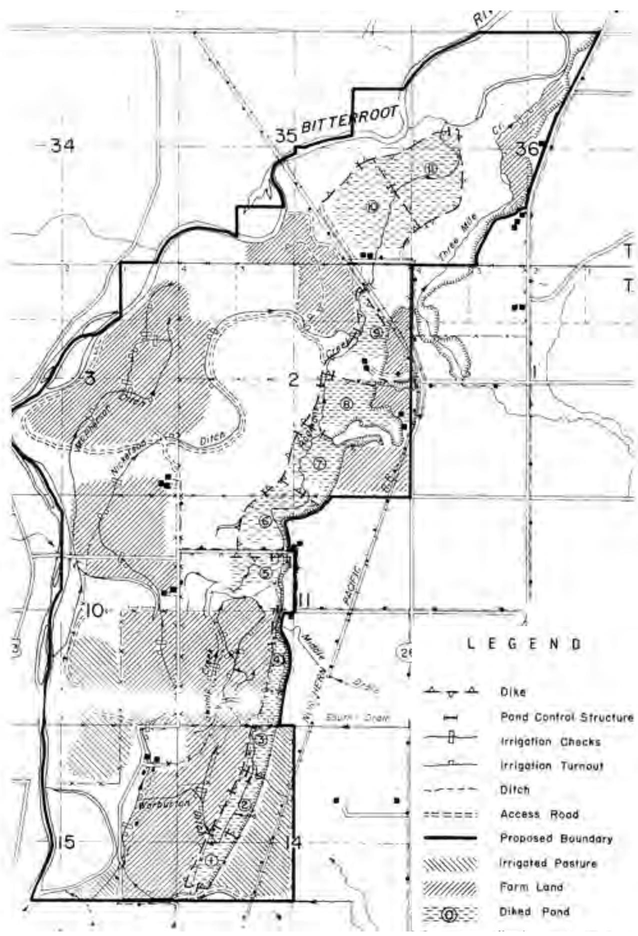
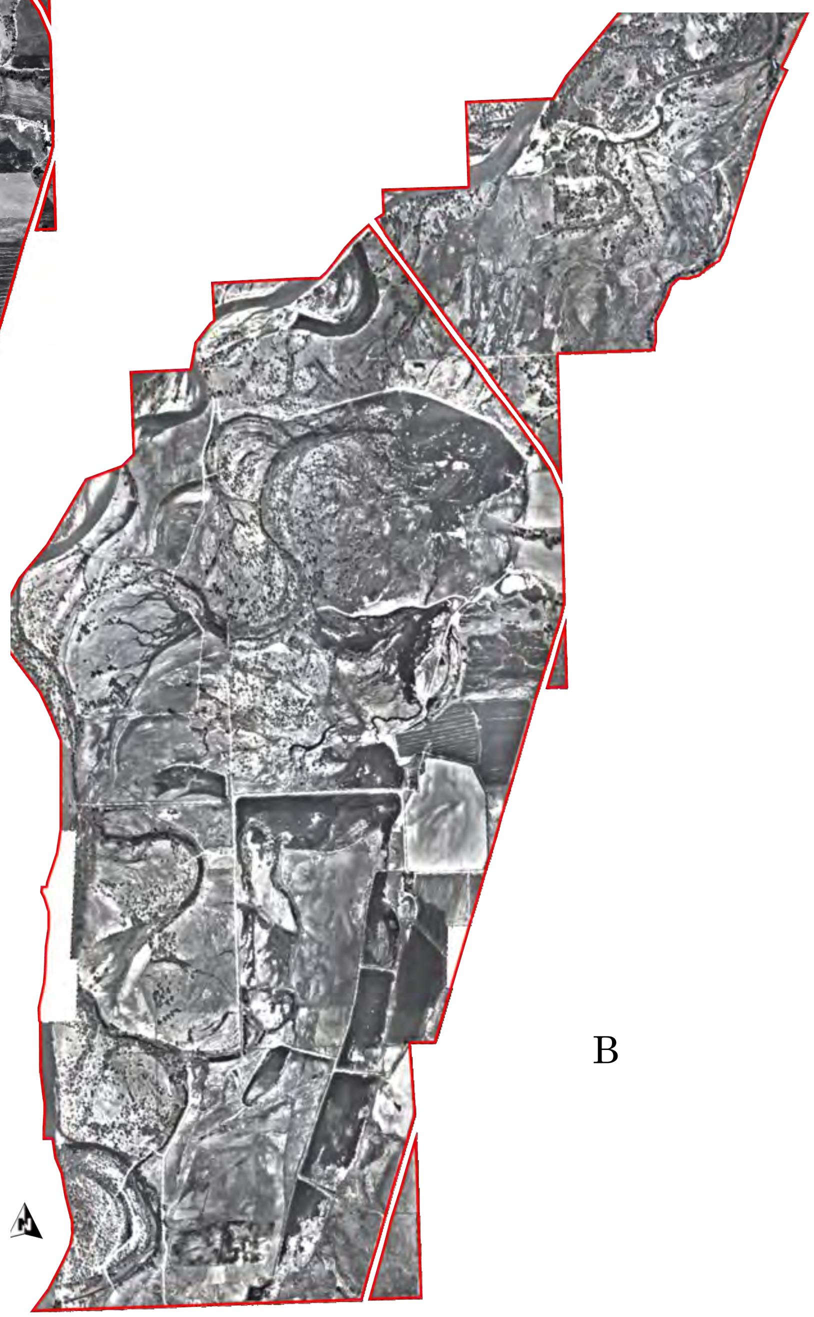
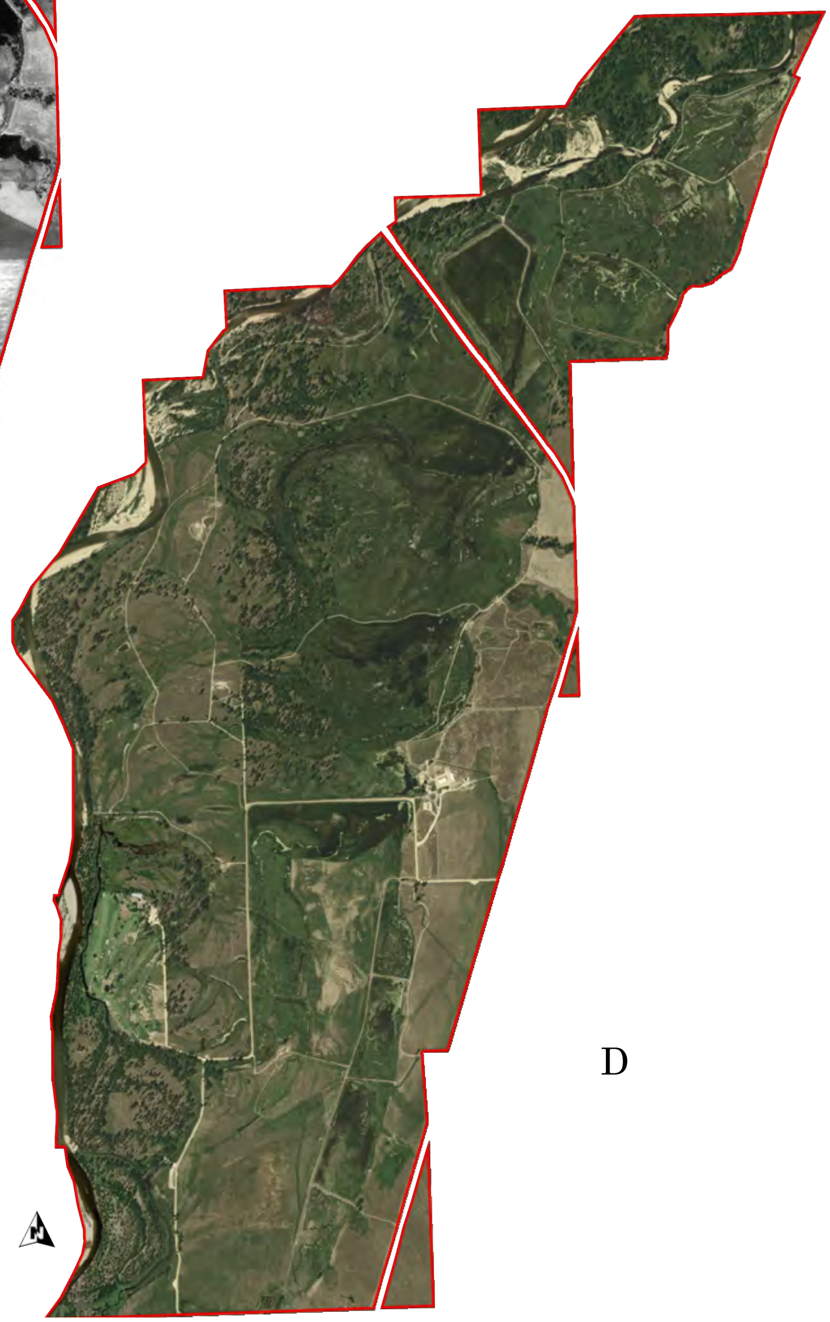


Figure 14. Drainage and irrigation ditches and infrastructure and land use on Lee Metcalf National Wildlife Refuge in the early 1960s.

Figure 15. Sequence of aerial photographs of Lee Metcalf National Wildlife Refuge in a) 1960s, b) 1970s, c) 1983, and d) 2006.



C



D

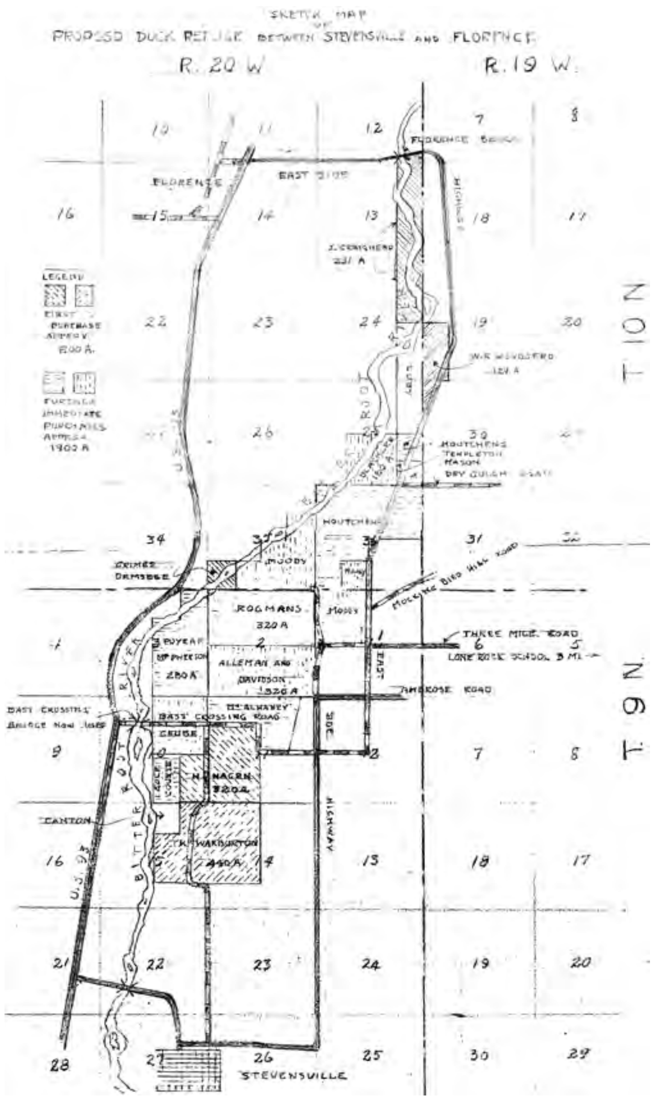


Figure 16. Ownership map of lands within the eventual Lee Metcalf National Wildlife Refuge in the late 1950s.

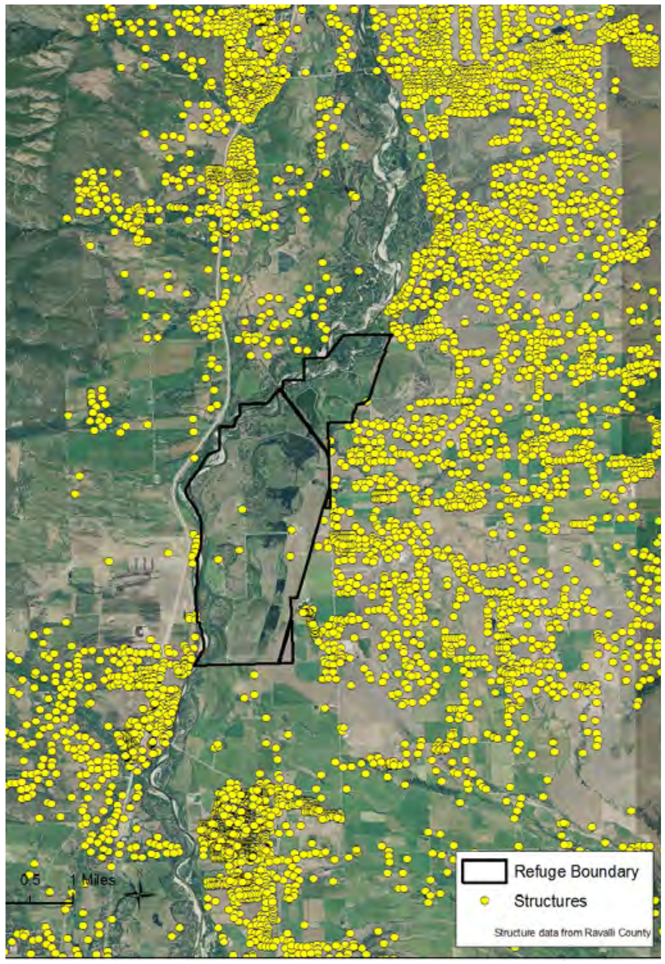


Figure 17. Location of residential structures in the vicinity of Lee Metcalf National Wildlife Refuge (data from Ravalli County, Montana).

and floodplain depressions on Lee Metcalf NWR (Lee Metcalf NWR, unpublished annual narratives).

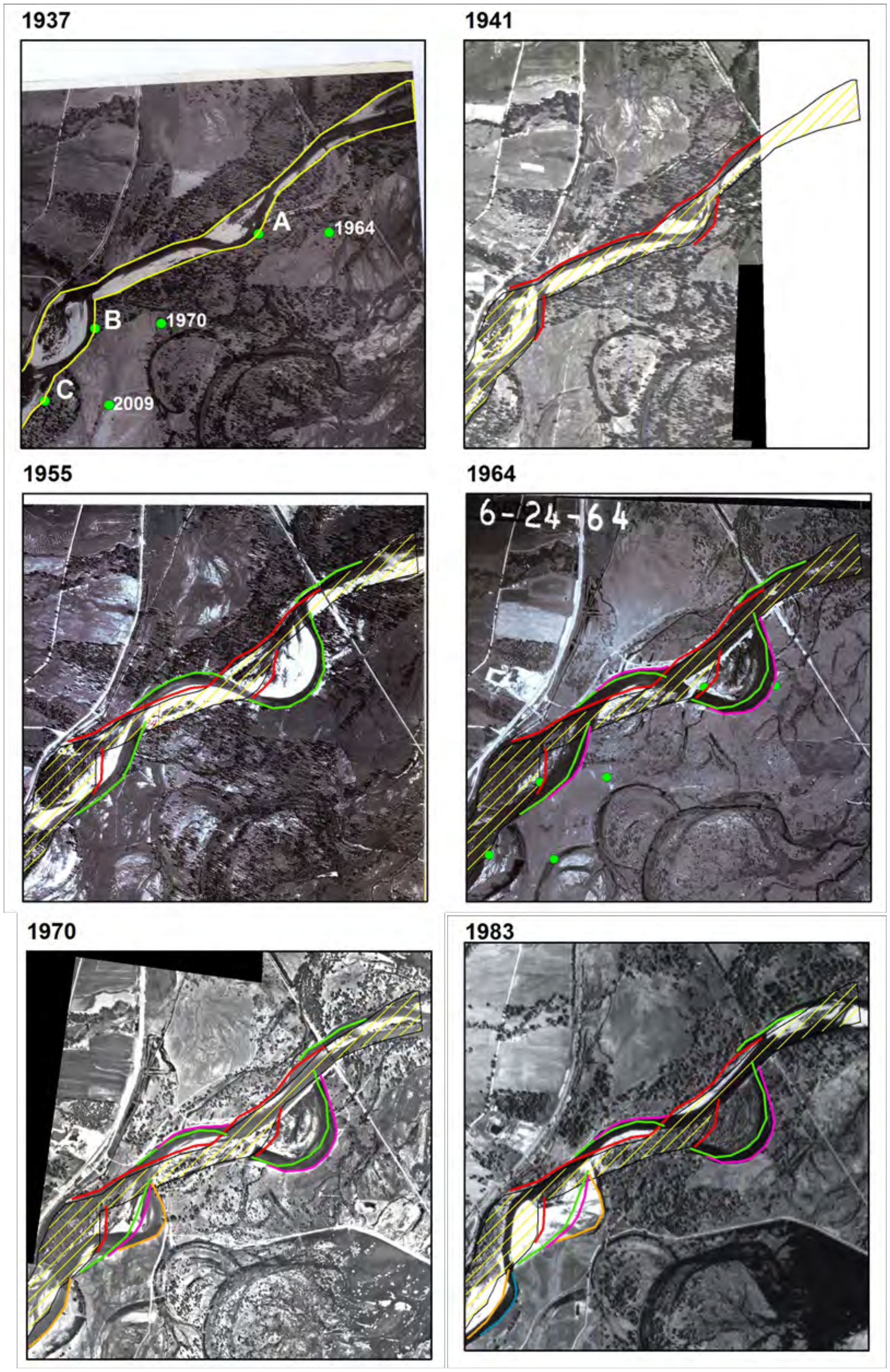
The channel morphology and discharge of the Bitterroot River also has been affected by land and water use in the valley (Gaeuman 1997). Certain evidence suggests the sediment bed load of the river has increased and now delivers about 300,000 metric tons of sediment to the Clark Fork River each year. During the period of 1936 to 1972, the Bitterroot River underwent significant adjustments in sinuosity and braided character causing a nearly 4% reduction in channel length between Darby and Missoula (Cartier 1984). Other data suggest increased instability, channel migration, and overall widening of the river "braid belt" in the last decade from Hamilton to Stevensville compared to other above and below reaches of the Bitterroot River (Gaeuman 1997). This instability has caused rapid erosion of river banks on Lee Metcalf NWR (Fig. 19) and increased physical dynamics of sediment and water flow that facilitate rapid lateral channel migration across the Lee Metcalf NWR floodplain. In contrast to the highly active river migration physics from Hamilton to Stevensville, substantial narrowing of the Bitterroot River occurred near Stevensville and Lee Metcalf NWR after 1937 in part because of artificial control structures. Part of the river has been channelized immediately upstream of rip-rap bank stabilization structures near the railroad embankment on the refuge (Fig. 18). This artificial narrowing of the Bitterroot River to control river migration and bank erosion actually has heightened river migration tendencies immediately upstream of structures and currently is threatening to carve new channels across the floodplain at Lee Metcalf NWR (Fig. 19).

Figure 18. Photograph of car bodies, acting as rip-rap material along the Bitterroot River on the north end of Lee Metcalf National Wildlife Refuge.

Aerial photograph maps of a 2.5 mile stretch of the Bitterroot River on the north end of Lee Metcalf NWR from 1937 to 2009 demonstrate the highly unstable channel location of the river (Fig. 20). Three key points (labeled A, B, and C on the photographs) of river migration are apparent through the time-series of photographs and typical movement of the outer river banks average about 2.5 m/year. During more active periods of river channel bank migration, the rate of erosion is > 10 m/year. The 1955 photograph indicates that the river migrated significantly to the south and was deemed a threat to the existing railroad bank and trestle. Subsequently, actions were taken by the railroad to stop the river migration by placing car bodies (Fig. 18) along the river bank, to act as rip-rap and cut off the river, which created an oxbow that still is present. The most active area of river migration in 2009-2010 is at Point "C." Between 2004 and 2009, the river migrated about 60 m east, or about 12 m/year. If this rate of river migration continues, then the river may reach the main road on Lee Metcalf NWR in about 15 years and effectively remove about 10.5 acres of current floodplain land.

The Bitterroot Irrigation District Main Supply Canal continues to transport water to most of the eastern benches in the Bitterroot Valley, including

Figure 19. Photograph of bank and levee erosion along the Bitterroot River on the west side of Lee Metcalf National Wildlife Refuge.


1937
A
1964
B
1970
C
2009
1941
1955
1964
6-24-64
1970
1983

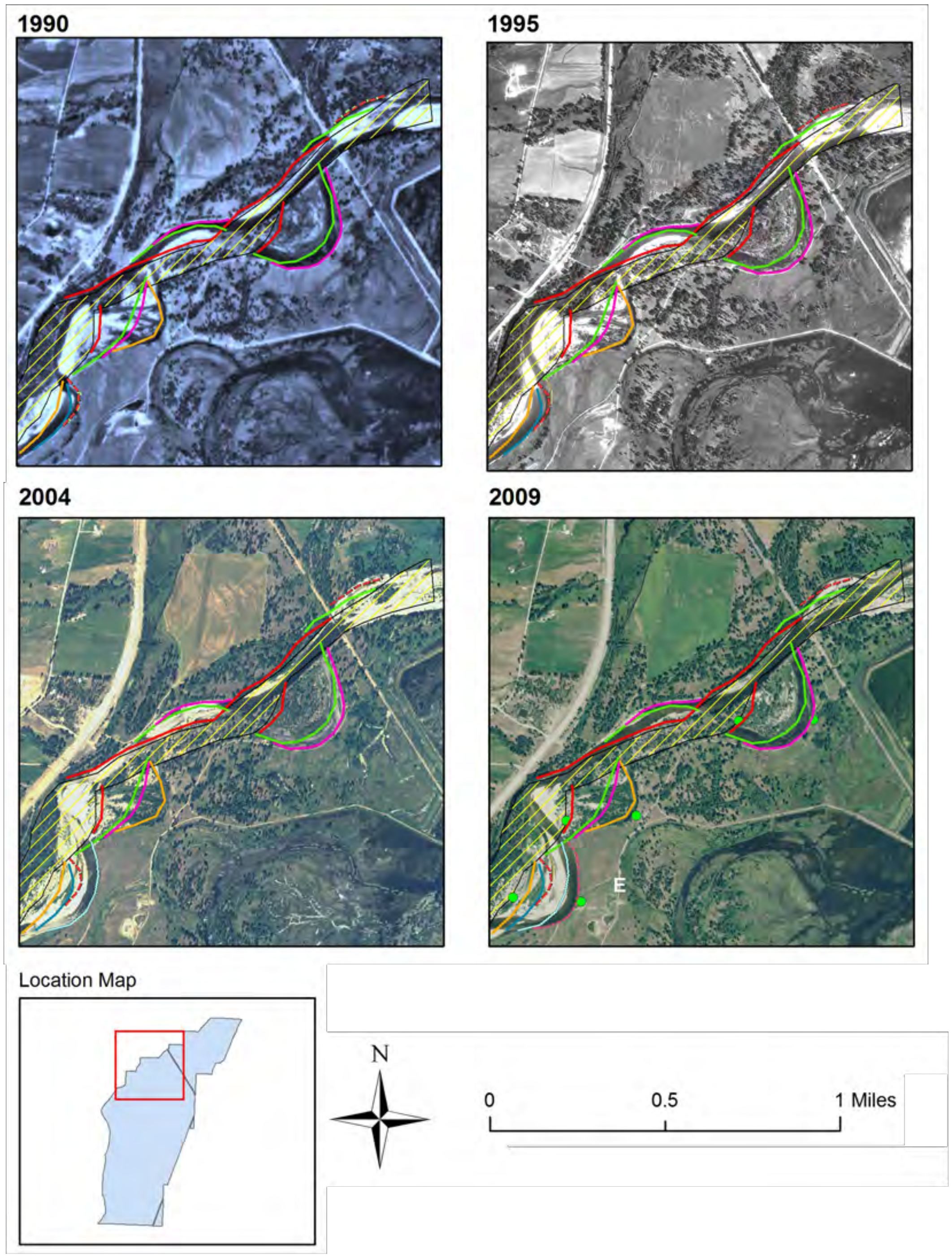


Figure 20. Changes in the location of the main channel of the Bitterroot River over a 2.5 km stretch along the north boundary of Lee Metcalf National Wildlife Refuge, 1937 to 2009. Historical photographs were acquired from a variety of sources including the National Archives and Records Administration, U. S. Fish and Wildlife Service files, U.S. Department of Agriculture, Natural Resources Conservation Service, and U.S. Geological Survey. Each time frame is presented at the same scale and extent, and the color of the lines representing the river location for a particular year is maintained throughout the series of maps for ease of comparison.

those adjacent to Lee Metcalf NWR. The Main Supply Canal facilitates a net transfer of about 75,000 acre-feet/year of water from the west side of the valley to the eastern benches/terraces. During summer, irrigation withdrawals significantly reduce flow in the Bitterroot River and some of its tributaries. Part of the diverted flow eventually drains back into the river system; this irrigation return flow is about 280,000 acre-feet/year in normal precipitation years. Average discharge of the Bitterroot River near Florence is 1,540,000 acre-feet/year, and indicates about 13% current loss of discharge at this point from irrigation use, evapotranspiration and other consumptive uses. Over 10,000 wells now occur in the valley and the extraction of water from these wells, coupled with irrigation diversion, may be affecting groundwater levels, recharge to floodplain wetlands, ground and surface water quality, and anastomosis of the Bitterroot River (e.g., Briar and Dutton 2000).

