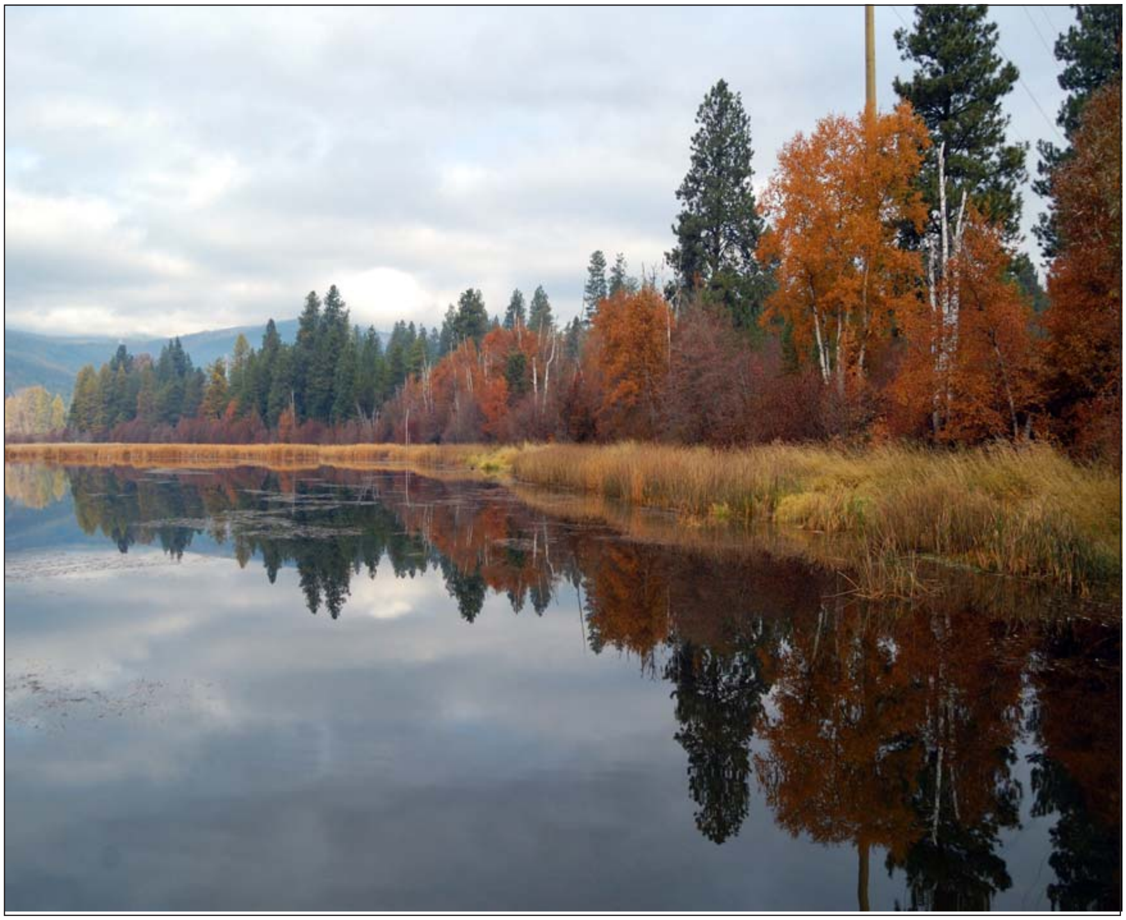
WASHINGTON NATURAL HERITAGE PROGRAM



Change in the Extent and Ecological Condition of Wetlands Surrounding Lake Pend Oreille, Idaho

Prepared for NatureServe,
Arlington, VA

Prepared by
F. Joseph Rocchio

December 2009

Natural Heritage
Report 2009-12

WASHINGTON STATE DEPARTMENT OF
Natural Resources

Change in the Extent and Ecological Condition of Wetlands Surrounding Lake Pend Oreille, Idaho.

December 31, 2009

Report Prepared for:
NatureServe
Arlington, Virginia

and

U.S Environmental Protection Agency, Region 10
Seattle, Washington

Prepared by:
F. JOSEPH ROCCHIO
Washington Natural Heritage Program
Washington Department of Natural Resources
Olympia, Washington 98503-1749

Conducted under NatureServe Work Assignment 2-12
Contract Number: EP-W-07-080
Heritage Data Access and Technical Support

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

In order to make informed management decisions aimed at minimizing loss or protecting wetland resources, data on how human activities have and continue to affect the extent and ecological conditions of wetlands are needed (EPA 2002).

To determine wetland extent, mapping resources such as those provided by the U.S. Fish and Wildlife Service's National Wetland Inventory and soil surveys conducted by the Natural Resources Conservation Service are often used by wetland managers. Other spatial data such as vegetation, ecosystem, or biophysical maps can also be helpful in determining contemporary and historical wetland extent. Assessing the ecological integrity of an ecosystem requires developing indicators of the structure, composition, and function of an ecosystem as compared to reference examples operating within the bounds of natural or historic disturbance regimes. The overall purpose of this project is to utilize such resources to evaluate historic changes in the extent of wetlands along the Lake Pend Oreille, Idaho shoreline (Pend Oreille Lake watershed, USGS HUC 17010214) in order to provide local stakeholders information about historic changes of wetlands along the shoreline of Lake Pend Oreille and to identify potential conservation and restoration sites. To accomplish this, the following objectives will be implemented: (1) describe historic changes in wetland extent and condition primarily focused on vegetation community changes; (2) describe in general terms and map as appropriate the restoration potential of shoreline wetlands or former wetlands; and (3) identify and map as appropriate any significant wetlands (wildlife, biodiversity, water quality improvement) in the study area.

The project study area is a 1-mile buffer around the high water mark of Lake Pend Oreille. Additional areas beyond the 1-mile buffer in these areas were included in the analysis due to the abundance and importance of wetlands in those areas (Figure 1). The focus of analysis for this project is historical and current extent and ecological conditions of wetlands within this buffered polygon around Lake Pend Oreille.

Existing data was used to determine historic changes in the extent and ecological condition of wetlands in the Lake Pend Oreille, Idaho shoreline and the Project Boundaries layer was used to clip all of the data used in further analysis. All of the layers used for analysis are included as a deliverable for this project. Other data such as geology, ownership, elevation, relief, hydrography, orthophotos, etc. were downloaded in October, 2009 from the Idaho Interactive Numeric and Spatial Information Data Engine and Idaho Department of Water GIS data site.

The GIS layers used in data analysis are based on two distinct classification schemes: Cowardin and Ecological Systems. Based on a cursory reconnaissance field trip to the study area, the Ecological Systems map appeared to over-represent the extent of current wetlands and riparian areas. In addition, the Ecological System map either missed many of the smaller wetland types or classified them into one of the two wetland/riparian types in the map legend. In contrast, the National Wetland Inventory maps appeared to under-represent the extent of wetlands in many areas but were able to distinguish more physiognomic differences in vegetation cover.

These conclusions are not based on a systematic accuracy assessment of each map rather are based on a four-day reconnaissance field trip comparing the two wetland maps (Ecological Systems and NWI) with the location of wetlands on the ground. Utilizing both classification schemes and maps for determining change in wetland extent provides two independent estimates of wetland loss in the study area. Given that Ecological Systems appear to over-represented while NWI seems to under-represented wetland extent, the use of both maps provides a range of wetland loss.

Three different methods were used to estimate wetland loss from their historical extent: (1) comparison of Ecological Systems map (current extent of wetlands) with the Biophysical Setting map (historical extent of wetlands); (2) comparison of National Wetland Inventory maps (current extent of wetlands) with hydric soil maps (historical extent); and (3) compilation of data from construction and operational losses associated with Albeni Falls Dam.

In order to determine changes in ecological condition of the study area wetlands, a Landscape Integrity Index was used to estimate current ecological integrity as compared to historical conditions. Although not as accurate as a probabilistic assessment of ecological condition using rapid or intensive assessment methods, a Level 1 assessment (EPA 2006) such as the Landscape Integrity Index provides a cursory assessment of ecological condition using readily available GIS data. In addition to this approach, a brief description of ecological changes as found in the literature is provided.

The conservation or ecological significance of wetlands in the study area is based on previous studies and data from the Idaho Conservation Data Center including Important Bird Areas, Wetland Conservation Sites, and Wetland Priority Areas. Inquiries about these conservation sites should be directed to the Idaho Conservation Data Center.

Identifying restoration potential of each wetland polygon was not feasible with readily available datasets. However, based on recommendations from the literature, restoration potential for some locations in the study area is provided.

Estimates of current and historical extent were higher when determined with the Ecological System and Biophysical Settings maps than the National Wetland Inventory and Hydric Soil maps (Figures 3-6; Table 4). Estimated wetland loss varied by the two GIS methods. For example, analysis based on Ecological Systems and Biophysical Settings maps suggest overall wetland loss was 35% whereas the National Wetland Inventory and Hydric Soil overlay suggest overall wetland loss to be 43%. Although the two methods differ by 8%, both indicate a substantial loss of the extent of wetlands and riparian areas in the study area. The most substantial loss has occurred in the Pack River valley north of the lake and the Clark Fork River Delta. These two areas also supported the highest concentration of historical wetlands and continue to support the highest concentration of existing wetlands in the study area. Historically, land clearing, drainage, and agriculture conversion have been the primary reasons for wetland loss in northern Idaho and these trends appear to hold for the study area.

The wetland losses estimated in this report reflect a coarse approach to measuring change in wetland extent. A systematic accuracy assessment of the data layers used in the analyses has not been conducted. Thus, the estimates provided do not incorporate errors associated with inaccurate mapping or labeling (i.e., classification) of wetlands on the ground. In addition, the historical extent of wetlands is based on either an ecological model (e.g., Biophysical Settings) or potentially incomplete representation (e.g., Hydric Soils) of the historical extent of wetlands in the study area. Nonetheless, the GIS analyses both suggest that a substantial portion (between 35-43%) of historical wetlands have been lost from the landscape. These losses are associated with land conversion, drainage, development, and other land uses outside the zone impacted by the construction of the Albeni Falls Dam.

Losses associated with the construction of Albeni Falls Dam occurred within the fluctuation zone (i.e., area between the shoreline prior to dam construction and post-construction summer pool levels). The construction and subsequent operation of the dam inundated 6,617 acres that were formerly wetlands. The highest concentration of losses occurred in the Clark Fork River Delta and Denton Slough area (2,029 acres) and the Pack River area (1,444 acres). In terms of wetland types, the most significant loss was suffered by Deciduous Forested Wetlands which were reduced 72% from their former extent. Herbaceous wetlands were also severely impacted with 67% of their former acreage being lost from inundation. Deciduous Scrub Shrub wetlands were increased slightly. The very significant increase in Open Water areas is equal to the negative changes observed in Palustrine wetland types.

In addition to the initial impact associated with inundation of wetlands following dam construction, the ongoing operation of Albeni Falls Dam has resulted in substantial erosion of wetlands in the study area. Wind and wave action during summer lake levels (i.e., high lake levels) is thought to be the primary culprit of erosion of wetlands along the lake's shoreline. It has been estimated that 30 acres of wetlands are annually lost due to erosion stemming from operation of hydroelectric dams. Roughly half of that loss is occurring in the Clark Fork River Delta where erosional losses from Albeni Falls Dam are exacerbated by upstream dams (Cabinet Gorge and Nixon Rapids) on the Clark Fork River. Another study estimated that average bank recession (i.e., horizontal erosion) along Lake Pend Oreille was nearly 5 feet/year. Recent work by Ducks Unlimited and Idaho Department of Fish and Game show that these losses continue, especially in the Clark Fork River Delta.

The Landscape Integrity Index showed that regardless of the base map used (e.g., Ecological Systems vs. NWI), wetlands in the study area had an overall ecological integrity rank of Fair. Except for Open Water wetlands (e.g., aquatic beds) in the Ecological Systems layer and Riverine wetlands in the NWI layer, each wetland type also was rated as being in Fair ecological condition throughout the study area. The Landscape Integrity Index assumes that a rank of Excellent/Good reflects historic conditions. Thus, the change in ecological condition of wetlands in the study area is substantial with degradation being prominent in almost all wetlands types.

Agriculture and residential development near Sandpoint and in the Pack River area appear to have a substantial impact on the ecological integrity of wetlands in the study area.

The Landscape Integrity Index is a useful surrogate measure of site conditions based on obvious onsite and adjacent land use(s). However, the coarse nature of the model often doesn't incorporate site-specific stressors such as invasive or nonnative species, nutrient and metal contamination, sediment deposition, grazing, etc. A more detailed assessment of ecological condition using onsite Level 2 (rapid) or Level 3 (intensive) assessment methods such as the NatureServe and the Natural Heritage Network's Ecological Integrity Assessment protocol would provide more detailed information concerning site and overall ecological condition of wetlands in the study area.

The various historical and ongoing human activities affecting wetlands in the study area have resulted in numerous biotic and abiotic shifts from their natural range of variation. The Clark Fork River Delta was historically a mosaic of forested, shrub, and herbaceous wetlands. However, many of the old growth western redcedar stands have been logged and many areas of the delta, especially the extreme northern and southern portions, have been ditched and drained for hay pasture. Historically, the Pack River appears to have been dominated by the mature riparian forests. However, large-scale logging activities have left these habitat types largely absent or degraded along the contemporary Lower Pack River floodplain. The Pack River delta has been substantially altered by the construction and operation of Albeni Falls Dam. High water levels created by the dam have raised the water table in the delta area thereby converting forested wetlands dominated by cottonwoods and western redcedar into herbaceous or shrub wetlands. Prior to dam construction much of the riparian vegetation in the Pack River delta was converted to pasture in the late 1800's.

Historical and contemporary human-induced stressors have not only resulted in the loss of wetland acreage but have also resulted in dramatic degradation of ecological conditions of the wetlands that remain on the landscape. Species composition has shifted, with an increase in nonnative, invasive, and undesirable native species (e.g., increaser species) along with a corresponding decrease in native species sensitive to anthropogenic disturbances. The vegetation structure of many wetlands has also shifted due to past and present stressors such as logging, clearing, grazing, erosion, and drainage. Other changes include degradation of ecological processes such as the hydrological regime and nutrient and sediment dynamics brought on by the myriad of land uses in the study area. These abiotic changes are often the cause of many of the vegetation changes, although vegetation composition can serve as a feedback toward worsening existing degradation in ecological processes.

Ecologically significant wetlands in the study area were identified by previous efforts of the Idaho Conservation Data Center. Inquiries about these conservation sites should be directed to the Idaho Department of Fish and Game, Data Conservation Center. The Clark Fork Delta site is ranked as one of the top 10 wetland priority areas in Idaho. Pack River and McArthur Lake are ranked as the 15th and 17th wetland priority areas in Idaho. Beaver Lake South, Lost Lake, Gamlin Lake, McArthur Lake, and Walsh Lake all support peatlands, which are a rare wetland type in northern Idaho (Lichthardt 2004). Morton Slough is the only site considered to be fully protected. The Clark Fork Delta, Gamlin Lake, McArthur Lake, and Pack River all have some portion of their areas protected but the remaining portions of these sites are still in need of protection actions. Cocolalla Slough, Beaver Lake South, Lost Lake, and Walsh Lake currently have no formal protection.

Restoration opportunities are abundant in the Pack River and Clark Fork River Delta area, given the extensive historic and contemporary impacts as well as the importance of these sites statewide. Erosion control along both the Pack River and Clark Fork River are priorities for restoration. Many of the conservation sites identified have experienced significant impacts from human activities. These include Cocolalla Slough, Morton Slough, and Pack River. All of these sites have the potential for restoration or enhancement activities due to past impacts resulting from livestock grazing and/or hydrological alterations. Restoration actions could range from fencing out livestock to more intensive actions such as revegetation, channel stabilization, weed control, and hydrological restoration.

The results of this work provide an indication of the level of change, both in extent and ecological condition, of wetlands in the study area. However, these estimates are mostly based on coarse GIS analyses with an unknown source of error. Additional research such as reviewing U.S. Army Corp of Engineer Section 404 permits could improve estimate of wetland loss associated with impacts from development and road construction. Consulting General Land Office records for the study area might also provide a more accurate estimate of historical wetland extent.

The Level 1 assessment of ecological integrity (i.e., the Landscape Integrity Index) of the study area wetlands could be greatly improved by conducting a probabilistic survey of wetland condition in the study area. The Washington Natural Heritage Program is currently developing Level 2 (rapid) and Level 3 (intensive) Ecological Integrity Assessment protocols for the ecological systems which occur in Washington State. Most of the wetland types which occur in northeastern Washington also occur in the study area. Thus, these EIAs protocols would be available for implementing a systematic and scaled assessment of the study area's wetland profile which would provide a statistically valid estimate of the ecological conditions of wetlands around Lake Pend Oreille.

A more sophisticated approach to identifying potential restoration sites in the study area could be initiated by implementing a Level 1 assessment. For example, the Landscape Integrity Index could be utilized to first identify degraded wetlands in the study area. Then an analysis of land use surrounding the degraded wetlands could be used to determine whether any limiting factors occur adjacent to or near the wetland.

Implementing these recommended future research efforts would help provide more accurate data concerning the change in extent and ecological integrity of wetlands around Lake Pend Oreille, relative to historical conditions.

1.0 Introduction

1.1 Project Objective

In order to make informed management decisions aimed at minimizing loss or protecting wetland resources, data on how human activities have and continue to affect the extent and ecological conditions of wetlands are needed (EPA 2002).

To determine wetland extent, mapping resources such as those provided by the U.S. Fish and Wildlife Service's National Wetland Inventory and soil surveys conducted by the Natural Resources Conservation Service are often used by wetland managers. Other spatial data such as vegetation, ecosystem, or biophysical maps can also be helpful in determining contemporary and historical wetland extent. Assessing the ecological integrity of an ecosystem requires developing indicators of the structure, composition, and function of an ecosystem as compared to reference or benchmark examples of those ecosystems operating within the bounds of natural or historic disturbance regimes (Lindenmayer and Franklin 2002, Young and Sanzone 2002). NatureServe and the Natural Heritage Network have recently developed an approach for assessing ecological condition called the Ecological Integrity Assessment (Faber-Langendoen et al. 2006, 2008, 2009a, 2009b) and are now implementing it for a variety of small- and large-scale projects (Lemly and Rocchio *In Preparation*, Faber-Langendoen et al. 2009b, Tierney et al. 2009, Vance et al. *In Progress* WNHP *In Progress*). The Ecological Integrity Assessment (EIA) can be used a variety of spatial scales ranging from a remote-sensing, GIS-based approach to an on the ground, quantitative analysis. For this project, a Level 1 (GIS) approach was used to determine overall condition of wetlands in the study area (Tuffly and Comer 2005; Comer and Hak 2009).

The overall purpose of this project is to utilize the resources discussed above to evaluate historic changes in the extent of wetlands along the Lake Pend Oreille, Idaho shoreline (Pend Oreille Lake watershed, USGS HUC 17010214) in order to provide local stakeholders information about historic changes of wetlands along the shoreline of Lake Pend Oreille and to identify potential conservation and restoration sites. To accomplish this, the following objectives will be implemented: (1) describe historic changes in wetland extent and condition primarily focused on vegetation community changes; (2) describe in general terms and map as appropriate the restoration potential of shoreline wetlands or former wetlands; and (3) identify and map as appropriate any significant wetlands (wildlife, biodiversity, water quality improvement) in the study area.

1.2 Study Area

Lake Pend Oreille is located in Bonner County in the panhandle of northern Idaho (Figure 1). Lake Pend Oreille is the largest and deepest lake in Idaho (Tri-State Water Quality Council 2007). High lake level occurs at about 2,062 feet and the surrounding terrain reaches up to about 6,000 feet. Maximum depth of the lake is 1,150 feet (Breckenridge and Sprenke 1997).

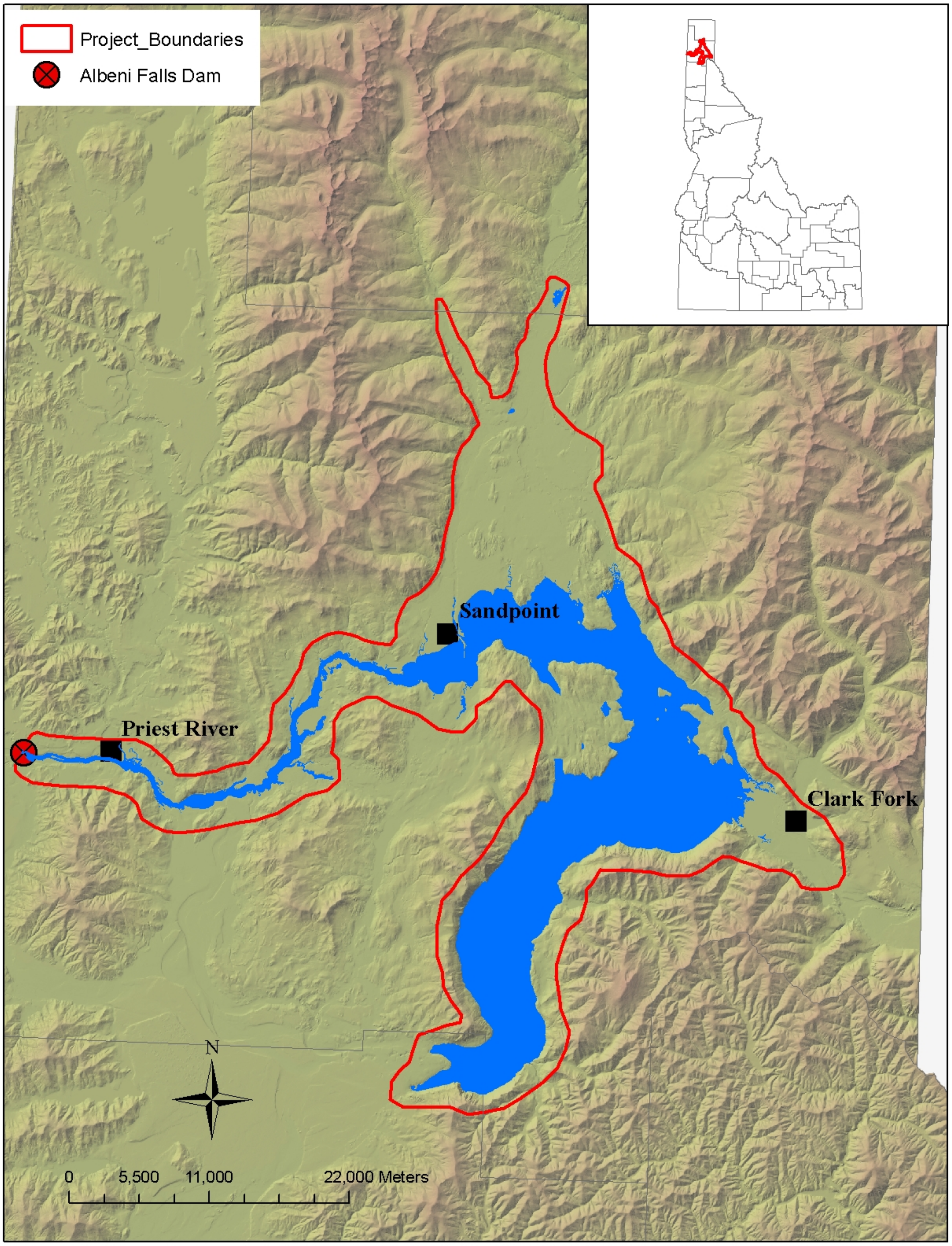


Figure 1. Location of Lake Pend Oreille, Idaho.