ACQUISITION AND DEVELOPMENT OF LEE METCALF NWR

Lee Metcalf NWR was authorized/established in 1963. Originally named the Ravalli NWR, the refuge name was changed in 1978 in honor of long-time U.S. Senator Lee Metcalf who grew up in Stevensville and was involved with its establishment and many other conservation initiatives. The primary purpose of the refuge is to provide habitat for migratory birds and federally-listed endangered and threatened species.

The USFWS began physical developments on floodplain lands on Lee Metcalf NWR in 1965-66. By the late 1980s over 1,000 acres had been partly or completely impounded in 14 "ponds" for managed wetland units (Table 3; Figs. 21, 22). These wetland ponds typically were impounded by levees or dams to back water up drainages and depression areas. Currently, the Lee Metcalf NWR impoundments and other naturally flooded depressions and drainage corridors comprise > 20% of all palustrine wetlands present in the Bitterroot Valley (Kudray and Schemm 2008). Dams or weirs that significantly alter direction and amount of surface water flow in natural drainages have been constructed on Three-Mile Creek, Rogmans Creek, Barn Slough, and Francois Slough/North Burnt Fork Creek (Fig. 22). Wetland impoundments have been managed by diverting irrigation and tile drain water, flows in minor channels and tributaries, and Three Mile Creek water into and through the impoundments. Lee Metcalf NWR has 24 water rights claims and one permit totaling 50,495 acre-feet/year (Appendix E, USFWS, unpublished water rights files). Some of these claims were originally based on decreed rights that had been adjudicated during the early 1900s when landowners (that owned what is now Lee Metcalf NWR) petitioned district courts for adjudications of individual streams. Other claims were based on filed rights made by former land owners. Some claims were submitted for use rights that were vested with Migratory Bird Conservation Commission approval for acquisition of the NWR. All NWR water rights are "supplemental", meaning the water sources are comingled to supply water to the refuge for past desired management of wetland impoundments. Water rights submissions made by the USFWS for the refuge in 1982 stated a need for consumptive volume of 7,386 acre-feet/yr and an additional 10,840 acre-feet for non-consumptive flow through. Consumptive volume is 2,190 acre-feet for natural sub irrigation of 730 acres, 717.5 acre-feet for flood and sprinkler irrigation of fields, 3,349.6 acre-feet for 632 acres of wetland impoundment surface area, and 1,129 acre-feet for timber, brush and grass areas that receive return-flow and runoff. Non-consumptive use is for conveyance, filling, and freshening of impoundments. The refuge also receives up to 2,600 acre-feet/yr, at a diversion rate of 8.57 cfs from the Bitterroot Irrigation District Supply Ditch.

Water that enters, or can be diverted to, Lee Metcalf NWR comes from multiple points of diversion (POD). Certain sources, such as the South and Middle Drain supply private property in addition to the NWR and often the private property has "priority" of use in limited water periods. Tile drain water also enters the refuge from "open" tile drain or irrigation recovery, ditches from surrounding private lands. One specific tile drain originates from the privately owned "Bison Field" and contributes organic contaminants to Ponds 3 and 4 and commonly causes algal blooms in these and other ponds that receive gravity flow water from Ponds 3 and 4. Most water enters managed wetland impoundments from the south end of the refuge and sequentially is routed via gravity flow through Ponds 1 to 10. However, the various sources of water often results in variable amounts and timing of water being available for individual ponds. For example, water originating from the South Drain can be moved via gravity flow into most ponds on the refuge, whereas water from Rogmans Creek can only be used for Ponds 6-13. Spring Creek POD is only siphoned from Pond 10 to Otter Pond, where it then flows to Ponds 12 and 13. Three Mile Creek POD water is available for Ponds 11-13 and the North Slough. Currently, Three Mile Creek contains high sediment loading and is not diverted to ponds, and instead flows to the Bitterroot River.

Since establishment, most wetland impoundments have been managed to promote waterfowl production by holding water through summer or year round; and occasionally draining areas for vegetation management using tillage, grazing, and burning (Lee Metcalf NWR, unpublished annual narratives). Otter Pond was stocked with warm-water fish in 1989 to provide prey for nesting osprey and limited public fishing opportunity. Other wetland/hydrological developments included construction of siphons to move water, level-ditching in Ponds 3, 4, 11, and 12; mitigation construction near the Potato Cellar Pond, and sediment removal in Three-Mile Creek (Table 3, Fig. 22). Over 25 miles of roads are present on the refuge and many buildings, trails, and berms also have been constructed on the refuge. Certain upland areas were converted to warm-season grasses for dense nesting cover for waterfowl and predator-exclusion fences were built around some fields (Fig. 23). In the 1960s and early 1970s some higher elevation fields on the refuge were used for small grain production.

In 1971, the refuge contracted the placement of rip-rap material along 1,250 feet of the east bank of the Bitterroot River west of McPherson Ditch (Lee Metcalf NWR, unpublished annual narratives). This rip-rap subsequently was eroded and moved by high river flows and by 1984 the rip-rap was no longer present and the bank at this location was moving eastward. Since the mid 2000's, levees built along the Bitterroot River, including the area where the rip-rap was placed in 1971, have eroded, and been at least partly breached in places as the Bitterroot River is attempting to move laterally (Figs. 19, 20). Also, the Bitterroot River appears to be moving more discharge through the North Slough area immediately north of Otter Pond on the north side of the refuge. These river movements potentially could impact the north Otter Pond levee and cause water movement across other floodplain areas on the refuge that might impact other structures, roads, and the railroad bed.

Table 3. Summary of wetland development/management activities on Lee Metcalf National Wildlife Refuge (from refuge annual narratives and aerial imagery

Refuge authorized by Migratory Bird Conservation Commission on December 10, 1963.
First parcel purchased in February 1964, refuge officially established.
Pools 1 thru 4 completed the summer of 1966.
Pool 5 - The mid 1960s photos show the stream channels coming through the present pool, but no clear pond area is visible. By June 1970, water control structures in place and impoundment completed.
Pools 6, 8, and 10 were constructed sometime between 1967 and 1970 based on the imagery.
Ponds 11-13 were built between 1970 and 1973. Flood photos from 1974 show impoundments in place. Pond E, which was a small impoundment on Rogman's Creek, near pool 11, likely built around the same time frame. Pond E was ultimately expanded by the creation of Otter Pond in 1989.
Ditch Leveling done in Pools 3, 4, 11, 12 in 1990, clearly visible in the 1995 photos, but not in 1990.
Otter Pond built in 1989, which expanded the existing pond E to about 65 surface areas. 18" PVC siphon brings water over 3-mile bypass to pool 11.
Pair ponds by July 1988 – designs completed, 10 acres, up to 3 feet deep.
Montana Power Company – channel ponds. Mitigation work conducted in Section 2, near Potato Cellar ponds. Originally built in the late 2960s or early 1970s, then washed out in floods during mid 1970's. Dry from the mid 1970s until a rehab project in 1988. About 3 acres in size.
Early 1980s focus on 3-mile creek sedimentation issues. This creek flowed into pool 11 and out through pool 13 to the river. Three sediment ponds constructed in 1984, two supply ditches cleaned out in 1985 (from annual water management plan 1986/1987 RO). Ultimately, the bypass channel takes 3-mile creek directly to the river.
Pool levels maintained at high levels for several reasons, cattail control, fishery for osprey, and to prevent waterfowl access to lead shot. 1987 – pools 1 drawdown entire year, and pool 6 in drawdown in spring, refilled in July for cattail control. At end of july, pool 6 drained again for remainder of year. 1987-1988 water management plan RO
Francios Slough – no dikes or structures on it in mid 1960s, North Burnt Fork creek unimpeded on refuge. By 1970, 3 water control structures constructed. These remain in place today.
Barn Slough area – Evidence that a diversion structure sending water through the Mcpherson and Nickerson Ditch was present pre-refuge (see below). Image from mid-1960s.

VEGETATION COMMUNITIES

Collectively, the many landscape and hydrological changes in the Bitterroot Valley since the Presettlement period have dramatically altered the physical nature, hydrology, and vegetation communities of the Lee Metcalf NWR. Prior to European settlement, the relatively dry climate of the Valley

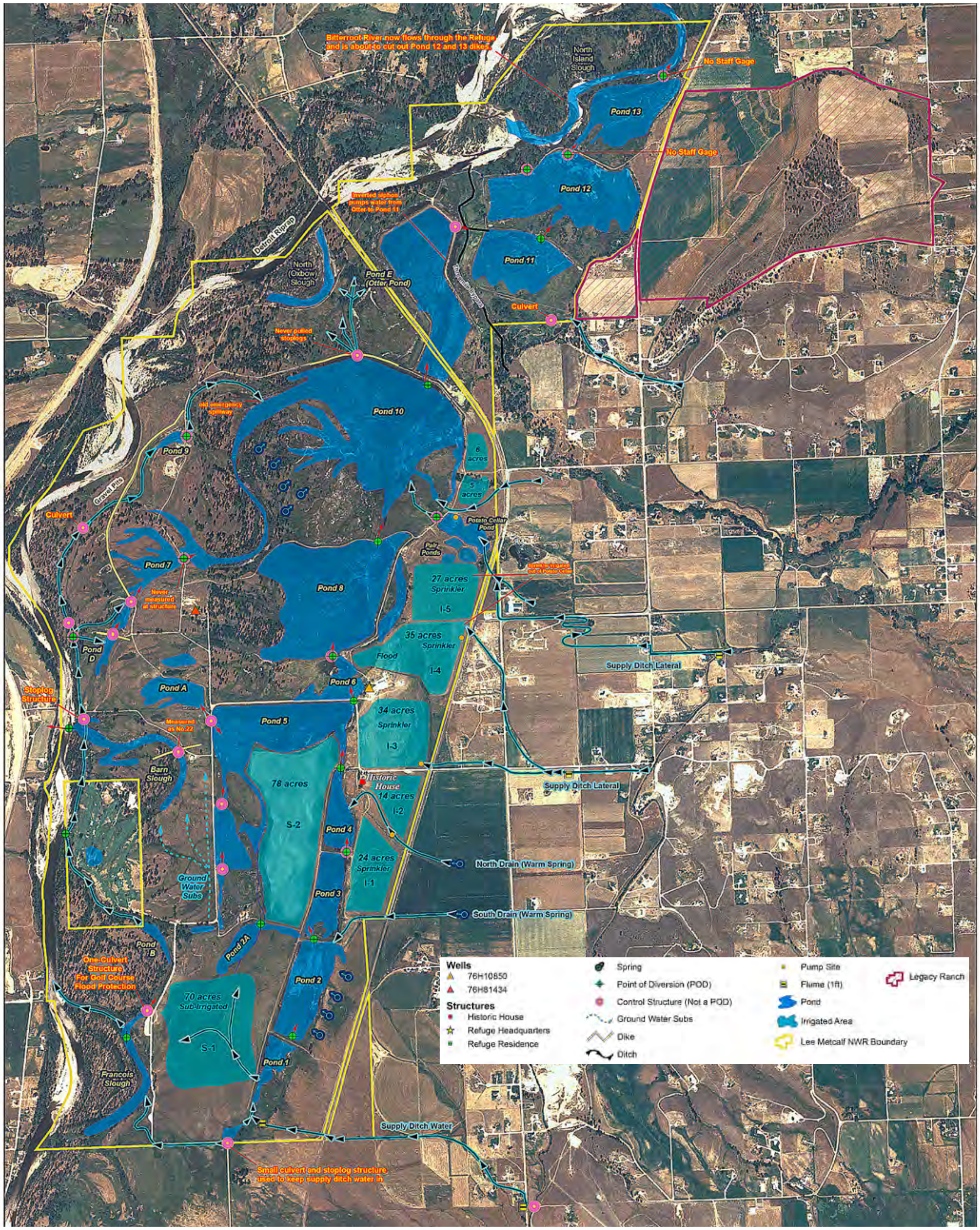


Figure 21. Contemporary water, drainage, and water-control features on Lee Metcalf National Wildlife Refuge.

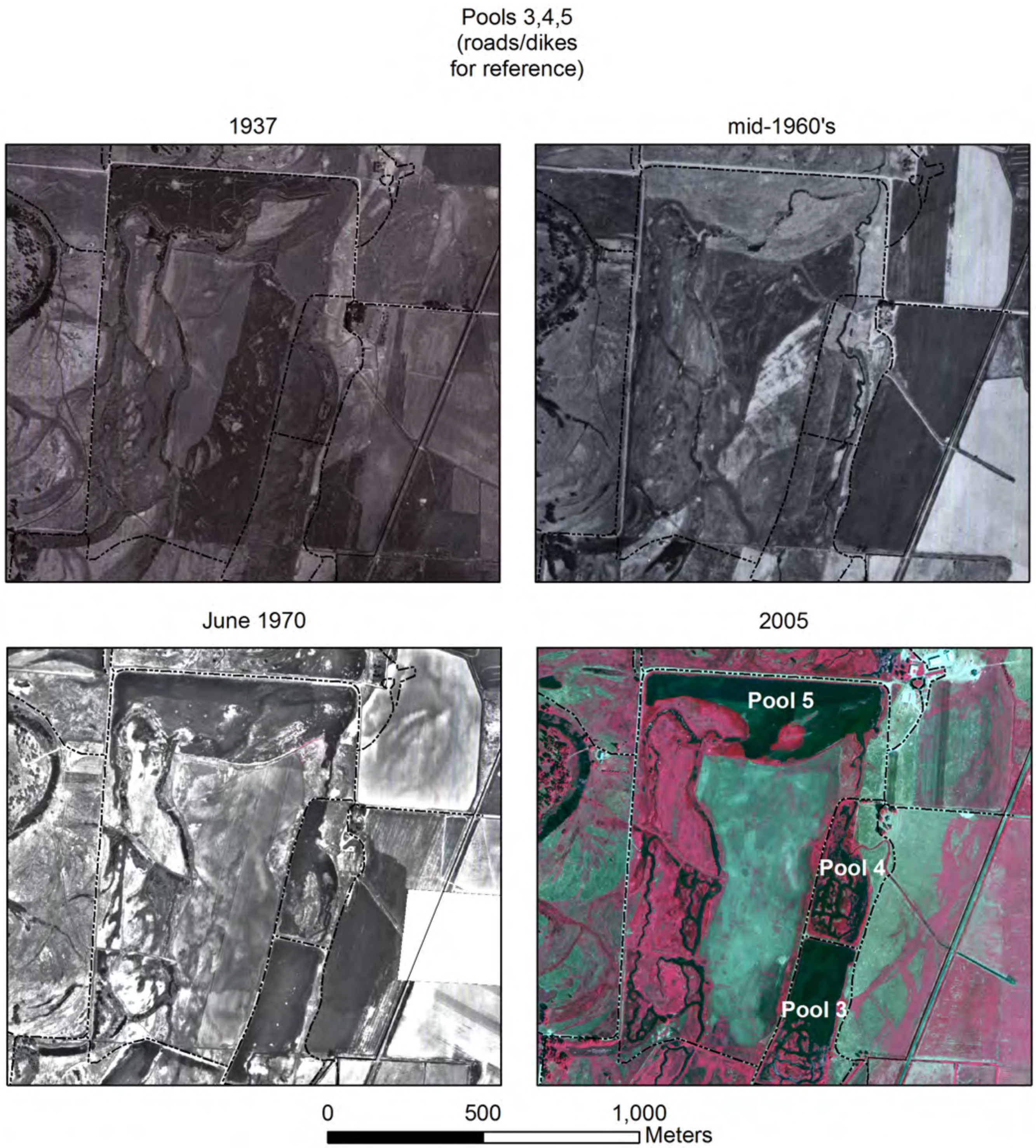


Figure 22. Aerial photographs of wetland pond and management developments on Lee Metcalf National Wildlife Refuge before (1960s and 1970s) and after (2005) construction. (cont'd on next page)

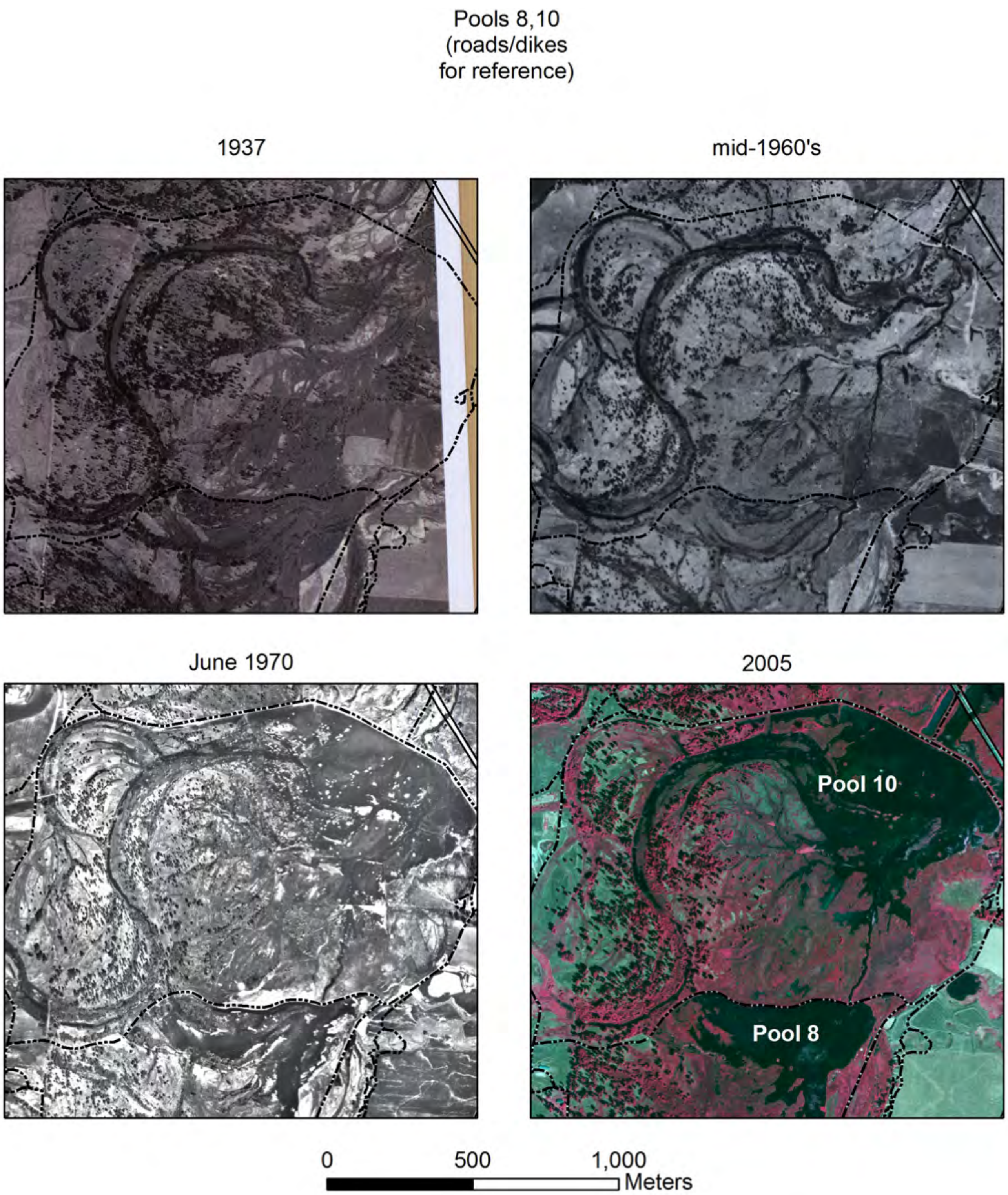


Figure 22 (cont'd). Aerial photographs of wetland pond and management developments on Lee Metcalf National Wildlife Refuge before (1960s and 1970s) and after (2005) construction.

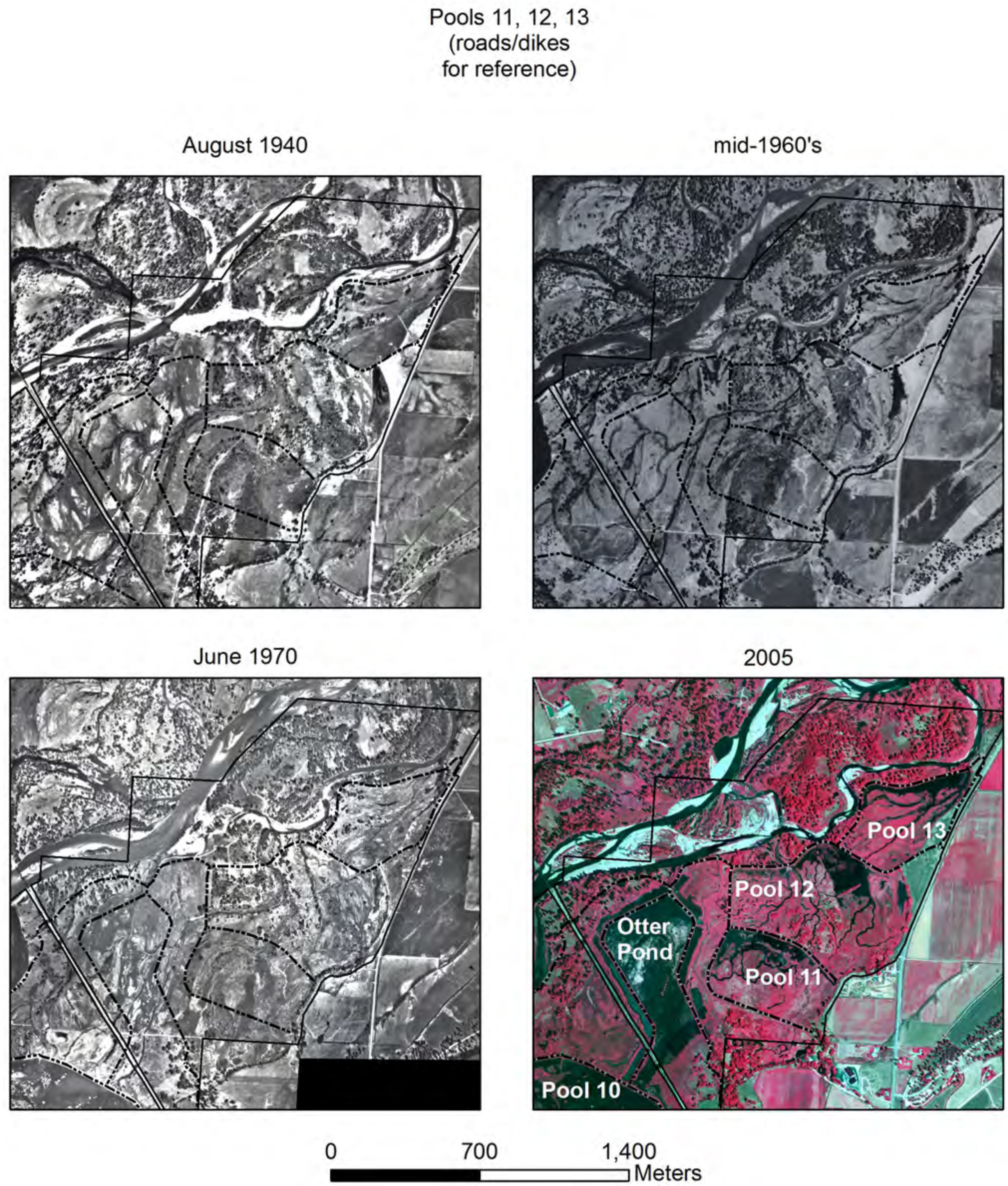


Figure 22 (cont'd). Aerial photographs of wetland pond and management developments on Lee Metcalf National Wildlife Refuge before (1960s and 1970s) and after (2005) construction.