The project study area is a 1-mile buffer around the high water mark of Lake Pend Oreille. Additional areas beyond the 1-mile buffer in these areas were included in the analysis due to the abundance and importance of wetlands in those areas (Figure 1). The focus of analysis for this project is historical and current extent and ecological conditions of wetlands within this buffered polygon around Lake Pend Oreille.

1.2.1 Climate

The climate of the study can be described as cool temperate with a maritime influence. Westerly, maritime air masses from the Pacific Ocean create what is often called the "inland maritime" climate. These air masses are associated with long gentle rains, deep snow accumulations at high elevations, abundant clouds, and frequent fog (Lichthardt 2004). Sandpoint, Idaho, located on the northern shore of Lake Pend Oreille (2,100 ft. elevation), receives about 32 inches of annual precipitation (Western Regional Climate Center 2009). Annual snowfall in Sandpoint is approximately 70 inches. Most precipitation occurs from November to March, mostly as snow but rain-on-snow events are common. Mean maximum and minimum temperatures in Sandpoint range from $32/20^{o}$ F in December and $82/48^{o}$ F in July. At higher elevations overall temperatures are colder and precipitation is greater.

1.2.2 Geology and Topography

Lake Pend Oreille occurs in a basin (Purcell trench) formed by glaciers (Breckenridge and Sprenke 1997). The Purcell trench is a north-south trending, glacially-modified valley. A series of faults through the trench suggest that the valley was originally formed from fault movement prior to being modified by later glacial activity (Doughty and Price 2000). Within the study area, the Purcell trench is incised between the metamorphic/granitic Selkirk Mountains to the west and sedimentary Cabinet Mountains to the east. Cordilleran glacial ice advanced into the Purcell trench repeatedly, carving deep basins into the bedrock. The lower reach of the Pack River traverses through a part of this basin while Lake Pend Oreille occupies much of it. The Clark Fork River also occupies a glacially carved valley.

The various extensions of ice down the Purcell trench blocked the Clark Fork River near the southeastern part of contemporary Lake Pend Oreille. Each extension resulted in a massive impoundment of water known as Glacial Lake Missoula. Behind this ice dam, thick layers of lacustrine silt and clay, as well as coarser alluvium, were deposited in the contemporary Clark Fork River delta area (Parametrix 1998 as cited in Heck and Cousins 2009). The periodic failure of the ice dams (which occurred multiple times) resulted in catastrophic flooding which eroded much of the Lake Pend Oreille basin carrying previously deposited glacial till and outwash downstream. These floods have left a compacted and exposed layer of clay and silt throughout the Clark Fork River delta area (Parametrix 1998 as cited in Heck and Cousins 2009). The last advance of ice did not result in catastrophic flooding and terminal and proglacial deposits are found near the south end of the lake (Breckenridge and Sprenke 1997). Lower elevations in the study area are underlain by Quaternary glacial and fluvial deposits. Such deposits can also be found on some of the lower slopes and valley bottoms where ice lobes impounded water behind them (Golder Associates 2003). Glacial-origin landforms such as kettles, glacial basins, and outwash channels today support many kinds of wetlands (Chadde et al. 1998).

Much of the shoreline of Lake Pend Oreille is bordered by steep slopes (Figure 1). Relatively flat terrain abuts the lake in the major river valleys such as Pack River and Clark Fork River (Figure 1). Because of the steep nature of most of the shoreline, most wetlands occurring within the study area are located within the Pack River and Clark Fork River valleys. Consequently, these areas receive disproportionate attention than other areas around the lake in this report.

1.2.3 Hydrology

The surface area of the lake is approximately 143 square miles (95,000 acres) with about 175 miles of shoreline (Tri-State Water Quality Council 2007). Outflow from Lake Pend Oreille into the Pend Oreille River is regulated by Albeni Falls Dam near the Idaho/Washington border, which is operated by U.S. Army Corps of Engineers. The dam was completed in 1955. Major tributaries to the lake include the Clark Fork River, Pack River and Sand Creek along with numerous other smaller creeks. Surface outflow consists of the Pend Oreille River and groundwater contributions from the lake to the Spokane Valley-Rathdrum Prairie Aquifer (constitutes about 3.8 to 7% of total recharge to aquifer) (Tri-State Water Quality Council 2007). The Clark Fork River contributes about 92% of total inflow into the lake (Tri-State Water Quality Council 2007). Surface flow from the Clark Fork River into the lake is regulated by the Cabinet Gorge Dam at the Idaho and Montana border (Tri-State Water Quality Council 2002). The unregulated Pack River is the second largest tributary to Lake Pend Oreille. In addition to these large tributaries, there is a band of land surrounding the lake (called the nearshore zone) that is not associated with a larger tributary system and instead drains directly into the lake (Tri-State Water Quality Council 2002).

The U.S. Army Corps of Engineers control water levels in Lake Pend Oreille at Albeni Falls Dam. Lake levels are typically held at 2,062 feet during the summer and early fall months (Heck and Cousins 2009). Through late fall, winter, and early spring lake levels are typically drawn down to between 2,051 and 2,055 feet. Minimum lake levels are typically reached in early December (Tri-State Water Quality Council 2002).

The mean annual flow of the Clark Fork River is approximately 22,000 cubic feet per second (cfs). Spring and early summer flows exceed 30,000 cfs for one to three months (Heck and Cousins 2009). The delta formed by the Clark Fork River in Lake Pend Oreille supports an abundance of wetlands and riparian habitats. Mean annual flow of the Pack River is 320 cfs and ranges from 142 to 530 cfs (Golder Associates 2003). The lower reach of the Pack River flows through glacial outwash over relatively flat terrain. This area (between Samuel and the Pack River delta in Lake Pend Oreille) contains numerous wetlands associated with recent and historical glaciofluvial activity.

1.2.4 Vegetation

The ecological systems (Comer et al. 2003) found within the study area are listed in Table 1. Approximately 80% of Lake Pend Oreille's watershed is forested (Tri-State Water Quality Council 2007). The Northern Rocky Mountain Mesic Montane and Dry-Mesic Montane Mixed Conifer Forests are the dominant upland forest vegetation. Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), western white pine (*Pinus monticola*), ponderosa pine (*P. ponderosa*), and lodgepole pine (*P. contorta*) are the predominant trees in the Dry-Mesic Montane forests while Douglas-fir, grand fir (*Abies grandis*), western redcedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) are the predominant trees in the Mesic Montane Forests (NatureServe 2009).

The most common wetland and riparian types are the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland and Northern Rocky Mountain Conifer Swamp (Table 1). The upper canopy of the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland type is dominated by cottonwood (*Populus balsamifera* ssp. *trichocarpa*), western redcedar, aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and red alder (*Alnus rubra*) while devil's club (*Oplopanax horridum*), Rocky Mountain maple (*Acer glabrum*), and snowberry (*Symphoricarpos albus*) are common shrub species. Historically, the Pack River appears to have been dominated by the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Ecological System type. Specific vegetation types included the western redcedar/oak fern (*Thuja plicata/Gymnocarpium dryopteris*) and western redcedar/devil's club (*Thuja plicata/Oplopanax horridum*) habitat types (Golder Associates 2003). However, large-scale logging activities have left these habitat types largely absent or degraded along the contemporary Pack River floodplain. The Northern Rocky Mountain Conifer Swamp generally occurs in riparian settings (outside the influence of overbank flooding) toeslopes, valley bottoms and benches. Dominant species typically include western redcedar, western hemlock, skunk cabbage (*Lysichiton americanus*), and lady fern (*Athyrium filix-femina*). Although the Ecological Systems map used for this project (see Methods) did not map them, Rocky Mountain Subalpine-Montane Fens and Rocky Mountain Alpine-Montane Wet Meadows (includes marshes) are also found in the study area. Due to the small-scale of these ecological systems, they were likely lumped into either the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland system (if located in riparian environments) or Northern Rocky Mountain Conifer Swamp (if outside riparian environments) when the Ecological System maps was created.

1.2.5 Land Use

Most of the northern and eastern portions of the lake's watershed (especially mountainous terrain) are under public land management while the lowlands and river valleys are mostly in private ownership (Tri-State Water Quality Council 2007). Close to 65% of the lakeshore is under management by the U.S. National Forest Service. Logging has been the primary land use of the study area. Livestock grazing and agricultural crops such as hay, wheat, oats, and barley are the most common land use in many of the lowland valleys. Agricultural is very prevalent in the Pack River and Clark Fork River valleys (Figure 2). Timber harvesting occurs on National

Forest, Bureau of Land Management, State of Idaho, and some private lands (Pack River TAC 2006). Residential development is prevalent around much of the lakeshore, especially the northern and eastern shorelines (Figure 2).

When summed all the agricultural and development land uses comprise the fourth largest land cover type in the study area (Table 1). These land uses all contribute to the loss of extent and degradation of existing wetlands in the study area. For example, the Pack River contributes the highest source of nitrates and phosphorous (per acre loading) and is also a significant source of sediment to Lake Pend Oreille (Golder Associates 2003).

Table 1. Ecological Systems in the Study Area. (listed in decreasing order of areal extent). Note: some of the upland ecological systems listed appear to have been mislabeled.

Ecological System (those in italics are cultural or semi-natural types)	**Total Acres**
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	64,543
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	29,224
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	28,407
(All Agriculture and Development)	(17,848)
Introduced Upland Vegetation - Perennial Grassland and Forbland	9,061
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	7,120
Agriculture - Pasture/Hay	5,540
Agriculture - General	3,521
Developed-Low Intensity	3,427
Rocky Mountain Subalpine-Montane Mesic Meadow	2,969
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	2,729
Developed-Open Space	2,405
Inter-Mountain Basins Montane Sagebrush Steppe	1,970
Open Water	1,953
Agriculture - Cultivated Crops and Irrigated Agriculture	1,823
Non-Specific Disturbed	1,563
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	990
Developed-Medium Intensity	959
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	956
Columbia Plateau Low Sagebrush Steppe	581
Inter-Mountain Basins Big Sagebrush Steppe	512
Northern Rocky Mountain Conifer Swamp	375
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	290
Rocky Mountain Alpine Bedrock and Scree	285
Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland	238
Inter-Mountain Basins Big Sagebrush Shrubland	176
Developed-High Intensity	173
Rocky Mountain Lodgepole Pine Forest	99
Northern Rocky Mountain Subalpine Deciduous Shrubland	23
Rocky Mountain Poor-Site Lodgepole Pine Forest	14
Rocky Mountain Aspen Forest and Woodland	13
Great Basin Xeric Mixed Sagebrush Shrubland	10
Northern Rocky Mountain Subalpine-Upper Montane Grassland	4
Columbia Basin Foothill and Canyon Dry Grassland	3
Rocky Mountain Cliff, Canyon and Massive Bedrock	2
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	1

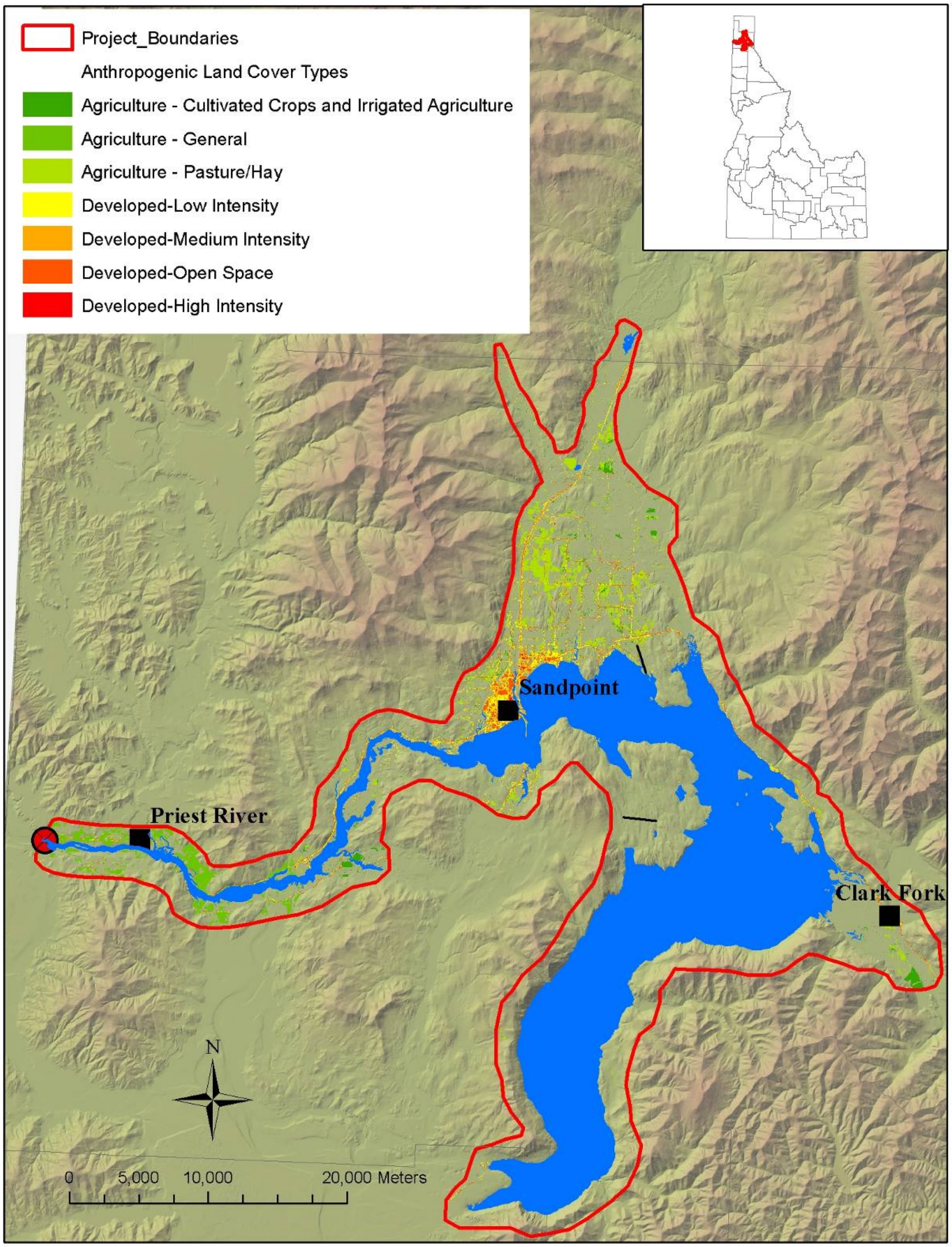


Figure 2. Anthropogenic Land Cover Types in the Study area

2.0 Methods

2.1 Development of Data Layers

The study area boundaries (i.e. Project Boundaries layer) were created in ArcMap 9.2 using a 1-mile buffer of the high water mark of the lake (elevation approximately 2,062 feet or 629 m). Due to the abundance and importance of wetlands found along the Pack River and Clark Fork River and their deltas beyond the 1-mile buffer, the study area boundaries were extended to include these areas (Figure 1). Previous studies of water quality in Lake Pend Oreille have focused on the nearshore zone (areas draining directly into Lake Pend Oreille) around the lake as land use within these areas have been shown to have a significant impact on the ecological integrity of the lake (Tri-State Water Quality Council 2002). The 1-mile buffer encompasses these areas.

Existing data was used to determine historic changes in the extent and ecological condition of wetlands in the Lake Pend Oreille, Idaho shoreline (Table 2) and the Project Boundaries layer was used to clip all of the data used in further analysis. All of the layers listed in Table 2 are included as a deliverable for this project.

Other data such as geology, ownership, elevation, relief, hydrography, orthophotos, etc. were downloaded in October, 2009 from the Idaho Interactive Numeric and Spatial Information Data Engine (http://insideidaho.org/asp/geodata.asp) and Idaho Department of Water GIS data site (http://www.idwr.idaho.gov/GeographicInfo/gisdata/gis_data.htm).

2.2 Classification of Wetland Types

The GIS layers used in data analysis are based on two distinct classification schemes: Cowardin and Ecological Systems. Each is briefly described below.

2.2.1 Cowardin

The Cowardin classification system uses five Systems (Marine, Estuarine, Riverine, Lacustrine, and Palustrine) as the highest level of a classification hierarchy (Cowardin et al. 1979). Only three of these Systems occur in the study area: Riverine, Palustrine, and Lacustrine.

The Riverine System has four Subsystems, Tidal, Lower Perennial, Upper Perennial, and Intermittent. The Lacustrine System has two Subsystems, Littoral and Limnetic, and the Palustrine Systems has no Subsystems. Classes are used to further divide Subsystems and are based on substrate and flooding regime or on vegetative life form. The same Classes may appear under one or more Systems or Subsystems. The Classes based on vegetative form include: (1) Aquatic Bed, dominated by plants that grow principally on or below the surface of the water; (2) Moss- Lichen Wetland, dominated by mosses or lichens; (3) Emergent Wetland,

Table 2. GIS Data Used in Analysis

Data Layer File Name[1]	Description/Source
Current Wetlands (Ecological Systems)	Map of Ecological Systems of the United States (Comer et al. 2003); Online: http://www.natureserve.org/getData/USecologyData.jsp; Map used was created March, 2009.
Current Wetlands (National Wetland Inventory Maps(NWI))	National Wetland Inventory Maps (U.S. Fish and Wildlife Service 2009); Online: http://www.fws.gov/wetlands/
Current Wetlands (NWI overlay on hydric soils)	Only contains NWI polygons which intersect the hydric soil layer.
Historical Wetlands (Biophysical Settings)	Biophysical Settings layer represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime. See http://www.landfire.gov/NationalProductDescriptions20.php for further documentation. Map layer was provided by NatureServe.
Historical Wetlands (hydric soils)	Soil survey data was downloaded for the study area. Hydric soils were clipped from these datasets to create this layer. Online: http://soildatamart.nrcs.usda.gov/
Important Bird Areas	Map represents sites determined by Audubon Society as vital to birds and other biodiversity. Map layer was provided by Idaho Department of Fish and Game.
Lake Pend Oreille	Extent of Lake Pend Oreille was clipped from National Wetland Inventory digital layer.
Project Boundaries	Created for this project using ArcMap 9.2
Wetlands Lost (Ecological Systems)	Created for this project using ArcMap 9.2. The Historical Wetlands (Biophysical Settings) map layer was clipped using the Current Wetlands (Ecological Systems) layer. The remaining polygons represent those historical wetlands lost from the contemporary landscape.
Wetland Lost (NWI)	Created for this project using ArcMap 9.2. The Historical Wetlands (Hydric Soils) map layer was clipped using the Current Wetlands (NWI overlay on hydric soils) layer. The remaining polygons represent those historical wetlands lost from the contemporary landscape. See note below regarding use of NWI subset.
Wetland Conservation Sites	Represents those wetlands considered to be of significant by the Idaho Conservation Data Center due to their unique biodiversity and/or ecological integrity. Map layer was provided by Idaho Department of Fish and Game.
Wetland Priority Area (2005)	Represents those wetlands which meet three criteria: (1) support rare or declining wetland types; (2) experience a high level of threats to wetland functions; and (3) represent a diversity or high levels of important functions and values (including recreation), or especially high value for specific function (Hahn et al. 2005). Map layer was provided by Idaho Department of Fish and Game.

1 These GIS data layers are included as attachments with this report.

dominated by emergent herbaceous angiosperms; (4) Scrub-Shrub Wetland, dominated by shrubs or small trees; and (5) Forested Wetland, dominated by large trees. Additional modifiers are used in the Cowardin classification. However, for this project the classification units were grouped based on Systems and Classes.

2.2.2 Ecological Systems

The Ecological Systems classification (Comer et al. 2003) integrates vegetation with natural disturbance dynamics, soils, hydrology, landscape setting, and other ecological processes. Specifically, Ecological Systems are "a group of existing plant community types that tend to co-occur within landscapes sharing similar ecological processes, substrates, and/or environmental gradients" (Comer et al. 2003). Ecological system types facilitate mapping at meso-scales (1:24,000 – 1:100,000; Comer and Schulz 2007) and a comprehensive ecological systems map exists for the United States (http://www.natureserve.org/getData/USecologyData.jsp). Ecological systems have formed the basis for national mapping efforts, including the inter-agency LANDFIRE (www.landfire.gov) and Gap Analysis Program (http://gapanalysis.nbii.gov/portal/server.pt). NatureServe has combined results of these efforts into a national map. Ecological systems meet several important needs for conservation, management and restoration, because they provide:

- an integrated approach that is effective at constraining both biotic and abiotic variability within one classification unit.
- comprehensive maps of all ecological system types.
- explicit links to the U.S. National Vegetation Classification (FGDC 2008), facilitating crosswalks of both mapping and classifications.

The two wetland and riparian Ecological Systems found in the study area are the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland and Northern Rocky Mountain Conifer Swamp. Although not mapped, Rocky Mountain Subalpine-Montane Fens and Rocky Mountain Alpine-Montane Wet Meadows (includes marshes) are also found in the study area. Due to their small-scale these ecological systems were lumped into either the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland system (if located in riparian environments) or Northern Rocky Mountain Conifer Swamp (if outside riparian environments).

2.2.3 Need and Integration of Two Classification Schemes

Each of the classification schemes (and their corresponding map layers) has distinct advantages and disadvantages. Ecological Systems provide an ecoregional-specific classification unit which makes biodiversity and ecological assessments specific to local and regional ecological characteristics. In addition, Ecological Systems served as the map unit for the Biophysical Settings mapping effort (Table 2) by LANDFIRE allowing a straightforward comparison of current and historical extent of wetlands in the study area. The disadvantage to the Ecological Systems classification is that the map is based on an ecological model using data associated with vegetation cover (i.e. remotely sensed imagery), topography, soils, disturbance regimes, hydrology, etc. As a result of the modeling effort, many of the smaller Ecological Systems are often difficult to distinguish due to the scale at which distinguishing ecological processes occur on the ground versus the scale at which the map was modeled. The result is that some of the wetland types which occur in the study area (Rocky Mountain Subalpine-Montane Fens and Rocky Mountain Alpine-Montane Wet Meadows) are not represented in the Ecological Systems GIS layer.

The National Wetland Inventory (NWI) classification and associated maps are one of the standard wetland classification schemes used by wetland scientists, planners, and regulators throughout the United States. The NWI maps differ from Ecological Systems in that aerial photography, in lieu of ecological modeling, is used to delineate wetland polygons. The disadvantage of the NWI is that the classification units are not specific to local biodiversity and ecological processes but rather reflect broad-scale landform, hydrological, and vegetation patterns.

Based on a cursory reconnaissance field trip to the study area, the Ecological Systems map appeared to over-represent the extent of current wetlands and riparian areas. In addition, the Ecological System map either missed many of the smaller wetland types or classified them into one of the two wetland/riparian types in the map legend (Table 2). In contrast, the National Wetland Inventory maps appear to under-represent the extent of wetlands in many areas but were able to distinguish more physiognomic differences in vegetation cover. However, field work conducted by Idaho Department of Fish and Game (IDFG) found that NWI over-represented Palustrine Emergent Marsh polygons, which were often relatively dry hay fields and pastures (Chris Murphy, IDFG, personal communication). Additionally, IDFG found that NWI may have under-represented Palustrine Forested Wetlands due to the difficulties in distinguishing wet conifer forest from upland forest (Chris Murphy, IDFG, personal communication). The conclusions drawn from field work conducted for this project are not based on a systematic accuracy assessment of each map rather are based on a four-day reconnaissance field trip comparing the two wetland maps (Ecological Systems and NWI) with the location of wetlands on the ground. Utilizing both classification schemes and maps for determining change in wetland extent provides two independent estimates of wetland loss in the study area. Given that Ecological Systems appear to over-represent while NWI seems to under-represent, the use of both maps provides a range of wetland loss.

Because the underlying classification of the two GIS methods employed varied, *ad hoc* categories were used to cross-walk between the two classification schemes. These categories included Riparian, Wetland, and Open Water. The relationship between the two classification schemes and these *ad hoc* categories are shown in Table 3.

2.3 Determining Change in Extent

Three different methods were used to estimate wetland loss from their historical extent: (1) comparison of Ecological Systems map (current extent of wetlands) with the Biophysical Setting map (historical extent of wetlands); (2) comparison of National Wetland Inventory maps (current extent of wetlands) with hydric soil maps (historical extent); and (3) compilation of data from construction and operational losses associated with Albeni Falls Dam. Each of these approaches is described in more detail below.

Table 3. Integration of Cowardin and Ecological Systems Classification

	Merged Categories		
Original Classification	Riparian	Wetland	Open Water
National Wetland Inventory			
Palustrine Freshwater Emergent Wetland		**X**	
Palustrine Freshwater Forested/Shrub Wetland	**X**		
Palustrine Freshwater Pond		**X**	
Riverine	**X**		
Lacustrine			**X**
Ecological Systems			
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	**X**		
Northern Rocky Mountain Conifer Swamp		**X**	
Open Water			**X**

2.3.1. Method 1: Ecological Systems vs. Biophysical Settings

Two map layers were used for this analysis: (1) Ecological Systems of the United States and (2) Biophysical Settings. The former represent the current distribution of Ecological Systems (Comer et al. 2003) on the landscape (i.e., Current Wetlands (Ecological Systems) shapefile). The map is a result of ecological modeling using remote sensing imagery of vegetation patterns along with biophysical variables such as elevation, landform, surface geology, soils, and hydrography (Comer et al. 2003). The model fits the data into the *a priori* defined Ecological System types to define and label distinct units on the landscape. The Biophysical Settings layer (i.e., Historical Wetlands (Biophysical Settings) shapefile) represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime. The map units in the Biophysical Layer are Ecological Systems, however LANDFIRE's use of these classification units differs from their intended use as units of existing vegetation. In the Biophysical Setting layer, the map units represent the natural plant communities that may have been present prior to Euro-American settlement. The Biophysical Settings concept is similar to the concept of potential natural vegetation groups.

The Ecological Systems layer has mapped the Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland Ecological System as occurring in the study area. This is a mislabeling error and these map units are included in the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland.

The Biophysical Settings layer mapped riparian areas as Inter-Montane Basins Riparian Systems, Rocky Mountain Riparian Systems, and Rocky Mountain Subalpine/Upper Montane Riparian Systems. These were all lumped as Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland for data analysis.

To determine the amount of wetland loss in the study area, the Ecological Systems and Biophysical Settings maps were clipped to extent of the study area. The clipped layers were then compared to determine the difference. Thus, the extent of wetlands in the Current Wetlands (Ecological Systems) shapefile subtracted from the extent of wetlands in the Historical Wetlands (Biophysical Settings) shapefile equals the amount of wetlands lost in the study area (i.e., the Wetlands Lost (Ecological Systems) shapefile). This estimate of wetland loss should account for most types of stressors and impacts, excluding losses associated with the construction of Albeni Falls Dam, such as conversion to agriculture, urban and rural development, road construction, etc.

Both the Ecological Systems and Biophysical Settings maps are derived from models of ecological patterns. In addition, no systematic accuracy assessment has been conducted for either of these layers in the study area. Thus, the errors associated with classification and delineation of each map unit is unknown and use of the maps and conclusions from this analysis should be used conservatively. As mentioned above, field work associated with this project suggested that these layers overestimate the extent of wetlands and riparian areas in the study area. Finally, the comparison of these two maps layers represents change from historical conditions (pre-European settlement) to the time at which remote imagery was taken (between 1999-2002).

2.3.2 Method 2: National Wetland Inventory Maps vs. Hydric Soils

National Wetland Inventory (NWI) maps and hydric soil maps were used for the second analysis of wetland loss. The NWI layer (i.e., the Current Wetlands (NWI) shapefile) represents the current distribution of wetlands in the study area (between 1977 and the present). NWI maps were developed by delineating wetland and riparian map units using aerial photography. The hydric soil layer (i.e., the Historical Wetlands (hydric soils) shapefile) is a subset of the soil survey data for the study area, which were downloaded from the National Resource Conservation Service's SSURGO database (http://soildatamart.nrcs.usda.gov/). This map layer was used as a surrogate for the historical extent of wetlands in the study area. Hydric soils were not available for the southern portion of the study area (Figure 1). However, given that this area has very few wetlands, errors associated with this data gap are likely minimal.

The NWI layer mapped wetlands beyond the extent of the hydric soil layer. This may be due to the fact that the Partially Hydric soil map units (e.g., somewhat poorly drained soil types), which extend over a very large portion of the study area into areas which were mostly upland, were not included in the Historical Wetlands (hydric soils) shapefile (e.g., poorly drained and very poorly drained soil types). The NWI polygons which extend beyond the scope of mapped hydric soil are assumed to have not been a loss from historic conditions. However, those areas could represent changes (e.g., wetland creation or enhancement) from historical conditions. Unfortunately, we had no way of assessing this in this study. However, where NWI and Hydric soils do overlap, hydric soils may be a good surrogate of historical conditions.

For this analysis, the loss of historical wetland extent was assessed by first creating a subset of the NWI layer where it overlapped with hydric soils ensuring that the analysis was limited to the extent of both data layers. The NWI subset (i.e., the Current Wetlands (NWI overlay on hydric soils) shapefile) was then subtracted from the Historical Wetlands (hydric soils) shapefile to determine a percent loss from historic wetland extent (i.e., the Wetland Lost (NWI) shapefile).

Field work associated with this project suggested that the NWI maps underestimates the extent of wetlands observed in the field, however this is not based on a systematic accuracy assessment of the NWI maps.

2.3.3 Method 3: Initial and Operational Losses from Operation of Albeni Dam

Wetland loss associated with the construction and operation of Albeni Falls Dam are summarized from the literature. These data do not estimate wetland loss from any other anthropogenic land use or stressor other than those associated with the construction and operation of Albeni Falls Dam.

2.3.4 Accuracy Assessment

No systematic and quantitative accuracy assessment was performed within the project area. Thus, errors associated with misclassification and/or inaccurate delineation of wetland and riparian polygons have not been determined. As such data and conclusions from this report should be used with appropriate caution.

However, a four-day reconnaissance field trip to the study area provided a cursory and coarse assessment of the relative accuracy of each of the various map. The purpose of this field visit was to visit as many different locations within the study area as possible to get a general sense of the mapping accuracy of each data layer as well as an overall characterization of the stressors associated with wetlands in the study area.

2.4 Determining Change in Ecological Condition

Given the lack of detailed data about the historical composition, structure and function of wetlands in the study area, it is difficult to measure how ecological conditions of the various wetland types have changed from their historic or natural range of variation. However, the type and intensity of anthropogenic stressors currently affecting wetlands can be a surrogate measure of ecological change. In other words, those wetlands currently affected by no or minimal human-induced stress are assumed to be functioning within their natural range of variation whereas deviation from the natural range of variation is assumed to occur when wetlands are exposed to increasing degrees of human-induced stress.

In order to determine changes in ecological condition of the study area wetlands, a Landscape Integrity Index was used to estimate current ecological integrity as compared to historical conditions. Although not as accurate as a probabilistic assessment of ecological condition using rapid or intensive assessment methods, a Level 1 assessment (EPA 2006) such as the Landscape Integrity Index provides a cursory assessment of ecological condition using readily available GIS data. In addition to this approach, a brief description of ecological changes is provided as found in the literature.

2.4.1 Baseline Ecological Conditions

Baseline ecological conditions used in this study are predicated on the assumption that prior to Euro-American settlement, all wetlands in the study area were functioning within their natural range of variation. The concept of natural range of variability (NRV) is based on the temporal and spatial range of climatic, edaphic, topographic, and biogeographic conditions under which contemporary ecosystems evolved (Morgan et al. 1994; Quigley and Arbelbide 1997). The NRV delimits the range of ecosystem processes that remain relatively consistent over a specified temporal period (Morgan et al. 1994). Regional climatic regimes have undergone more recent changes than geological parameters, thus the climate under which contemporary biota have evolved is most useful for delineating a temporal limit to the NRV. Whitlock (1992) suggest modern vegetation patterns in the Pacific Northwest began about 5,000 – 1,500 years before present although she notes that climate and vegetation response is constantly shifting. Thus, the NRV is not considered to be static for any given variable but rather a range of responses to climatic fluctuations which have occurred over the past few thousand years.

Another consideration for describing the NRV is the degree to which anthropogenic impacts have altered natural ecosystems. There is disagreement over whether disturbances resulting from Native Americans' interaction with the landscape occurred over spatial and temporal scales in which native flora and fauna were able to adapt (see Vale 1998 and Denevan 1992). The hypothesis offered by Vale (1998), which notes that Native American impacts were not ubiquitous across the landscape, is accepted for this project. Furthermore, where Native American impacts did occur (i.e., intentional burning of ecosystems), it is accepted here that they occurred over spatial and temporal scales in which native biota were able to adapt and thus are included within the NRV (Quigley and Arbelbide 1997; Wilhelm and Masters 1996). European settlement is presumed to have introduced a myriad of land uses and impacts that, because of their intensity, frequency, and duration were novel changes to the ecological template upon which most contemporary ecosystems evolved.

Thus, for this project baseline ecological conditions are assumed to be those wetlands with minimal impact from land uses associated with post-European settlement. The Landscape Integrity Index can show which portions of the landscape deviate from baseline conditions.

2.4.2 Current Ecological Conditions

A Landscape Integrity Index (Comer and Hak 2009) was used to determine current ecological conditions of wetlands in the study area. This index is similar to the Landscape Development Intensity Index (Brown and Vivas 2005), human footprint model (Leu et al. 2008), and anthropogenic stress model (Danz et al. 2007). The Landscape Integrity Index integrates various land use GIS layers (roads, land cover, water diversions, groundwater wells, dams, mines, etc.) at a 30-90 m or 1 km pixel scale (Tuffly and Comer 2005, Comer and Hak 2009). These layers are the basis for various stressor-based metrics. The metrics are weighted according to their perceived impact on ecological integrity, into a distance-based, decay function to determine what effect these stressors have on landscape integrity (see Comer and Hak 2009 for more detail). The result is that each grid-cell (30 m or more) is assigned a stressor “score”. The product is a landscape or watershed map depicting areas according to their potential “integrity.” Stressor scores are categorized into ecological integrity rank classes, from Excellent/Good (stressor score > 0.8) to Fair (stressor score 0.65 – 0.79) and Poor integrity (<0.65). The Excellent/Good integrity rank represents historical ecological conditions while the Poor integrity rank is reflective of conditions that are severely deviated from historical ecological conditions.

To determine changes in ecological condition of the study area wetlands, the Landscape Integrity Index was used to determine overall ecological condition of the study area. This was done by first overlaying the Landscape Integrity Index grid over the Current Wetland Extent (Ecological Systems) and Current Wetland Extent (NWI) shapefiles. Then, zonal statistics were used to calculate an average Landscape Integrity Index score for each wetland polygon in those layers. These polygons scores were then average for each wetland type in the study area. The latter average scores were then used to assign one of the three ecological integrity ranks to each wetland type. Finally, average Landscape Integrity Index scores were average across all wetland types to obtain an overall ecological integrity rank for all wetland types. This was done for both Ecological Systems and NWI wetland types.

2.5 Determining Restoration Potential and Conservation Significance

2.5.1 Conservation Significance

The conservation or ecological significance of wetlands in the study area is based on previous studies (Jankovsky-Jones 1997, Lichthardt 2004; Hahn et al. 2005) and data from the Idaho Conservation Data Center including Important Bird Areas, Wetland Conservation Sites, and Wetland Priority Areas. Important Bird Areas are sites determined by Audubon Society as vital to birds and other biodiversity. Wetland Conservation Sites are those wetlands considered to be of ecological significance by the Idaho Conservation Data Center due to their unique biodiversity and/or ecological integrity. Wetland Priority Areas are Represents those wetlands which meet three criteria: (1) support rare or declining wetland types; (2) experience a high level of threats to wetland functions; and (3) represent a diversity or high levels of important functions and values (including recreation), or especially high value for specific function (Hahn et al. 2005).

The sites presented in this report are the direct result of efforts by Idaho Conservation Data Center and Idaho Fish and Game. Inquiries about these sites should be directed to those agencies.

2.5.2 Restoration Potential

Identifying restoration potential of each wetland polygon was not feasible with readily available datasets. However, based on recommendations from the literature, restoration potential for some locations in the study area is provided.

3.0 Result and Discussion

3.1 GIS Analysis of Change in Wetland Extent

Estimates of current and historical extent were higher when determined with the Ecological System and Biophysical Settings maps than the National Wetland Inventory and Hydric Soil maps (Figures 3-6; Table 4).

3.1.1 Overall Wetland Loss

Estimated wetland loss varied by the two GIS methods (Table 4). For example, analysis based on Ecological Systems and Biophysical Settings maps suggest overall wetland loss was 35% whereas the National Wetland Inventory and Hydric Soil overlay suggest overall wetland loss to be 43%. Although the two methods differ by 8%, both indicate a substantial loss of the extent of wetlands and riparian areas in the study area (Table 4; Figures 7- 18). The most substantial loss has occurred in the Pack River valley north of the lake (Figures 11-14) and the Clark Fork River Delta (Figures 15 and 16). These two areas also supported the highest concentration of historical wetlands (Figures 3 and 5) and continue to support the highest concentration of existing wetlands (Figures 4 and 6) in the study area.

3.1.2 Loss of Wetland Types

The Ecological System analysis distinguished three wetland types in the study area: (1) Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland; (2) Northern Rocky Mountain Conifer Swamp; and (3) Open Water (Table 4). The Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland was categorized as Riparian while the Northern Rocky Mountain Conifer Swamp was categorized as wetland. Both of these types likely include forested, shrub and herbaceous cover types; however, the data did not allow an analysis of these vegetation groups. The Open Water wetlands include small ponds with aquatic vegetation. Analysis of these three type showed that Wetlands (i.e., Northern Rocky Mountain Conifer Swamps) have experienced a very significant loss (79%) from historic extent (Table 4). Riparian wetlands (i.e., Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland) also suffered substantial loss, with 36% less acreage than historical extent (Table 4). Open Water wetlands have fared much better with only a 2% loss detected from their historical extent (Table 4).

As its name implies, the Hydric Soils map is a depiction of soil types. The accompanying tabular data associated with the Hydric Soil map (i.e., SSURGO data) did not allow each soil unit to be