Figure 23. Photograph of a field planted as waterfowl dense nesting cover on Lee Metcalf National Wildlife Refuge.

and the anastomosing nature of the Bitterroot Valley created a heterogeneous mix of communities including Riverfront and Gallery Forest adjacent to the Bitterroot River and floodplain drainages, Persistent Emergent wetland communities along floodplain drainages and fluvial-created depressions, Wet Meadow habitats, and Grassland/Sagebrush communities on higher elevation terraces and alluvial fans (Fig. 13). This community matrix was maintained by:

1) Periodic overbank flooding of the Bitterroot River that inundated much of the floodplain for relatively short periods in spring.

2) Regular backwater flooding of the Bitterroot River up tributaries and floodplain secondary channels into floodplain wetland depressions.

3) Annual spring discharge of water from tributaries, sheetwater flow across terraces and alluvial fans, and seep/spring discharge from mountain slopes and terraces.

4) Occasional fire and grazing that recycled nutrients and established germination and regeneration sites for specific plant species

Each of these primary ecological processes at the Lee Metcalf NWR has been systemically altered so that:

1) Water diversions, channel constriction, and river channel modification have reduced overbank flooding and restricted floodplain connectivity. Fewer extensive overbank events now occur, but lateral movement and bank erosion of the Bitterroot River have been accelerated in this river stretch.

2) The above changes have restricted backwater flow from the Bitterroot River into its floodplain and tributaries and floodplain secondary channels have been ditched, diverted, dammed, and impounded.

3) Water flow across the floodplain has been altered by extraction and diversion of water from drainages prior to reaching the floodplain. Sheetflow across terraces and alluvial fans is almost completely eliminated and groundwater aquifers and discharge from seeps/springs are changed, usually by reduction, from Presettlement times.

4) Fire and grazing by native ungulates have been eliminated or greatly reduced in occurrence.

In addition to changes in the primary ecological processes of the Bitterroot Valley ecosystem at Lee Metcalf NWR, the local and regional landforms and vegetation communities have been negatively affected by numerous alterations to topography, drainages, clearing, conversion to various agricultural crops or livestock forage, extensive grazing by cattle and sheep, sedimentation, expansion of nonnative plants, and recently urban expansion (e.g., Fig. 17). Vegetation changes at Lee Metcalf are documented in aerial photographs from the 1940s to the present (Figs. 4, 15, 24). Collectively, the system now has:

1) Reduced area of Riparian and Gallery Forest
2) Increased Persistent Emergent and Open Water habitat
3) Increased Herbaceous Wetland vegetation
4) Decreased native Grassland communities
5) Increased agricultural and tame grass fields
6) Increased presence of invasive and exotic plant species

Invasions of sulphur cinquefoil, Dalmation toadflax, leafy spurge, spotted knapweed, Canada and musk thistle, Hound's tongue, St. John's wort, and yellow flag iris are present in many areas on the refuge (Kudray and Schemm 2008, U.S. Fish and Wildlife Service, Lee Metcalf NWR unpublished data). Of 34 currently considered noxious weeds in Montana, 15 species are present on the refuge.

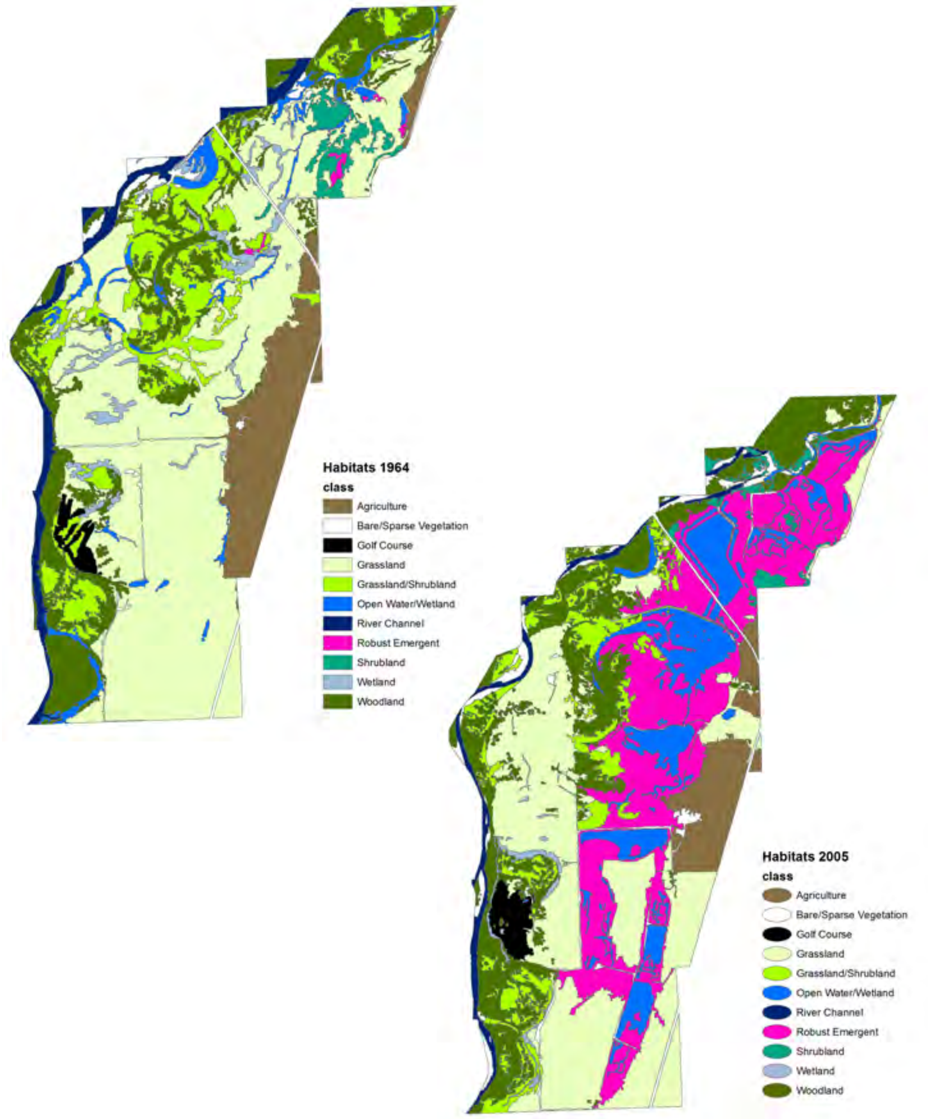


Figure 24. Composite vegetation community model for Lee Metcalf National Wildlife Refuge 1964 compared to 2005.

FISH AND WILDLIFE POPULATIONS

The many ecological and community changes to the Lee Metcalf NWR ecosystem have caused corresponding affects on fish and wildlife populations using the area. Unfortunately, little quantitative data are available on animal use of the area during historic times, but correlations of species occurrence with specific habitat types can infer relative abundance for at least some groups. Apparently, waterbirds and other wetland associated birds increased in number and seasonal occurrence on Lee Metcalf NWR, at least during the 1970s and 1980s after wetland impoundments were built and managed for more prolonged water regimes during summer and fall (e.g., Hess 1978). Peak numbers of dabbling and diving ducks, shorebirds, and wading birds exceeded 20,000 birds on Lee Metcalf NWR, especially in spring and fall migration during some years in the 1970s and 1980s, but now seldom exceed 5,000 (Lee Metcalf NWR, unpublished annual narratives). Production of ducks on the refuge also reached 10,000 in some years during the 1970s and 1980s, but now annual production typically is < 1,000 ducklings. Other birds associated with more permanently flooded wetlands including osprey and certain passerines also apparently increased after wetland impoundments were initially built, but now are declining. For example, Osprey production on Lee Metcalf reached a peak of 40 young in 1988, but has declined since (Fig. 25). Concerns about mercury contamination of osprey eggs and young relate to the consumption of warm-water fish stocked in Otter Pond and high mercury levels in other refuge impoundments and regional waters. Mercury concentration in fish (mainly large-mouth bass) on Lee Metcalf average > 0.1 mg/kg wet weight for 14-22 inch size classes (Fig. 26). Wetland bird species of concern present on the refuge include common loon, Clark's grebe, white pelican, American bittern, black-crowned night heron, white-faced ibis, trumpeter swan, bald eagle, long-billed curlew, Franklin's gull,

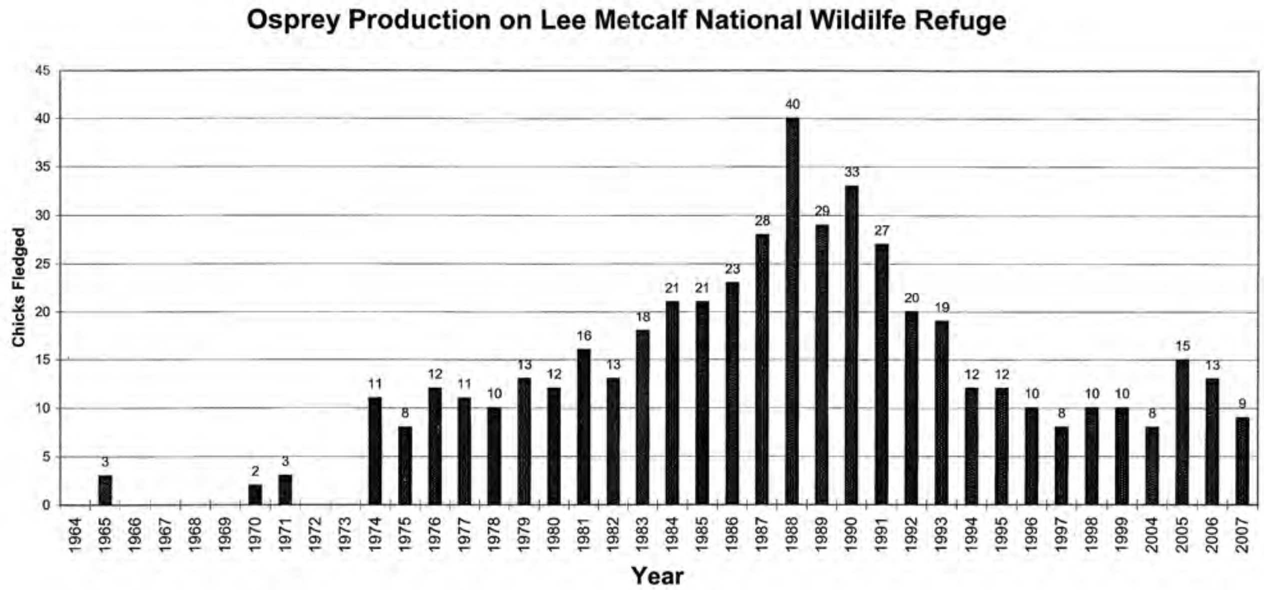


Figure 25. Number of osprey produced on Lee Metcalf National Wildlife Refuge 1964 to 2007.

Black tern, common tern, Caspian tern, and Forster's tern (Appendix C).

Limited data suggest declines in animals using floodplain channels and tributaries to the Bitterroot River, Riparian forest, and Grassland/Sagebrush communities over time (e.g., U.S. Fish and Wildlife Service, unpublished NWR inventories, Brandt 2000, USFWS 2005). Reduced area of Riparian Forest habitat causes less foraging, nesting, loafing, and stopover habitat for numerous passerine birds, raptors, and native resident species. Conversion of native Grassland to pasture, hay land, and agricultural crops also has reduced resources for many birds, mammals, and amphibians. Forest and Grassland bird species of concern documented on Lee Metcalf NWR include peregrine falcon, black swift, burrowing owl, Great gray owl, Flammulated owl, Lewis' woodpecker, olive-sided flycatcher, Clark's nutcracker, loggerhead shrike, black-and-white warbler LeConte's sparrow, and bobolink. Further, four mammals, the boreal toad, two dragonflies, and two plants also are listed as species of concern on the refuge. Most large mammals that historically used the Bitterroot Valley floodplain near Lee Metcalf NWR are extirpated or rarely present, including bison, elk, cougar, and grizzly bear.

While the Bitterroot River and its floodplain did not support a large diversity of native fish, many species were highly abundant and widely distributed, especially when overbank and backwater floods occurred. Currently, fish diversity is reduced, comprised mainly of non-native species, and

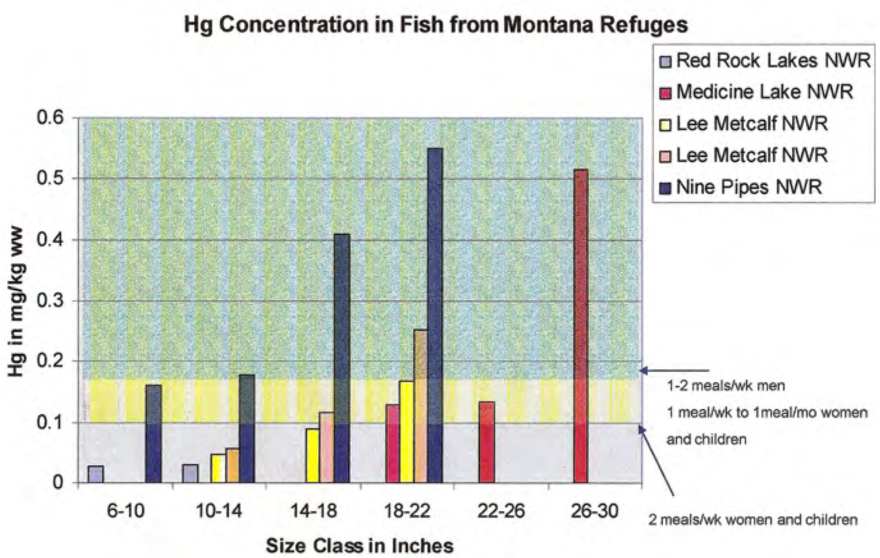
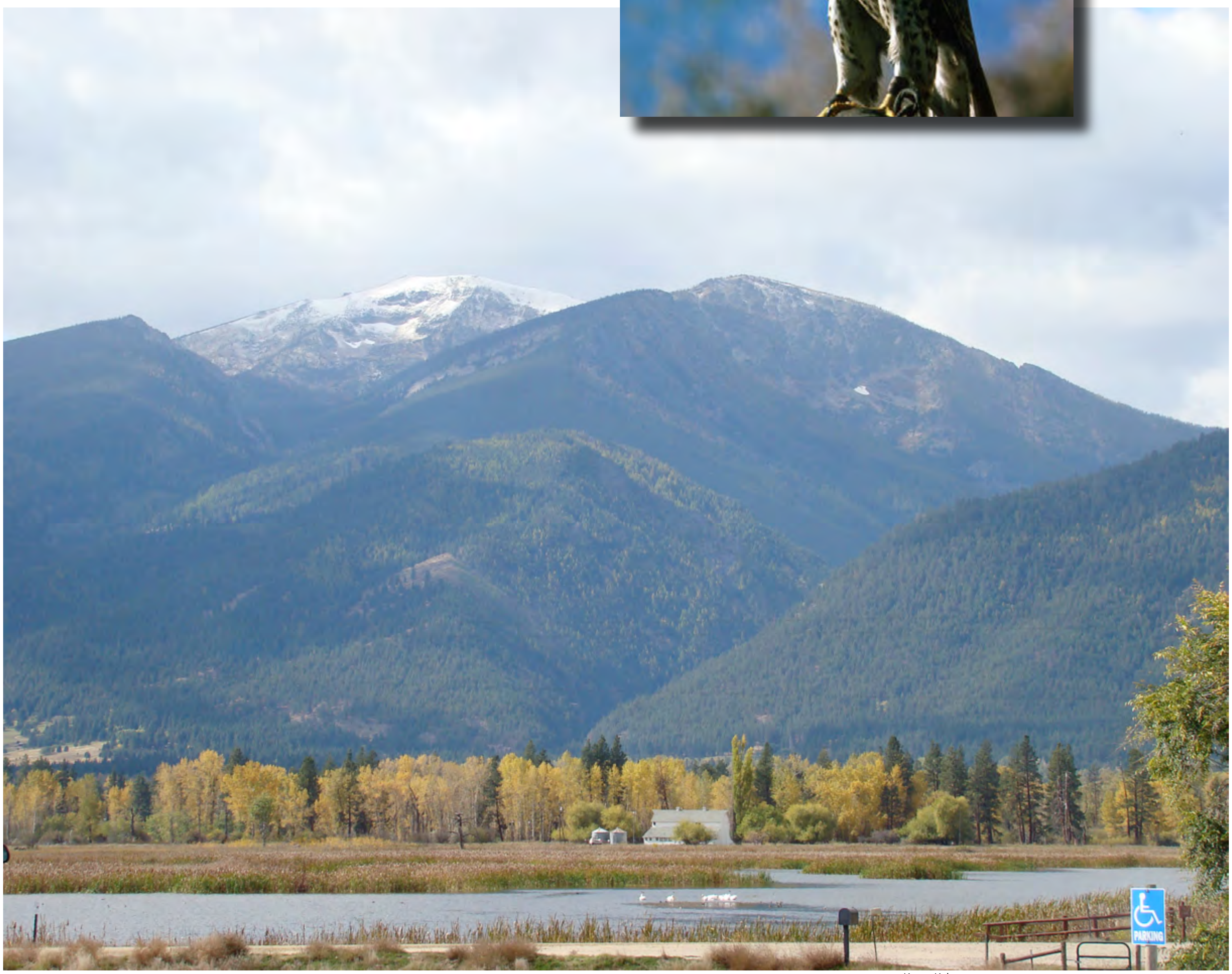


Figure 26. Mercury (Hg) concentration in fish from National Wildlife Refuges in Montana, 2005 (U.S. Fish and Wildlife Service, unpublished data).

distribution is restricted to primary channels of the Bitterroot River and man-made impoundments/ponds (Brandt 2000). The native bull trout, that historically was present in North Burnt Fork Creek, now has reduced and restricted abundance largely because of dammed and diverted water flow, sedimentation, and increased water temperature in the creek and the impounded Francois Slough area (Stringer 2009).

Phil Million, USFWS



Karen Kyle

Ronald L. Bell, USFWS

ECOSYSTEM RESTORATION AND MANAGEMENT OPTIONS

A SUMMARY OF CONDITIONS

Information obtained and analyzed during this study were sufficient to conduct a HGM-based evaluation of historic and contemporary physical and biotic conditions on Lee Metcalf NWR and the surrounding region. Lee Metcalf NWR is a small refuge situated almost entirely within the recent, and active, floodplain of the Bitterroot River. The formation of land surfaces, soils, and drainages on and adjacent to the Lee Metcalf NWR floodplain were primarily created by active fluvial dynamics of the Bitterroot River. The historic floodplain system of seasonal patterns of surface water flow and inundation, overbank and backwater flooding of the Bitterroot River, and interactions of ground and surface water dictated the types and distribution of floodplain vegetation communities. The floodplain at Lee Metcalf NWR is bounded by higher elevation late Pleistocene terraces and alluvial fan complexes that created striking transitions in communities and ecological processes between the terraces and floodplain. Collectively, the complexity of river movements, floodplain drainages, topography, soils, and geomorphic surfaces created a heterogeneous mosaic of vegetation communities on the site ranging from Grassland-Sagebrush habitat on high elevation terraces to Persistent Emergent wetland habitats in low elevation depressions and drainage corridors in the floodplain (Fig. 13).

Apparently, the first major changes to the physical and biotic characteristics of lands now in Lee Metcalf NWR were made in 1871, when Peter Whaley began farming and modifying topography to qualify to receive lands under the Homestead Act. Larger changes to the historic Lee Metcalf NWR ecosystem occurred in the early 1900s when irrigation systems were constructed in the Bitterroot Valley and many lands in the Lee Metcalf NWR region were converted from Gallery Forest or Grassland to orchards, small grain crop fields, and pature-haylands (Eckmann and Harrington 1917). On specific Lee Metcalf NWR areas, former landowners converted many sites to agricultural uses and began constructing infrastructure to bring Bitterroot Irrigation Water to their properties and to divert and/or partly impound floodplain and regional drainages. Levees and berms were constructed along the Bitterroot River and floodplain drainages to protect low-lying areas from overbank and backwater flooding (Fig. 14). Other alterations included construction of numerous roads, levees, railroad beds and bridges, buildings, and a golf course on site. Parts of the Bitterroot River channel were straightened and sections of river banks have been stabilized with various rip-rap materials. Collectively, these ecosystem changes, prior to USFWS acquisition of the site in 1963, greatly disconnected the Bitterroot River from its floodplain and altered the basic hydrological features of the site including water flow pathways; depth, duration, and extent of flooding; and river migration tendencies. Further, native vegetation communities have become altered by decreases in Gallery Forest and native Grassland and increases in introduced grasses, orchards, and various agricultural crops.

After the USFWS acquired Lee Metcalf NWR, additional changes occurred to the Bitterroot River ecosystem. A major alteration to the site was the construction of 14 water impoundments or "ponds" to create more permanent water areas to enhance waterfowl production on the site. These ponds further altered water flow across the Bitterroot River floodplain, impounded and dammed drainages, drastically altered topographic features of the site, changed water regimes from seasonal flood pulses and spring runoff regimes to more permanent water sites, and caused additional diversion of water in the system. In addition to construction of levees, dikes, and water-control structures for these impoundments, level-ditching and islands were constructed in some sites that caused further disruption of topography and within-impoundment water movement. Some upland grassland and agricultural areas were planted to dense nesting cover and fields were fenced to inhibit mammalian predators from entering the nesting cover fields. Agricultural crops were grown in some areas to increase food availability for some waterfowl species. Additional roads, buildings and complexes, public access facilities, and structures have been constructed on the refuge in the last three decades. Collectively, these post-USFWS acquisition, changes attempted to convert this semi-arid and highly active western river floodplain-terrace ecosystem into more of a Northern Great Plains wetland "basin" system that supported consistent and higher waterfowl production. In essence, management and development of Lee Metcalf NWR since the 1960s has not been consistent with the naturally occurring physical, biotic, and basic formation and sustaining ecological features of the site.

The information provided in this report identifies the "mismatch" of management on Lee Metcalf NWR to historic conditions and the significant influence of off-site land uses to current and future management and restoration activities. The HGM-based data in this study identify what communities and ecological processes belong on the site, and also identify the many constraints to being able to restore them. The obvious challenge for future restoration and management of Lee Metcalf NWR is to understand what management actions are potentially possible, will be most effective/efficient to restore basic ecological attributes of this ecosystem, and if restored system processes and communities can be sustainable given the many competing and influential physical and biotic changes to the region.

Key summary data and observation obtained in this study are:

1. The Bitterroot River Valley, where Lee Metcalf NWR sets, is a structural trough formed during the late Cretaceous emplacement of the Idaho batholiths and is bounded by the Bitterroot Mountains on the west and the Sapphire Mountains on the east.

2. Four general geomorphologic zones occur in the Bitterroot Valley including: 1) the Holocene floodplain of the Bitterroot River, 2) low elevation alluvial fans that extend into the floodplain, 3) high elevation, mostly Quaternary-derived, terraces adjacent to the floodplain on the west side of the valley, and 4) high-elevation Tertiary-derived terraces adjacent to the floodplain on the east side of the valley.

3. At Lee Metcalf NWR, most geomorphic surfaces are "Qal" floodplain alluvium, with minor "Qaty" younger alluvial outwash terrace at the far north end of the refuge, and a large "Qafy" terrace and alluvial fan present on the east side of the refuge and floodplain.

4. The Bitterroot River has inherent unstable hydraulic configuration and high channel instability in, and immediately upstream from, the Lee Metcalf NWR area. This unique river stretch reflects the geology and slope form of the Bitterroot Valley at this position and has a complex multi-strand channel pattern that is characterized by numerous braided or anastomosing channels that spread laterally over a wide area of the valley floor.

5. Numerous abandoned channels, cut-off chutes, and minor or "secondary" channels are present in the Lee Metcalf floodplain; minor channels appear to have their genesis from groundwater discharge from surrounding mountain slopes.