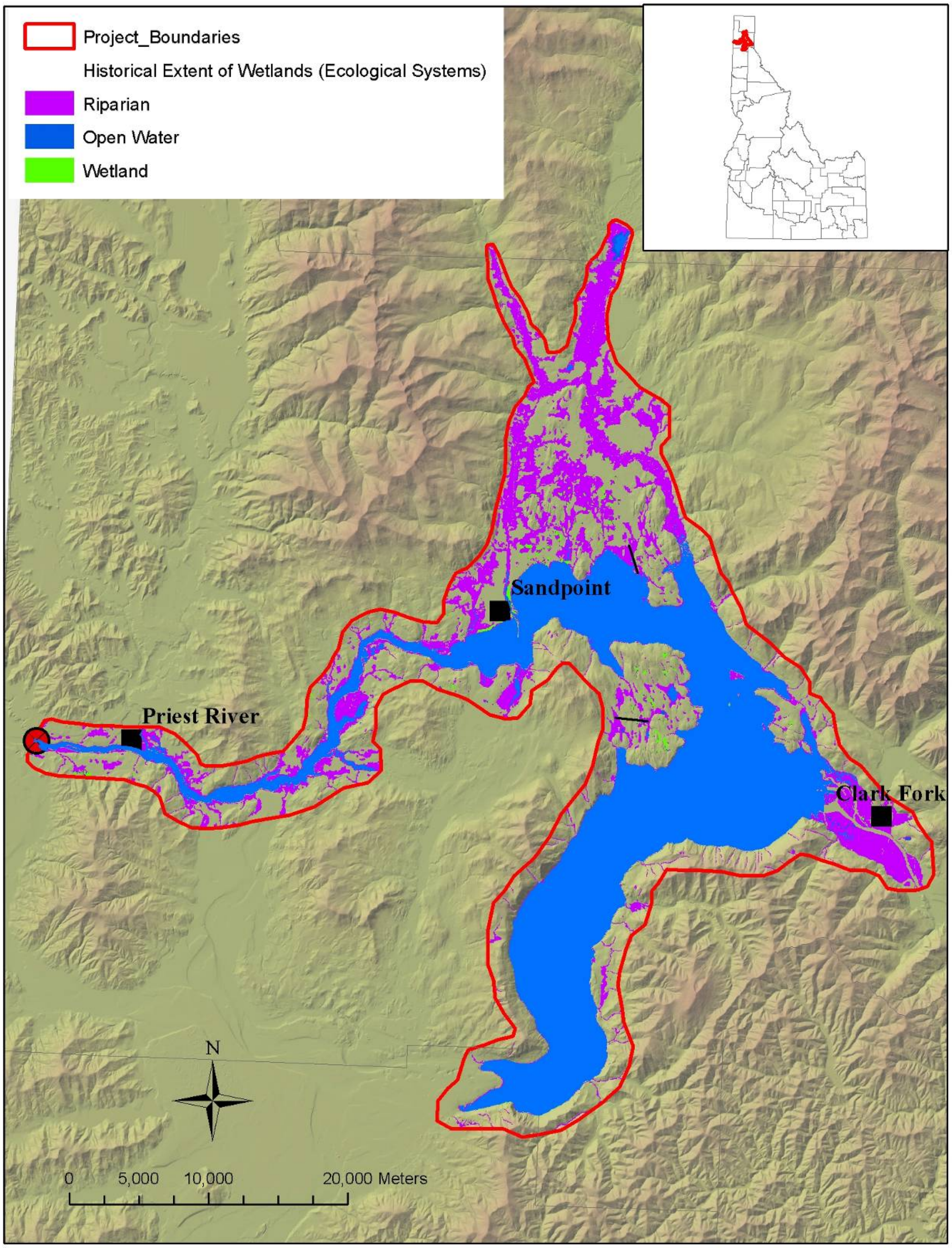


Figure 3. Historical Extent of Wetlands Based on Biophysical Settings Map

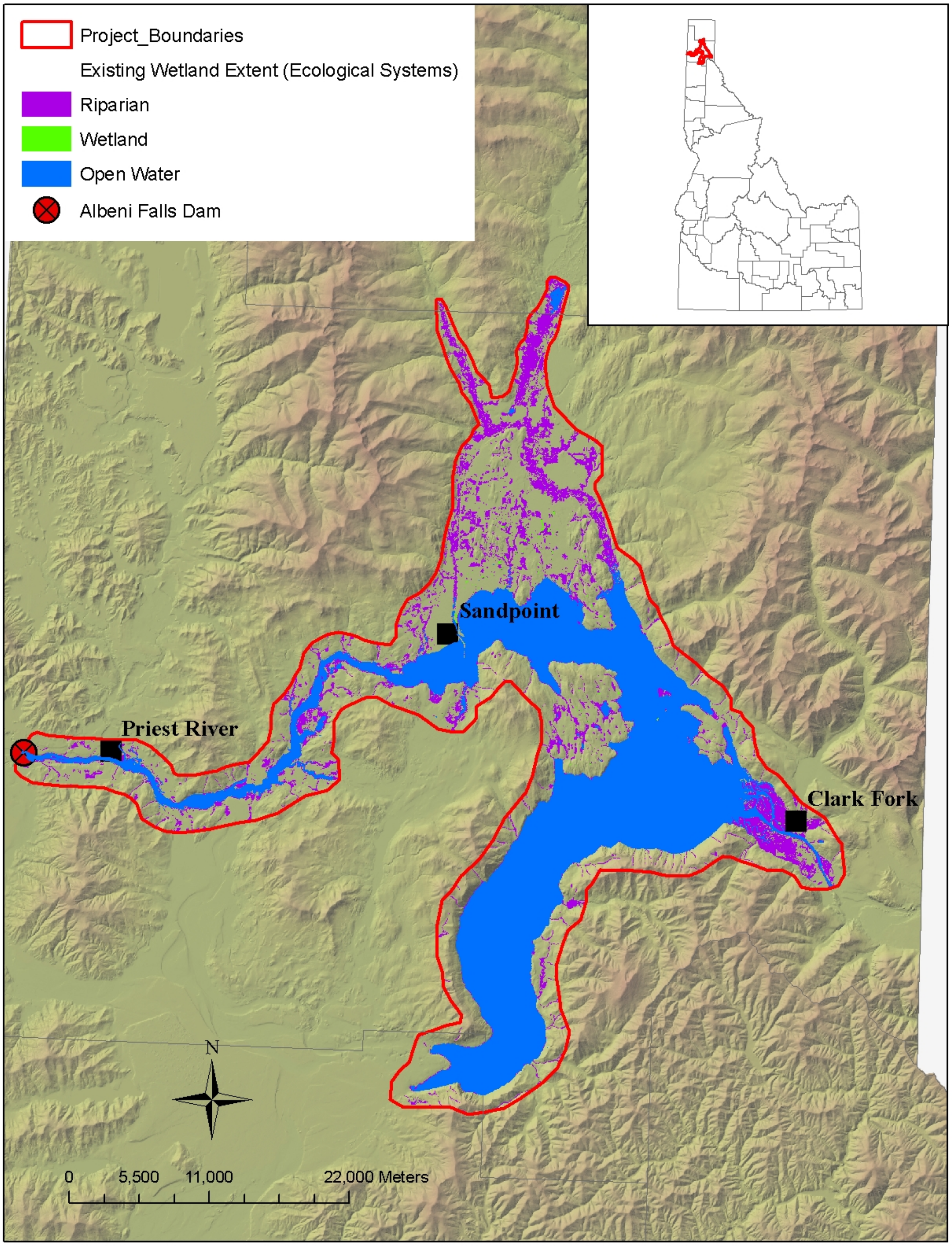


Figure 4. Current Extent of Wetlands Based on Ecological Systems Map

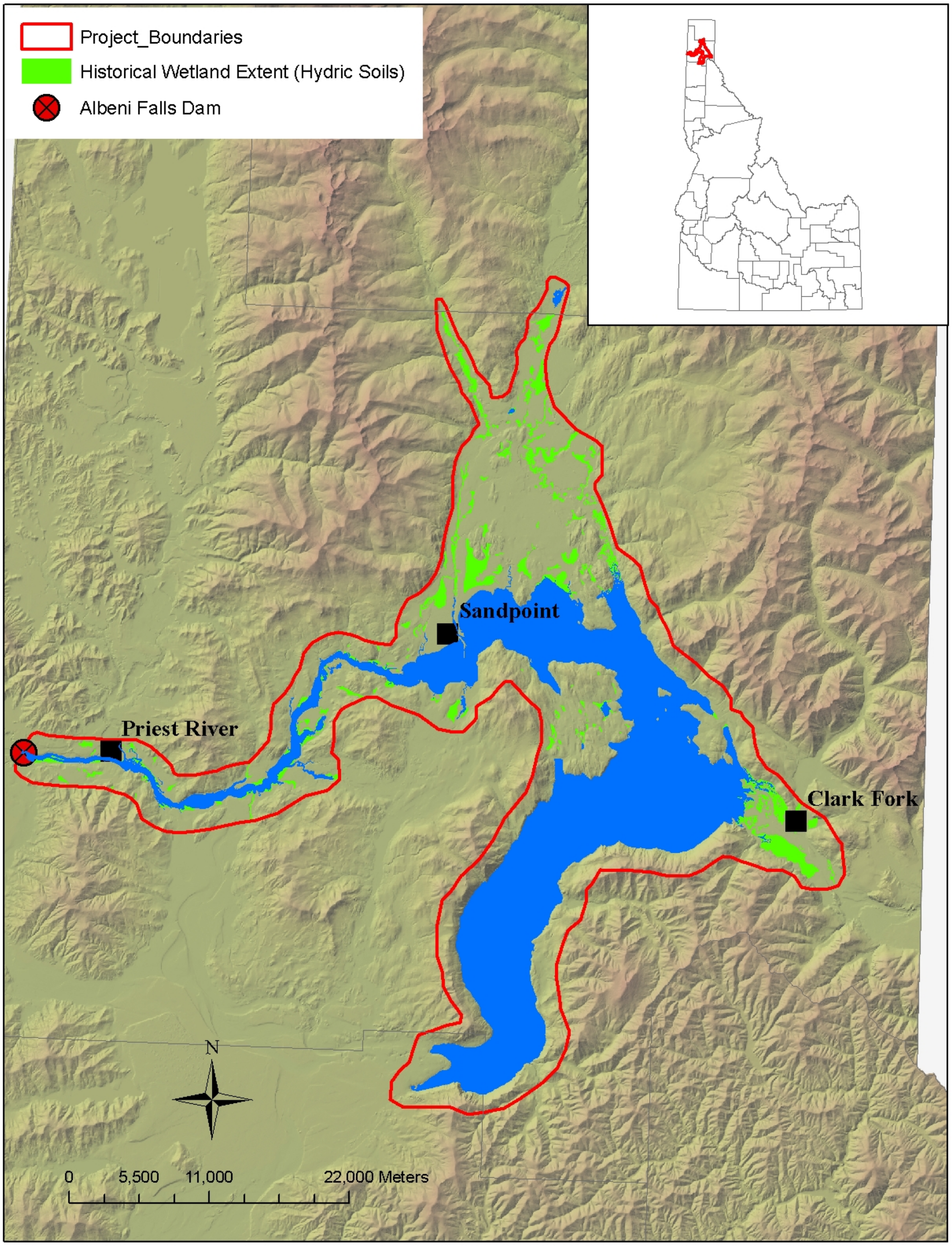


Figure 5. Historical Extent of Wetlands based on Hydric soil Distribution

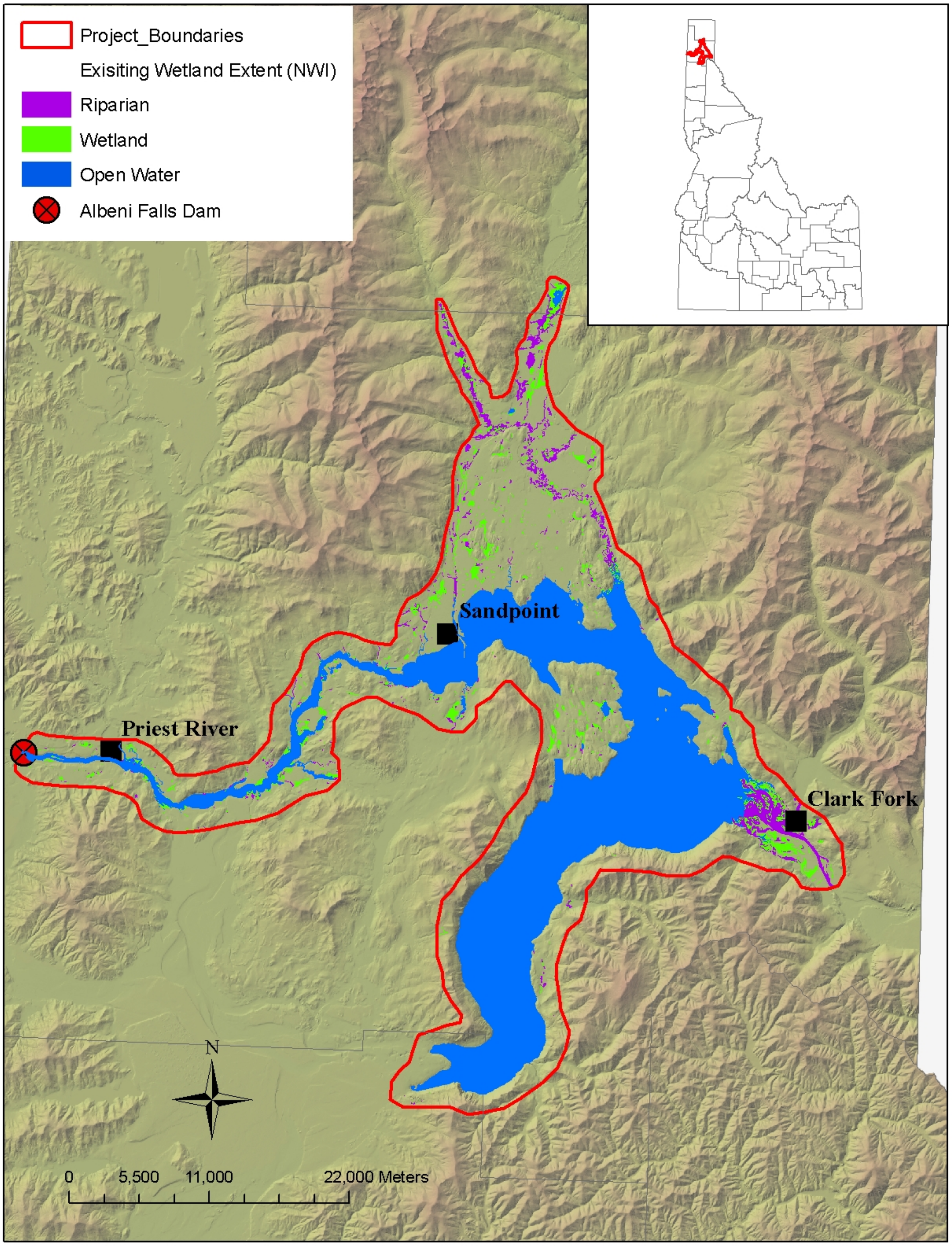


Figure 6. Current Extent of Wetlands Based on National Wetland Inventory Maps

Table 4. Summary of Wetland Loss in the Study Area.

	Ecological Systems/Biophysical Settings Analysis					National Wetland Inventory Maps/Hydric Soils Analysis[2]			
Wetland Type	**Historic (acres)**	**Current (acres)**	**Change (acres)**	**Change (percent)**	**Wetland Type**	**Historic (acres)[3]**	**Current (acres)**	**Change (acres)**	**Change (Percent)**
Riparian	45,553	29,224	-16,329	-36%	Riparian	?	2,879	?	?
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	*45,553*	*29,224*	*-16,329*	*-36%*	*Palustrine Freshwater Forested/Shrub Wetland*	?	*2,548*	?	?
					Riverine	?	*331*	?	?
Wetland	1,773	375	-1,398	-79%	Wetland	?	4,838	?	?
Northern Rocky Mountain Conifer Swamp	*1,773*	*375*	*-1,398*	*-79%*	*Palustrine Freshwater Emergent Wetland*	?	*4,838*	?	?
Open Water[1]	1,432	1,408	-24	-2%	Open Water		329		
					Palustrine Freshwater Pond	?	*131*	?	?
					Lacustrine	?	*198*	?	?
Totals	48,758	31,552	-17,206	-35%	Totals	14,128	8,048	-6,080	-43%

1 The current footprint of Lake Pend Oreille was not included in the analysis as it had the same area in both the Ecological System and Biophysical Settings layers. Thus, the wetland losses estimated do no account for wetlands inundated following the construction of Albeni Falls Dam. Those losses are addressed in Section 3.2

2 Analysis reflects acres of NWI polygons currently overlapping with hydric soil polygons. Total acres for NWI in the study area was 18,408, indicating that many NWI polygons did not intersect the hydric soils layer.

3 Historic wetland extent is based on Hydric Soils which not distinguishable by wetland type. Thus, only total wetland extent is provided.

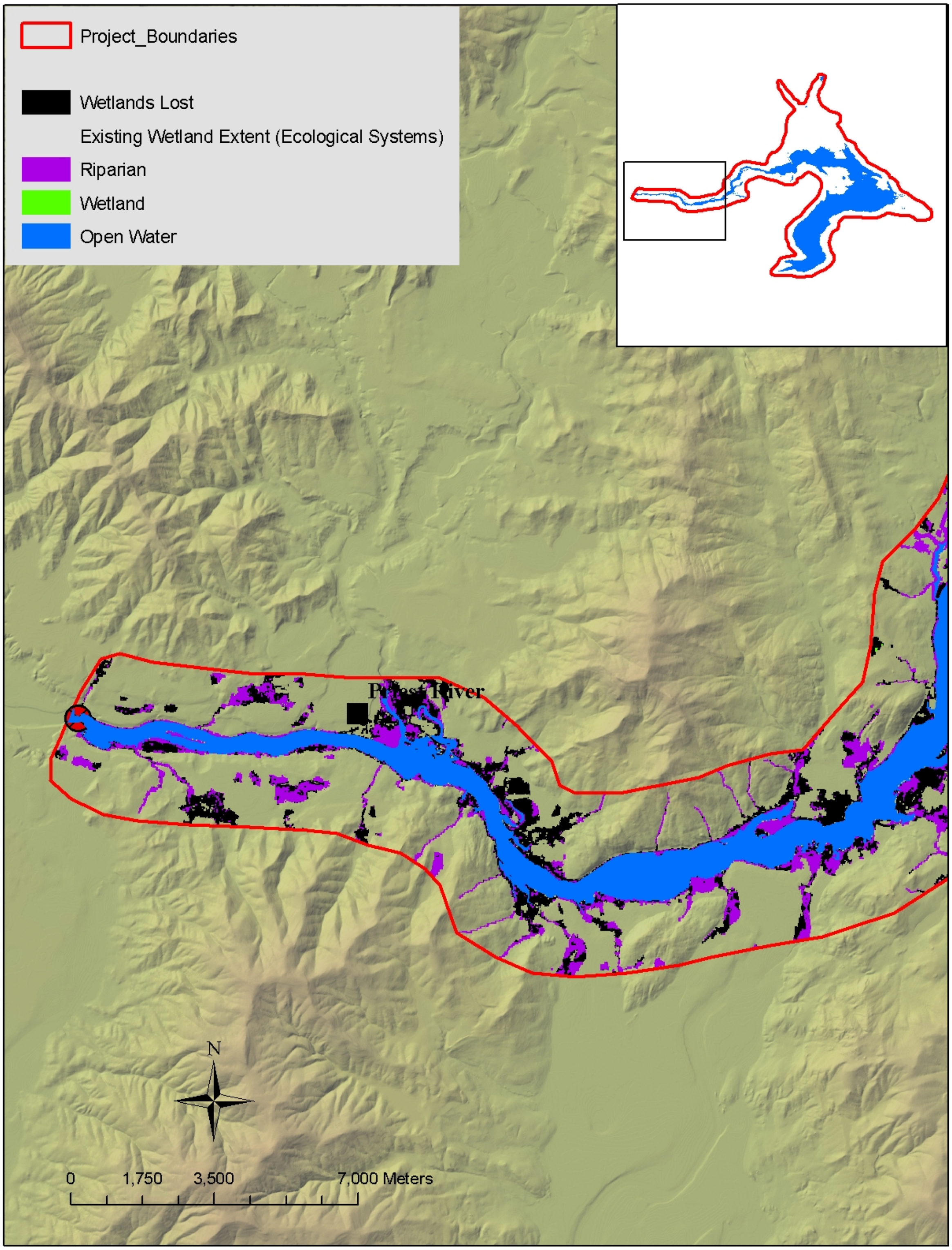


Figure 7. Wetland Loss (Based on Ecological Systems) in the Albeni Falls Dam Area

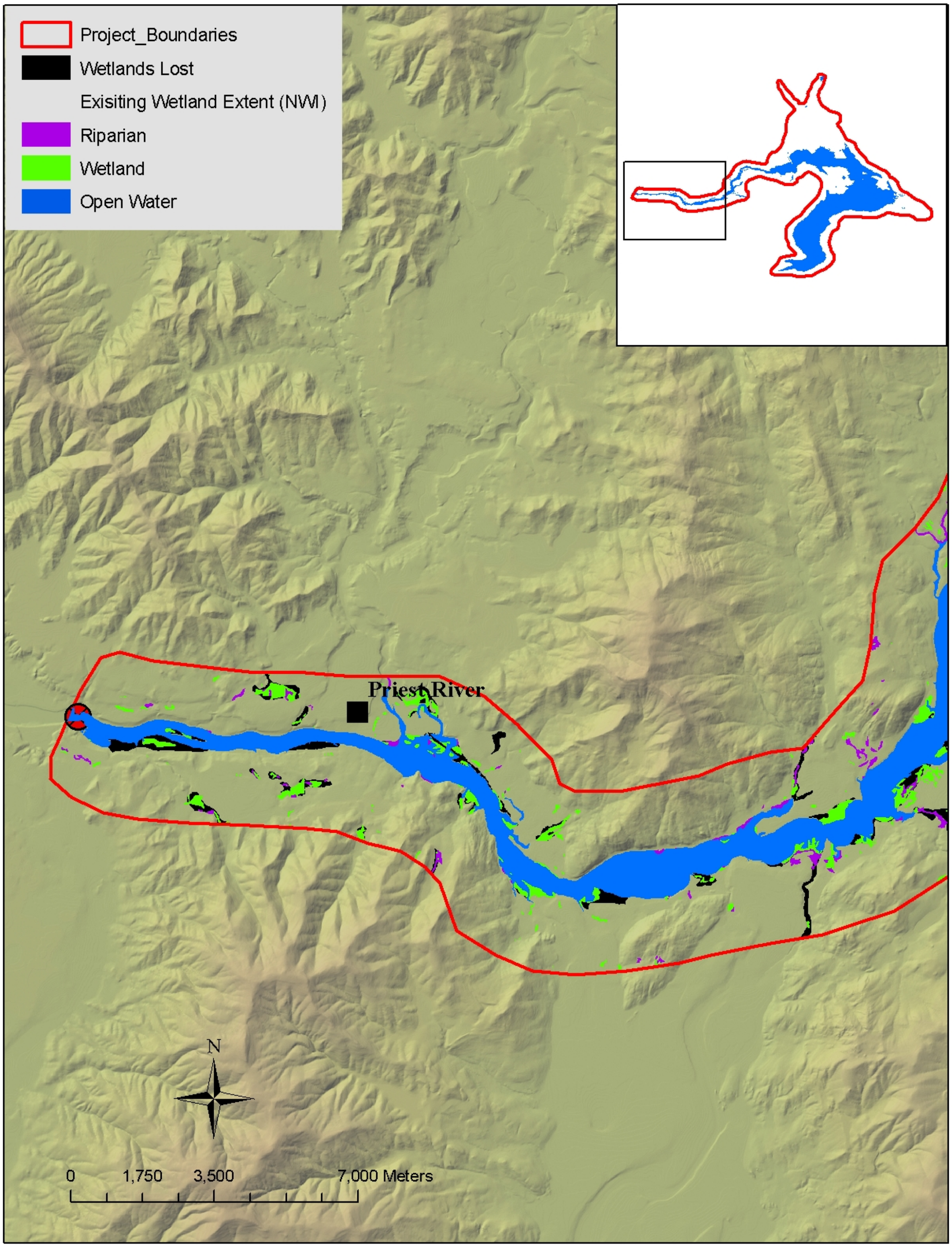


Figure 8. Wetland Loss (Based on NWI) in the Albeni Falls Dam Area

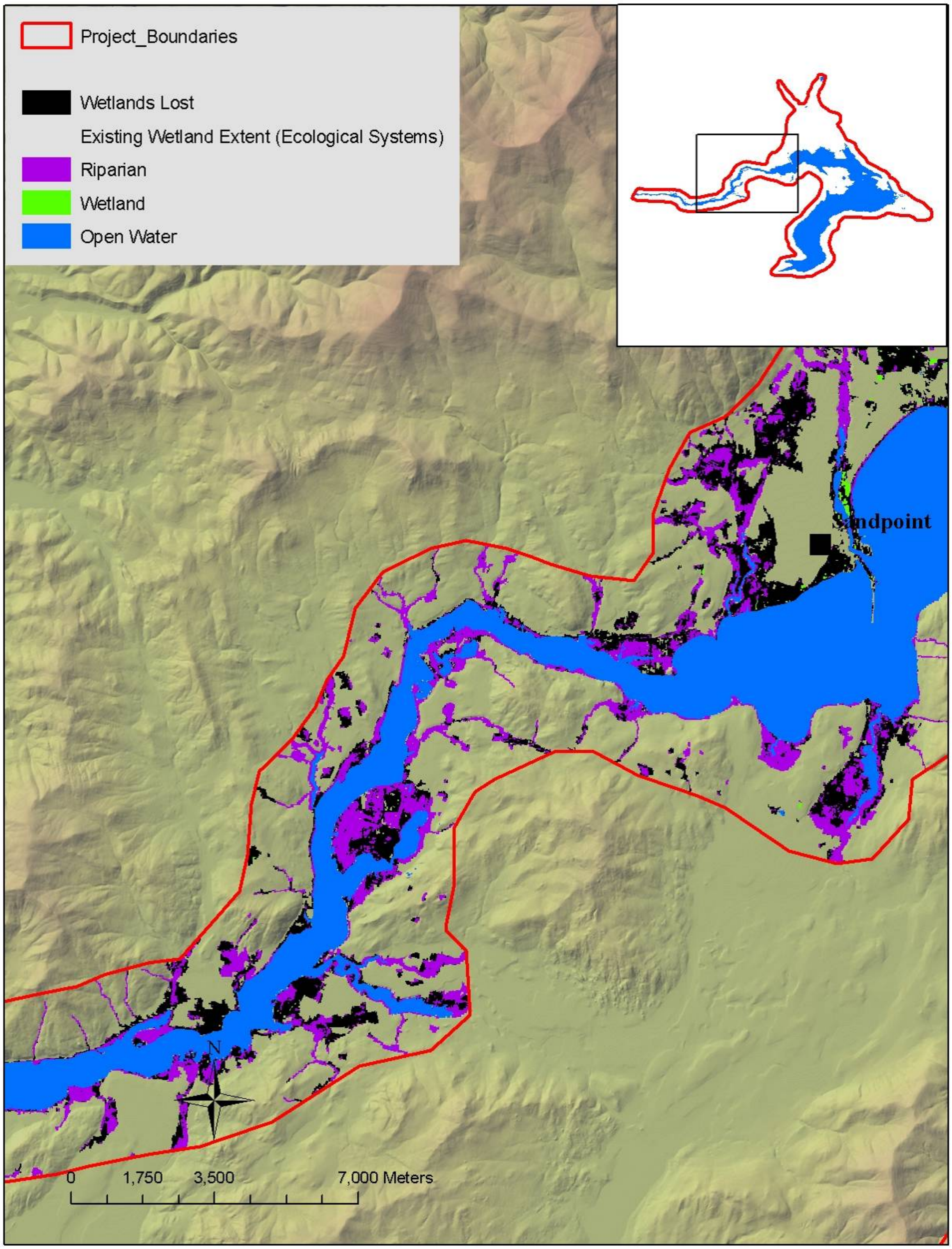


Figure 9. Wetland Loss (Based on Ecological Systems) in the Sandpoint Area.