6. Nearly 25 soil types/groups are present on or adjacent to Lee Metcalf and reflect the complex geomorphic and topographic configuration of the site. Most soils are shallow, with thin veneers of loam and sandy-loam overlying deeper sands and gravel deposited by the historic Bitterroot River.

7. Elevations on Lee Metcalf range from about 3,230 feet amsl on the north end of the refuge to about 3,260 feet on the south end. Terraces adjacent to the floodplain rise to 3,300 feet. Much topographic heterogeneity exists within the floodplain related to historic Bitterroot River and tributary channel migrations, floodplain scouring, and alluvial deposition.

8. The climate of the Bitterroot Valley is characterized by cool summers, low precipitation in the Valley floor, little wind, and relatively

mild winters. Annual average precipitation at the refuge is about 13 inches and the growing season averages about 103 days.

9. Precipitation is highest in spring, and this water coupled with runoff from snow melt in the region, creates a strong unimodal pulse of discharge in the Bitterroot River in May and June.

10. Overbank flooding of the Bitterroot River that covers much of the Lee Metcalf NWR area is infrequent (> 20-year recurrence interval), but spring backwater flooding into the floodplain occurs regularly (about a 2-5 year recurrence interval).

11. Historic water regimes in the Lee Metcalf NWR region were mostly seasonal "flow-through" inundations, rather than extended flooding regimes.

12. Alluvial aquifers in the Bitterroot Valley are generally unconfined and interconnected and contribute substantial subsurface water inputs to the floodplain at Lee Metcalf.

13. Historic (pre-European settlement) vegetation in the Bitterroot Valley near Lee Metcalf included seven relatively distinct communities/habitat types: 1) Riparian/Riverfront Forest, 2) Gallery Forest, 3) Persistent Emergent, 4) Wet Meadow, 5) Floodplain Grassland, 6) Saline Grassland where saline seeps occurred, and 7) Grassland-Sagebrush communities.

14. HGM-based mapping of potential distribution of communities indicates a complex mosaic of habitats based primarily on soil, hydrology, and geomorphic surface characteristics (Fig. 13).

15. The Bitterroot River ecosystem at Lee Metcalf NWR supported a wide diversity of animal species associated with the interspersed riverine, riparian/gallery forest, wetland, and grassland habitats. Most species were seasonal visitors utilizing resources provided by spring and early summer pulses of water into the system. During wet years, more prolonged flooding into summer and fall increased the availability of wetland-type habitats and probably supported more waterbird breeding and fall migration habitat in those years.

16. The Bitterroot Valley was inhabited by native people in the last 12,000 years, European settlement did not occur until the 1800s; St. Mary's Mission (the current site of Stevensville) was the first Anglo-American settlement in Montana, established by catholic priests in 1841.

17. Increased settlement of the Bitterroot Valley occurred in the mid to late 1800s and following a short surge in limited gold exploration, the Lee Metcalf NWR area was used primarily for cattle production and some agricultural cropping.

18. The relatively dry climate in the Bitterroot Valley created annual variation in water availability and therefore variable success in growing agricultural crops; consequently settlers began attempting to divert water from rivers and streams to crop and pasture areas in the late 1800s.

19. Beginning in 1905, the Bitterroot Valley Irrigation Company began construction on a major water infrastructure project to deliver surface irrigation water to lands on the east side of the Bitterroot Valley. This project included water storage in Lake Como, a diversion dam on Rock Creek, over 70 miles of canals, siphons under the Bitterroot River, and multiple water-control structures and delivery ditches.

20. Irrigation water from the Bitterroot Irrigation Company was originally planned for orchard development and production on lands now in the Lee Metcalf NWR. In the early 1900s some grassland and Gallery Forest was converted to orchards and former landowners constructed extensive ditch and water diversion infrastructure in the floodplain and adjacent terraces.

21. Limited water and other economic considerations caused this orchard "boom" to collapse and eventually the Bitterroot Irrigation Company went bankrupt in the early 1900s. In 1930, the U.S. Bureau of Reclamation secured past financial liabilities and rehabilitated the

system, now known as the Bitterroot Irrigation District. Subsequent irrigation flows and diversions have sustained cattle production and small grain farming in the Bitterroot Valley.

22. A railroad bed and bridge was built across the Bitterroot River and some floodplain areas in the late 1800s. Other rail and road bridges also were built across the river through the mid 1900s.

23. In the 1950s, attempts were made to stabilize the banks of the Bitterroot River with various rip-rap materials and also to straighten and effectively channelize portions of the river. Levees were constructed along the Bitterroot River by landowners in many areas. These channel projects attempted to mitigate or reduce the lateral migration of the Bitterroot River near Lee Metcalf NWR to protect rail and road beds and bridges, urban developments, and agricultural fields.

24. By the l970s, extensive agricultural production in the Bitterroot Valley had peaked and landowners began subdividing holdings for housing developments. Ravalli County had the most rapid population and residential expansion in Montana by the mid 1990s and many lands close to Lee Metcalf NWR now are residential.

25. The combination of irrigation development and land use changes significantly altered the hydrology and river channel morphology and movement in the Bitterroot Valley in the 1900s.

26. Lee Metcalf NWR, containing 2,800 acres, was authorized and established in 1963. Originally named Ravalli NWR, the refuge name was changed in 1978 in honor of long-time U.S. Senator Lee Metcalf.

27. The USFWS began physical developments on the refuge in 1965-66 and by the late 1980s, over 1,000 acres in 14 wetland pools had been partly or completely impounded with levees, dams, and water-control structures.

28. Wetland impoundments have been managed by diverting irrigation drain water, flows in floodplain channels, and Three Mile Creek into and through the impoundments. Most water enters the area from ditches and drainages in the south part of the refuge and is moved via gravity flow sequentially through pools.

29. The refuge has 24 water rights claims and one permit for water to manage wetland impoundments and other areas such as irrigation for agricultural fields, etc.

30. Since establishment, most wetland impoundments on the refuge have been managed to promote waterfowl production by holding water through summer or year round, and occasionally draining areas for vegetation management. Islands and level-ditching were built in some ponds in the 1980s to improve pair seclusion and nesting sites. Otter Pond was stocked with warmwater fish in 1989 to provide prey for nesting osprey and limited public fishing opportunity. This fish stocking has contributed to nonnative fish moving into other refuge impoundments and drainages and also into the Bitterroot River.

31. Collectively, the many landscape and hydrological changes at Lee Metcalf NWR have degraded basic ecological processes of the historic ecosystem system and shifted plant communities to: 1) reduced area of Gallery Forest and native grassland and 2) increased area of Persistent Emergent wetlands, agricultural fields, tame grassland, and invasive plant species.

32. Fish and wildlife populations on Lee Metcalf NWR apparently have changed over time coincident with changes in vegetation communities and hydrology of the system. Waterbirds and species associated with wetland impoundments apparently increased in occurrence and abundance at the sites in the first 20+ years after impoundment, but subsequently have declined. Native species of fish and wildlife associated with reduced area and condition of riverine, Riparian and Gallery Forest and Grassland habitats have declined throughout the Bitterroot Valley ecosystem

GENERAL RECOMMENDATIONS FOR RESTORATION AND MANAGEMENT OPTIONS

This study is an attempt to evaluate restoration and management options that will protect, restore, and sustain natural ecosystem processes, functions, and values at Lee Metcalf NWR. Lee Metcalf NWR provides key resources to meet annual cycle requirements of many plant and animal species in the Rocky Mountain region of the western U.S., and is an important area that provides opportunities for outdoor experiences, recreation, and education for large numbers of people. These public uses are important values of the refuge that hopefully can be sustained within the context of more holistic regional landscape- and system-based management. This study does not address where, or if, the many sometimes competing uses of the refuge can be accommodated, but rather this report provides information to support The National Wildlife Refuge System Improvement Act of 1997, which seeks to ensure that the biological integrity, diversity, and environmental health of the (eco)system (in which a refuge sets) are maintained (USFWS 1999,Meretsky et al. 2006). Administrative policy that guides NWR goals includes mandates for: 1) comprehensive documentation of ecosystem attributes associated with biodiversity conservation, 2) assessment of each refuge's importance across landscape scales, and 3) recognition that restoration of historical processes is critical to achieve goals (Mertetsky et al. 2006). Most of the CCP's completed for NWR's to date have highlighted ecological restoration as a primary goal, and choose historic conditions (those prior to substantial human related changes to the landscape) as the benchmark condition (Meretsky et al. 2006). General USFWS policy, under the Improvement Act of 1997, directs managers to assess not only historic conditions, but also "opportunities and limitations to maintaining and restoring" such conditions. Furthermore, USFWS guidance documents for NWR management "favor management that restores or mimics natural ecosystem processes or functions to achieve refuge purpose(s)" (USFWS 2001) and to improve biological integrity (USFWS 201:601.FW3).

Given the above USFWS policies and mandates for management of NWR's, the basis for developing recommendations for Lee Metcalf NWR is the HGM-approach used in this study. The HGM approach objectively seeks to understand: 1) how this ecosystem was created, 2) the fundamental processes that historically "drove" and "sustained" the structure and functions of the system and its communities, and 3) what changes have occurred that have caused ecosystem degradations and that might be reversed and restored to historic and functional conditions within a "new desired" environment. This HGM approach also evaluates the NWR within the context of appropriate regional and continental landscapes, and helps identify its "role" in meeting larger conservation goals and needs at different geographical scales. In many cases, restoration of functional ecosystems on NWR lands can help an individual refuge serve as a "core" of critical, sometimes limiting, resources than can complement and encourage restoration and management on adjacent and regional private and public lands.

Generally, comprehensive restoration of native ecosystems and their sustaining ecological processes at Lee Metcalf NWR will be difficult because of: 1) the small size of the refuge, 2) the "insular" nature of the refuge that increasingly is surrounded by urban/residential expansion and development (Fig. 17), 3) highly modified landforms and communities on and adjacent to the refuge, 4) constraints on sustaining the inherent morphology and basic hydrology attributes of the Bitterroot River, and 5) high public use and competing demands for refuge management and access. Despite these substantial challenges, based on the HGM context of information obtained and analyzed in this study, we believe that future management of Lee Metcalf NWR should seek to restore ecological communities and processes to the least degraded state possible, including attempts to:

1. Maintain the physical and hydrological character of the Bitterroot River and its floodplain on Lee Metcalf NWR.

2. Restore the natural topography, water regimes, and physical integrity of surface water flow patterns in and across the Bitterroot River floodplain and adjacent terraces and alluvial fans.

3. Restore and maintain the diversity, composition, distribution, and regenerating mechanisms of native vegetation communities in relationship to topographic and geomorphic landscape position.

The following general recommendations are suggested to meet these ecosystem restoration and management goals for Lee Metcalf NWR.

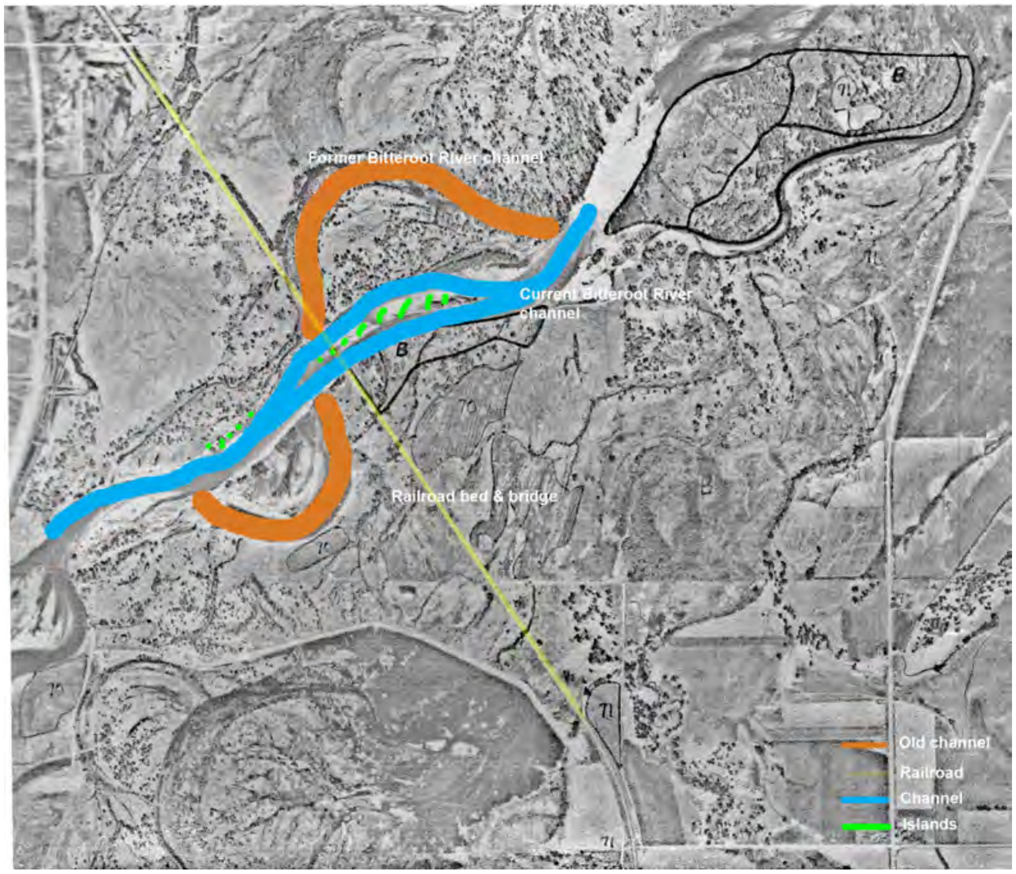
1. *Maintain the physical and hydrological character of the Bitterroot River and its floodplain on Lee Metcalf NWR.*

The Bitterroot River has an inherently unstable hydraulic configuration and high channel instability in the stretch immediately upstream from, and at, the Lee Metcalf NWR. The river in this area has a complex multi-strand channel patterns that is characterized by numerous braided, anastomosing, channels that spread over a wide area of the Bitterroot Valley floodplain. Complex networks of minor floodplain drainages and tributaries to the Bitterroot River are present on Lee Metcalf NWR and represent historic drainage patterns from adjacent mountain slopes and from groundwater discharge. Evidence of many historic abandoned channels of the Bitterroot River are evident on Lee Metcalf, some apparently quite recent in origin (Fig. 4).

Since the 1930s, lateral migration of the Bitterroot River channel has apparently accelerated and the river is actively attempting to cross the floodplain at Lee Metcalf NWR in new pathways, including shifting primary discharge through the North Slough (Fig. 20). Lateral migration of the river has been discouraged to date by land interests along the river, including the Lee Metcalf NWR, to protect existing roads, the railroad bed and bridge on the north end of Lee Metcalf NWR, and residential/farm owners. Control of river migration has been attempted by channelization and armoring channel banks with rip rap and other materials. Eventually, more channel stabilization will be needed to keep the Bitterroot River channel "in place" because hydraulic dynamics from future high flow events will continue to destabilize the current river channel configuration and destroy or damage existing physical structures. Current river stabilization structures on Lee Metcalf NWR including frontline levees and rip rap placed along the Bitterroot River in the 1970s and 1980s seem contradictory to the physical and hydraulic dynamics and character of the Bitterroot River and may ultimately be contributing to potential damage on other stretches or non-refuge lands along the river, both up and downstream from the refuge. Allowing the Bitterroot River to move more freely across the Lee Metcalf NWR floodplain seems desirable where it is possible and not detrimental to structures or interests that the USFWS has no control over. One of these structures is the railroad bridge and rail bed on the north end of the refuge. Unfortunately, this rail bed is located in an area of recently active river movement caused by the geological underlay of the site and the physical configuration of the river where the river has frequently moved and created recent abandoned channels and a braided river/island system (Fig. 27). Even with increasing attempts to stabilize the Bitterroot River at this point, ultimately this rail bed will be in jeopardy of river damage. Removal or relocation of the rail bed is outside of USFWS purview, but interest groups should be advised and aware of its precarious position and the ultimate consequences of its continued use and maintenance pending future alterations to the Bitterroot River channel and discharges. Furthermore, continued maintenance of this rail bed will limit and complicate future ecological restoration actions on Lee Metcalf NWR.

2. *Restore the natural topography, water regimes, and physical integrity of surface water flow patterns in and across the Bitterroot River floodplain.*

The diversity and productivity of the Bitterroot Valley ecosystem at and near Lee Metcalf NWR was created and sustained by a diverse floodplain geomorphic/topographic surface that was seasonally "hydrated" by a strong pulse of water input to the system each spring from Bitterroot River flooding and drainage/seepage from surrounding mountain slopes. Occasional overbank, and more regular backwater, flooding from the Bitterroot River into its floodplain at Lee Metcalf NWR historically helped create and sustain communities and basic ecological functions and values of the site. These flooding processes now are restricted by levees along the river, levees and dams on constructed wetland ponds and impoundments, roads, the railroad bed, and dams or other obstructions on tributary channels. Restoring the capability of the Bitterroot River to overflow its banks, and to back water up tributaries and into other floodplain channels is desirable to restore the floodplain ecosystem at Lee Metcalf NWR. This seasonal "pulsed" flooding regime provided uninhibited movement of water, nutrients, sediments, and animals between the river and the floodplain and supported critical life cycle events and needs of both plant and animal communities (Junk et al. 1989). Periodic long-term flood events also are important flood plain processes that help maintain community dynamics and productivity (e.g., Whited et al. 2007) For example, overbank flooding deposits silts and nutrients in floodplains that enhance soil development and productivity. Overbank flooding creates scouring and deposition surfaces critical for germination and regeneration of Gallery Forest species, especially cottonwood. Backwater flooding provides foraging habitat for pre-spawning native river fish and entrainment and development/growth habitat for larval and juvenile fishes. Annual backwater flooding recharges water regimes in depressions and shallow floodplain wetlands that serve as productive



A

B

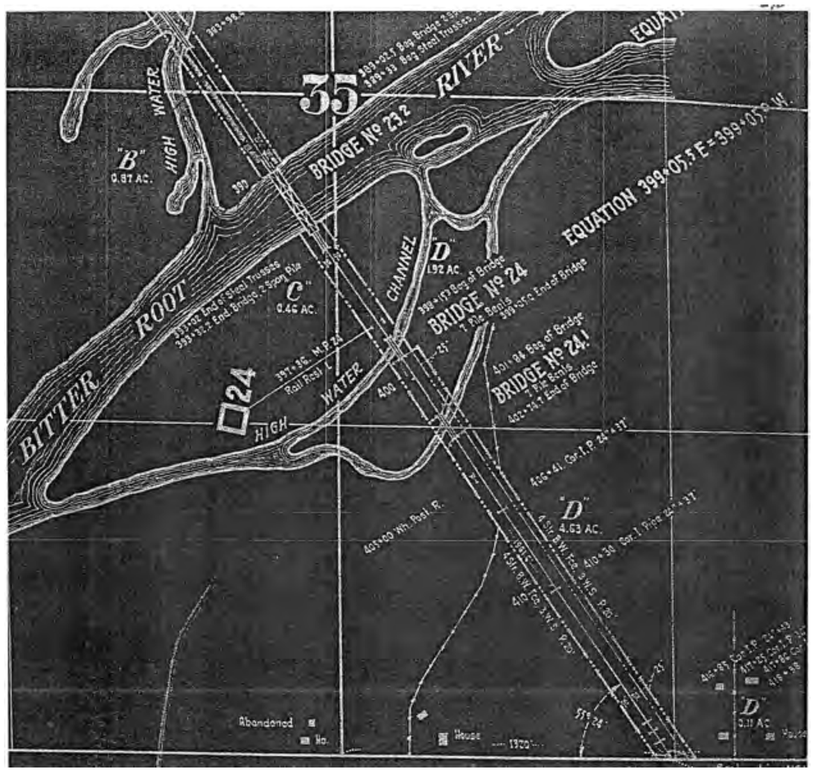


Figure 27. Location of the railroad bridge and bed across the Bitterroot River and its floodplain on Lee Metcalf National Wildlife Refuge showing: a) its position relative to current and former river channels and the braided channel-island geomorphology and b) the historical blueprint of the railroad corridor and its crossing of multiple active and abandoned channels of the Bitterroot River.

breeding habitat for amphibians and reptiles, waterbirds, and certain mammals. Subsequent drying of floodplains concentrates aquatic prey for fledgling waterbirds. Collectively, the body of scientific evidence suggests that restoring the hydrologic connectivity between the Bitterroot River and its floodplain at Lee Metcalf is desirable.

Topographic and soil/geomorphology variation created a heterogeneous mosaic of elevations and site-specific hydrology that supported many vegetation communities on Lee Metcalf NWR and provided diverse resources that supported many animal groups. Unfortunately, the topography and flow of water across the Lee Metcalf NWR area has been altered dramatically; initially from land conversion and physical developments and diversion of water for irrigating crop and pastureland and then by construction of water-control infrastructure by the USFWS in an attempt to create more permanent wetland areas (ponds) for breeding waterfowl. Both early 1900s and more recent physical developments on Lee Metcalf NWR have been detrimental to sustaining the natural ecosystem of the area/region, and do not match historic ecosystem structure or function.

Restoration of the physical and biotic diversity and productivity of the Lee Metcalf NWR ecosystem will require at least some restoration of natural topography, especially reconnecting water flow pathways or corridors, in the floodplain. Restoration of topography and water flow pathways is important to allow water, nutrients, and animals to move through the system in more natural patterns. Additionally, restoring water pathways can improve both flooding and drainage capabilities, more closely emulate natural hydroperiods that sustained native plant communities, and reduce prolonged flooding in ponds and other depressions during the growing season. Restoration and emulation of natural water regimes, and floodplain communities, on Lee Metcalf NWR will require a fundamental change in the philosophy of water management in wetland impoundments on the area. Past management of impoundments has sought to provide more annually predictable, and permanently flooded, water regimes to enhance waterfowl production. Impoundment infrastructure and more frequent and permanent growing season inundation has caused highly altered topography, disconnected natural flow patterns and corridors, conversion of native plant communities wetter types, and general degradation of historic Bitterroot Valley ecosystem processes. Future water and impoundment (if they are retained) management of Lee Metcalf NWR should seek to manage surface water with seasonal water regimes, driven by spring runoff and Bitterroot River backwater flooding, and by restoring drying periods in late summer and fall in most years.

3. *Restore and maintain the diversity, composition, distribution, and regenerating mechanisms of native vegetation communities in relationship to topographic and geomorphic landscape position.*

The diversity of vegetation communities historically present at Lee Metcalf NWR was distributed along geomorphic surface, soil, topographic, and flood frequency gradients. In this active river migration floodplain setting, the dominant factors determining distribution of vegetation was soil/geomorphology surfaces and topography as it was related to the seasonal flooding regime caused by interannual and intraannual dynamics of water flows and levels of the Bitterroot River and its tributaries. Major disturbance factors that sustained communities included seasonal and long-term flooding (Hansen et al. 1995), herbivory (Burkhardt 1996), and fire (Arno 1976, Fischer and Bradley 1987). Many factors have changed the presence, extent, and distribution of habitat types at Lee Metcalf NWR including land clearing and conversion to orchards and agricultural crops, construction of extensive irrigation systems, drainage, levee and water-control infrastructure, and altered hydrology and movement capability of the Bitterroot River. Certain of these land and water changes (e.g., floodplain drainage infrastructure) may be reversed, but others (e.g., residential developments, railroad beds) are not likely to change in the foreseeable future, or are not under the control of the USFWS.

Generally, ecosystem restoration strategies seek to restore elements of the diversity and natural distribution patterns of habitats in a region, where they have been highly altered (e.g. Heitmeyer 2007). This restoration is important to sustain plant and animal communities and to provide ecosystem functions and values such as nutrient flow, carbon sequestration, water filtration, groundwater recharge, flood water storage, etc. Restoration projects at Lee Metcalf NWR should attempt to restore at least some functional patches of all native habitat types that were present in the late 1800s (e.g., Porter 2008) and be integrated with Montana's Comprehensive Fish and Wildlife Conservation Strategy (Montana Fish and Wildlife Comprehensive Conservation Steering Committee 2006). The challenge at Lee Metcalf NWR will be to develop site-specific strategies to restore natural topography, river migration, and seasonal water flow regimes in areas that have had extensive alteration. Basically, restoration works that seek to restore some components and distribution of native plant communities (Knopf et al. 1988) will require "deconstruction" of many past infrastructure developments that may be controversial amidst the current expectations, uses, and competing demands of user groups and neighboring lands. Certain changes may not be possible (e.g., changing Bitterroot Irrigation District ditch and drain systems) or desirable, however other USFWS controlled changes can be conducted (e.g., removing impoundment levees, islands, and level-ditch spoil/dredge sites). Undoubtedly, some conflicts will occur among user groups, but priorities and management ultimately must be based on restoring sustainable communities to the site to meet resource/ecosystem goals.