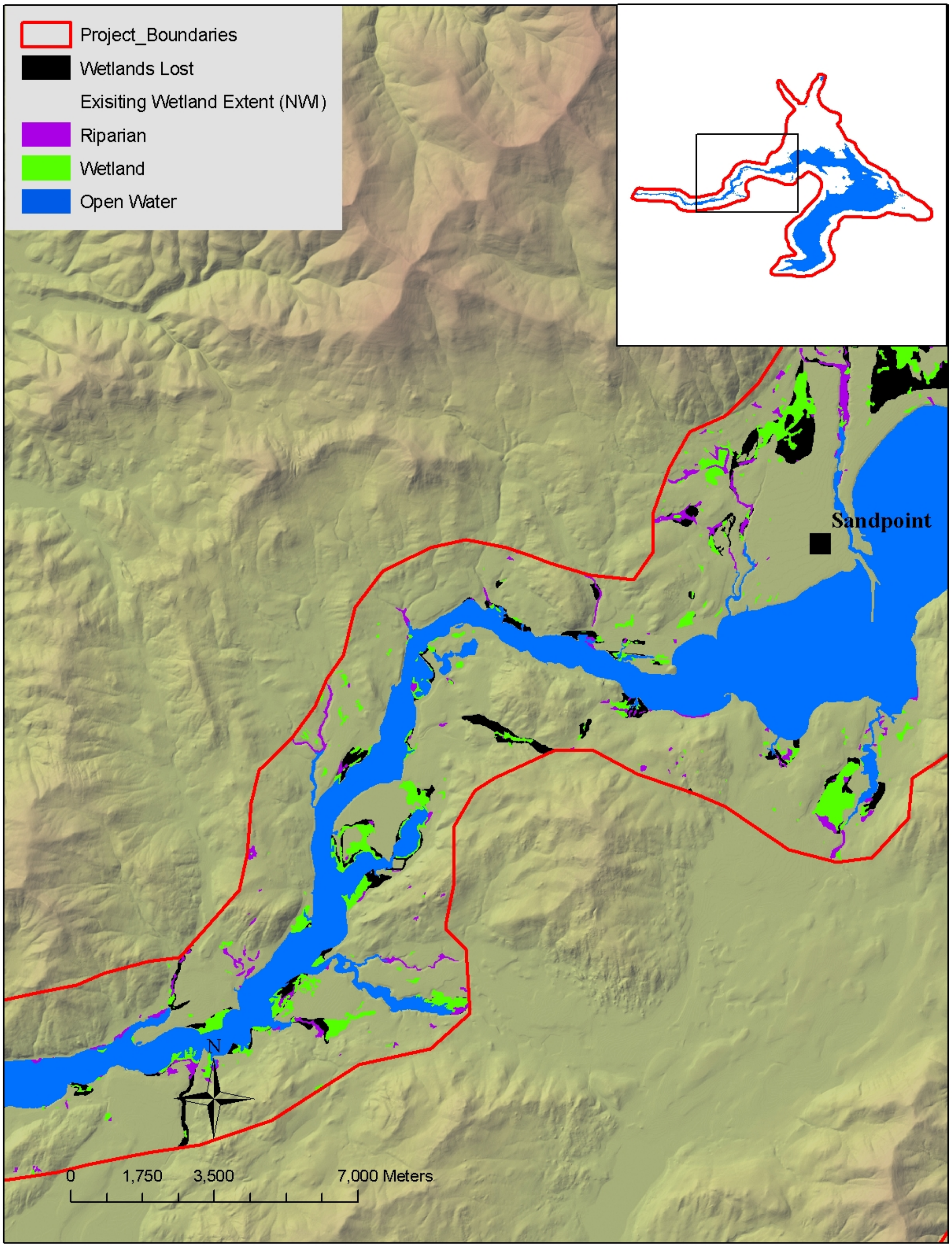


Figure 10. Wetland Loss (Based on NWI) in the Sandpoint Area.

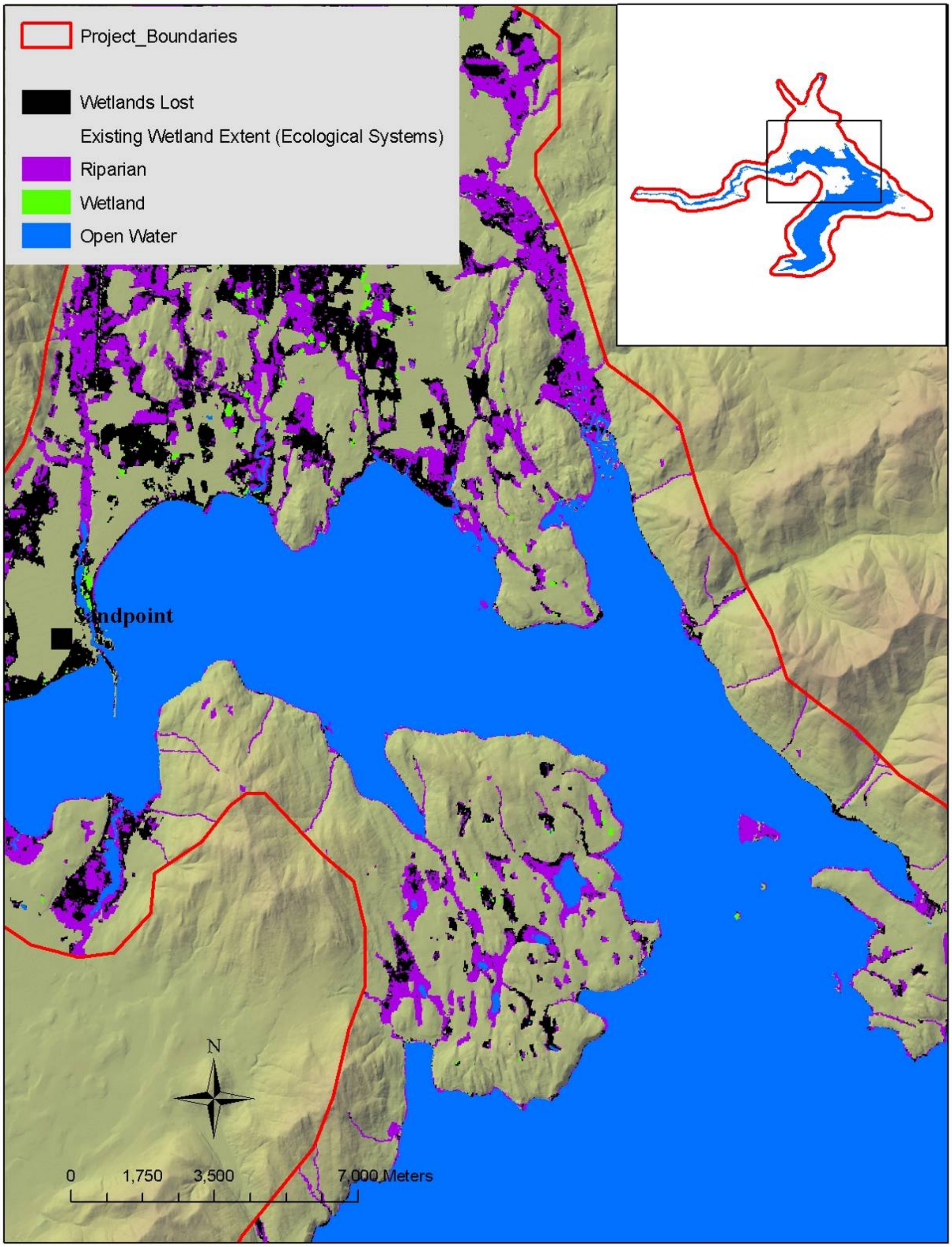


Figure 11. Wetland Loss (Based on Ecological Systems) in the Central Portion of the Study Area.

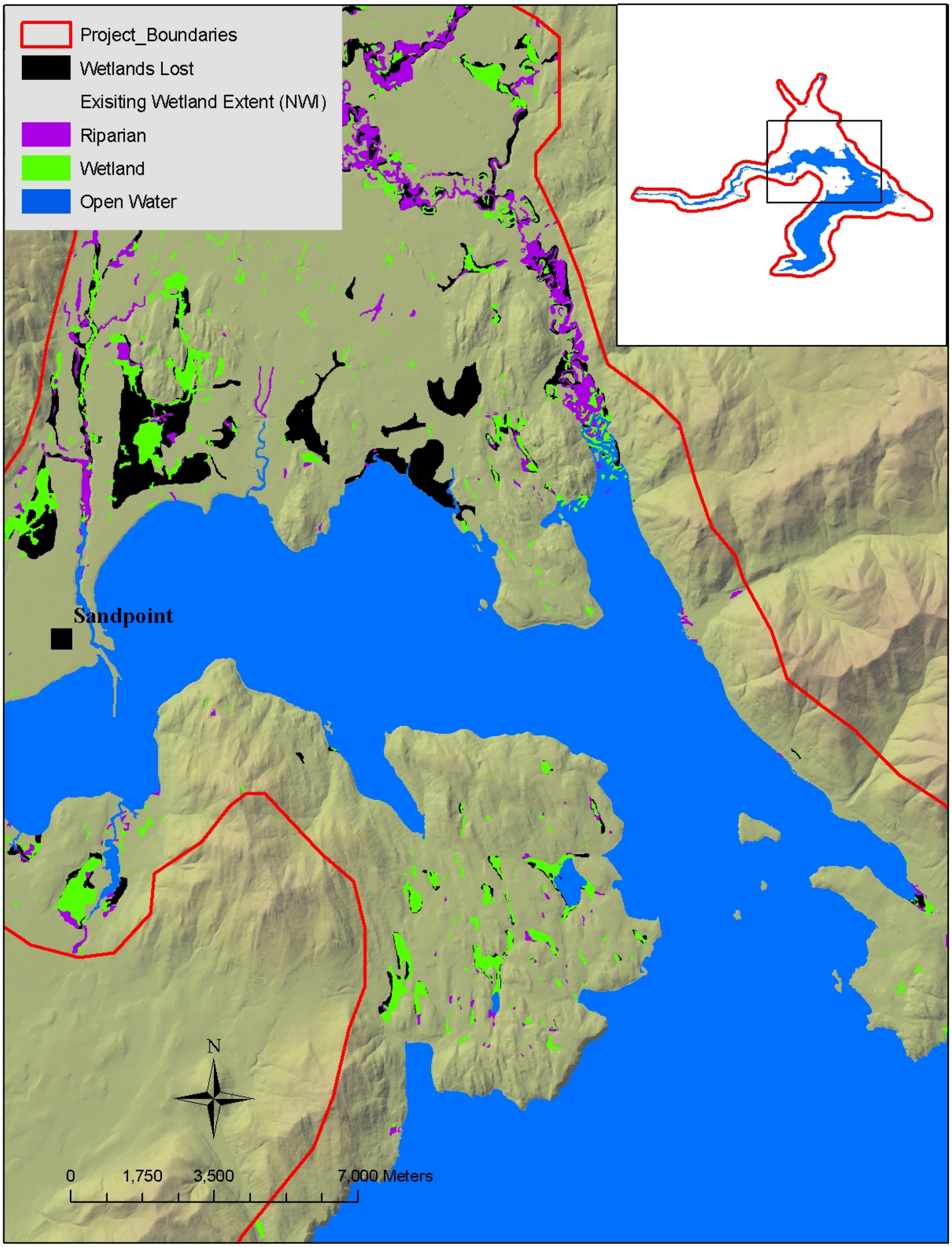


Figure 12. Wetland Loss (Based on NWI) in the Central Portion of the Study Area.

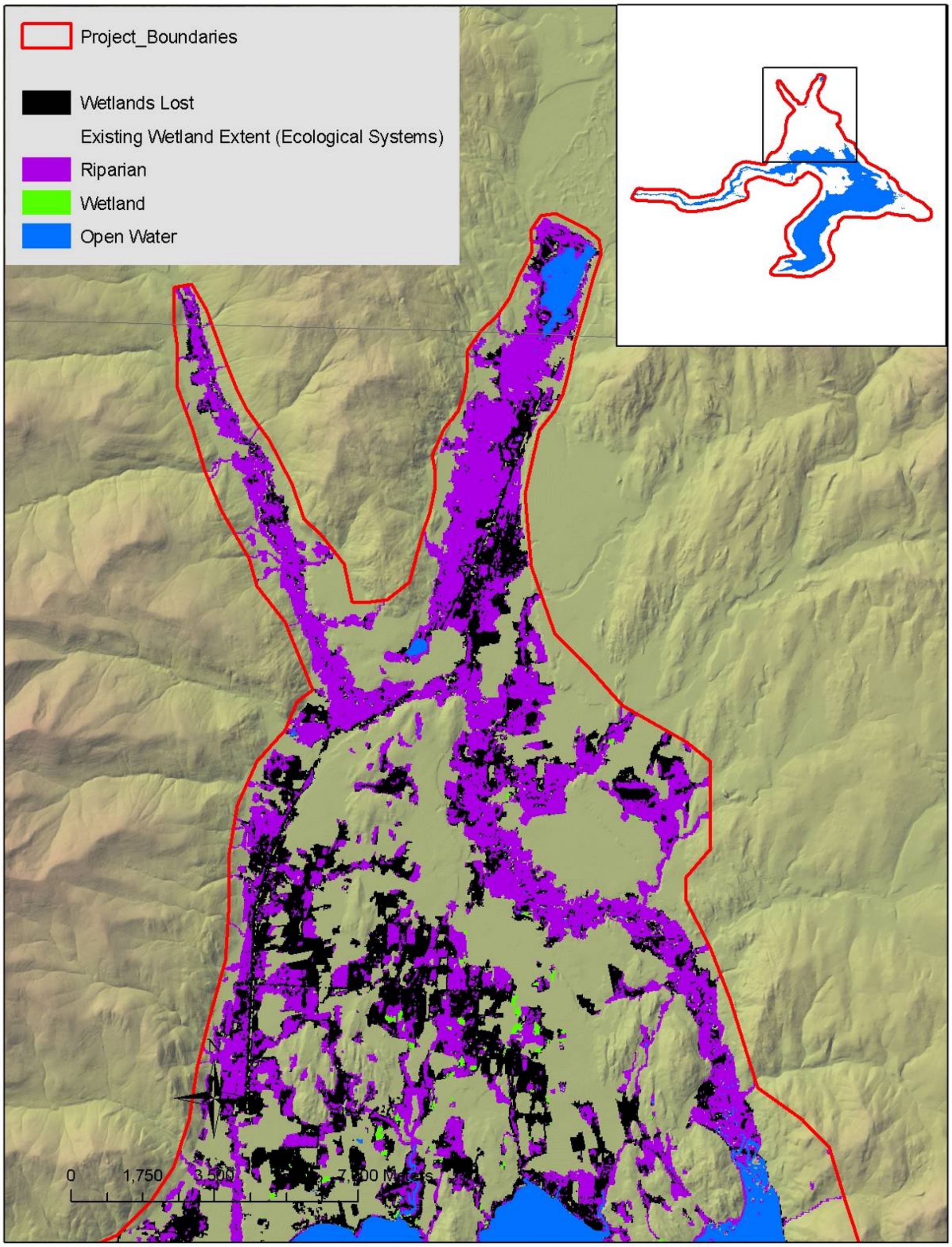


Figure 13. Wetland Loss (Based on Ecological Systems) in the Pack River Area.

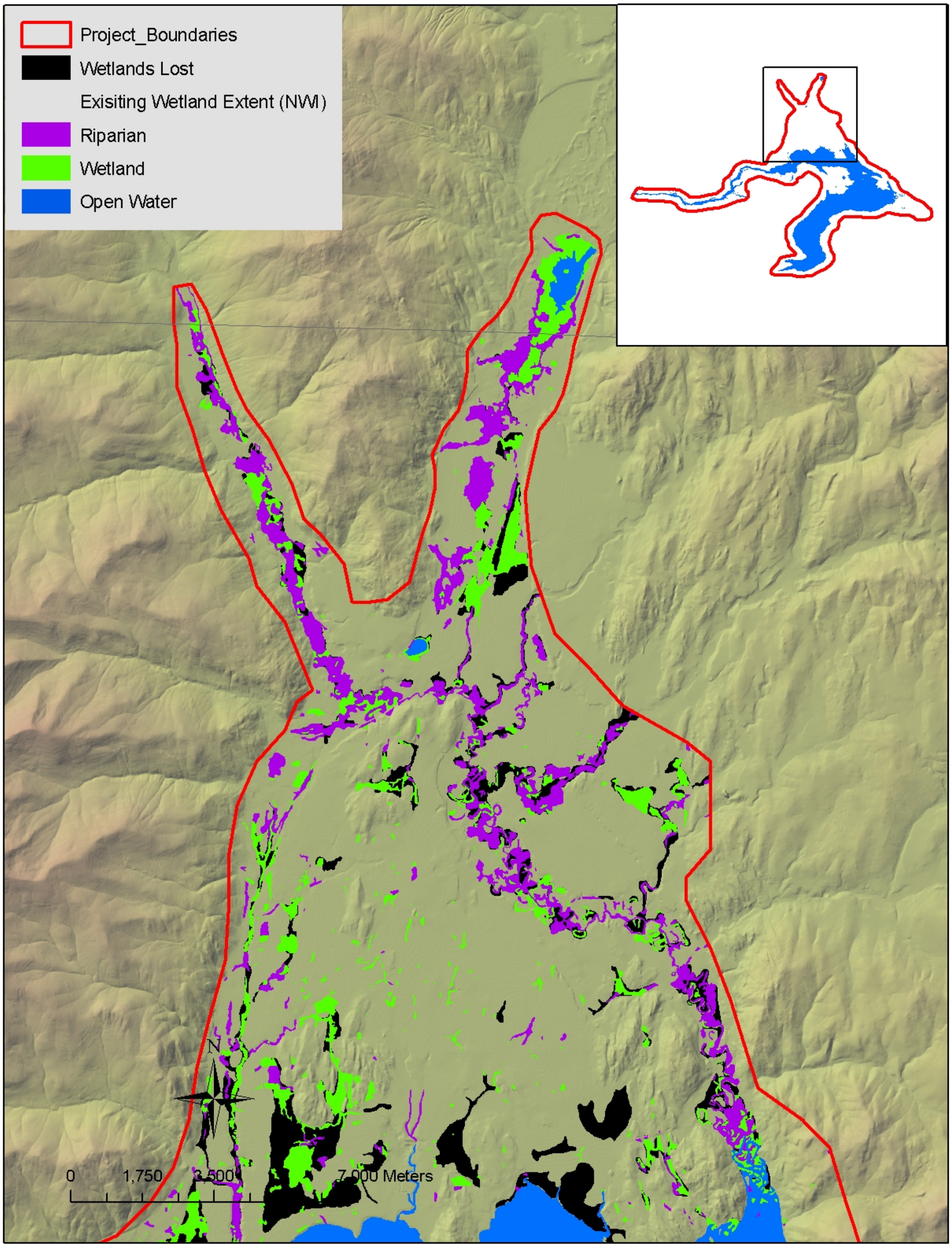


Figure 14. Wetland Loss (Based on NWI) in the Pack River Area.

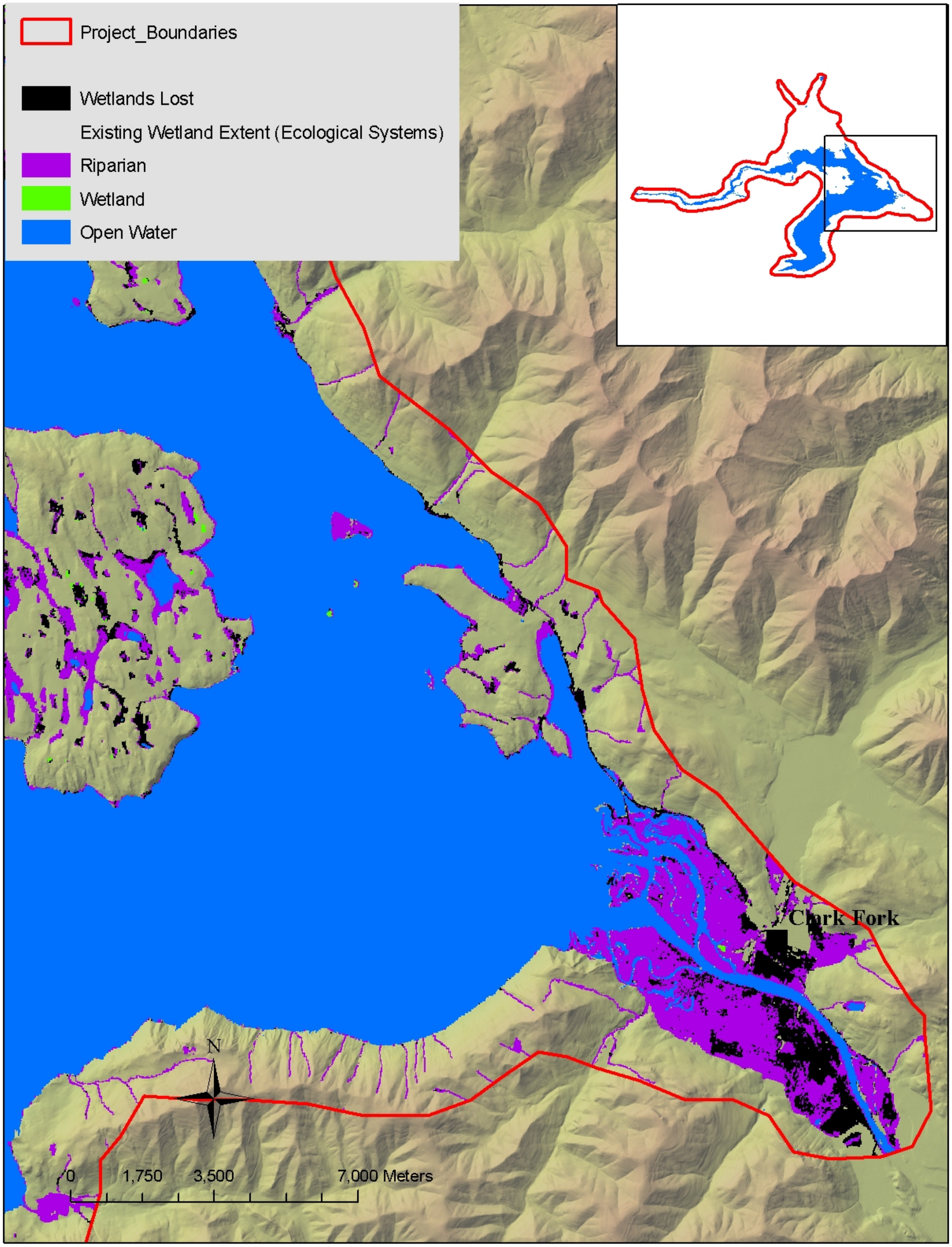


Figure 15. Wetland Loss (Based on Ecological Systems) in the Clark Fork River Delta Area.