SPECIFIC RECOMMENDATIONS FOR RESTORATION AND MANAGEMENT OPTIONS

Restore the Physical and Hydrological Character of the Bitterroot River System

As previously stated, the inherently unstable and dynamic physical and hydrological character of the Bitterroot River ecosystem at Lee Metcalf NWR was created by geological and hydrological processes that still exist in their general physical/hydraulic form. The presence of large mountains bounding the Bitterroot Valley that contribute sediment and water to the Bitterroot River and its floodplain exert basic physics to the system that must be understood and accommodated in management of specific sites in the Valley, including Lee Metcalf NWR. Clearly, many changes have occurred to this riverine-floodplain system and many changes may be irreversible or are unlikely to change in the near future (e.g., the Bitterroot Irrigation District infrastructure). Nonetheless, the USFWS has the opportunity to manage Lee Metcalf NWR in an exemplary way that contributes to the overall sustainability and restoration of the Bitterroot Valley, albeit in a small somewhat isolated scale. The following restoration opportunities seem possible:

1. *Allow the Bitterroot River to undergo natural anastomosing migration patterns across Lee Metcalf NWR, where possible.*

- Remove, or place wide carefully engineered spillways in, main stem levees along the Bitterroot River. Where old or existing levees have been breached or destroyed, do not rebuild them.

- Remove or do not replace hard points or rip rap along the channel banks of the Bitterroot River on Lee Metcalf NWR properties unless they protect non-USFWS property or structures.

- Do not inhibit tendencies for the Bitterroot River to move primary discharge through the North Island Slough.

- Evaluate removal of levees along the north sides of Otter Pond and Ponds 12 and 13 to allow the Bitterroot River to move into, and seasonally flood, these areas.

2. *Reconnect floodplain habitats with the Bitterroot River to allow natural overbank and backwater flooding into and out of the floodplain.*

- Remove, or construct wide spillways in, levees, berms, dams roads, and ditches that prohibit overbank and backwater flooding from the Bitterroot River into the floodplain on Lee Metcalf NWR property.

- Allow, or restore, seasonal flows of the Bitterroot River into and through North Island and Francois sloughs, respectively.

3. *Reconnect unimpeded flow from Valley/Mountain channels and tributaries into the Bitterroot River.*

- Remove dams and obstructions in tributary and floodplain channels to allow water to move freely into the Bitterroot River and allow fish and other aquatic animals to use this flowage corridor.

- Reconnect the North Burnt Fork Creek with flow pathways through Francois Slough and into the Bitterroot River to reduce creek water temperatures, improve water and nutrient flow, and help restore native populations of bull trout.

Restore Floodplain Topography, Water Regimes, and Water Flow Patterns

Restoration of ecological communities and processes at Lee Metcalf NWR will require at least some restoration of natural topography, water flow, and flooding/drainage regimes. Unfortunately, some past infrastructure developments and management of Lee Metcalf NWR lands and water have been contradictory, not complementary, to these restoration needs. In general, the Bitterroot River floodplain at Lee Metcalf NWR is semi-arid and water regimes are dominated by early spring flooding and surface water runoff followed by drying through summer and fall to low more stable levels in winter. Superimposed on this strongly seasonal pattern are occasional long-term punctuations (> 20-year recurrences) of more extreme flooding of the Bitterroot River that caused prolonged inundation of the floodplain and its drainages/depressions throughout summer/fall and across a few consecutive years. Past management and development of wetland impoundments on Lee Metcalf NWR have not emulated seasonal or long-term dynamics of flooding or maintained floodplain water flow corridors. A return to more natural dynamics may require significant changes to current landforms and management strategies. Possible changes include:

1. *Restore natural topography and reconnect natural water flow patterns and corridors where possible.*

- Remove and/or breach spoil material berms and levees along major drainages.

- Improve water flow into and through historic slough and swale channels by removing obstructions, levees, and dams in and across these drainages.

- Restore at least some natural topography in all wetland impoundments, fields, and terraces and remove islands and level-ditch dredge and spoil sites.

- Evaluate all levees and roads to determine if they are necessary, or are detrimental, to water management on the area. Remove unnecessary levees and roads and construct spillway breaches in some pond levees to allow water to move among units during high water flow or flood events.

- Do not construct additional wetland impoundments, roads, levees, or other structures that altered water flow into or across the floodplain.

- Remove roads, berms, and ditches etc. that disrupt natural "sheetflow" of water across mountain slope alluvial fans into the floodplain.

2. Manage wetland impoundments/ponds for natural seasonal and long-term water regimes.

- Manage water regimes in all ponds for a more seasonally and annually dynamic water regime that emulates natural increases in distribution and depth in spring, followed by drying in summer and fall.

- Emulate long-term patterns of drier conditions in floodplain wetlands in most years including periodic complete drying in some years and occasional prolonged flooding in a few years.

Restore Natural Vegetation Communities

The native vegetation communities present on Lee Metcalf NWR provided critical resources to many animal species and populations and contributed to the many functions and values of the Bitterroot Valley. Degradation of these native communities began in earnest in the early 1900s and subsequent changes in land form, hydrology, and management have continued alterations. Despite these alterations, some restoration of communities is possible by:

1. *Restore distribution of plant communities to appropriate sites based on HGM-documented geomorphology, soils, topography, and hydrologic features identified in Table 2, Fig. 13).*

- Sustain Riverfront Forest along the margins of the Bitterroot River on newly deposited/scoured coarse material surfaces.

- Sustain and expand Gallery Forest on higher elevation floodplain areas with sandy-loam soils, on natural levees, and other floodplain ridges that have 2-5 year flood recurrence intervals.

- Restrict Persistent Emergent habitats to deeper depressions, poorly drained Slocum muck soils, and more permanent water regimes.

- Sustain Wet Meadow communities adjacent to Persistent Emergent communities with 2-5 year flood frequencies.

- Restore native Grassland in silt loam soils on higher floodplain elevations and on terraces.

- Restore Saline Grassland to terrace areas with saline soils.

- Sustain Grassland-Sagebrush communities on alluvial fans.

2. *Improve conditions to increase the distribution and composition of native Grassland in higher floodplain elevations and on terraces/alluvial fans.*

- Remove introduced and tame grassland from locations where native Grassland communities historically were present and restore native species where possible.

- Restore intermittent and seasonal water regimes to higher elevation sites and restore patterns of "sheetflow" surface water movement across the sites by removing unnecessary roads, ditches, levees, etc.

- Convert higher elevations of current impounded wetlands back to Grassland, where it was historically present, by removing levees and water-control structures, and restoring seasonal water regimes.

- Providing occasional disturbance from fire or grazing to recycle nutrients and regenerate grass and forb species.

3. *Restore regenerating mechanisms for Gallery Forest communities on well drained floodplain natural levees and benches.*

Gallery Forests in the Bitterroot Valley were sustained by fertile floodplain soils and seasonal inundation for generally short periods at about 2-5 year intervals. Further, occasional disturbance mechanisms provided suitable substrates for regenerating tree species and shrubs. Cottonwood Gallery Forests in Montana generally are in poor condition if the shrub components are not present, most commonly due to overgrazing (Hansen et al. 1995). Gallery Forest on Lee Metcalf NWR is in better condition (i.e., more shrub component) in the north end of the refuge compared to the middle and south end of the refuge along the Bitterroot River. Regenerating mechanisms, that need to be reinstated into the management of Lee Metcalf NWR include:

- Occasional large flood events to occur in the floodplain to scour surfaces, deposit sands, and create regeneration sites for cottonwood.

- Occasional fire and perhaps some grazing during dry periods to sustain occurrence of grasses and forbs and to scarify pine cones and permit germination of ponderosa pine (e.g., Fischer and Bradley 1987).

4. *Reduce the area of more permanently flooded wetland impoundments and Persistent Emergent vegetation.*

- Change water management of impounded areas that might be maintained, to seasonal water regimes and periodic dry conditions.

- Remove levees, ditches, and water-control structures from all higher elevation areas within the floodplain and on terraces.

- Eliminate the warm-water fishery in Otter Pond.

5. *Actively control invasive and exotic plant species.*

- Actively control invasive and exotic plant species using appropriate chemical, mechanical, and biological methods.

Karen Kyle

MONITORING AND EVALUATION

Future management of Lee Metcalf NWR will require regular monitoring and directed studies to determine how ecosystem structure and function are changing, regardless of whether restoration options identified in this report are pursued or not. Ultimately, the success in restoring and sustaining communities and ecological functions/values at Lee Metcalf NWR will depend on how well management can support the integrity of the Bitterroot River system and its floodplain and emulate natural water regimes that supported specific habitat types and ecological processes. This report identifies the critical issues related to these management considerations, and acknowledges the difficulty in making certain changes. Furthermore, uncertainty exists about the ability of some management actions to make the desired changes in river integrity, water regimes and flow patterns, and ultimately responses in native vegetation and animal communities. Whatever changes future management of Lee Metcalf NWR makes, the work should be done in an adaptive management framework where: 1) predictions about community restoration and water issues are made (e.g., conversion of higher elevation floodplain areas to Grassland) relative to specific management actions (e.g., removing levees and changing water management regimes to short duration seasonal flooding) and then 2) follow-up to systematically monitor and evaluate ecosystem responses to the action. Critical issues that need this monitoring are described below.

Maintaining the Physical/Hydrological Integrity of the Bitterroot River and its Floodplain

If actions are taken to allow the Bitterroot River to migrate into and through its floodplain at Lee Metcalf NWR then several ecosystem consequences might be expected including changes in the configuration and path of the Bitterroot River, scouring and deposition of floodplain surfaces, and enhanced connectivity and frequency of overbank and backwater flooding into the floodplain. Specific data should be collected on:

- Channel morphology and bank erosion/stabilization along the refuge
- Frequency, timing, depth, location, and duration of overbank and backwater flooding of Bitterroot River water into the floodplain
- Effects on non-USFWS structures and lands, including the railroad bed and bridge, private lands areas above and below the refuge, and pond levees and infrastructure on the refuge

Restoring Natural Regimes and Water Flow Patterns

This report recommends many changes to water management and water flow patterns on Lee Metcalf NWR. Most changes involve restoring at least some natural water flow through floodplain drainages and tributaries and seasonally- and annually-dynamic flooding and drying regimes that will reduce the permanence of surface water on the site. The following data and monitoring programs are needed:

- Document annual water budgets and use for all management ponds including source, delivery mechanism, and extent and duration of flooding. These data also will provide data on how existing water rights are used and maintained.
- Water movement through and across the refuge, including routing through natural and man-

made drainages in the floodplain and sheetflow across terraces and alluvial fans.

- The efficiency and effectiveness of all water-control structures.

- Water quality in all drainage and floodplain areas.

Long Term Changes in Vegetation and Animal Communities

One important goal at Lee Metcalf NWR is to restore native plant communities in composition and distribution similar to historic conditions where possible. Certain past developments and changes in hydrology will constrain complete restoration of communities in exactly the same position and size as in pre-alteration periods. Nonetheless, general changes in community distribution should occur if the recommended changes in water management, topographic restoration, and annual disturbances are followed. Specific monitoring needs are:

- Distribution and composition of major plant communities in all areas of the refuge.

- Survival, growth, regeneration, and reproduction of key individual species associated with each community/habitat type.

- Presence and distribution of invasive and exotic species and efficacy of control methods

- Occurrence and abundance of select animal species representing various taxon, guilds, and status. For example, response of bull trout to reestablishing more natural and complete connectivity between the Bitterroot River and Burnt Fork Creek.

Karen Kyle

ACKNOWLEDGEMENTS

This HGM evaluation was supported by a grant from the USFWS to Blue Heron Conservation Design and Printing LLC, Contract No. 601818C688. Wayne King of the USFWS helped initiate the project and was the primary administrative support from the Regional Office In Lakewood, CO. He also assisted with field visits, obtained data, and reviewed drafts of the report. Staff at Lee Metcalf including Erin Holmes, Deb Goslin, Bob Danley, and Tom Reed assisted with all field visits and meetings, obtaining data and information for the report, and reviewed drafts of the report. Laura King of the USFWS provided coordination between the HGM evaluation and the CCP for the refuge. Karen Kyle of Blue Heron Conservation Design and Printing administered the contract for the project and provided assistance with analyses and collation of the data and geographic information, preparation of report drafts and figures, and publication of the final report.

Lee Karney; USFWS

Lee Karney USFWS

Karen Kyle

Karen Kyle

LITERATURE CITED

Arno, S.F. 1976. The historical role of fire on the Bitterroot National Forest. U.S. Department of Agriculture, Forest Service Research Paper INT -187. Intermountain Forest and Range Experiment Station, Ogden, UT.

Bourne, W.C., P. Grammous, G.Doll, C. Pile, W.H. Cardon, R.C. McConnell, A. Pope and W. Bullette. 1959. Soil surveys of Bitterroot Valley Area, Montana. U.S. Department of Agriculture, Soil Conservation Service, Washington, DC.

Brandt, T.M. 2000. Fish diversity, behavior, and microhabitat use in secondary channels of the Bitterroot River, Montana. M.S. Thesis, University of Montana, Missoula.

Briar, D.W. and D.M. Dutton. 2000. Hydrogeology and aquifer sensitivity of the Bitterroot Valley, Ravalli County, Montana. U.S. Geological Survey Water-Resources Investigations Report 99-4219. Helena, MT.

Browman, L.G. et al. 1989. Some Bitterroot Memories, 1860-1930: a homey account of the Florence Community. Gateway Printing and Litho, Florence, MT.

Burkhardt, J.W. 1996. Herbivory in the Intermountain West: an overview of evolutionary history, historic cultural impacts and lessons from the past. Idaho Forest, Wildlife and Range Agricultural Experiment Station, Bulletin 58. University of Idaho, College of Natural Resources, Boise, ID.

Cappious, S.L. 1939. A history of the Bitter Root Valley to 1914. M.A. Thesis, University of Washington.

Cartier, K.D.W. 1984. Sediment, channel morphology, and streamflow characteristics of the Bitterroot River drainage basin, southwestern Montana. M.S. Thesis, University of Montana, Missoula.

Chaffin, G. 1971. The last horizon. Pine Trail Press.

Clary, J., P.B. Hastings, J. O'Neill and R. Winthrop. 2005. First roots: the story of Stevensville, Montana's oldest community. Stoneydale Press Publishing Company, Stevensville, MT.

Cooper, D.J., D.M. Merritt, D.C. Andersen and R.A. Chimner. 1999. Factors controlling the establishment of Fremont cottonwood seedlings on the Upper Green River, USA. Regulated Rivers: Research and Management 15:419-440.

Eckmann, E.C. and G.L. Harrington. 1917. Soil survey of the Bitterroot Valley Area, Montana. U.S. Department of Agriculture, Bureau of Soils. Washington, DC.

Fischer, W.C. and A.F. Bradley. 1987. Fire ecology of western Montana forest habitat types. U.S. Department of Agriculture Forest Service General Technical Report INT-223. U.S. Forest Service Intermountain Research Station, Ogden, UT.

Gaeuman, D. 1997. Historical channel changes and processes of the Central Bitterroot River, Ravalli County, Montana. M.S. Thesis, University of Montana, Missoula.

Hansen, P.L., R.D. Pfister, K. Boggs, B.J. Cook, J. Joy and D.K. Hinckley. 1995. Classification and management of Montana's riparian and wetland sites. Montana Forest and Conservation Experiment Station, University of Montana Miscellaneous Publication No. 54. Missoula, MT.

Heitmeyer, M.E. 2007. Conserving lacustrine and palustrine natural communities. Missouri Natural Areas Newsletter 5(1): 3-5.

Heitmeyer, M.E. and L.H. Fredrickson. 2005. An evaluation of ecosystem restoration and management options for the Ouray National Wildlife Refuge, Utah. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 8. Puxico, MO.

Heitmeyer, M.E., F.A. Nelson and L.H. Fredrickson. 2006. An evaluation of ecosystem restoration and management options for the Duck Creek/Mingo Basin area of southeast Missouri. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 12. Puxico, MO.

Heitmeyer, M.E. and K. Westphall. 2007. An evaluation of ecosystem restoration and management options for the Calhoun and Gilbert Lake Divisions of Two Rivers National Wildlife Refuge. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 13. Puxico, MO.

Heitmeyer, M.E., V.L. Fields, M.J. Artmann and L.H. Fredrickson. 2009. An evaluation of ecosystem restoration and management options for Benton Lake National Wildlife Refuge. Greenbrier Wetland Services Report 09-01, Blue Heron Conservation Design and Printing LLC, Bloomfield, MO.

Hess, C.J. 1978. Wetland habitat structure of nongame birds of the Ravalli National Wildlife Refuge, Stevensville, Montana. M.S. Thesis, University of Montana, Missoula.

Hodges, K.V. and J.D. Applegate. 1993. Age of Tertiary extension in the Bitterroot metamorphic core complex, Montana and Idaho. Geology 21: 161-164.

Hyndman, D.W., J.L. Talbot and R.B. Chase. 1975. Boulder batholiths – a result of emplacement of a block detached from the Idaho batholiths infrastructure. Geology 3: 401-404.

Junk, W.J., P.B. Bayley and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems. Canadian Special Publication in Fisheries and Aquatic Sciences 106:110-127.

Kudray, G.M. and T. Schemm. 2008. Wetlands of the Bitterroot Valley: change and ecological functions. Prepared for the Montana Department of Environmental Quality, Agreement # DEQ #206028. Montana Natural Heritage Program, Helena, MT.

Knopf, F.L., R.R. Johnson, T. Rish, F.B. Samson and R.C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100:272-284.

Langton, C.M. 1935. Geology of the northeastern part of the Idaho batholiths and adjacent region in Montana. Journal of Geology 43:27-60.

Lankston, R.W. 1975. A geophysical investigation in the Bitterroot Valley, western Montana. Ph.D. Dissertation, University of Montana, Missoula.

Leiberg, J.B. 1899. The Bitterroot Forest Reserve. Extract from the Nineteenth Annual Report of the Survey 1897, Part V Forest Reserves. U.S. Department of the Interior, U.S. Geologic Survey, Washington, DC. Pages 252-282.

Lonn, J.D. and J.W. Sears. 1998. Geologic map of the Bitterroot Valley, Montana. Montana Bureau of Mines and Geology Open File Report 362. Butte, MT.

Lonn, J.D. and J.W. Sears. 2001. Surficial geologic map of the Bitterroot Valley, Montana. Montana Bureau of Mines and Geology Open File Report 441a, 441b, and 441c. Butte, MT.

Losensky, B.J. 1993. Historical vegetation in Region One by climatic area. U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT.

McMurtrey, R.G., R.L. Konizeski, M.V. Johnson and J.H. Bartells. 1972. Geology and water resources of the Bitterroot Valley, southwestern Montana, with a section on chemical quality of water, by H.A. Swenson. U.S. Geological Survey Water-Supply Paper 1889.

Meretsky, V.J., R.L. Fischman, J.R. Karr, D.M. Ashe, J.M. Scott, R.F. Noss and R.L. Schroeder. 2006. New directions in conservation for the National Wildlife Refuge System. Bioscience 56:135-143.

Montana Fish and Wildlife Comprehensive Conservation Steering Committee. 2006. Implementation planning process for Montana's Comprehensive Fish and Wildlife Conservation Strategy. Fwp.mt.gov/specieshabitat/strategy/fullplan.html.

Noble, R.A., R.N. Bergantino, T.W. Patton, B.C. Sholes and D.F.S. Judeykay. 1982. Occurrence and characteristics of ground water in Montana – Volume 2, the Rocky Mountain Region. Montana Bureau of Mines and Geology Open File Report 99. Butte, MT.

Pardee, J.T. 1950. Late Cenozoic block faulting in Western Montana. Geological Society of America Bulletin 61:359-406.

Popham, C. 1998. Early days in the sagebrush country. Pictorial Histories Publishing Company, Missoula, MT.

Porter, G. 2008. Grassland restoration efforts at Lee Metcalf National Wildlife Refuge: a three year assessment (2005-2007). Unpublished report prepared for U.S. Fish and Wildlife Service, Lee Metcalf NWR.

Richey, E.D. 1998. Subdividing Eden: land use and change in the Bitterroot Valley 1930-1998. M.S. Thesis, University of Montana, Missoula.

Ross, C.P. 1952. The eastern front of the Bitterroot Range. U.S. Geological Survey Bulletin 974-E: 135-175.

Scott, M.L., G.T. Auble and J.M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological Applications 7:677-690.

Stevensville Historical Society. 1971. Montana genesis: a history of the Stevensville area of the Bitterroot Valley. Mountain Press Publishing Company, Missoula, MT.

Stringer, A. 2009. Effect of constructed wetlands on water temperature in Lower Burnt Fork Creek: implications for native trout populations and possible stream restoration. Unpublished report to Sentinel High School, Missoula, MT.

U.S. Bureau of Reclamation. 1939. Bitter Root Irrigation District. U.S. Department of the Interior, Bureau of Reclamation, Hamilton, MT.

U.S. Bureau of Reclamation. 1982. Bitter Root Project, Montana, Ravalli County. U.S. Department of the Interior, Pacific Northwest Region, Bureau of Reclamation.

U.S. Fish and Wildlife Service. 1974. 1974 Flood Report, Ravalli National Wildlife Refuge, Stevensville, MT.

U.S. Fish and Wildlife Service. 1989. Lee Metcalf National Wildlife Refuge Fish Management Plan 1988-89. Technical Assistance Office, Creston Fish and Wildlife Center, Kalispell, MT.

U.S. Fish and Wildlife Service. 1999. Fulfilling the promise: the National Wildlife Refuge System. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

U.S. Fish and Wildlife Service. 2001. Fish and Wildlife Service, Refuge management manual, Part 601, National Wildlife System. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

U.S. Fish and Wildlife Service. 2005. Clark Fork River recovery unit chapter of the bull trout recovery plan. U.S. Fish and Wildlife Service, Missoula, MT.

Uthman, W. 1988. Hydrogeology of the Hamilton North and Corvallis quadrangles, Bitterroot Valley, southwestern Montana. M.S. Thesis, University of Montana, Missoula.

Ward, L.C. 1973. Prehistory of the Bitterroot Valley. M.A. Thesis, University of Montana, Missoula.

Weber, W.M. 1972. Correlation of Pleistocene glaciations in the Bitterroot Range, Montana, with fluctuations of glacial Lake Missoula. Montana Bureau of Mines and Geology Memoir 42.

Whited, , D.C., M.S. Lorang, M.J. Harner, F.R. Hauer, J.S. Kimball and J.A. Stanford. 2007. Climate, hydrologic disturbance and succession: drivers of floodplain patterns. Ecology 88:940-953.

Gary M. Stolz USFWS

USFWS

Karen Kyle

APPENDICES

A - E

Gary Kramer; USFWS

Appendix A. North American Glacial Episodes and General Geologic Time Scale.

Geologic Period	Geologic Epoch	Sub-Division	O Isotope Stage [2]	Years (BP)
QUATERNARY	**Holocene**		(1)	0 to 10-12 ka*
	Late Pleistocene	Late Wisconsin	(2)	10-12 to 28 ka
		Middle Wisconsin	(3, 4)	28 to 71 ka
		Early Wisconsin	(5a - 5d)	71 to 115 ka
		Late Sangamon Sangamon	(5e)	115 to128 ka
	Pleistocene *Middle Pleistocene*	Late – Mid Pleistocene *(Illinoian)*	(6 - 8)	128 to 300 ka
		Middle – Mid Pleistocene	(9 - 15)	300 to 620 ka
		Early – Mid Pleistocene	(16 - 19)	620 to 770 ka
	Early Pleistocene			770 ka to 1.64 Ma**
TERTIARY	**Pliocene**			1.64 to 5.2 Ma
	Miocene			5.2 to 23.3 Ma
	Oligocene			23.3 to 35.4 Ma
	Eocene			35.4 to 56.5 Ma
	Paleocene			56.5 to 65.0 Ma
CRETACEOUS	*Late Cretaceous*			65.0 to 97.0 Ma
	Early Cretaceous			97.0 to 145.6 Ma
JURASSIC				145.6 to 208.8 Ma
TRIASSIC				208.8 to ≈ 243.0 Ma
PERMIAN				≈ 243.0 to 290.0 Ma
PENNSYLVANIAN				290.0 Ma to 322.8 Ma
MISSISSIPPIAN				322.8 to 362.5 Ma
DEVONIAN				362.5 to 408.5 Ma
SILURIAN				408.5 to 439.0 Ma
ORDIVICIAN				439.0 to 510.0 Ma
CAMBRIAN				510.0 to ≈ 570.0 Ma
PRECAMBRIAN				> ≈ 570.0 Ma

* ka = x 1,000; ** Ma = x 1,000,000

≈ = "approximately"

[2] Oxygen isotope.

Appendix B. Representative plant species distribution among 7 habitats on Lee Metcalf National Wildlife Refuge, Montana. Plants are categorized as native (historic occurrence on site), naturalized (plant from another continent or in some cases status unknown), or invasive (compromises natural system functions and is costly to control). The status of plants from Checklist of Montana Vascular Plants by Scott Mincemoyer (http://mtnhp.org/plant/default.asp). Plants with a ? were not listed. *** indicates species of concern.

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Riparian/Riverfront					
Rocky Mountain Maple	*Acer glabrum*	Aceraceae	x		
Oregon Grape	*Berberis repens*	Berberidaceae	x		
Thin-leaved Alder	*Alnus incana*	Betulaceae	x		
River Birch	*Betula occidentalis*	Betulaceae	x		
Red-osier Dogwood	*Cornus stolonifera*	Cornaceae	x		
Black Cottonwood	*Populus trichocarpa*	Salicaceae	?		
Peach-leaf Willow	*Salix amygdaloides*	Salicaceae	x		
Bebb Willow	*Salix bebbiana*	Salicaceae	x		
Sandbar Willow	*Salix exigua*	Salicaceae	x		
Geyer Willow	*Salix geyeriana*	Salicaceae	x		
Whiplash Willow	*Salix lasiandra*	Salicaceae	x		
Mackenzie Willow	*Salix rigida*	Salicaceae	?		
Floodplain (Gallery) Forest					
Brittle Bladder-fern	*Cystopteris fragilis*	Polypodiaceae	?		
Rocky Mountain Juniper	*Juniperus scopulorum*	Pinaceae	x		
Lodgepole Pine	*Pinus contorta*	Pinaceae	x		
Ponderosa Pine	*Pinus ponderosa v. ponderosa*	Pinaceae	x		
Douglas Fir	*Pseudotsuga menziesii v. glauca*	Pinaceae	x		
Scotch Harebell	*Campanula rotundifolia*	Campanulaceae	x		
Blue Elderberry	*Sambucus caerulea*	Caprifoliaceae	x		
Common Snowberry	*Symphoricarpos albus*	Caprifoliaceae	x		
High-bush Cranberry	*Viburnum opulus*	Caprifoliaceae	x		
White Pyrola	*Pyrola elliptica*	Ericaceae	?		
Pinedrops	*Pterospora andromeda*	Ericaceae	?		
Common Current	*Ribes sativum*	Grossulariaceae		x	
Missouri Gooseberry	*Ribes setosum*	Grossulariaceae	x		
Dwarf Mistletoe	*Arceuthobium ssp.*	Loranthaceae	?		
Fireweed	*Epilobium angustifolium*	Onagraceae	x		
Miner's Lettuce	*Montia perfoliata*	Portulacaceae	?		
Tall Meadowrue	*Thalictrum dasycarpum*	Ranunculaceae	x		
Western Meadowrue	*Thalictrum occidentale*	Ranunculaceae	x		
Few-flowered Meadowrue	*Thalictrum sparsiflorum*	Ranunculaceae	x		
Fairy Candelabra	*Androsace occidentalis*	Primulaceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Woodland Shooting Star	*Dodecatheon pulchellum*	Primulaceae	x		
Serviceberry	*Amelanchier alnifolia*	Rosaceae	x		
River Hawthorn	*Crataegus douglasii*	Rosaceae	x		
Woods Strawberry	*Fragaria vesca*	Rosaceae	x		
Blueleaf Strawberry	*Fragaria virginiana*	Rosaceae	x		
Large-leaved Avens	*Geum macrophyllum*	Rosaceae	x		
Water Avens	*Geum rivale*	Rosaceae	x		
Prairie Smoke	*Geum triflorum*	Rosaceae	x		
Silverweed	*Potentilla anserina*	Rosaceae	?		
Silvery Cinquefoil	*Potentilla argentia*	Rosaceae		x	
Biennial Cinquefoil	*Potentilla biennis*	Rosaceae	x		
Sticky Cinquefoil	*Potentilla glandulosa*	Rosaceae	x		
Elmer's Cinquefoil	*Potentilla gracilis v. elmeri*	Rosaceae	x		
Sulfur Cinquefoil	*Potentilla recta*	Rosaceae		x	
Bitter Cherry	*Prunus emarginata*	Rosaceae	x		
Chokecherry	*Prunus virginiana v. melanocarpa*	Rosaceae	x		
Wood's Rose	*Rosa woodsii*		x		
Red Raspberry	*Rubus idaeus*	Rosaceae	x		
Lombardy Poplar	*Populus nigra v. italica*	Salicaceae		x	
Quaking Aspen	*Populus tremuloides*	Salicaceae	x		
Nodding Onion	*Allium cernuum*	Liliaceae	x		
Asparagus	*Asparagus officinalis*	Liliaceae		x	
Wild Hyacinth	*Brodiaea douglasii*	Liliaceae	?		
Starry False Solomon's Seal	*Smilacina stellata*	Liliaceae	x		
Common Death Camas	*Zigadenus venenosus*	Liliaceae	x		
Compact Clubmoss	*Selaginella densa v. densa*	Selaginallaceae	x		
Emergent Wetland					
Northern Water-starwort	*Callitriche hermaphroditica*	Callitricheceae	x		
Different Lvd. Water-starwort	*Callitriche heterophylla*	Callitricheceae	x		
Pond Water-starwort	*Callitriche stagnates*	Callitricheceae		x	
Common Hornwort	*Ceratophyllum demersum*	Ceratophyllaceae		x	
Beggar-ticks	*Bidens cernua*	Asteraceae	x		
Northern Water Milfoil	*Myriophyllum sibricum*	Haloragaceae	x		
Mare's-tail	*Hippuris vulgaris*	Hipparidaceae	x		
Little Bladderwort	*Utricularia minor*	Lentibulariaceae	x		
Common Bladderwort	*Utricularia vulgaris*	Lentibulariaceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Indian Pond Lily	*Nuphar polysepalum*	Nymphaeaceae	x		
Water Smartweed	*Polygonum amphibium*	Polygonaceae	x		
Dooryard Knotweed	*Polygonum aviculare*	Polygonaceae		x	
Water Smartweed	*Polygonum coccineum*	Polygonaceae	x		
Marshpepper	*Polygonum hydropiper*	Polygonaceae		x	
Smartweed	*Polygonum hydropiperoides*	Polygonaceae	?		
Willow Weed	*Polygonum lapathifolium*	Polygonaceae		x	
Spotted Ladysthumb	*Polygonum persicaria*	Polygonaceae		x	
Marsh Cinquefoil	*Potentilla palustris*	Rosaceae	?		
Dotted Smartweed	*Polygonum punctatum*	Polygonaceae	x		
America Water-plantain	*Alisma plantago-aquatica v. americanum*	Alismataceae	x		
Narrowleaf Water-plantain	*Alisma gramineum v. angustissimum*	Alismataceae	x		
Arumleaf Arrowhead	*Sagittaria cuneata*	Alismataceae	x		
Awned Sedge	*Carex atherodes*	Cyperaceae	x		
Water Sedge	*Carex aquatilis*	Cyperaceae	x		
Hardstem Bulrush	*Schoenoplectus acutus*	Cyperaceae	x		
Small-fruited Bulrush	*Schoenoplectus microcarpus*	Cyperaceae	x		
Softstem Bulrush	*Schoenoplectus tabernaemontani*	Cyperaceae	x		
Canada Waterweed	*Elodea canadensis*	Hydrocharitaceae	x		
Nuttall's Waterweed	*Elodea nuttallii*	Hydrocharitaceae	x		
Water Lentil	*Lemna minor*	Lemnaceae	x		
Star Duckweed	*Lemna trisulca*	Lemnaceae	x		
Great Duckweed	*Spirodela polyrhiza*	Lemnaceae	x		
Watermeal	*Wolffia punctata*	Lemnaceae	x		
Guadalupe Water-nymph***	*Najas guadalupensis*	Najadaceae	x		
Reddish Pondweed	*Potamogeton alpinus*	Potamegetonaceae	x		
Large-leaved Pondweed	*Potamogeton amplifolius*	Potamegetonaceae	x		
Berchtold's Pondweed	*Potamogeton berchtoldii*	Potamegetonaceae	?		
Ribbon-leaved Pondweed	*Potamogeton epihydrus*	Potamegetonaceae	x		
Slender-leaved Pondweed	*Potamogeton filiformis*	Potamegetonaceae	x		
Illinois Pondweed	*Potamogeton illinoensis*	Potamegetonaceae	x		
Floating-leaved Pondweed	*Potamogeton natans*	Potamegetonaceae	x		
Fennel-leaved Pondweed	*Potamogeton pectinatus*	Potamegetonaceae	x		
Small Pondweed	*Potamogeton pusillus*	Potamegetonaceae	x		
Richardson's Pondweed	*Potamogeton richardsonii*	Potamegetonaceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Eel-grass Pondweed	*Potamogeton zosteriformis*	Potamegetonaceae	x		
Narrow-leaved Bur-reed	*Sparganium angustifolium*	Parganiaceae	?		
Simple Stem Bur-reed	*Sparganium emersum v. multipedunculatum*	Parganiaceae	?		
Common Cat-tail	*Typha latifolia*	Typhaceae	x		
Horned Pondweed	*Zannichellia palustris*	Zannichelliaceae	x		
Pepperwort	*Marsilea vestita*	Marsileaceae		x	
Marchantiaceae	*Marcantia polymorphia*	Marchantiaceae	?		
Ricciaceae	*Riccio carpus natans*	Ricciaceae	x		
Characeae (Green Algae)	*Nostoc ssp.*	Characeae	?		
	Hydrodictnon reticulatum	Characeae	?		
	Riccia fluitins	Characeae	x		
	Nitella spp	Characeae	?		
	Chara spp	Characeae	x		
	Tolypella spp	Characeae	?		
Wet Meadow					
Spurless Jewelweed	*Impatiens ecalcarata*	Balsaminaceae	?		
Fat Hen	*Atriplex patula v hastata*	Chenopodiaceae		x	
Canada Thistle	*Cirsium arvense*	Asteraceae			x
Cocklebur	*Xanthium strumarium*	Asteraceae		x	
Lanceleaf Stonecrop	*Sedum lanceolatum*	Crassulaceae		x	
Western Yellowcress	*Rorippa curvisiliqua*	Cruciferae	?		
Marsh Yellowcress	*Rorippa islandica*	Cruciferae		x	
Watercress	*Rorippa nasturtiumaquaticum v.glabrata*	Cruciferae		x	
Red Sorrel	*Rumex acetosella*	Polygonaceae		x	
Curly Dock	*Rumex crispus*	Polygonaceae		x	
Seaside Dock	*Rumex maritimus*	Polygonaceae	?		
Western Dock	*Rumex occidentalis*	Polygonaceae	x		
Willow Dock	*Rumex salicifolius*	Polygonaceae	x		
Water Buttercup	*Ranunculus aquatilis v. capillaceus*	Ranunculaceae	x		
Yellow Water Buttercup	*Ranunculus flabellaris*	Ranunculaceae	?		
Western Clematis	*Clematis ligusticifolia*	Ranunculaceae	x		
Sedge Mousetail	*Myosurus aristatus*	Ranunculaceae	?		
Kidney-leaved Buttercup	*Ranunculus abortivus*	Ranunculaceae	x		
Tall Buttercup	*Ranunculus acris*	Ranunculaceae		x	
Shore Buttercup	*Ranunculus cymbalaria*	Ranunculaceae	x		
Creeping Buttercup	*Ranunculus flammula*	Ranunculaceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Sagebrush Buttercup	*Ranunculus glaberrimus v. glaberrimus*	Ranunculaceae	x		
Gmelin's Buttercup	*Ranunculus gmelinii v. limosus*	Ranunculaceae	x		
Long-beaked Water-Buttercup	*Ranunculus longirostris*	Ranunculaceae	?		
Macoun's Buttercup	*Ranunculus macounii*	Ranunculaceae	x		
Bristly Buttercup	*Ranunculus pensylvanicus*	Ranunculaceae	x		
Creeping Buttercup	*Ranunculus repens*	Ranunculaceae		x	
Celery-leaved Buttercup	*Ranunculus sceleratus*	Ranunculaceae	x		
Stiff-leaf Water Buttercup	*Ranunculus subriqidus*	Ranunculaceae	?		
Little Buttercup	*Ranunculus uncinatus v. uncinatus*	Ranunculaceae	x		
Blue Vervain	*Verbena hastata*	Verbenaceae	x		
Clustered Sedge	*Carex arcta*	Cyperaceae	x		
Slenderbeaked Sedge	*Carex anthrostachya*	Cyperaceae	x		
Golden Sedge	*Carex aurea*	Cyperaceae	x		
Bebb's Sedge	*Carex bebii*	Cyperaceae	x		
Lesser Panicled Sedge	*Carex diandra*	Cyperaceae	x		
Douglas' Sedge	*Carex douglassii*	Cyperaceae	x		
Wooly Sedge	*Carex lasiocarpa*	Cyperaceae	?		
Kellog's Sedge	*Carex lenticularis*	Cyperaceae	x		
Nebraska Sedge	*Carex nebrascensis*	Cyperaceae	x		
Retrose Sedge	*Carex retrosa*	Cyperaceae	x		
Sawbeaked Sedge	*Carex stipata*	Cyperaceae	x		
Beaked Sedge	*Carex utriculata (C. rostrata)*	Cyperaceae	x		
Inflated Sedge	*Carex vesicaria*	Cyperaceae	x		
Fox Sedge	*Carex vulpinoidea*	Cyperaceae	x		
Awned Flatsedge	*Cyperus aristatus*	Cyperaceae	?		
Shining Flatsedge***	*Cyperus rivularis*	Cyperaceae	?		
Needle Spike-rush	*Eleocharis acicularis*	Cyperaceae	x		
Delicate Spike-rush	*Eleocharis bella*	Cyperaceae	x		
Common Spike-rush	*Eleocharis palustris*	Cyperaceae	x		
Bluejoint Reedgrass	*Calamagrostis Canadensis v. canadensis*	Poaceae	x		
Foxtail Barley	*Hordeum jubatum*	Poaceae	x		
Reed Canary Grass	*Phalaris arundinacea*	Poaceae			x
Yellow Flag	*Iris pseudacorus*	Iridaceae		x	
Blue-eyed Grass	*Sisyrinchium angustifolium*	Iridaceae	?		
Wire Grass	*Juncus balticus*	Juncaceae	x		
Toad Rush	*Juncus bufonius*	Juncaceae	x		
Soft Rush	*Juncus effusus*	Juncaceae	x		
Dagger-leaf Rush	*Juncus ensifolius*	Juncaceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Tuberous Rush	*Juncus nodosus*	Juncaceae	x		
Slender Rush	*Juncus tenuis v. tenuis*	Juncaceae	x		
Torrey's Rush	*Juncus torrei*	Juncaceae	x		
Smooth Rush	*Luzula hitchcockii*	Juncaceae	x		
Common Horsetail	*Equisetum arvense*	Equisetaceae	x		
Water Horsetail	*Equisetum fluviatile*	Equisetaceae	x		
Co. Scouring Rush	*Equisetum hyemale*	Equisetaceae	x		
Smooth Scouring Rush	*Equisetum laevigatum*	Equisetaceae	x		
Marsh Horsetail	*Equisetum palustre*	Equisetaceae	x		
Shady Horsetail	*Equisetum pratense*	Equisetaceae	x		
Water Hemlock	*Cicuta douglasii*	Umbelliferae	x		
Cow-parsnip	*Heracleum lanatum*	Umbelliferae	x		
Mountain Sweet-cicely	*Osmorhiza chilensis*	Umbelliferae	x		
Wild Parsnip	*Pastinaca sativa Wild Parsnip*	Umbelliferae		x	
Black Snakeroot	*Sanicula marilandica*	Umbelliferae	x		
Water Parsnip	*Sium suave*	Umbelliferae	x		
Floodplain Grassland					
Slender Cryptantha	*Cryptantha affinis*	Boraginaceae	x		
Hound's-tongue	*Cynoglossum officinale*	Boraginaceae		x	
Western Stickseed	*Lappula redowskii*	Boraginaceae	x		
Corn Gromwell	*Lithospermum arvense*	Boraginaceae		x	
Wayside Gromwell	*Lithospermum ruderale*	Boraginaceae	x		
Field Forget-me-not	*Myosotis arvensis*	Boraginaceae			
Small Flowered Forget-me-not	*Myosotis laxa*	Boraginaceae		x	
Blue Forget-me-not	*Myosotis micrantha*	Boraginaceae		x	
Common Forget-me-not	*Myosotis scorpioides*	Boraginaceae		x	
Early Forget-me-not	*Myosotis verna*	Boraginaceae		x	
Scouler's Popcorn-flower	*Plagiobothrys scouleri*	Boraginaceae	x		
Blunt Leaved Sandwort	*Arenaria lateriflora*	Caryophyllaceae	?		
Thyme-leaved Sandwort	*Arenaria serpyllifolia*	Caryophyllaceae		x	
Field Chickweed	*Cerastium arvense*	Caryophyllaceae	x		
Nodding Chickweed	*Cerastium nutans*	Caryophyllaceae	x		
Jagged Chickweed	*Holosteum umbellatum*	Caryophyllaceae		x	
White Champion	*Lychnis alba*	Caryophyllaceae	?		
Menzies' Silene	*Silene menziesii*	Caryophyllaceae	x		
Red Sandspurry	*Spergularia rubra*	Caryophyllaceae		x	
Long Leaved Starwort	*Stellaria longifolia*	Caryophyllaceae	x		
Lambs Quarter	*Chenopodium album*	Chenopodiaceae		x	
Jerusalem Oak	*Chenopodium botrys*	Chenopodiaceae		x	
Maple Leaved Goosefoot	*Chenopodium nybridum*	Chenopodiaceae	?		
Yarrow	*Achillea millefolium*	Asteraceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
False Dandelion	*Agoseris glauca*	Asteraceae	x		
Pearly Everlasting	*Anaphalis margaritacea*	Asteraceae	x		
Nuttals Pussy-toes	*Antennaria parviflora*	Asteraceae	x		
Rosy Pussy-toes	*Antennaria microphylla*	Asteraceae	x		
Umber Pussy-toes	*Antennaria umbrinella*	Asteraceae	x		
Common Burdock	*Arctium minus*	Asteraceae		x	
Meadow Arnica	*Arnica chamissonis*	Asteraceae	x		
Western Absinthium	*Artemisia absinthium*	Asteraceae		x	
Biennial Sagewort	*Artemisia biennis*	Asteraceae	x		
Northern Sagewort	*Artemisia campestris v scouleriana*	Asteraceae	x		
Tarragon	*Artemisia dracunculus*	Asteraceae	x		
Fringed Sagewort	*Artemisia frigida*	Asteraceae	x		
Western Mugwort	*Artemisia ludoviciana v. latiloba*	Asteraceae	x		
Prairie Sage	*Artemisia ludoviciana v. ludoviciana*	Asteraceae	x		
Smooth Aster	*Aster laevis*	Asteraceae	x		
White Prairie Aster	*Aster pansus*	Asteraceae	?		
Musk Thistle	*Carduus nutans*	Asteraceae			x
Spotted Knapweed	*Centaurea maculosa*	Asteraceae			x
Oxeye Daisy	*Chrysanthemum leucanthemum*	Asteraceae		x	
Wavy Leaved Thistle	*Cirsium undulatum*	Asteraceae	x		
Bull Thistle	*Cirsium vulgare*	Asteraceae		x	
Horseweed	*Conyza canadensis*	Asteraceae	x		
Cutleaf Daisy	*Erigeron compositus*	Asteraceae	x		
Spreading Fleabane	*Erigeron divergens*	Asteraceae	x		
Shaggy Fleabane	*Erigeron pumilus*	Asteraceae	x		
Showy Fleabane	*Erigeron speciosis*	Asteraceae	x		
Daisy Fleabane	*Erigeron strigosus v. strigosus*	Asteraceae	x		
Field Filago	*Filago arvensis*	Asteraceae		x	
Blanket Flower	*Gaillardia aristata*	Asteraceae		x	
Lowland Cudweed	*Gnaphalium palustre*	Asteraceae	x		
Gumweed	*Grindelia squarrosa*	Asteraceae	x		
Sunflower	*Helianthus annuus*	Asteraceae	x		
Nuttals Sunflower	*Helianthus nuttallii*	Asteraceae	x		
Narrow-leaved Hawkweed	*Hieracium umbellatum*	Asteraceae	x		
Poverty Weed	*Iva xanthifolia*	Asteraceae		x	
Prickly Lettuce	*Lactuca serriola*	Asteraceae		x	
Pineapple Weed	*Matricaria matricarioides*	Asteraceae		x	
Nodding Microseris	*Microseris nutans*	Asteraceae	x		
False-agroseris	*Microseris troximoides*	Asteraceae	?		
Woolly Groundsel	*Senecio canus*	Asteraceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Groundsel	*Senecio indecorus*	Asteraceae	x		
Tall Butterweed	*Senecio serra*	Asteraceae	x		
Canada Goldenrod	*Solidago canadensis*	Asteraceae	x		
Late Goldenrod	*Solidago gigantea*	Asteraceae	x		
Missouri Goldenrod	*Solidago missouriensis*	Asteraceae	x		
Western Goldenrod	*Solidago occidentalis*	Asteraceae	x		
Common Sow-thistle	*Sonchus oleraceus*	Asteraceae		x	
Marsh Sow-thistle	*Sonchus uliginosus*	Asteraceae	?		
Common Tansy	*Tanacetum vulgare*	Asteraceae			x
Smooth Dandelion	*Taraxacum laevigatum*	Asteraceae		x	
Common Dandelion	*Taraxacum officinale*	Asteraceae		x	
Goatsbeard	*Tragopogon dubius*	Asteraceae		x	
Field Bindweed	*Convolvulus arvensis*	Convovulaceae	x		
Pale Alyssum	*Alyssum alyssoides*	Cruciferae		x	
Desert Alyssum	*Alyssum desertorum*	Cruciferae		x	
Holboell's Rockcress	*Arabis holboellii*	Cruciferae	x		
Nuttall's Rockcress	*Arabis nuttallii*	Cruciferae	x		
Wintercress	*Barbarea orthoceras*	Cruciferae	x		
Field Mustard	*Brassica campestris*	Cruciferae		x	
Black Mustard	*Brassica nigra*	Cruciferae		x	
Hairy False Flax	*Camelina microcarpa*	Cruciferae		x	
Shepherd's Purse	*Capsella bursa-pastoris*	Cruciferae		x	
Little W. Bittercress	*Cardamine oligosperma*	Cruciferae	x		
Pennsylvania Bittercress	*Cardamine pensylvanica*	Cruciferae	x		
Tansy Mustard	*Descurainia sophia*	Cruciferae		x	
Woods Draba	*Draba nemorosa*	Cruciferae		x	
Whitlow-grass	*Draba verna*	Cruciferae		x	
Wormseed Mustard	*Erysimum cheiranthoides*	Cruciferae	x		
Dame's Rocket	*Hesperis matronalis*	Cruciferae		x	
Field Pepper Grass	*Lepidium campestre*	Cruciferae		x	
Common Pepper Grass	*Lepidium densiflorum*	Cruciferae	x		
Clasping Pepper Grass	*Lepidium perfoliatum*	Cruciferae		x	
Jix Hill Mustard	*Sisymbrium altissimum*	Cruciferae		x	
Tuxmble Mustard	*Sisymbrium loeselii*	Cruciferae		x	
Fanweed	*Thlaspi arvense*	Cruciferae		x	
Teasel	*Dipsacus sylvestris*	Dipsacaceae		x	
Leafy Spurge	*Euphorbia esula*	Euphorbiaceae			x
Corrugate-seeded Spurge	*Euphorbia glyptosperma*	Euphorbiaceae	x		
Thyme-leaf Spurge	*Euphorbia serpyllifolia*	Euphorbiaceae	x		
Crane's Bill	*Erodium cicutarium*	Geraniaceae		x	
Bicknell's Geranium	*Geranium bicknelli*	Geraniaceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Small Field Geranium	*Geranium pusillum*	Geraniaceae		x	
Sticky Geranium	*Geranium viscosissimum*	Geraniaceae	x		
Sand Phacelia	*Phacelia linearis*	Hydrophyllaceae	x		
Western St. John's-wort	*Hypericum formosum v. scouleri*	Hypericaceae	?		
Canada St. John's-wort	*Hypericum majus*	Hypericaceae	?		
Goatweed	*Hypericum perforatum*	Hypericaceae		x	
Hemp Nettle	*Galeopsis tetrahit*	Labiatae		x	
Water Horehound	*Lycopus americanus*	Labiatae	x		
Rough Bugleweed	*Lycopus asper*	Labiatae	x		
Northern Bugleweed	*Lycopus uniflorus*	Labiatae	x		
Field Mint	*Mentha arvensis*	Labiatae	x		
Wild Bergamot	*Monarda fistulosa*	Labiatae	x		
Wild Bergamot	*Nepeta cataria*	Labiatae		x	
Purple Dragonhead	*Physostegia parviflora*	Labiatae	x		
Self-heal	*Prunella vulgaris*	Labiatae	x		
Marsh Skullcap	*Scutellaria galericulata*	Labiatae	x		
Hedge Nettle	*Stachys palustris v. pilosa*	Labiatae	x		
Canada Milkvetch	*Astragalus canadensis v. mortonii*	Leguminosae	x		
Weedy Milkvetch	*Astragalus miser*	Leguminosae	x		
Wild Licorice	*Glycyrrhiza lepidota*	Leguminosae	x		
Velvet Lupine	*Lupinus leucophyllus*	Leguminosae	x		
Washington Lupine	*Lupinus polyphyllus*	Leguminosae	x		
Blue-bonnet	*Lupinus sericeus*	Leguminosae	x		
Black Medic	*Medicago lupulina*	Leguminosae		x	
Alfalfa	*Medicago sativa*	Leguminosae		x	
White Sweet-clover	*Melilotus alba*	Leguminosae		x	
Yellow Sweet-clover	*Melilotus officinalis*	Leguminosae		x	
Alsike Clover	*Trifolium hybridum*	Leguminosae		x	
Wooly Clover	*Trifolium microcephalum*	Leguminosae	x		
Red Clover	*Trifolium pratense*	Leguminosae		x	
White Clover	*Trifolium repens*	Leguminosae		x	
White-tip Clover	*Trifolium variegatum*	Leguminosae		x	
American Vetch	*Vicia americana*	Leguminosae	x		
Common Vetch	*Vicia sativa*	Leguminosae		x	
Slender Vetch	*Vicia tetrasperma*	Leguminosae		x	
Hairy Vetch	*Vicia villosa*	Leguminosae		x	
Hops	*Humulus lupulus*	Moraceae	?		
Enchanter's Nightshade	*Circaea alpina*	Onagraceae	x		
Swamp Willow-herb	*Epilobium palustre*	Onagraceae	x		
Annual Willow-herb	*Epilobium paniculatum*	Onagraceae	?		
Shrubby Willow-herb	*Epilobium suffruticosum*	Onagraceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Watson's Willow-herb	*Epilobium watsonii*	Onagraceae	?		
Yellow Evening Primrose	*Oenothera strigosa*	Onagraceae	x		
Yellow Wood-sorrel	*Oxalis corniculata*	Oxalidaceae		x	
Ribgrass	*Plantago lanceolata*	Plantaginaceae		x	
Common Plantain	*Plantago major v. major*	Plantaginaceae		x	
Indian Wheat	*Plantago patagonica*	Plantaginaceae	x		
Narrow-leaved Collomia	*Collomia linearis*	Polemoniaceae	x		
Scarlet Gillia	*Gilia aggregata*	Polemoniaceae	x		
Pink Microsteris	*Microsteris gracilis*	Polemoniaceae	?		
Annual polemonium	*Polemonium micranthum*	Polemoniaceae	x		
Jacob's Ladder	*Polemonium pulcherrimum v. calycinum*	Polemoniaceae	x		
Umbrella Plant	*Erigonum umbellatum v. subalpinum*	Polygonaceae	x		
Knotweed	*Polygonum achoreum*	Polygonaceae	x		
Ivy Bindweed	*Polygonum convolvulus*	Polygonaceae		x	
Douglas' Knotweed	*Polygonum douglasii v. douglasii*	Polygonaceae	x		
Narrow-leaved Miners Lettuce	*Montia linearis*	Portulacaceae	x		
Purslane	*Portulaca oleracea*	Portulacaceae		x	
Bitterroot	*Lewisia rediviva*	Portulacaceae	x		
Fringed Loosestrife	*Lysimachia ciliata*	Primulaceae	x		
Tufted Loosestrife	*Lysimachia thrysiflora*	Primulaceae	x		
Smooth Fringecup	*Lithophragma glabra*	Saxifragaceae	x		
Small-flowered Fringecup	*Lithophragma parviflora*	Saxifragaceae	x		
Blue-eyed Mary	*Collinsia parviflora*	Scrophulariaceae	x		
Common Hedge-hyssop	*Gratiola neglacta*	Scrophulariaceae	x		
Dalmation Toadflax	*Linaria dalmatica*	Scrophulariaceae			x
Yellow Toadflax	*Linaria vulgaris*	Scrophulariaceae		x	
Monkey Flower	*Mimulus guttatus v. guttas*	Scrophulariaceae	x		
Musk Plant	*Mimulus moschatus Musk Plant*	Scrophulariaceae	x		
Little Penstemon	*Penstemon procerus*	Scrophulariaceae	x		
Common Mullein	*Verbascum thapsus*	Scrophulariaceae		x	
American Speedwell	*Veronica americana*	Scrophulariaceae	x		
Water Speedwell	*Veronica anagallis-aquatica*	Scrophulariaceae		x	
Chain Speedwell	*Veronica catenata*	Scrophulariaceae		x	
Purslane Speedwell	*Veronica peregrina*	Scrophulariaceae	x		
Thyme-leaved Speedwell	*Veronica serpyllifolia v. serpyllifolia*	Scrophulariaceae	x		
Vernal Speedwell	*Veronica verna*	Scrophulariaceae		x	