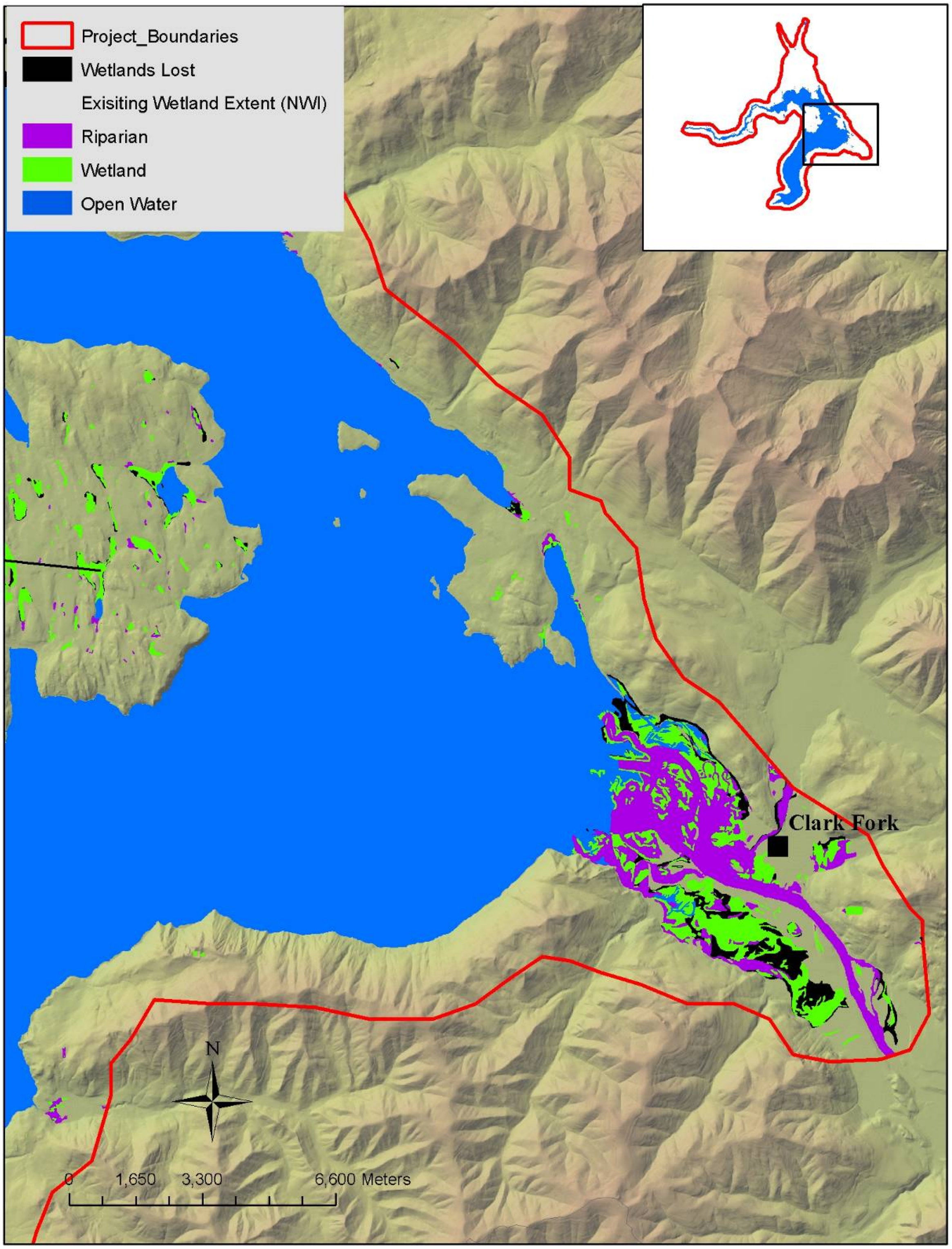


Figure 16. Wetland Loss (Based on NWI) in the Clark Fork River Delta Area.

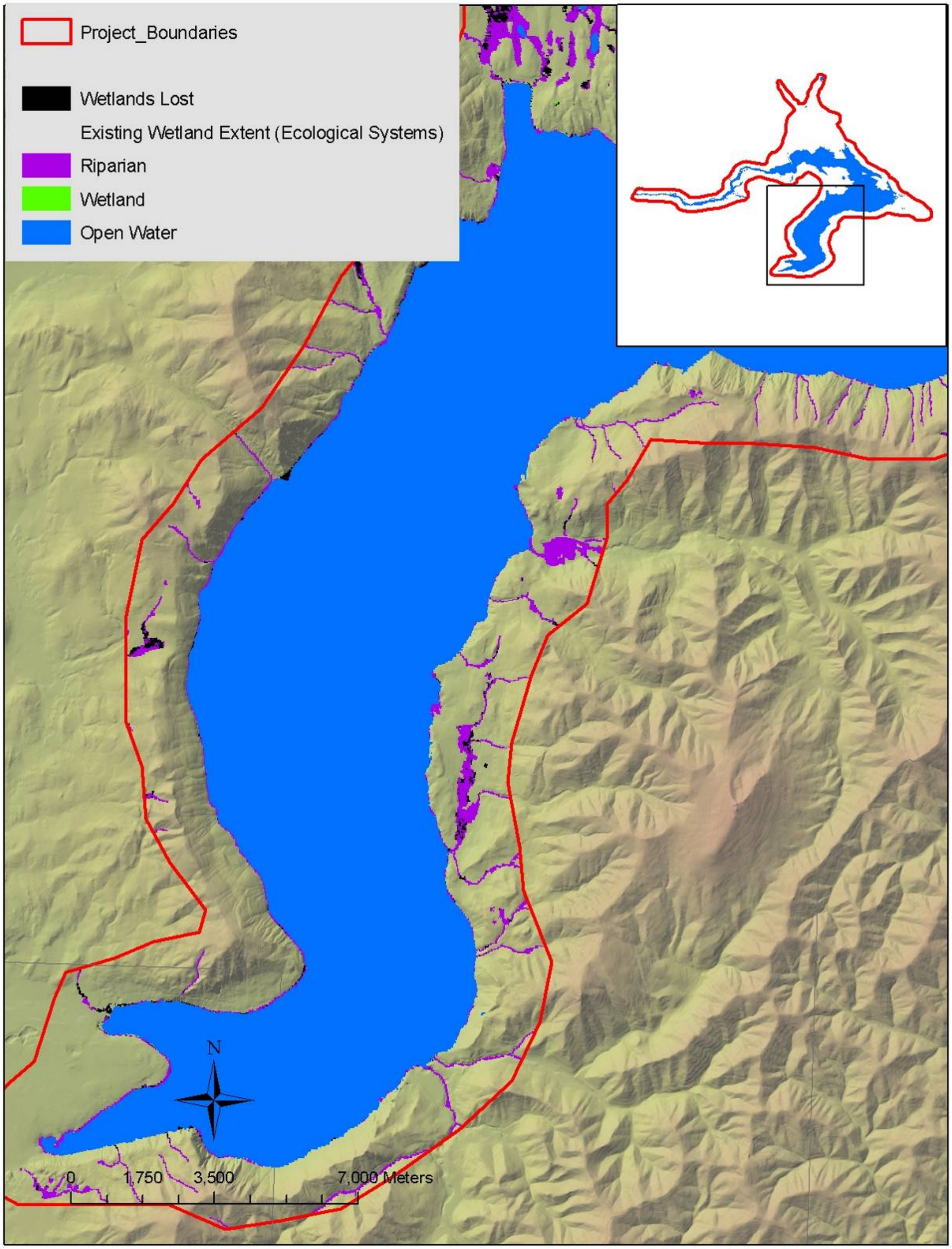


Figure 17. Wetland Loss (Based on Ecological Systems) in the Southern Portion of the Study Area.

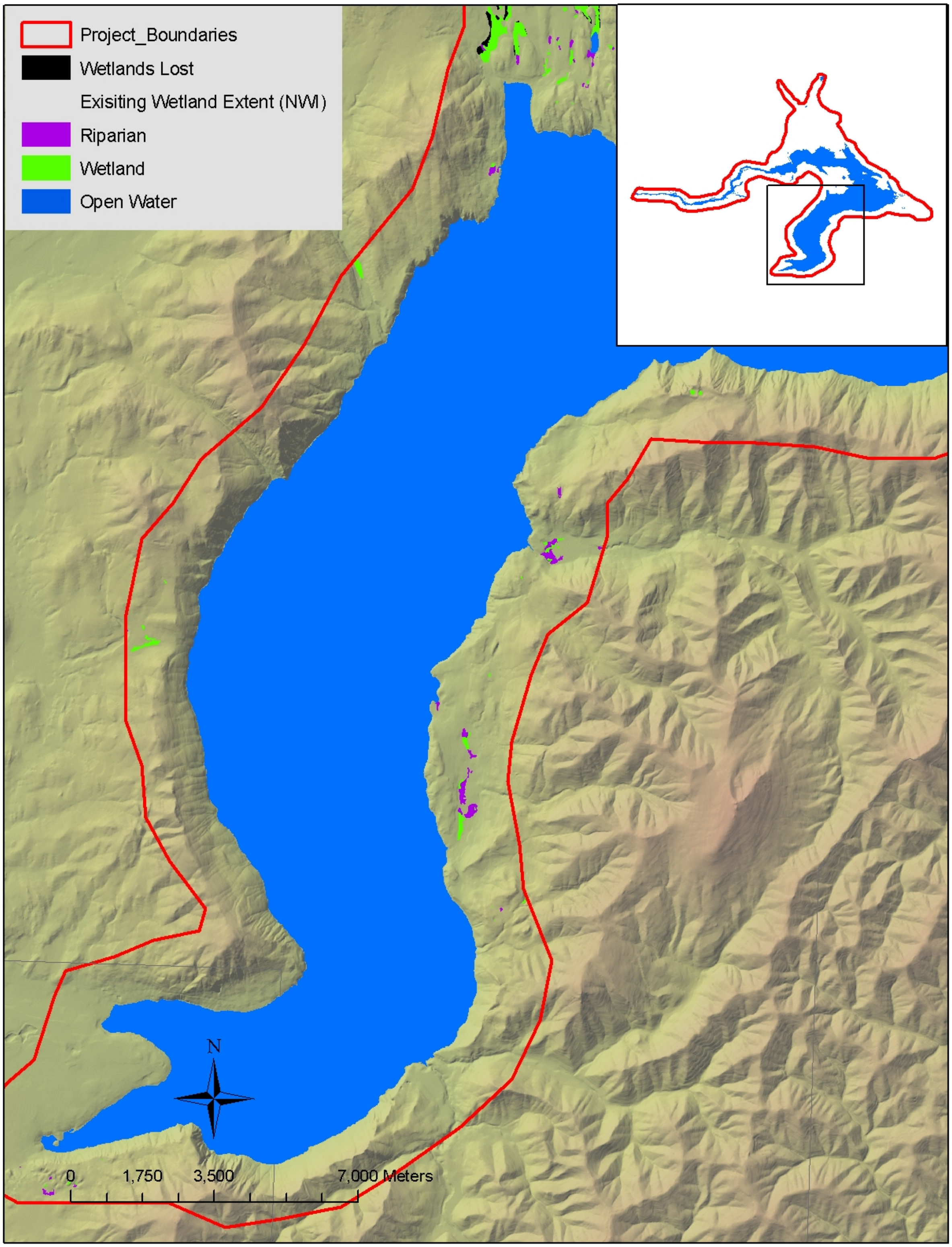


Figure 18. Wetland Loss (Based on NWI) in the Southern Portion of the Study Area.

characterized into unique wetland types. As such, documenting changes in the specific NWI wetland types from historic conditions was not possible for this project. However, the current extent of the various NWI types is shown in Table 4.

An assessment of change in wetland types (i.e., the conversion of one wetland type into another) was not conducted due to the coarse nature of the classification units in the available data sets. However, such changes can have a significant impact on ecological integrity and ecological services provided by wetlands in the study area.

3.1.3 Potential Causes of Wetland Loss

The Wetlands Lost (Ecological System) shapefile was overlaid on the Current Wetlands (Ecological System) shapefile in order to estimate which land uses and/or land covers have displaced wetlands lost from the historical extent (Table 5). Hay fields and pastures account for the largest replacement (~19%) of historical wetlands (Table 5). Introduced Upland Vegetation (Perennial Grassland and Forbland) contributed approximately 18% of wetland loss. This land cover includes significantly altered or disturbed lands by introduced, non-native perennial grasses and forbs. Natural vegetation types are no longer recognizable in these areas. The specific expression of this land cover in the study area was not determined from field work but it may include old fields, hay meadows, or other meadows dominated by nonnative species. When aggregated, the various types of agricultural land uses account for 30% (48% if Introduced Upland Vegetation is included) of wetland loss while various types of development account for 15% of wetland loss (Table 5). There are numerous natural vegetation types also on the list in Table 5. Some of these may be mapping errors while others may reflect natural succession of upland vegetation following drainage of wetland areas.

Historically, land clearing, drainage, and agriculture conversion have been the primary reasons for wetland loss in northern Idaho (Jankovsky-Jones 1997). The land uses/land covers listed in Table 5 appear to reflect this trend.

3.1.4 Summary of GIS Wetland Loss Analysis

The wetland losses estimated in this report reflect a coarse approach to measuring change in wetland extent. A systematic accuracy assessment of the data layers used in the analyses has not been conducted. Thus, the estimates provided do not incorporate errors associated with inaccurate mapping or labeling (i.e., classification) of wetlands on the ground. In addition, the historical extent of wetlands is based on either an ecological model (e.g., Biophysical Settings) or potentially incomplete representation (e.g., Hydric Soils) of the historical extent of wetlands in the study area. Nonetheless, the GIS analyses both suggest that a substantial portion (between 35-43%) of historical wetlands have been lost from the landscape. These losses are associated with land conversion, drainage, development, and other land uses outside the zone impacted by the construction of the Albeni Falls Dam. Losses associated with the dam are addressed in Section 3.2.

Table 5. Land Use Accounting for Wetland Loss (Ecological Systems)

Land Use/Land Cover	Percent Wetlands Displaced
Agriculture - Pasture/Hay	18.77%
Introduced Upland Vegetation - Perennial Grassland and Forbland	17.80%
Inter-Mountain Basins Montane Sagebrush Steppe	10.24%
Developed-Low Intensity	8.05%
Rocky Mountain Subalpine-Montane Mesic Meadow	7.43%
Agriculture - General	7.10%
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	6.11%
Developed-Open Space	6.06%
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	5.20%
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	4.61%
Agriculture - Cultivated Crops and Irrigated Agriculture	4.29%
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	2.09%
Developed-Medium Intensity	0.94%
Inter-Mountain Basins Big Sagebrush Steppe	0.88%
Inter-Mountain Basins Big Sagebrush Shrubland	0.20%
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	0.16%
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	0.04%
Open Water	0.03%
Non-Specific Disturbed	0.02%
Developed-High Intensity	0.01%

Note: Based on field work conducted for this project and input from IDFG (Chris Murphy, personal communication), it is unlikely that sagebrush steppe is as abundant as suggested in this table or even present in the study area. These areas might be better characterized as "upland shrub". Also, IDFG suggested that the Rocky Mountain Mesic Meadow Ecological System may be inclusive of wetland or dry meadows, including native bluejoint reedgrass (*Calamagrostis canadensis*) meadows, reed canarygrass (*Phalaris arundinacea*) meadows, or noxious weed-infested pastures (Chris Murphy, IDFG, personal communication).

3.2 Wetland Loss Associated with Albeni Falls Dam

The GIS analyses discussed above did not account for wetland losses associated with the construction and operation of the Albeni Falls Dam. The next two sections provide these estimated losses as cited in the literature.

3.2.1 Losses Associated with Construction of Albeni Falls Dam

Prior to construction of the Albeni Falls Dam, the Corp of Engineers delineated a study area boundary around the lake (Martin et al. 1988). Within this boundary the acreage of wetlands was calculated using 1935 (1:20,000) and 1950 (1:12,000) black and white aerial photography (Martin et al. 1988). Losses associated with the construction of Albeni Falls Dam occurred within the fluctuation zone (i.e., area between the shoreline prior to dam construction and post-construction summer pool levels) and are shown in Table 6. The construction and subsequent operation of the dam inundated 6,617 acres that were formerly wetlands. The highest concentration of losses occurred in the Clark Fork River Delta and Denton Slough area (2,029 acres) and the Pack River area (1,444 acres). In terms of wetland types, the most significant loss was suffered by Deciduous Forested Wetlands which were reduced 72% from their former extent (Table 6). Herbaceous wetlands were also severely impacted with 67% of their former acreage being lost from inundation (Table 6). Deciduous Scrub Shrub wetlands were increased slightly. The very significant increase in Open Water areas is equal to the negative changes observed in Palustrine wetland types (Table 6).

Table 6. Wetland Loss Associated with the Construction of Albeni Falls Dam (Data are from Martin et al. 1988)

	Albeni Falls Data			
Wetland Type	**Pre Construction (acres)**	**Post Construction (acres)**	**Change (acres)**	**Change (percent)**
Deciduous Forested Wetland	3,221	907	-2,314	-72%
Deciduous Scrub-Shrub Wetland	361	434	+73	+20%
Herbaceous Wetland	6,572	2,196	-4,376	-67%
Totals	**10,154**	**3,537**	**-6,617**	**-65%**
Open Water	1,556	8,173	**+6,617**	+425%

3.2.2 Losses Associated with Ongoing Operation of Albeni Falls Dam

In addition to the initial impact associated with inundation of wetlands following dam construction, the ongoing operation of Albeni Falls Dam has resulted in substantial erosion of wetlands in the study area. Wind and wave action during summer lake levels (i.e., high lake levels) is thought to be the primary culprit of erosion of wetlands along the lake's shoreline (Heck and Cousins 2009). Martin et al. (1988) estimated that 30 acres of wetlands are annually lost due to erosion stemming from operation of hydroelectric dams. Roughly half of that loss is occurring in the Clark Fork River Delta where erosional losses from Albeni Falls Dam are exacerbated by upstream dams (Cabinet Gorge and Nixon Rapids) on the Clark Fork River. These upstream dams impede sediment transport to the delta and thereby limit the opportunity for the delta to rebuild (Martin et al. 1988). Another study estimated that average bank recession (i.e., horizontal erosion) along Lake Pend Oreille was nearly 5 feet/year (Gatto and Doe 1987, as cited in Heck and Cousins 2009). In 2008, Heck and Cousins (2009) revisited numerous survey points established in 1997 in the Clark Fork River Delta to detect erosional losses of shoreline banks in the intervening period. Erosional loss (e.g., horizontal recession of the shoreline bank) of the survey points ranged from 1.0 feet/year to 6-8 feet/year (Heck and Cousins 2009). In one location, the shoreline bank receded approximately 50 feet in 10 years (Figure 19). Vertical erosion is also substantial in many areas, ranging from 1 – 6 feet (Figure

Figure 19. Recession of the Shoreline Bank in the Clark Fork River Delta. Photo Courtesy of Kathy Cousins (Idaho Department of Fish and Game)

20). In another location, wave scour has eroded away the substrate that previously supported a forested wetland (prior to harvesting) in the Clark Fork River Delta (Figure 21). The aggregate loss of wetlands from erosion stemming from operation of Albeni Falls Dam was not calculated for this project. However, previous research (Martin et al. 1988; Gatto and Doe 1987, and Heck and Cousins 2009) suggests these losses are significant.

Figure 20. Bank Erosion in the Clark Fork River Delta. Photo taken on November 16, 2009. Bank pins were put in on April 8, 2008. 2.6 feet now exposed. Photo Courtesy of Kathy Cousins (Idaho Department of Fish and Game)

Figure 21. Rooted Stump of Previously Harvested Tree Showing the Degree of Vertical and Horizontal Erosion in the Clark Fork River Delta. Photo Courtesy of Kathy Cousins (Idaho Department of Fish and Game)

3.3 Change in Ecological Condition

A Landscape Integrity Index was used to estimate the overall condition of extant wetland types in the study area. In addition, a brief qualitative characterization of changes in ecological conditions is provided.

3.3.1. Landscape Integrity Index Estimates

The Landscape Integrity Index showed that regardless of the base map used (e.g., Ecological Systems vs. NWI), wetlands in the study area had an overall ecological integrity rank of Fair (Table 7; Figure 22). Except for Open Water wetlands (e.g., aquatic beds) in the Ecological Systems layer and Riverine wetlands in the NWI layer, each wetland type also was rated as being in Fair ecological condition throughout the study area (Table 7).

Table 7. Summary of Landscape-Based Assessment of the Ecological Integrity of Wetlands in the Study Area. Values represent averages across all polygons in each category.