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
Henbane	*Hyoscyamus niger*	Solanaceae		x	
Bittersweet Nightshade	*Solanum dulcamara*	Solanaceae		x	
Cut-leaved Nightshade	*Solanum triflorum*	Solanaceae	x		
Cleavers	*Galium aparine*	Rubiaceae	x		
Thinleaf Bedstraw	*Galium bifolium*	Rubiaceae	x		
Northern Bedstraw	*Galium boreale*	Rubiaceae	x		
Small Cleavers	*Galium trifidum*	Rubiaceae			
Stinging Nettle	*Urtica dioica spp. gracilis*	Urticaceae	?		
Early Blue Violet	*Viola adunca v. bellidifolia*	Violaceae	x		
Marsh Violet	*Viola palustris*	Violaceae	x		
Bog Violet	*Viola nephrophylla*	Violaceae	x		
Goat Grass	*Aegilops cylindrica*	Poaceae	x		
Bearded Wheatgrass	*Agropyron canium v. andinum*	Poaceae	?		
Crested Wheatgrass	*Agropyron cristatum*	Poaceae	x		
Thin Spiked Wheatgrass	*Agropyron dasystachyum*	Poaceae	?		
Intermediate Wheatgrass	*Agropyron intermedium*	Poaceae	?		
Quack Grass	*Agropyron repens*	Poaceae	?		
Western Wheatgrass	*Agropyron smithii*	Poaceae	?		
Bluebunch Wheatgrass	*Agropyron spicatum*	Poaceae	?		
Redtop	*Agropyron alba v. alba*	Poaceae	?		
Tickle-grass	*Agropyron scabra*	Poaceae	?		
Shortawn Foxtail	*Alopecurus aequalis*	Poaceae	x		
Meadow Foxtail	*Alopecurus partensis*	Poaceae		x	
Common Oats	*Avena sativa*	Poaceae		x	
Slough Grass	*Beckmania syzigachne*	Poaceae	x		
Smooth Brome-grass	*Bromus inermis spp. Inermus*	Poaceae		x	
Soft Brome-grass	*Bromus mossi*	Poaceae	?		
Cheatgrass	*Bromus tectorum*	Poaceae			x
Slim Reedgrass	*Calamagrostis neglecta*	Poaceae	?		
Brook Grass	*Catabrosa aquatica*	Poaceae	x		
Woodreed	*Cina latifolia*	Poaceae	x		
Orchard Grass	*Dactylis glomerata*	Poaceae		x	
Canada Wildrye	*Elymus canadensis*	Poaceae	x		
Great Basin Wildrye	*Elymus cinereus*	Poaceae	x		
Stinkgrass	*Eragrostis cilienensis*	Poaceae		x	
Tall Fescue	*Festuca arundinacea*	Poaceae		x	
Six Weeks Fescue	*Festuca octoflora*	Poaceae	?		
Northern Mannagrass	*Glyceria borealis*	Poaceae	x		
Tall Mannagrass	*Glyceria elata*	Poaceae	x		
American Mannagrass	*Glyceria grandis*	Poaceae	x		
Fowl Mannagrass	*Glyceria striata*	Poaceae	x		

(Cont'd next page)

Common Name	Scientific Name	Family	Native	Naturalized	Invasive
June Grass	*Koeleria cristata*	Poaceae	x		
Perennial Ryegrass	*Lolium perenne*	Poaceae	x		
Indian Ricegrass	*Oryzopsis hymenoides*	Poaceae		x	
Common Witchgrass	*Panicum capillare*	Poaceae	x		
Common Timothy	*Phleum pratense*	Poaceae		x	
Annual Bluegrass	*Poa annua*	Poaceae		x	
Viviparous Bluegrass	*Poa bulbosa*	Poaceae		x	
Canada Bluegrass	*Poa compressa*	Poaceae		x	
Fowl Bluegrass	*Poa palustris*	Poaceae		x	
Kentucky Bluegrass	*Poa pratensis*	Poaceae		x	
Sandbergs Bluegrass	*Poa sandbergii*	Poaceae	x		
Green Bristlegrass	*Setaria viridis*	Poaceae		x	
Sand Dropseed	*Sporobolis cryptandrus*	Poaceae	x		
Squirreltail	*Sitanion hystrix*	Poaceae	x		
Needle and Thread	*Stipa comata*	Poaceae	x		
Green Needlegrass	*Stipa viridula*	Poaceae	x		
Powell's Amaranth	*Amaranthus powellii*	Amaranthaceae	x		
Redroot Amaranth	*Amaranthus retroflexus*	Amaranthaceae			
Showy Milkweed	*Asclepias speciosa*	Asclepiadaceae		x	
Spreading Dogbane	*Apocynum androsaemifolium*	Apocynaceae	x		
Clasping Leaved Dogbane	*Apocynum sibiricum*	Apocynaceae	x		
Saline Grassland					
Red Belvedere	*Kochia scoparia*	Chenopodiaceae		x	
Poverty Weed	*Monolepis nuttalliana*	Chenopodiaceae	x		
Tumbleweed	*Amaranthus albus*	Amaranthaceae		x	
Prostrate Pigweed	*Amaranthus graecizans*	Amaranthaceae		x	
Grassland/Sagebrush					
Brittle Cholla	*Opuntia fragilis*	Cactaceae	x		
Russian Thistle	*Salsola kali*	Chenopodiaceae		x	
Rabbit-brush	*Chrysothamnus nauseosus*	Asteraceae	x		
Common Mallow	*Malva neglecta*	Malvaceae		x	
Cheese Weed	*Malva parviflora*	Malvaceae		x	
Few-flowered Aster	*Aster modestus*	Asteraceae	?		
Hairy Golden Aster	*Chrysopsis villosa*	Asteraceae	?		

Appendix C. Key fish, amphibian, reptile, bird, and mammal species present within 7 habitats on Lee Metcalf National Wildlife Refuge, Montana. Data for list came from surveys, brochures, annual narratives as well as bioblitz and FWP data. Codes for Other Habitats include SC (stream or tributary channel), SB (stream bank), AF (aerial forager), and MMS (man-made structure). ** indicates Non-native species and *** indicates Species of Concern.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
FISH									
Rainbow Trout**	Oncorhynchus mykiss								SC
Brown Trout**	Salmo trutta			x					SC
Brook Trout**	Salvelinus fontinalis								SC
Bull Trout***	Salvelinus confluentus			x					SC
Mountain Whitefish	Prosopium willlansoni			x					SC
Largescale Sucker	Catostomus macrocheilus			x					SC
Longnose Sucker	Catostomus catostomus			x					SC
Northern Pike Minnow	Ptychocheilus oregonensis			x					SC
Redside Shiner	Richardsonius balteatus								SC
Largemouth Bass**	Micropterus salmoides			x					SC
Pumpkinseed**	Lepomis gibbosus			x					SC
Yellow Perch**	Perca flavescens			x					SC
AMPHIBIANS									
American Bullfrog**	Lithobates catesbeianus			x					
Columbia Spotted Frog	Rana luteiventris			x	x				
Western Toad (Boreal)***	Bufo boreas	x	x	x	x				
Long-toed Salamander	Ambystoma macrodactylum	x	x	x	x				
REPTILES									
Common Garter Snake	Thamnophis sirtalis	x	x	x	x	x	x		
Terrestrial Garter Snake	Thamnophis elegans	x	x	x	x	x	x		
Rubber Boa	Charina bottae	x				x	x		
Racer	Colber constrictor	x				x	x		
Western Rattlesnake	Crotalus viridis	x	x			x	x	x	
Gopher Snake	Pituophis catenifer	x	x	x	x	x	x		
Painted Turtle	Chrysemys picta			x					
BIRDS									
Gaviiformes									
Common Loon***	Gavia immer			x					
Podicipediformes									

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Red-necked Grebe	Podiceps grisegena			x					
Horned Grebe	Podiceps auritus			x					
Eared Grebe	Podiceps nigricollis			x					
Pied-billed Grebe	Podylimbus podiceps			x					
Western Grebe	Aechmophorus occidentalis			x					
Clark's Grebe***	Aechmorphorus clarkii			x					
Pelicaniformes									
American White Pelican***	Pelecanus erythrorhynchos			x					
Double-crested Cormorant	Phalacrocorax auritus			x					
Ciconiformes									
American Bittern***	Botaurus lentiginosus			x	x				
Great Blue Heron***	Ardea herodias	x	x	x	x	x			
Great Egret	Ardea alba			x					
Snowy Egret	Egretta caerulea			x					
Cattle Egret	Bubulcus ibis			x	x	x	x	x	
Black-crowned Night Heron***	Nycticorax nycticorax			x					
White-faced Ibis	Plegadis chihi			x	x				
Anseriformes									
Trumpeter Swan***	Cygnus buccinators			x					
Tundra Swan	Cygnus columbianus			x					
Canada Goose	Branta canadensis			x	x	x			
Greater White-fronted Goose	Anser albifrons			x	x	x			
Ross's Goose	Chen rossi			x	x	x			
Lesser Snow Goose	Chen caerulescens			x	x	x			
Wood Duck	Aix sponsa	x	x	x					
Mallard	Anas platyrhunchos			x					
Gadwall	Anas strepera			x					
Northern Pintail	Anas acuta			x	x	x			
American Wigeon	Anas americana			x	x				
Eurasian Wigeon**	Anas penelope			x	x				
Northern Shoveler	Anas clypeata			x					
Cinnamon Teal	Anas cyanoptera			x					
Blue-winged Teal	Anas discors			x					
Green-winged Teal	Anas crecca	x		x					
Canvasback	Aythya valisineria			x					

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Redhead	Aythya americana			x					
Ring-necked Duck	Aythya collaris			x					
Greater Scaup	Aythya marila			x					
Lesser Scaup	Aythya affinis			x					
Surf Scoter	Melanitta perspicillata			x					
Black Scoter	Melanitta nigra			x					
White-winged Scoter	Melanitta fusca			x					
Common Goldeneye	Bucephala clangula	x	x	x					SC
Barrow's Goldeneye	Bucephala islandica	x	x	x					SC
Bufflehead	Bucephala albeola	x	x	x					SC
Hooded Merganser	Lophodytes cucullatus	x	x	x					
Common Merganser	Mergus merganser	x	x	x					
Red-Breasted Merganser	Mergus serrator	x	x	x					
Ruddy Duck	Oxyura jamaicensis			x					
Falconiformes									
Turkey Vulture	Cathartes aura	x	x	x	x	x	x	x	
Northern Harrier	Circus cyaneus			x	x	x	x		
White-tailed Kite	Elanus leucurus	x	x	x					
Sharp-shinned Hawk	Accipiter striatus	x	x	x					
Cooper's Hawk	Accipiter coperii	x	x	x	x	x			
Northern Goshawk	Accipiter gentillis	x	x	x					
Swainson's Hawk	Buteo swainsoni					x	x	x	
Red-tailed Hawk	Buteo jamaicensis	x	x		x	x	x	x	
Rough-legged Hawk	Buteo lagopus				x	x	x	x	
Golden Eagle***	Aquilla cyrysaetos				x	x	x	x	
Bald Eagle***	Haliaeetus leucocephalus	x	x	x	x				
Osprey	Pandion haliaetus	x		x					
Merlin	Falco columbarius			x	x	x	x		
American Kestrel	Falco sparverius	x	x	x	x	x	x	x	
Prairie Falcon	Falco mexicanus			x	x	x	x	x	
Gyrfalcon	Falco rusticolus			x	x	x	x		
Peregrine Falcon***	Falco peregrinus			x	x	x	x		
Galliformes									
Gray Partridge**	Perdix perdix					x	x	x	
Ring-necked Pheasant**	Phasianus colchicus			x	x	x	x	x	

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							Other
		Forest		Wetland		Grassland			
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Ruffed Grouse	Bonasa umbellus	x	x						
Gruiformes									
American Coot	Fulica americana			x					
Virginia Rail	Rallus limicola			x					
Sora	Porzana carolina			x	x				
Sandhill Crane	Grus canadensis			x	x	x	x	x	SB
Charadriiformes									
Black-bellied Plover	*Pluvialis squatarola*			x	x	x	x		SB
American Golden Plover	Pluvialis dominica			x	x	x	x		SB
Semiplamated Plover	Charadrius semipalmatus			x	x	x	x		SB
Killdeer	Charadrius vociferous			x	x				SB
American Avocet	Recurvirostra americana			x	x				
Black-necked Stilt	Himantopus mexicanus			x	x				
Greater Yellowlegs	Tringa melanoleuca			x					
Lesser Yellowlegs	Tringa flavipes			x					
Solitary Sandpiper	Tringa solitaria			x	x				
Willet	Catoptrohorus semipalmatus			x	*x*				
Spotted Sandpiper	Actitis macularia	x		x					SB
Whimbrel	Numenius phaeopus			x					
Long-billed Curlew***	Numenius americanus			x	x	x	x		
Marbled Godwit	Limosa fedoa			x					
Sanderling	Calidris alba	x		x					SB
Dunlin	Calidris alpine			x	*x*				
Pectoral Sandpiper	Calidris melanotos			x	x				
White-rumped Sandpiper	Calidris fuscicollis			x					
Baird's Sandpiper	Calidris bairdii			x					
Western Sandpiper	Calidris mauri			x					
Western Sandpiper	Calidris mauri			x					
Semipalmated Sandpiper	Calidris pusilla			x	x				
Least Sandpiper	Calidris minutilla			x	x				
Stilt Sandpiper	Calidris himantopus			x	x				
Long-billed Dowitcher	Limnodromus scolopaceus			x	x				
Short-billed Dowitcher	Limnodromus griseus			x	x				

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Common Snipe	Gallinago gallinago			x	x				
Ruddy Turnstone	Arenaria interpres			x	x				SB
Wilson's Phalarope	Phalaropus tricolor			x					
Red Phalarope	Phalaropus fulicarius			x					
Red-necked Phalarope	Phalaropus lobatus			x					
Bonaparte's Gull	Larus philadelphia			x					
Franklin's Gull***	Larus pipixcan			x					
Ring-billed Gull	Larus delawarensis			x					
California Gull	Larus californicus			x					
Herring Gull	Larus argentatus			x					
Caspian Tern***	Sterna caspia			x					
Common Tern***	Sterna hirundo			x					
Forster's Tern***	Sterna forsteri			x					
Black Tern***	Sterna nigra			x					
Least Tern***	Sterna			x					SB
Columbiformes									
Mourning Dove	Zenaida macroura	x	x			x			
Rock Dove	Columbia livia					x			MMS
Cuculiformes									
Yellow-billed Cuckoo***	Cocczus americanus	x	x						
Black-billed Cuckoo***	Cocczus erythropthalmus	x	x						
Strigiformes									
Long-eared Owl	Asio otus	x	x			x	x	x	
Short-eared Owl	Asio flammeus			x	x	x	x	x	
Great-horned Owl	Bubo virginianus	x	x	x	x	x	x	x	
Snowy Owl	Bubo scandiacus			x	x	x	x	x	
Great Gray Owl***	Strix nebulosa	x	x						
Northern Saw-whet Owl	Aegolius acadicus	x	x						
Burrowing Owl***	Athene cunicularia					x	x	x	
Flammulated Owl***	Otus flammeolus	x	x						
Western Screech Owl	Megascops kennicottii	x	x						
Northern Pygmy-Owl	Glaucidium gnoma	x	x						
Caprimulgiformes									
Common Nighthawk	Chordeiles minor								AF
Piciformes									
Lewis' Woodpecker***	Melanerpes lewis		x	x					

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats: Forest – River-front	Forest – Flood-plain	Wetland – Emer-gent	Wetland – Wet Meadow	Grassland – Flood-plain	Grassland – Saline	Grassland – Sage-brush	Other
Red-naped Sapsucker	Sphyrapicus nuchalis		x	x					
Downy Woodpecker	Picoides pubescens		x	x					
Hairy Woodpecker	Picoides villosus		x	x					
Northern Flicker	Colaptes auratus		x	x		x	x		
Pileated Woodpecker***	Dryocopus pileatus		x	x					
Passeriformes									
Olive-sided Flycatcher	Contopus cooperi		x	x					
Western Wood-pewee	Contopus sordidulus		x	x					
Cordilleran Flycatcher	Empidonax occidentalis		x	x					
Willow Flycatcher	Empidonax traillii		x	x	x				
Least Flycatcher	Empidonax minimus		x	x					
Hammond's Flycatcher	Empidonax hammondii		x	x					
Dusky Flycatcher	Empidonax oberholseri		x	x					
Say's Phoebe	Saynoris saya		x	x					
Eastern Kingbird	Tyrannus forficatus		x	x	x	x	x		
Western Kingbird	Tyrannus verticalis					x	x	x	
Northern Shrike	Lanius excubitor					x	x	x	
Loggerheaded Shrike***	Lanius ludovicianus					x	x	x	
Red-eyed Vireo	Vireo olivaceus		x	x					
Warbling Vireo	Vireo gilvus		x	x					
Plumbeous Vireo	Vireo plumbeus		x	x					
Cassin's Vireo	Vireo cassinii		x	x					
Steller's Jay	Cynaocitta stelleri		x	x					
Pinyon Jay***	Gymnorhinus cyanocephalus		x	x					
Clark's Nutcracker	Nucifraga columbiana		x	x					
Black-billed Magpie	Pica hudsonia		x	x					
Common Raven	Corvus corax		x	x					
Horned Lark	Eremophila alpestris					x	x	x	
Northern Rough-winged									SB
Swallow	Stelgidopteryx serripennis								SB
Bank Swallow	Riparia ripiria								
Violet-green Swallow	Tachycineta thalassina		x	x					
Tree Swallow	Tachycineta bicolor		x	x	x	x			