Ecological System	**% of Wetland Acreage**	**Average of MEAN Polygon Scores**	**Average of MAX Polygon Scores**	**Average of MIN Polygon Scores**	**Average of RANGE Polygon Scores**	**Average of STD Polygon Scores**	**Level 1 EIA Rank (based on MEAN)**
Open Water	3%	0.94	0.99	0.25	0.74	0.07	Excellent/ Good
Northern Rocky Mountain Conifer Swamp	4%	0.69	0.97	0.23	0.74	0.14	Fair
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	93%	0.79	0.99	0.19	0.79	0.14	Fair
Total	**100%**	**0.81**	**0.98**	**0.22**	**0.76**	**0.12**	**Fair**
NWI Wetland Type	**% of Wetland Acreage**	**Average of MEAN Polygon Scores**	**Average of MAX Polygon Scores**	**Average of MIN Polygon Scores**	**Average of RANGE Polygon Scores**	**Average of STD Polygon Scores**	**Level 1 EIA Rank (based on MEAN)**
Freshwater Emergent Wetland	42%	0.75	0.78	0.72	0.06	0.02	Fair
Freshwater Forested/Shrub Wetland	32%	0.78	0.81	0.75	0.05	0.02	Fair
Freshwater Pond	3%	0.75	0.75	0.74	0.02	0.01	Fair
Lake	6%	0.76	0.80	0.70	0.09	0.03	Fair
Riverine	17%	0.81	0.83	0.76	0.06	0.02	Excellent/ Good
Total	**100%**	**0.77**	**0.79**	**0.74**	**0.06**	**0.02**	**Fair**

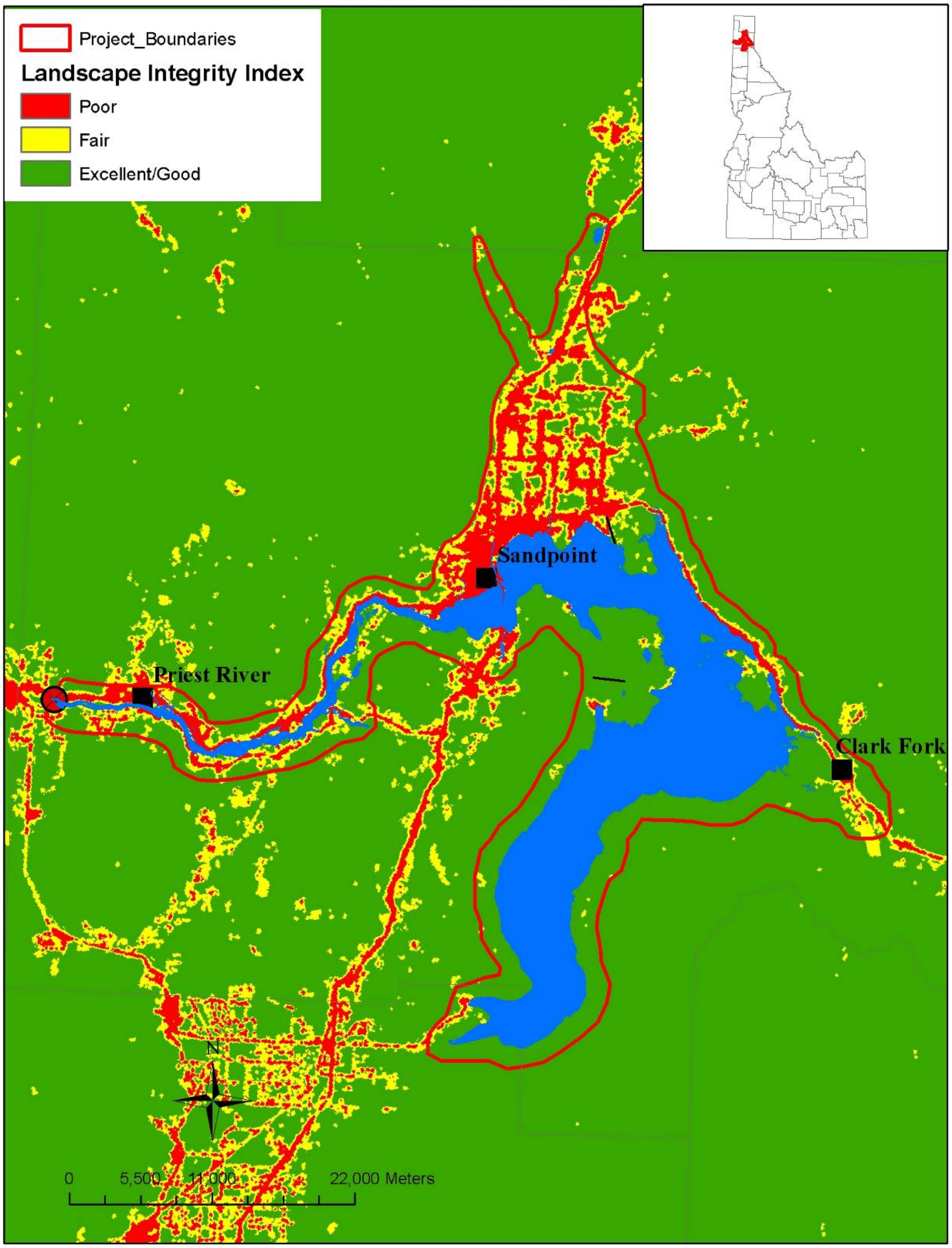


Figure 22. Landscape Integrity of the Study Area.

The Landscape Integrity Index assumes that a rank of Excellent/Good reflects historic conditions. Thus, the change in ecological condition of wetlands in the study area is substantial with degradation being prominent in almost all wetlands types. Agriculture and residential development near Sandpoint and in the Pack River area appear to have a substantial impact on the ecological integrity of wetlands in the study area (Figure 22).

The Landscape Integrity Index is a useful surrogate measure of site conditions based on obvious onsite and adjacent land use(s). However, the coarse nature of the model often doesn't incorporate site-specific stressors such as invasive or nonnative species, nutrient and metal contamination, sediment deposition, grazing, etc. A more detailed assessment of ecological condition using onsite Level 2 (rapid) or Level 3 (intensive) assessment methods such as the NatureServe and the Natural Heritage Network's Ecological Integrity Assessment protocol would provide more detailed information concerning site and overall ecological condition of wetlands in the study area.

3.3.2 Qualitative Assessment of Changes in Ecological Conditions

Overview

The various historical and ongoing human activities affecting wetlands in the study area have resulted in numerous biotic and abiotic shifts from their natural range of variation. For example, nonnative species and less desirable native species has increased in many wetlands in the study area (Jankovsky-Jones 1997). Noxious weeds such as leafy spurge (*Euphorbia esula*), Canada thistle (*Cirsium arvense*), bull thistle (*C. vulgare*), dalmation toad-flax (*Linaria dalmatica*), and knapweeds (*Centaurea* spp.) are prevalent along wetland margins or in drier wetlands. Reed canarygrass (*Phalaris arundinacea*) has been widely planted for forage and also invades wetlands where it hasn't been deliberately introduced. Reed canarygrass creates dense monocultures eliminating many native species. Other species planted as pasture grasses which have now invaded many other wetlands include Kentucky bluegrass (*Poa pratensis*), orchard grass (*Dactylis glomerata*), and fowl bluegrass (*Poa palustris*). These species are dominant in the understory of many riparian wetlands (Jankovsky-Jones 1997). These grass species have less ability to protect stream and shoreline banks from erosion than most other native wetland species. Consequently, their presence makes wetlands more susceptible erosional loss.

Prior to the construction of the Albeni Falls Dam, wetlands surrounding Lake Pend Oreille were primarily dominated by cottonwoods (*Populus balsamifera* ssp. *trichocarp*a), western redcedar (*Thuja plicata*), willows (*Salix* spp.), alders (*Alnus* spp.), snowberry (*Symphoricarpos albus*), rose spirea (*Spirea douglasii*), sedges (*Carex* spp.), bentgrasses (*Agrostis* spp.), and bluejoint reedgrass (*Calamagrostis canadensis*) (Martin et al. 1988). Emergent and aquatic plants included waterweed (*Elodea* spp.), pondweeds (*Potamogeton* spp.), spikerushes (*Eleocharis* spp.), bulrushes (Schoenoplectus and Scirpus spp.), arrowgrass (*Sagittaria* spp.), horsetail (*Equisetum* spp.), and water smartweed (*Polygonum amphibium*) (Martin et al. 1988). Post construction, many forested and herbaceous wetlands were inundated resulting in the original vegetation being displaced by open water "wetlands" in the summer (during high water levels) and exposed mudflats during the winter (low lake levels) (Martin et al. 1988). Many extant herbaceous wetlands around the shoreline of Lake Pend Oreille have experienced a shift in species composition being replaced by depauperate stands of reed canarygrass and cattails (*Typha* spp.). The aquatic plant communities which occur along the Lake Pend Oreille shoreline have also experience degradation. Species tolerant of deeper water conditions, such as algae like brittlewort (*Nitella* spp.) and stonewort (*Chara* spp.), have replaced species adapted to shallower water like pondweed and arrowgrass resulting in decrease habitat value for waterfowl (Martin et al. 1988). In addition, Lake Pend Oreille is infested with Eurasian milfoil (*Myriophyllum spicatum*).

Clark Fork River Delta

The Clark Fork River Delta was historically a mosaic of forested, shrub, and herbaceous wetlands. However, many of the old growth western redcedar stands have been logged (Figure 21) and many areas of the delta, especially the extreme northern and southern portions, have been ditched and drained for hay pasture (Jankovsky-Jones 1997).

Today, most wetlands are dominated by a mosaic of cottonwood, red-osier dogwood (*Cornus sericea*), Bebb's willow (*Salix bebbiana*), sandbar willow (*Salix exigua*), snowberry, and reed canarygrass (Jankovsky-Jones 1997). Expansive meadows occupy the former floodplain of the Clark Fork River at the south end of the delta. The wettest portions of the meadows which have not been drained are dominated by cattail, spikerush, and various bulrush species. In areas where hydrological alteration has occurred, reed canarygrass is the dominant species. Reed canarygrass is an aggressive competitor with native emergent vegetation and may reduce cottonwood and shrub regeneration. Reed canarygrass has likely replaced plant communities previously dominated by northern mannagrass (*Glyceria borealis*), beaked sedge (*Carex utriculata*), spikerushes, and bulrushes (Jankovsky-Jones 1997). Reed canarygrass is also abundant in the understory of forested and shrub wetlands. Eradication or control of reed canarygrass has proven to be very difficult.

Pack River

Historically, the Pack River appears to have been dominated by the western redcedar/oak fern (*Thuja plicata/Gymnocarpium dryopteris*) and western redcedar/devil's club (*Thuja plicata/Oplopanax horridum*) habitat types (Golder Associates 2003). However, large-scale logging activities have left these habitat types largely absent or degraded along the contemporary Lower Pack River floodplain. Most of the mature riparian forests have been lost resulting in significant impacts on channel stability, thermal regulation, and erosional processes (Pack River TAC 2006). For example, cedar dominated riparian forests are effective at streambank stabilization and, as decadent trees fall into the channel, provide diverse habitat and sediment storage (Pack River TAC 2006). Large western redcedar stumps are present on the banks of the river, devil's club is less frequent, and cover of many riparian forbs has been reduced (Golder Associates 2003). In addition, reaches of the Lower Pack River are unstable with high eroding banks, accelerated lateral movement of the channel and are characterized by wide, shallow channels resulting in loss of wetland acreage and lowering of water tables of remaining streamside wetlands (Golder Associates 2003).

The Pack River delta has been substantially altered by the construction and operation of Albeni Falls Dam. High water levels created by the dam have raised the water table in the delta area. This hydrological alteration has resulted in the conversion of forested wetlands dominated by cottonwoods and western redcedar into herbaceous or shrub wetlands (Pack River TAC 2006). Prior to dam construction much of the riparian vegetation in the Pack River delta was converted to pasture in the late 1800's (Pack River TAC 2006).

3.3.3 Summary of Changes in Ecological Conditions

Historical and contemporary human-induced stressors have not only resulted in the loss of wetland acreage but have also resulted in dramatic degradation of ecological conditions of the wetlands that remain on the landscape. Species composition has shifted, with an increase in nonnative, invasive, and undesirable native species (e.g., increaser species) along with a corresponding decrease in native species sensitive to anthropogenic disturbances. The vegetation structure of many wetlands has also shifted due to past and present stressors such as logging, clearing, grazing, erosion, and drainage. Other changes include degradation of ecological processes such as the hydrological regime and nutrient and sediment dynamics brought on by the myriad of land uses in the study area. These abiotic changes are often the cause of many of the vegetation changes, although vegetation composition can serve as a feedback toward worsening existing degradation in ecological processes. For example, as discussed previously, the lowering of the water table provides suitable conditions for species such as Kentucky bluegrass and orchardgrass to survive. These species, in turn, can make the wetland more susceptible to erosion and thus further lowering of the water table.

The shift in both species composition and structure has likely resulted in a change in the types of functional plant groups present in study area wetlands. Such changes can have subsequent effects on, or be indicators of change in, ecological functions and services provided by wetlands. For example, as noted above, as obligate wetland species are replaced by species more tolerant of mesic conditions, the susceptibility of the wetland to erosion is higher due to the fact that many obligate and facultative-wetland species are more effective as bank stabilization than FAC or facultative-upland species (Pritchard et al. 1998). Decreases in overall vegetation cover due to stressors like grazing or seasonal water fluctuations (i.e., water levels associated with Albeni Falls Dam) can increase the cover of bare ground exposed in a wetland. Depending on the type of wetland impacted, changes in carbon dynamics might occur from increased exposure of the soil surface. For example, in fens of the southern Sierra Nevada Mountains, a negative carbon balance (i.e., loss of peat) resulted when bare ground increased above 20% (Cooper et al. 2005). The percentage of non-native species present could be indicative of many different stressors and shifts in ecological processes such as increased nutrients (Zedler and Kercher 2004), grazing (Jones 2005; Kauffman et al. 1983), alterations in hydrology (Zedler and Kercher 2004), and soil disturbances and sedimentation (Zedler and

Kercher 2004). Increased abundance of annual species likely reflects physical disturbances resulting from grazing, recreation, and other activities which create disturbed bare ground, since annuals thrive in such conditions (Grime 2001; Galatowitsch et al. 2000). A shift from rhizomatous to non-rhizomatous species may also highlight a functional shift from vegetative to sexual reproduction in the wetland.

In summary, changes in vegetation composition and structure can be indicative or a cause of numerous changes in the ecological function of wetlands. Future research might focus on determining the specific changes in vegetation functional groups associated with wetlands in the study area in order to provide a better assessment of how historical shifts in vegetation composition and structure effects the delivery of ecological functions and services in the study area.

3.4 Conservation Sites

Ecologically significant wetlands in the study area were identified by previous efforts of the Idaho Conservation Data Center (Jankovsky-Jones 1997; Hahn et al. 2005, IDCDC database) and are listed in Table 8. The locations of each of the conservation sites are shown in Figures 23-25. Inquiries about these conservation sites should be directed to the Idaho Department of Fish and Game, Data Conservation Center.

The Clark Fork Delta site is ranked as one of the top 10 wetland priority areas in Idaho. Pack River and McArthur Lake are ranked as the 15th and 17th wetland priority areas in Idaho. Beaver Lake South, Lost Lake, Gamlin Lake, McArthur Lake, and Walsh Lake all support peatlands, which are a rare wetland type in northern Idaho (Lichthardt 2004).

Morton Slough is the only site considered to be fully protected. The Clark Fork Delta, Gamlin Lake, McArthur Lake, and Pack River all have some portion of their areas protected but the remaining portions of these sites are still in need of protection actions. Cocolalla Slough, Beaver Lake South, Lost Lake, and Walsh Lake currently have no formal protection.

Table 8. Wetland Sites with Conservation Significance in the Study Area.

Site Name	Wetland Conservation Sites	Wetland Priority Areas 2005	Important Bird Area	Protection Status[1]	Ecological Significance[1]
Beaver Lake South	X			Private; No current protection and threat is low.	High biodiversity significance; rich fen; rare plants; excellent waterfowl habitat; Ranked 76th as statewide Wetland Priority Area
Boyer Slough		X		Unknown	Ranked 102nd as statewide Wetland Priority Area;
Clark Fork Delta	X	X	X	Partial protection in ID Wildlife Mgmt. Area; Undeveloped private islands and shoreline should be high priority for acquisition or conservation easements	Very high biodiversity significance; several rare birds breed in area; bull trout present; rare plants; very high quality black cottonwood and red-osier dogwood plant communities; Ranked 7th as statewide Wetland Priority Area
Cocolalla Slough	X	X		Private; No current protection; threat is high; Acquisitions or easements should be pursued.	Moderate biodiversity significance; Bald Eagle forage and wintering site; rare plant communities; Ranked 50th as statewide Wetland Priority Area
Colburn Creek	X	X		Unknown	Ranked 164th as statewide Wetland Priority Area
Denton Slough Important Bird Area	X		X	Included as part of the Clark Fork Delta site above	Included as part of the Clark Fork Delta site above
Farragut	X			Unknown	Unknown
Fisherman Island & Oden Bay (IBA only)	X		X	Unknown	High concentration of waterfowl during migration and winter;
Gamlin Lake	X	X		Partial protection by The Nature Conservancy and Bureau of Land Management; Acquisitions or easements should be a priority on private parcels	High biodiversity significance; rich fen; rare plants; excellent waterfowl habitat; Ranked 76th as statewide Wetland Priority Area
Keyser's Slough		X		Unknown	Ranked 104th as statewide Wetland Priority Area
Lost Lake	X			Private and U.S. Forest Service; No current protection; Acquisitions or easements should be a priority on private parcels; Special designation by USFS could be pursued	High biodiversity significance; rich and intermediate fens; rare plants; excellent waterfowl habitat;

Site Name	Wetland Conservation Sites	Wetland Priority Areas 2005	Important Bird Area	Protection Status[1]	Ecological Significance[1]
McArthur Lake	X		X	Private and Idaho Dept. Fish and Game; Partial protection in ID Wildlife Mgmt. Area;	High biodiversity significance; high habitat and floristic diversity; rich fen; rare plants and plant communities; excellent waterfowl habitat; Ranked 17th as statewide Wetland Priority Area
Morton Slough	X	X	X	Protected as ID Wildlife Management Area	General biodiversity interest and valuable open space; important waterfowl area; Ranked 74th as statewide Wetland Priority Area
Muskrat Lake		X		Unknown	Ranked 72nd as statewide Wetland Priority Area
Pack River	X	X	X	Private and Idaho Dept. Fish and Game; Partial protection in ID Wildlife Mgmt. Area; Acquisitions or easements should be a priority on private parcels	General biodiversity interest and high values for open space; supports thousands of waterfowl during spring and fall migration; rare plant communities; Ranked 15th as statewide Wetland Priority Area
Springy Point	X			Unknown	Unknown
Walsh Lake	X	X		Private; No current protection; Acquisitions or easements should be a priority on private parcels	High biodiversity significance; rich fen; rare plants; Ranked 114th as statewide Wetland Priority Area

1 Information about Protection Status and Ecological Significance was extracted from Jankovsky-Jones (1997); Hahn et al. (2005), and the IDCDC database

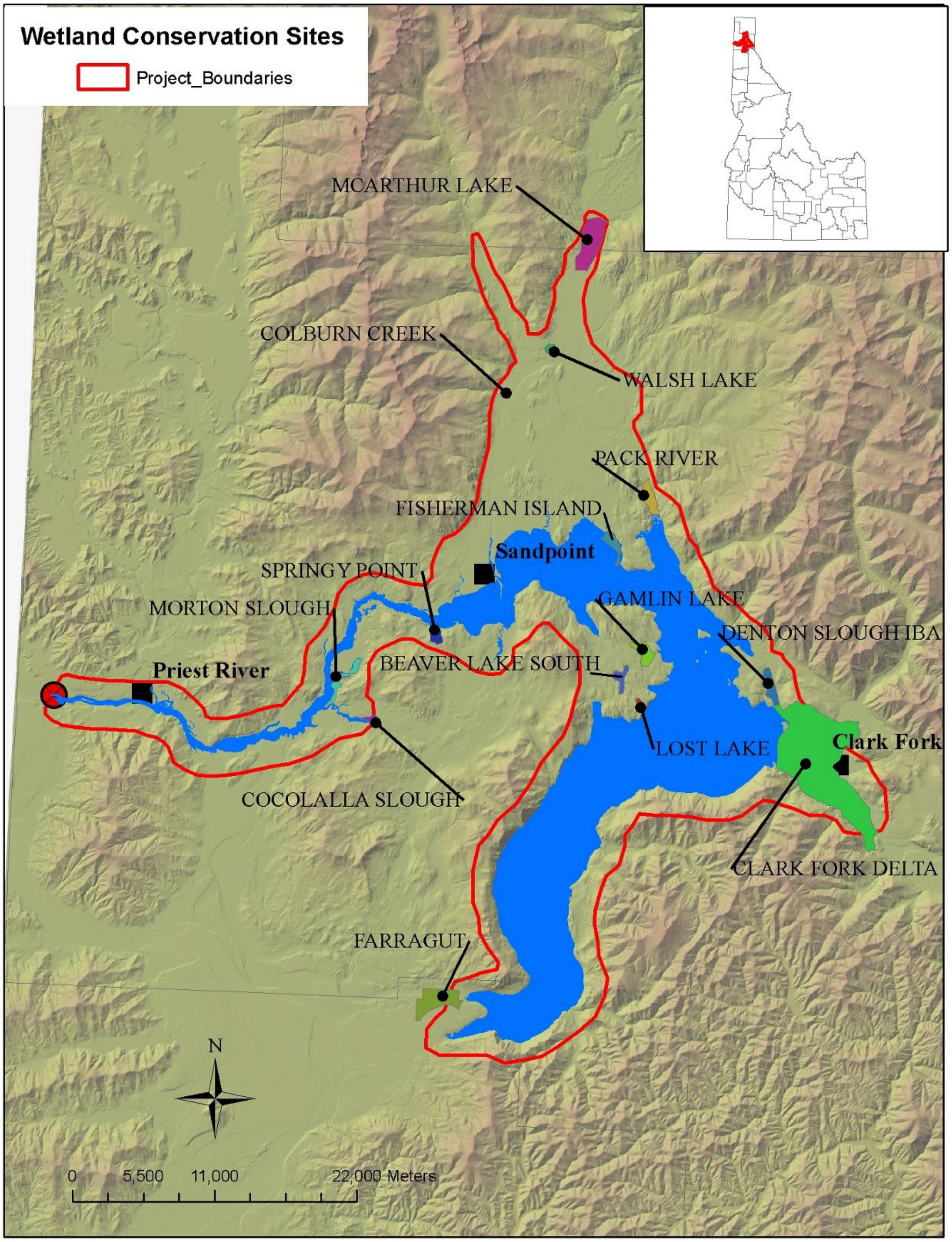


Figure 23. Wetland Conservation Sites in the Study Area As Identified by Idaho Conservation Data Center.

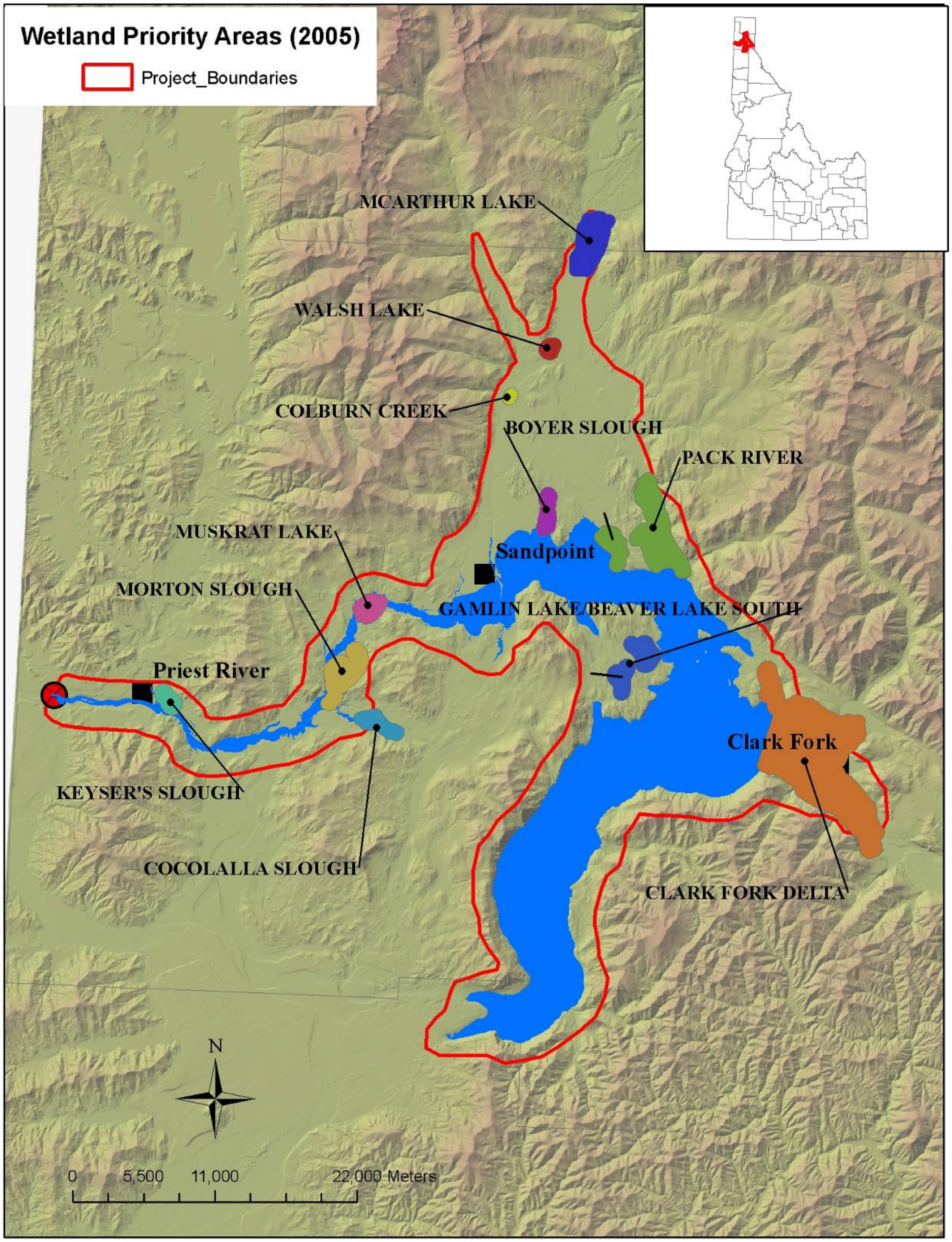


Figure 24. Wetland Priority Areas in the Study Area As Identified by Idaho Conservation Data Center.

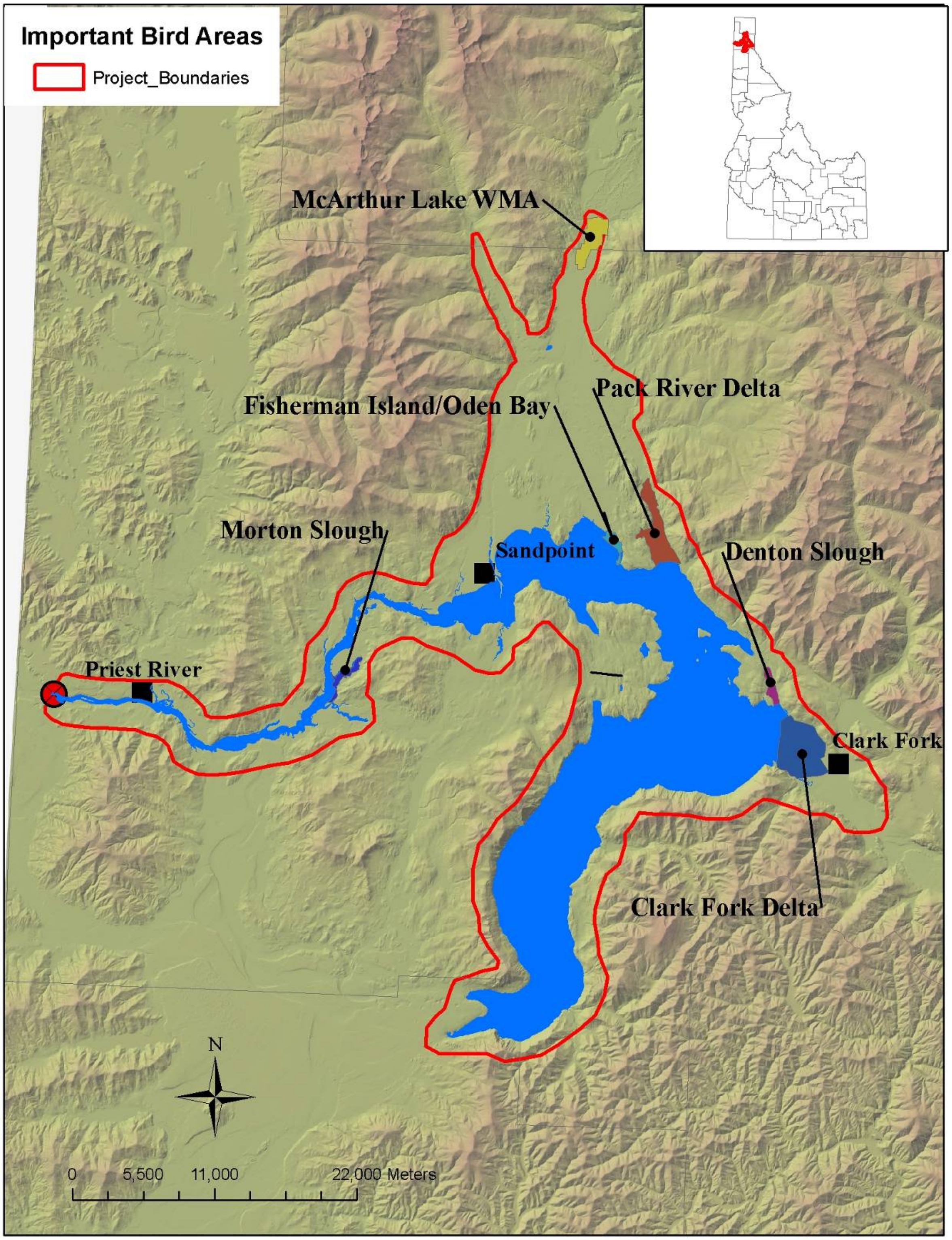


Figure 25. Important Bird Areas in the Study Area.

3.5 Restoration Sites

Restoration sites are difficult to identify and prioritize without knowing what specific restoration objectives are being targeted (e.g., ecological integrity, habitat quality, water quality functions, etc.). For this project, sites with restoration potential were gleaned from available literature.

Restoration opportunities are abundant in the Pack River and Clark Fork River Delta area, given the extensive historic and contemporary impacts as well as the importance of these sites statewide. Ducks Unlimited and Idaho Fish and Game have identified a few specific priority restoration sites in the Clark Fork River Delta where erosion is a significant problem (Heck and Cousins 2009). Erosion control along both the Pack River and Clark Fork River are priorities for restoration. Soil bioengineering/geotechnical construction (e.g., bundles of live brush, brush mattresses, live stakes, and root wads) hold promise over traditional engineering approaches given that they result in less disturbance than the latter (Pack River TAC 2006).

Many of the conservation sites identified above have experienced significant impacts from human activities. These include Cocolalla Slough, Morton Slough, and Pack River and were categorized by Jankovsky-Jones (1997) as “Habitat Sites”. All of these sites have the potential for restoration or enhancement activities due to past impacts resulting from livestock grazing and/or hydrological alterations. Restoration actions could range from fencing out livestock to more intensive actions such as revegetation, channel stabilization, weed control, and hydrological restoration (Jankovsky-Jones 1997).

4.0 Future Research

The results of this work provide an indication of the relative magnitude of change, both in extent and ecological condition, of wetlands in the study area. However, these estimates are mostly based on coarse GIS analyses with an unknown source of error. Additional research such as reviewing U.S. Army Corp of Engineer Section 404 permits could improve estimate of wetland loss associated with impacts from development and road construction. Consulting General Land Office records for the study area might also provide a more accurate estimate of historical wetland extent.

The Level 1 assessment of ecological integrity (i.e., the Landscape Integrity Index) of the study area wetlands could be greatly improved by conducting a probabilistic survey of wetland condition in the study area. The Washington Natural Heritage Program is currently developing Level 2 (rapid) and Level 3 (intensive) Ecological Integrity Assessment protocols for the ecological systems which occur in adjacent Washington State. Most of the wetland types which occur in northeastern Washington also occur in the study area. Thus, these EIAs protocols would be available for implementing a systematic and scaled assessment of the study area’s wetland profile which would provide a statistically valid estimate of the ecological conditions of wetlands around Lake Pend Oreille. In addition, Idaho Department of Fish and Game is currently conducting a landscape-scale assessment of wetland condition in northern Idaho. This work will further aid in understanding the ecological condition of wetlands in the study area.

The plant species lists gathered from a Level 2 or 3 EIA assessments would aid in determining the specific changes in vegetation functional groups associated with wetlands in the study area. This would provide a better assessment of how historical shifts in vegetation composition and structure effects the delivery of ecological functions and services in the study area.

A more sophisticated approach to identifying potential restoration sites in the study area could be initiated by implementing a Level 1 assessment. For example, the Landscape Integrity Index could be utilized to first identify degraded wetlands in the study area. Then an analysis of land use surrounding the degraded wetlands could be used to determine whether any limiting factors occur adjacent to or near the wetland.

Implementing these recommended future research efforts would help provide more accurate data concerning the change in extent and ecological integrity of wetlands around Lake Pend Oreille, relative to historical conditions.

Literature Cited

Breckenridge, R.M. and K.F. Sprenke. 1997. An overdeepened glaciated basin, Lake Pend Oreille, northern Idaho. Glacial Geology and Geomorphology, 1997, rp01/1997. Online: http://ggg.qub.ac.uk/papers/full/1997/rp011997/rp01.pdf

Brown, M.T. and M.B. Vivas. 2005. Landscape Development Intensity Index. Environmental Monitoring and Assessment 101: 289-309

Chadde, S.W., J.S. Shelly, R.J. Bursik, R.K. Moseley, A.G. Evenden, M. Mantas, F. Rabe, and B. Heidel. 1997. Peatlands on National Forests of the Northern Rocky Mountains: Ecology and Conservation. General Technical Report RMRS-GTR-11, United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, VA. Online: http://www.natureserve.org/library/usEcologicalsystems.pdf

Comer, P.J. and J. Hak. 2009. NatureServe Landscape Condition Model. Internal documentation for NatureServe Vista decision support software engineering, prepared by NatureServe, Boulder CO.

Comer, P., and K. Schulz. 2007. Standardized Ecological Classification for Meso-Scale Mapping in Southwest United States. Rangeland Ecology and Management 60 (3) 324-335.

Cooper, D.J., R.A. Chimner, and E.C. Wolf. 2005. Livestock Use and Sustainability of Southern Sierra Nevada Fens. Unpublished report prepared for the Inyo National Forest. Colorado State University, Fort Collins, CO.

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/1998/classwet/classwet.htm (Version 04DEC98).

Dahl, T.E. 2006. Status and trends of wetlands in the conterminous United States 1998 to 2004. U.S. Department of the Interior; Fish and Wildlife Service, Washington, D.C. 112 pp.

Danz, N.P., G.J. Neimi, R.R.Regal. et al. 2007. Integrated measures of anthropogenic stress in the U.S. Great Lakes Basin. Environmental Management 39:631-647.

Denevan, W.M. 1992. The Pristine Myth: The Landscape of the Americas in 1492. Annals of the Association of American Geographers 82(3): 369-385.

Doughty, P.T. and R.A. Price. 2000. Geology of the Purcell Trench rift valley and Sandpoint Conglomerate: Eocene en echelon normal faulting and synrift sedimentation along the eastern flank of the Priest River metamorphic complex, northern Idaho. GSA Bulletin; September 2000; v. 112; no. 9; p. 1356–1374.

Faber-Langendoen, D., J. Rocchio, M. Shafale, C. Nordman, M. Pyne, J. Teague, and T. Foti. 2006. Ecological Integrity Assessment and Performance Measures for Wetland Mitigation. NatureServe, Arlington VA. Available online at: http://www.natureserve.org/getData/eia_integrity_reports.jsp

Faber-Langendoen, D., G. Kudray, C. Nordman, L. Sneddon, L. Vance, E. Byers, J. Rocchio, S. Gawler, G. Kittel, S. Menard, P. Comer, E. Muldavin, M. Schafale, T. Foti, C. Josse, J. Christy. 2008. Ecological Performance Standards for Wetland Mitigation based on Ecological Integrity Assessments. NatureServe, Arlington, VA. + Appendices

Faber-Langendoen, D., G. Kudray, C. Nordman, L. Sneddon, L. Vance, E. Byers, J. Rocchio, S. Gawler, G. Kittel, S. Menard, P. Comer, E. Muldavin, M. Schafale, T. Foti, C. Josse, J. Christy. 2009a. NatureServe Level 2 and Level 3 Ecological Integrity Assessments: Wetlands. NatureServe, Arlington, VA. + Appendices

Faber-Langendoen, Don, Regan Lyons, and Pat Comer. 2009b. Developing options for establishing reference conditions for wetlands across the lower 48 states. A report to the U.S. Environmental Protection Agency. NatureServe, Arlington, VA.

Federal Geographic Data Committee (FGDC). 2008. Vegetation Classification Standard, version 2 FGDC-STD-005, v2. Washington, DC.

Galatowitsch, S.M., D.C. Whited, R. Lehtinen, J. Husveth, and K. Schik. 2000. The vegetation of wet meadows in relation to their land use. Environmental Moniotoring and Assessment 60: 121-144.

Gatto, L.W. and W.W. Doe III. 1987. Bank Conditions and Erosion Along Selected Reservoirs. Environmental Geology Journal, Volume 9, Number 3, pp. 143-154.

Grime, J.P. 2001. Plant Strategies, Vegetation Processes, and Ecosystem Properties. Second Edition. John Wiley and Sons, LTD. West Sussex, England.

Golder Associates, Inc. 2003. Pack River Stream Channel Assessment. Prepared for Avista Utilities, Noxon, Montana and Pack River Technical Advisory Committee. Golder Associates, Inc. Redmond, Washington.

Hahn, L., C. Murphy, A. Schmidt, and T. Fields. 2005. Idaho Wetland Conservation Prioritization Plan. Prepared for Idaho State Park and Recreation. Idaho Conservation Data Center, Department of Fish and Game. Boise, Idaho.

Heck, B. and K. Cousins. 2009. Report on the Clark Fork River Delta, Idaho Bank Erosion Control and Habitat Restoration Alternatives (Unpublished preliminary report, October 11, 2009). Idaho Department of Fish and Game, Panhandle Region, pp. 39.

Jankovsky-Jones, M. 1997. Conservation Strategy for Northern Idaho Wetlands. Prepared for U.S. Environmental Protection Agency. Contract No. CD990484-01-0. Idaho Conservation Data Center, Idaho Department of Fish and Wildlife, Natural Resource Policy Bureau. Boise, Idaho.

Jones, W. M. 2005. A vegetation index of biotic integrity for small-order streams in southwestern Montana and a floristic quality assessment for western Montana wetlands. Report to the Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Montana Natural Heritage Program, Helena, Montana. 29 pp. plus appendices.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983. Effects of late season cattle grazing on riparian plant communities. J. Range Manage. 36:685-691.

Lemly, J.M. & Rocchio, J.R. (*In prep*) Field Testing and Validation of the Subalpine-Montane Riparian Shrublands Ecological Integrity Assessment (EIA) Scorecard in the Blue River Watershed, Colorado. Unpublished report prepared for the Colorado Division of Wildlife and US EPA Region 8 by the Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Leu, M., S.E. Hanser, and S.T. Knick. 2008. The Human Footprint in the West: A Large-Scale Analysis of Anthropogenic Impacts. Ecological Applications 18(5): 1119-1139

Lichthardt, J. 2004. Conservation Strategy for Idaho Panhandle Peatlands. Report Prepared for the Idaho Panhandle National Forests. Idaho Conservation Data Center, Idaho Department of Fish and Game. Boise, Idaho.

Lindenmayer, D.B., and J.F. Franklin. 2002. Conserving forest biodiversity: A comprehensive multiscaled approach. Island Press, Washington, DC. 351 p.

Martin, R.C., H.J. Hansen, and G.A. Meuleman. 1988. Albeni Falls Wildlife Protection, Mitigation, and Enhancement Plan. Final Report 1987. Prepared for Bonneville Power Administration, Division of Fish and Wildlife, U.S. Department of Energy, Portland, Oregon. Contract No. DE-A179-87BP36154

Morgan, P., G.H. Aplet, J.B. Haufler, H.C. Humphries, M.M. Moore, and W.D. Wilson. 1994. Historical Range of Variability: A Useful Tool For Evaluating Ecosystem Change. *In:* N. Sampson and D. L. (editors) Assessing Forest Ecosystem Health in the Inland West. Haworth Press. New York, NY. Pages 87-111.

NatureServe. 2009. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: December 5, 2009).

Pack River Technical Advisory Committee (TAC). 2006. Pack River Watershed Management Plan and TMDL Implementation Plan. Prepared in Cooperation with Bonner Soil and Water Conservation District, Pack River Technical Advisory Committee, and Pack River Watershed Council. Bonner County, Idaho.

Parametrix, Inc. 1998. Assessment of Geomorphic Process, Clark Fork Hydroelectric Project Relicensing for WWP. Prepared for Washington Water Power. Spokane, WA.

Tierney, G.L., D. Faber-Langendoen, B.R. Mitchell et al. 2009. Monitoring and evaluating the ecological integrity of forest ecosystems. Frontiers in Ecology and the Environment 7(6): 308-316

Prichard, D., J. Anderson, C. Correll, J. Fogg, K. Gebhardt, R. Krapf, S. Leonard, B. Mitchell, and J. Staats. 1998. Riparian Area Management: A User's Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas. Technical Reference 1737-15. Bureau of Land Management, U.S. Department of Interior, Denver, CO.

Quigley, T. M. and S.J. Arbelbide (technical editors). 1997. An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins: Volume 2. Gen. Tech. Rep. PNW-GTR-405. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 4 Volumes. (Quigley, T.M., technical editor; The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment).

Tri-State Water Quality Council. 2002. Total Maximum Daily Load (TMDL) for Nutrients for the Nearshore Waters of Pend Oreille Lake, Idaho. Sandpoint, Idaho.

Tri-State Water Quality Council. 2007. Clark Fork-Pend Oreille Watershed Management Plan. Management Strategies for the Next Decade 2007-2017. Sandpoint, Idaho.

Tuffly, M. and P. Comer. 2005. Calculating landscape integrity: A working model. Internal report for NatureServe Vista decision support software engineering, prepared by NatureServe, Boulder CO.

United States Environmental Protection Agency (EPA). 2002. Methods for Evaluating Wetland Condition: #1 Introduction to Wetland Biological Assessment. Office of Water, U.S. Environmental Protection Agency, Washington D.C. EPA-822-R-02-014.

United States Environmental Protection Agency (EPA). 2006. Application of Elements of a State Water Monitoring and Assessment Program For Wetlands. Wetlands Division, Office of Wetlands, Oceans and Watersheds. U.S. Environmental Protection Agency, Washington D.C.

U. S. Fish and Wildlife Service. 2009 (date downloaded from USFWS website). National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/wetlands/

Vale, T.R. 1998. The Myth of the Humanized Landscape: An Example from Yosemite National Park. Natural Areas Journal 18: 231-236.

Vance, L., J. Lemly, G. Jones and K. Newlon. *In progress*. Identification of Ecological Integrity Attributes, Indicators and Metrics for Six Wetland Ecological Systems in the Rocky Mountains. A Regional Environmental Monitoring and Assessment Program (REMAP) project funded by U.S. EPA Region 8.

Western Regional Climate Center. 2009. Sandpoint Experiment Station, Idaho. Accessed December 2009. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?idsand

Whitlock, C. 2002. Vegetational and Climatic History of the Pacific Northwest during the Last 20,000 Years: Implications for Understanding Present-day Biodiversity. The Northwest Environmental Journal 8: 5-28.

Wilhelm, G. and L. Masters. 1996. Floristic Quality Assessment in the Chicago Region. The Morton Arboretum, Lisle, IL.

Young, T.F. and S. Sanzone (editors). 2002. A framework for assessing and reporting on ecological condition. Prepared by the Ecological Reporting Panel, Ecological Processes and Effects Committee. EPA Science Advisory Board. Washington, DC. 142 p.

Zedler, J.B and S. Kercher. 2004. Causes and Consequences of Invasive Plants in Wetlands: Opportunities, Opportunists, and Outcomes. Critical Reviews in Plant Sciences 23(5): 431-452.

APPENDIX: GIS SHAPEFILES

The GIS files listed in Table 2 have been submitted along with this report.