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Cliff Swallow	Petrochelidon pyrrhonota								MMS
Barn Swallow	Hirundo rustica								MMS
Black-capped Chickadee	Poecile atricappila		x	x					
Mountain Chickadee	Poecile gambili		x	x					
Red-breasted Nuthatch	Sitta canadensis		x	x					
White-breasted Nuthatch	Sitta carolinensis		x	x					
Pygmy Nuthatch	Sitta pygmaea		x	x					
Brown Creeper***	Certhia americana		x	x					
House Wren	Troglodytes aedon		x	x					
Winter Wren***	Troglodytes troglodytes		x	x	x				
Marsh Wren	Cistothorus palustris				x	x			
American Dipper	Cinclus mexicanus		x						SB
Golden-crowned Kinglet	Regulus satrapa		x	x					
Rudy-crowned Kinglet	Regulus calendula		x	x					
Townsend's Solitaire	Myadestes townsendi								
Mountain Bluebird	Sialia currucoides		x	x					
Western Bluebird	Sialia mexicana					x	x		
Varied Thrush	Ixoreus naevius		x	x					
American Robin	Turdus migratorius		x	x					
Veery***	Catarus fuscescens		x	x					
Swainson's Thrush	Catharus ustulatus		x	x					
Hermit Thrush	Catharus guttatus		x	x					
Gray Catbird	Dumetelia carolinensis		x	x					
Sage Thrasher***	Oreoscoptes montanus				x	x	x		
European starling	Sturnus vulgaris								MMS
American pipit	Anthus rubescens				x	x			SB
Bohemian Waxwing	Bombycilla garrulous		x	x					
Cedar Waxwing	Bombycilla cedrorum		x	x					
Nashville Warbler	Vermivora ruficapilla		x	x					
Orange-crowned Warbler	Vermivora celata		x	x					
Yellow Warbler	Dendroica petechia		x	x	x	x			
Yellow-rumped Warbler	Dendroica coronate		x	x					

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Townsend's Warbler	Dendroica townsendi		x	x					
Blackpoll Warbler	Dendroica striata		x	x					
Black-and-white Warbler	Mniotilta varia		x	x					
American Redstart	Setophaga ruticilla		x	x					
Northern Waterthrush	Seiurus noveboracensis		x		x	x			
MacGillivray's Warbler	Oporornis tolmiei		x	x					
Common Yellowthroat	Geothlipis trichas		x	x		x			
Wilson's Warbler	Wilsonia pusilla		x	x					
Yellow-breasted Chat	Icteria virens		x	x					
Western Tanager	Piranga ludoviciana		x	x					
Black-headed Grosbeak	Pheucticus melanocephalus		x	x					
Lazuli Bunting	Passerina amoena		x	x					
Spotted Towhee	Pipilo maculates		x	x					
American Tree Sparrow	Spizella arborea				x	x			
Chipping Sparrow	Spizella passerine		x	x					
LeConte's Sparrow***	Ammodramus leconteii				x	x	x	x	
Savannah Sparrow	Passerculus sandwichensis					x	x	x	
Vesper Sparrow	Pooecetes gramineus					x	x	x	
Harris's Sparrow	Zonotrichia querula					x	x	x	
White-crowned Sparrow	Zonotrichia laucophrys		x	x		x	x	x	
Fox Sparrow	Passerella iliaca		x	x					
Song Sparrow	Melospiza melodia		x		x	x	x	x	
Lincoln's Sparrow	Melospiza lincolnii					x	x	x	
Swamp Sparrow	Melospiza georgiana				x	x			
Dark-eyed Junco	Junco hyemalis		x	x					
Snow Bunting	Plectrophenax nivalis					x	x	x	
Western Meadowlark	Sturnella neglecta					x	x	x	
Bobolink***	Dolichonyx oryzivorus					x	x	x	
Brown-headed Cowbird	Molothrus ater		x	x					
Yellow-headed Blackbird	Xanthocephalus santheocephalus		x	x					
Red-winged Blackbird	Agelalius phoeniceus		x	x					

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Brewer's Blackbird	Euphagus cyanocephalus		x	x					
Rusty Blackbird	Euphagus carolinus		x	x					
Common Grackle	Quiscalus quiscula		x	x					
Bullock's Oriole	Icterus bullockii		x	x					
Evening Grosbeak	Coccothrauster vespertinus		x	x					
Pine Grosbeak	Pinicoa enucleator		x	x					
House Finch	Carpodacus mexicanus		x	x					
Red Crossbill	Loxia curvirostra		x	x					
Common Redpoll	Careuelis flammea		x	x					
Pine Siskin	Carduelis pinus		x	x					
American Goldfinch	Carduelis tristis		x	x					
House Sparrow	Passer domesticus								MMS
MAMMALS									
Insectivora									
Vagrant Shrew	Sorex vagrans				x	x			
Common (masked) Shrew	Sorex cinereus				x	x			
Chiroptera									
California Myotis	Myotis californicus		x	x					
Western small-footed Myotis	Myotis cillolabrum		x	x					
Western Long-eared Myotis	Myotis evotis		x	x					
Little Brown Bat	Myotis lucifugus		x	x					
Fringed Myotis***	Myotis thysanodes		x	x					
Long-legged Myotis	Myotis volans		x	x					
Townsend's Big-eared Bat***	Carynohinus townsendii		x	x					
Hoary Bat***	Lasiurus cinereus		x	x					
Big Brown Bat	Epsesicus fuscus		x	x					
Silver-haired Bat	Lasionycteris noctivagans		x	x					
Rodentia			x	x					
Yellow-bellied Marmot	Marmota flaviventris		x	x		x	x	x	
Yellow-pine Chipmunk	Tamias amoenus		x	x					
Eastern Fox Squirrel	Scirus niger		x	x					

(Cont'd next page)

Appendix C, cont'd.

Common Name	Scientific Name	Habitats							
		Forest		Wetland		Grassland			Other
		River-front	Flood-plain	Emer-gent	Wet Meadow	Flood-plain	Saline	Sage-brush	
Carnivora			x	x					
Gray Wolf***	Canis lupus		x	x	x	x	x	x	
Coyote	Canis latrans		x	x	x	x	x	x	
Red Fox	Vulpes vulpes				x	x	x	x	
Black Bear	Ursus americanus		x	x	x	x			
Raccoon	Procyon lotor		x	x	x	x	x		
Short-tailed Weasel	Mustela frenata		x	x	x	x	x		
Mink	Mustela vison		x	x	x	x	x	x	
American Badger	Taxidea taxus					x	x	x	
Striped Skunk	Mephitis mephitis		x	x		x	x	x	
Northern River Otter	Lutra canadensis		x		x				
Mountain lion	Felis concolor		x	x					
Bobcat	Lynx rufus		x	x					
Artiodactyla			x	x					
Elk	Cervus elaphus		x	x	x	x	x	x	
Mule Deer	Odocoileus hemionus		x	x	x	x	x	x	
White-tailed Deer	Odocoileus virginianus		x	x	x	x	x	x	
Moose	Alces alces		x	x	x	x			

Karen Kyle

Appendix D. Conspicuous Invertebrates of Lee Metcalf National Wildlife Refuge, Montana. ** indicates Non-native species and *** indicates Species of Concern.

Common Name	Scientific Name
Class Insecta	
Ephemeroptera	
Mayfly	*Baetis tricaudatus*
Mayfly	*Drunella coloradensis*
Mayfly	*Ephemerella excrucians*
Mayfly	*Siphlonurus occidentalis*
Mayfly	*Callibaetis pictus*
Mayfly	*Rhitrhogena robusta*
Mayfly	*Ameletus similior*
Mayfly	*Sweltsa spp*
Mayfly	*Serratella tibialis*
Mayfly	*Drunella doddsi*
Odonata	
Spotted spreadwing	*Lestes congener*
Emerald spreadwing	*Lestes dryas*
Boreal bluet***	*Enallagma boreale*
Marsh bluet	*Enallagma ebrium*
Pacific forktail	*Ischnura cervula*
Western forktail	*Ischnura perparva*
Western red damsel	*Amphiagrion abbreviatum*
Black-tipped darner	*Aeshna tuberculifera*
Canada darner	*Aeshna canadensis*
Lance-tipped darner	*Aeshna constricta*
Paddle-tailed darner	*Aeshna palmata*
Shadow darner	*Aeshna umbrosa*
Blue-eyed darner	*Rhionaeschna multicolor*
Common green darner	*Anax junius*
Pale snaketail	*Ophiogomphus severus*
Sinuous snaketail	*Ophiogomphus occidentis*
Pacific spiketail	*Cordulegaster dorsalis*
Mountain emerald	*Somatochlora semicircularis*
Ocellated emerald	*Somatochlora minor*
Common whitetail	*Plathemis lydia*
Four-spotted skimmer	*Libellula quadrimaculata*
Eight-spotted skimmer	*Libellula forensis*
Twelve-spotted skimmer	*Libellula pulchella*
Dot-tailed whiteface	*Leucorrhinia intacta*
Hudsonian whiteface	*Leucorrhinia hudsonica*
Crimson-ringed whiteface	*Leucorrhinia glacialis*
Boreal whiteface***	*Leucorrhinia borealis*
Variegated meadowhawk	*Sympetrum corruptum*
Red-veined meadowhawk	*Sympetrum madidum*
White-faced meadowhawk	*Sympetrum obtrusum*
Cherry-faced meadowhawk	*Sympetrum internum*
Saffron-winged meadowhawk	*Sympetrum costiferum*
Band-winged meadowhawk	*Sympetrum semicinctum*
Plecoptera	
Stonefly	*Claassenia sabulosa*
Stonefly	*Hesperoperla pacifica*
Stonefly	*Kogotus modestus*
Stonefly	*Isoperla spp*
Stonefly	*Pteronarcella*

(Cont'd next page)

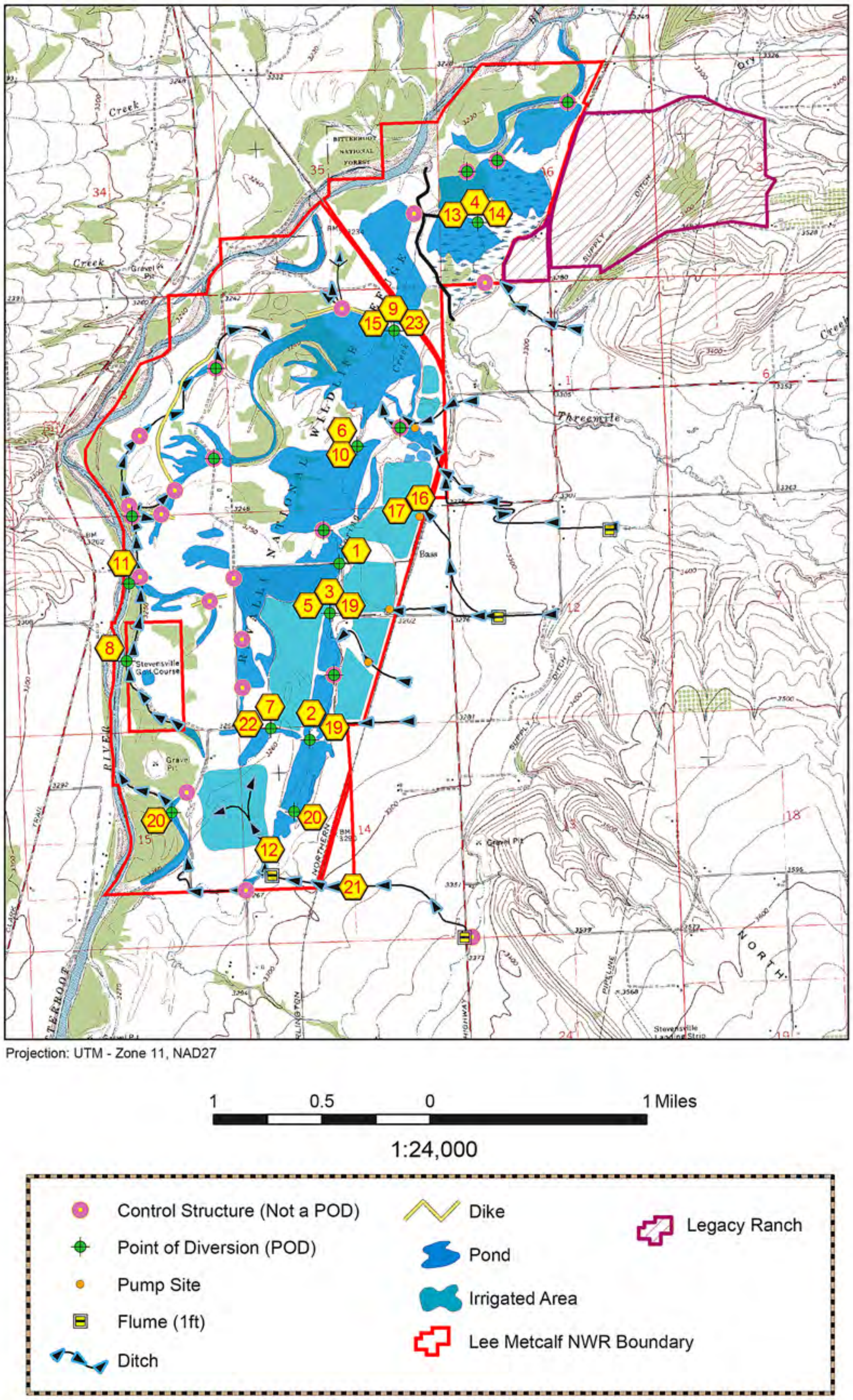
Common Name	Scientific Name
Coleoptera	
Blister beetle	*Epicauta spp*
Tiger beetle	*Cincidela oregona*
Leaf beetle	*Chrysomelidae latreille*
Rifle beetle	*Optioservus quadrimaculatus*
Beetle	*Troposternus latoralis*
Tumbling flower beetle	*Mordellidae latreille*
Carrion beetle	*Silphidae latreille*
Ground beetle	*Pterostichus spp*
Leaf beetle	*Systena spp*
Predaceous diving beetle	*Platambus spp*
Weevil	*Larinus spp*
Weevil	*Rhinocyllus conicus*
Tricoptera	
Caddisfly	*Parapsyche almota*
Caddisfly	*Limnephelus spp*
Caddisfly	*Hydropsyche californica*
Lepidoptera	
Two-tailed swallowtail	*Papilio multicaudata*
Western tiger swallowtail	*Papilio rutulus*
Pale swallowtail	*Papilio eurymedon*
Western white	*Pontia occidentalis*
Cabbage white**	*Pieris rapae*
Becker's white	*Pontia beckerii*
Checkered white	*Pontia protodice*
Clouded sulphur	*Colias philodice*
Sara orangetip	*Anthocharis sara*
Orange sulfur	*Colias eurytheme*
Edith's copper	*Lycaena editha*
Purplish copper	*Lycaena helloides*
Bronze copper	*Lycaena hyllus*
Western pine elfin	*Callophrys eryphon*
Gray hairstreak	*Strymon melinus*
Melissa blue	*Lycaeides melissa*
Spring azure	*Celastrina ladon*
Arrowhead blue	*Glaucopsyche piasus*
Great spangled fritillary	*Speyeria cybele*
Silver-bordered fritillary	*Boloria selene*
Mormon fritillary	*Spreyeria mormonia*
Mylitta crescent	*Phyciodes mylitta*
Northern crescent	*Phyciodes cocyta*
Field crescent	*Phyciodes pratensis*
Edith's checkerspot	*Euphydryas editha*
Satyr anglewing	*Polygonia satyrus*
Oreas anglewing	*Polyfonia oreas*
Zephyr anglewing	*Polyfonia zephyrus*
Mourning cloak	*Nymphalis antiopa*
Milbert's tortoiseshell	*Nymphalis milberti*
California tortoiseshell	*Nymphalis californica*
Red admiral	*Vanessa atalanta*
West coast lady	*Vanessa annabella*
Painted lady	*Vanessa cardui*
Lorquin's admiral	*Limenitis lorquini*
Viceroy	*Limenitis archippus*
Common wood nymph	*Cercyonis pegala*
Small wood nymph	*Cercyonis oetus*
Common alpine	*Eregia eipsoodea*
Common ringlet	*Coenonympha ampelos*
Peck's skipper	*Polites peckius*
Sandhill skipper	*Polites sabuleti*

(Cont'd next page)

Common Name	Scientific Name
Long dash	*Polites mystic*
Common branded skipper	*Hesperua comma*
Woodland skipper	*Ochlodes sylvanoides*
Artic skipper	*Carterocephalus palaemon*
Garita skipperling	*Oarisma garita*
Roadside skipper	*Amblyscirtes vialis*
Common sootywing	*Pholisora catullus*
Common checkered skipper	*Pyrgus communis*
Isabella tiger moth	*Pyrrharctia isabella*
Carpenterworm moth	*Cossoidea spp*
Big poplar sphinx	*Pachysphinx occidentalis*
One-eyed sphinx	*Smerinthus cerisyi*
Polyhemus moth	*Antheraea polyphemus*
Large yellow underwing	*Noctua pronuba*
Catocaline moth	*Catocala spp*
Diptera	
Deerfly	*Chrysops spp*
Class Gastropoda	
Snails/Slugs	
Forest disc	*Discus whitneyi*
Marsh pondsnail	*Stagnicola elodes*
Mountain marshsnail	*Stagnicola montanensis*
Coeur d'Alene Oregonian	*Cryptomastix mullani*
Brown hive	*Euconolus fulvus*
Garlic glass snail**	*Oxychilus alliarus*
Two-ridge ram's-horn snail	*Helisoma anceps*
Big-eared radix**	*Radix auricularia*
Mimic lymnaea snail**	*Pseudosuccinea columella*
Glossy pillar	*Cochilicopa lubrica*
Grey fieldslug**	*Derocerus reticulatum*
Idaho forestsnail	*Allogona ptychophora*
Lovely vallonia	*Vallonia pulchella*
Meadow slug**	*Derocerus laeve*
Quick gloss	*Zonitoides arboreus*
Dusky arion**	*Arion subfuscus*


Karen Kyle

Appendix E. Summary of water rights on Lee Metcalf National Wildlife Refuge (unpublished, U. S. Fish and Wildlife Service, Region 6 files.



Appendix E, cont'd.

1
76H-W-188239
POD: NE SE NW Sec 11, T9NR20W
SOURCE: Rogmans Creek
PRIORITY: 10-Jun-1882
RATE: 5.0 cfs
VOLUME: 560.0 acre-ft
PERIOD: 1/1-12/31

2
76H-W-142482
POD: NW NE NW Sec 14, T9NR20W
SOURCE: South Drain
PRIORITY: 15-Jun-1903
RATE: 10.0 cfs
VOLUME: 276.5 acre-ft
IRRIGATED ACRES: 79.0
PERIOD: 1/1-12/31
COMMENTS: Pond 2 - Measured

3
76H-W-188233
POD: SE SE NW Sec 11, T9NR20W
SOURCE: Unnamed tributary of Bitterroot River
PRIORITY: 15-Jun-1905
RATE: 4.0 cfs
VOLUME: 322.0 acre-ft
PERIOD: 1/1-12/31
COMMENT: Pond 4 - Unknown if staff gage present.

4
76H-W-142483
POD: SE NW SW Sec 36, T10NR20W
SOURCE: Threemile Creek
PRIORITY: 10-May-1930
RATE: 1.0 cfs
VOLUME: 49.0 acre-ft
IRRIGATED ACRES: 14.0
PERIOD: 1/1-12/31
COMMENTS: Pond 11 - Unknown if staff gage still present.
Threemile Creek not used due to water quality issue.

5
76H-W-188235
POD: SE SE NW Sec 11, T9NR20W
SOURCE: Middle (aka North) Drain or Unnamed
tributary of Biterroot River
PRIORITY: 02-Jul-1931
RATE: 2.5 cfs
VOLUME: 374.5 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 4 - Unknown if staff gage still present.

6
76H-W-188236
POD: SW NW SE Sec 2, T9NR20W
SOURCE: Rogmans Creek
PRIORITY: 07-May-1938
RATE: Natural Flow
VOLUME: 1120.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 8 - Staff gage is gone.

7
76H-W-188231
POD: NE NW NW Sec 14, T9NR20W
SOURCE: Swamp Creek
PRIORITY: 15-Aug-1941
RATE: 10.0 cfs
VOLUME: 199.5 acre-ft
IRRIGATED ACRES: 57.0
PERIOD: 1/1-12/31

8
76H-W-142493
POD: SE NE SW Sec 10, T9NR20W
SOURCE: Bitterroot River
PRIORITY: 29-Jan-1947
RATE: 10.0 cfs
VOLUME: 679.0 acre-ft
IRRIGATED ACRES: 194.0
PERIOD: 1/1-12/31

9
76H-W-188238
POD: SW NE NE Sec 12, T9NR20W
SOURCE: Rogmans Creek
PRIORITY: 04-Nov-1950
RATE: 25.0 cfs
VOLUME: 980.0 acre-ft
IRRIGATED ACRES: 19.0
PERIOD: 1/1-12/31
COMMENTS: Pond 10 - Measured

10
76H-W-142492
POD: SW NW SE Sec 2, T9NR20W
SOURCE: Springs/Swamps
PRIORITY: 01-Apr-1952
RATE: 400.0 gpm
VOLUME: 212.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 8 - Staff gage is gone

11
76H-W-142491
POD: NW SW NE Sec 10, T9NR20W
SOURCE: Unnamed tributary of Bitterroot River
PRIORITY: 15-May-1953
RATE: 5.0 cfs
VOLUME: 301.0 acre-ft
IRRIGATED ACRES: 86.0
PERIOD: 1/1-12/31
COMMENTS: Structure used to let Bitterroot water in
and push water up Refuge.

12
76H-W-142489
POD: NE NW NW Sec 14, T9NR20W
SOURCE: Spring/Swamp
PRIORITY: 13-Nov-1957
RATE: Natural Flow
VOLUME: 486.5 acre-ft
PERIOD: 1/1-12/31

13
76H-W-142484
POD: SE NW SW Sec 36, T10NR20W
SOURCE: Threemile Creek
PRIORITY: 13-Jul-1960
RATE: 1.0 cfs
VOLUME: 49.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 11 - Unknown if staff gage is present.
Threemile Creek not used due to water quality issue.

14
76H-W-142485
POD: SE NW SW Sec 36, T10NR20W
SOURCE: Threemile Creek
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 1347.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 11 - Unknown if staff gage is present.
Threemile Creek not used due to water quality issue.

15
76H-W-188237
POD: SW NE NE Sec 2, T9NR20W
SOURCE: Rogmans Creek
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 11794.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 10 - Measured

16
76H-W-188232
POD: SW NW SE Sec 2, T9NR20W
SOURCE: Drains & Nautral Channels of
Bitterroot River
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 6085.5 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pump House

17
76H-W-142490
POD: NE NE NE Sec 11, T9NR20W
SOURCE: Drain #2
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 1445.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pump House

18
76H-W-188234
POD: SE SE NW Sec 11, T9NR20W
SOURCE: Middle (aka North) Drain or
Unnamed tributary of Bitterroot River
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 2917.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 4 - Unknown if staff
gage is present.

19
76H-W-154100
POD: NW NE NW Sec 14, T9NR20W
SOURCE: South Drain
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 6950.5 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 2 - Measured

20
76H-W-142488
POD: SE SW NW Sec 14, T9NR20W
SOURCE: Drain #1
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 1445.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Pond 1 - Measured
Needs to be amended. Staff states no drain here.
Springs emanate up on bank, as shown.
Second POD is in Sec 15, also not a "drain".

21
76H-W-188240
POD: W2 Sec 14, T9NR20W
SOURCE: Ground water sub-irrigation,
tributary to Bitterroot River
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 7386.0 acre-ft
PERIOD: 1/1-12/31
COMMENTS: Needs to be amended.
Staff states only supply ditch water enters
Refuge at this point.

22
76H-W-188230
POD: NE NW NW Sec 14, T9NR20W
SOURCE: Swamp Creek
PRIORITY: 10-Dec-1963
RATE: Natural Flow
VOLUME: 3414.0 acre-ft
PERIOD: 1/1-12/31

23
69642-S76H
POD: SW NE NE Sec 2, T9NR20W
SOURCE: Spring Creek
PRIORITY: 14-Oct-1988
RATE: 25.0 cfs
VOLUME: 300.0 acre-ft
PERIOD: 1/1-12/31

The water right point-of-diversions above are sorted by priority.
Note that although the 22 claims, and one permit, total 48,418 acre-ft/yr, most of the rights are supplemental to one another and have overlapping places-of-use.

NOTES: