

Estimating Wetland Condition Locally: An Intensification Study in the Blackfoot and Swan River Watersheds

Prepared for:

The U.S. Environmental Protection Agency

Prepared by:

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EXECUTIVE SUMMARY

This report summarizes the results of our fourth statewide rotating basin assessment, focusing on wetlands in the Blackfoot and Swan subbasins of western Montana. We assessed wetland condition within nine watersheds at multiple spatial scales. We conducted Level 1 GIS analyses that produced: 1) wetland landscape profiles, which summarize information on wetland abundance, type, and extent within a given watershed; and 2) a landscape characterization, which characterizes the anthropogenic stressors such as roads and land uses, as well as general information regarding wetland landscape context, using readily available digital datasets. We carried out Level 2 assessments to provide rapid, field-based assessments of wetland condition based on four attributes: 1) Landscape Context; 2) Vegetation; 3) Physicochemical; and 4) Hydrology. Finally, Level 3 intensive assessments provided detailed information on the structure and composition of wetland vegetation at a subset of sites. This multi-tiered framework allows for the incorporation of multiple scales of assessment, integrating landscape-level information, ambient wetland condition, and site-specific data.

We included all digitally mapped wetlands to produce wetland landscape profiles for the project area. For the Level 1 landscape characterization and Level 2 and Level 3 wetland assessments, the target population included all mapped palustrine wetlands greater than 0.1 ha. We followed a spatially balanced sampling approach to select wetlands for assessment.

For Level 1 values and Level 2 assessment scores, we calculated descriptive statistics and assessed the range and distribution of each metric by examining frequency histograms. For Level 3 assessments, we calculated multiple vegetation metrics to conduct a floristic quality assessment (FQA). The FQA accounts for the presence of both native and exotic species, as well as individual plant species' tolerance of disturbance. We determined the relationships between Level 3 vegetation metric values, Level 2 assessment scores, and stressors recorded at assessment sites by examining Spearman's correlation coefficients.

Based on digital mapping, wetlands and other water bodies within the study area totaled 97,847 acres (39,597 hectares). The majority (76%) of the mapped acres are palustrine wetlands. These totals include deepwater areas such as lakes and river channels, which provide critical aquatic habitat and other valuable ecosystem services, but are not considered wetlands.

We conducted a Level 1 landscape characterization of 1,000 mapped palustrine wetland polygons at three spatial scales, examining our recently developed Human Disturbance Index (HDI) within 100-m, 300-m, and 1,000-m envelopes around each polygon. Mean HDI scores were relatively consistent across all three scales for wetland types in the Blackfoot and Swan subbasins, suggesting moderate levels of disturbance. When scores were calculated separately for surveyed and non-surveyed (randomly chosen) wetlands, results suggested a public land effect: 1) randomly chosen wetlands had lower mean HDI scores for public than for private lands, whereas surveyed wetlands – tending to be nearer roads – showed no statistically significant difference between public and private lands; and 2) across all wetland sites, mean

HDI scores were lower for surveyed sites (which tended to be on public land) than they were for randomly selected sites.

We visited 126 sites during the summer of 2013 and 2014, sampling 24 probabilistic sites and 26 targeted sites with the MTNHP Level 3 EIA protocol, and the rest with the Level 2 protocol. The Intermontane Prairie Pothole was the most common system sampled (37 sites). Rocky Mountain Subalpine-Montane Fen was the second most commonly sampled ecological system (26). Other systems encountered in this study included Alpine-Montane Wet Meadow, Western North America Emergent Marsh, Wooded Conifer Swamp, Rocky Mountain Vernal Pool, and several Riparian Woodland and/or Shrubland systems.

Level 2 condition scores were calculated for all 126 wetlands sampled. Scores ranged from 52-100 out of a possible range of 21.5-100. We divided our assessment scores into four categories defined relative to their departure from reference standard. Most sites were either at or near the reference standard, or slightly departed from reference. Thirty-eight sites had no observed stressors in the assessment area (AA), whereas only 17 sites had no observed stressors within the 200-m envelope. No site's impact rating was categorized as Very High. Impact scores tended to be highest for the Landscape Context and Vegetation attributes within both the AA and the 200-m envelope (Tables 16 and 17). The Physicochemical attribute made the least contribution to higher impact scores, with nearly all sites falling in the No Impact and Low Impact categories.

Recreation/human visitation and livestock grazing were the most common stressors potentially impacting Landscape Context within the AA, while unpaved roads were the most observed stressor in the 200-m envelope. Vegetation stressors included browsing by native ungulates, livestock grazing, and beaver activity. Beaver activity was also the most common Hydrologic stressor, along with impoundments. Trash or refuse dumping was the most common Physicochemical stressor.

We completed 24 Level 3 intensive assessments within the project area, encountering 309 plant taxa. The average number of species encountered per site was 34 (*range* 7-76). Of the 282 taxa identified to species, 260 (92%) were native species and 19 (7%) were exotic species. We calculated FQA metrics for all 24 Level 3 assessment sites. Mean C-value across these sites was 4.91 (*range* 3.44 – 6.34). Most C-values for native species encountered fell between 3 and 8 (Figure 25). Species at the lower end of that range are found in diverse habitats with little to moderate disturbance, while those at the higher end tend to be habitat specialists or have low tolerance for disturbance.

To understand the effectiveness of this assessment framework in determining the condition of wetlands in the southeast Montana project area, we compared Level 3 assessment results with Level 2 assessment results. Impact ratings within the AA and within the 200-m envelope around the AA showed moderate correlations with overall Level 2 assessment scores. The Landscape Context and Hydrologic attribute scores were most strongly correlated with overall impact rating for both the AA and the 200-m envelope (with *r* values ranging from 0.35-0.54).

There were 16 vegetation metrics evaluated in the FQA. Most of the vegetation metrics showed some degree of correlation with either stressors or overall wetland condition, but none of the

correlations was strong. The strongest correlation was observed between mean C-value of native species and overall condition score. Non-native species richness was negatively correlated with stressor impact scores and overall condition scores, meaning that as impact and condition scores increased toward their maximum values (indicating reference conditions on the ground), the number of non-native species decreased.

FQA metrics that were correlated with overall condition scores also were correlated with one or more individual Level 2 attribute scores (Table 24). Not surprisingly, nearly all FQA metrics showed moderate correlation with the Vegetation attribute. Again, non-native species richness was negatively correlated with all four attributes, meaning that as EIA attribute scores increased toward 100 (reference conditions), non-native species richness decreased.

Results from this project indicate the wetlands in the Blackfoot-Swan area of Montana are in good to excellent condition. Except for unpaved roads, which are common throughout the study area as a legacy of logging, wetlands are relatively unimpacted by human stressors. However, these unpaved roads often act as sites for weedy species to establish, threatening wetlands and their adjacent buffers.

The rotating basin assessment was complemented by an analysis of data from this and previous projects to evaluate whether water permanence is a predictor of wetland condition. Analysis of the National Wetland Plant List for the Western Mountains and Valleys against the Coefficients of Conservatism (C-values) for Montana wetland plants shows that the mean C-value for OBL and FACW species is 5.83, while for FAC, FACU and UPL species it is 2.87. In this study, we saw a moderate negative correlation (-0.55) between the percentage of FACW or OBL species at a site and its overall native plant richness, and a slightly weaker correlation between the unadjusted Floristic Quality Index (FQI) of native species and the percentage of hydrophytes (-0.45). Scores on the Adjusted Cover-weighted FQI are moderately and positively correlated (0.49) with the proportion of hydrophytes. Examining these factors across several of our rotating basin assessments, we found that Mean C and Mean C of native species were moderately correlated with the proportion of FACW and OBL (0.58 and 0.46). We noted, too, that in both cases there was a moderate negative correlation between the proportion of hydrophytes and the number of exotic species. We also saw a moderate correlation between the Adjusted FQI for native species and the proportion of FACW and OBL species at a site. The analysis also showed that while there appears to be a clear relationship between the percent of standing water and proportion of FACW and OBL species, there does not appear to be any linear relationship between the percent of standing water and Mean C, except at the driest sites.

Finally, another goal of this project involved describing an ecological system that has not been previously described in Montana, the Intermontane Prairie Pothole. These sites are relatively abundant in the study area. Using data collected in this study, we were able to produce a detailed Ecological System description characterizing the environment, vegetation, dynamics and restoration considerations for these wetlands.

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1.0 INTRODUCTION

Wetlands provide multiple biological and economic benefits such as plant and wildlife habitat, flood attenuation, groundwater recharge, and improvements to water quality. Despite these benefits, wetlands continue to experience pressures from multiple uses including urban, exurban, and agricultural development, as well as resource extraction. Quantifying the impact of these uses on wetland resources requires scientifically sound metrics to assess wetland condition. Recognizing the need for information on wetland condition at a watershed scale, the Montana Natural Heritage Program (MTNHP) initiated a statewide monitoring and assessment program in 2008 to report on the ambient condition of Montana's wetlands. These basin-wide assessments provide regionally specific information on the ecological integrity of wetlands.

This report summarizes the results of the Blackfoot-Swan Intensification Project (BSIP), our fourth basin-wide assessment of wetlands in the Blackfoot and Swan River watersheds of western Montana. The Blackfoot and Swan watersheds are relatively undeveloped and still support the full suite of native wildlife species, including gray wolf, bull trout, trumpeter swan, and grizzly bear. These watersheds have some of the highest wetland densities in Montana and support a diversity of wetland systems, including forested wetlands, fens, and potholes. Conducting wetland assessments across this range of wetland types will allow us to validate and calibrate our wetland assessment metrics. There are also information gaps about the pothole wetlands left behind by large ice sheets that once covered the intermontane valleys of the region. These potholes support unique and highly diverse plant communities (Lesica 1994), yet no accepted ecological description exists for these systems. Collecting field data, reviewing the literature and developing such a description was an explicit goal of this study.

Our objective was to assess wetland condition within two watersheds in western Montana at multiple spatial scales. We conducted Level 1 GIS analyses that produced: 1) wetland landscape profiles, which summarize information on wetland abundance, type, and extent within a given watershed; and 2) a landscape characterization, which characterizes the anthropogenic stressors such as roads and land uses, as well as general information regarding wetland landscape context, using readily available digital datasets. We conducted Level 2 assessments to provide rapid, field-based assessments of wetland condition, and at a subset of sites, carried out Level 3 intensive assessments to acquire detailed information on the structure and composition of wetland vegetation. This multi-tiered framework allows for the incorporation of multiple scales of assessment, integrating landscape-level information, ambient wetland condition, and site-specific data.

As part of our ongoing development of wetland assessment tools, we also explored a separate question: when all other things are equal, are Floristic Quality Index scores higher for wetter wetlands than for drier ones? Casual observation and anecdotal evidence suggested that this was the case, in part because wetter wetlands appear to be less susceptible to invasion by exotic species. After several years of conducting rotating basin assessments across the state, we believed we had sufficient data to examine this question empirically.

2.0 STUDY AREA

2.1 Geography

The project area is focused within two USGS hydrologic basins in western Montana (Figure 1): Swan River (17010211) and Blackfoot River (17010203).

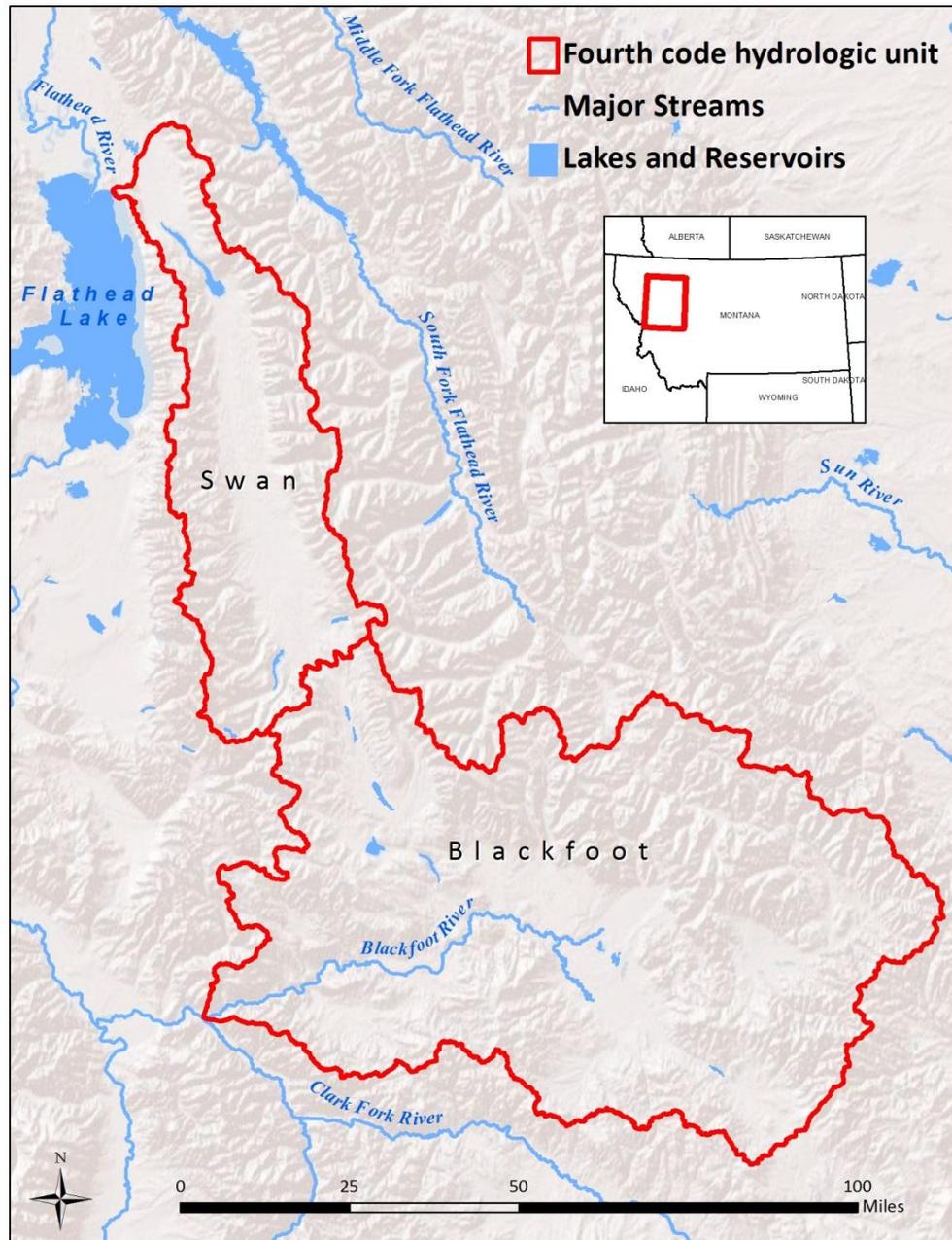


Figure 1. Blackfoot-Swan Intensification Project area.

The project area covers 1,944,455 ac (786,893 ha) and includes portions of Flathead, Lake, Lewis and Clark, Missoula, Powell, and Granite counties (Table 1). Major towns in the project area include Seeley Lake and Lincoln, with the towns of Bigfork and Bonner on the western periphery and many smaller communities scattered throughout. The area is a complex mix of publicly and privately owned lands; the U.S. Forest Service, the State of Montana, and Bureau of Land Management manage the largest public holdings (Figure 2). Timber harvest and livestock grazing are the historically predominant land uses, with recreation, wildlife habitat, and rural residential development becoming increasingly important.

Table 1. Land area of watersheds included in the Blackfoot-Swan Intensification Project.

Watershed	8-digit hydrologic unit code	Acres	Hectares	% of Project Area
	Blackfoot	17010203	1,478,394	598,285
Swan	17010211	466,061	188,608	24%

The topography of the project area, for the most part, has been shaped by glaciation. Continental glaciation yielded the long valley of the Swan, while disintegration of alpine glaciers shaped the hummocky moraines of the Blackfoot Valley. Quaternary alluvial, colluvial, glacial drift, ash deposits, and Precambrian Belt formations are also common. Soils are fine-textured and have low permeability, with many wetlands perched above the water table and receiving most hydrologic inputs from precipitation and runoff.

2.2 Climate and Hydrology

The climate of the project area is characterized by long, cold winters and moist springs; in the Swan drainage, climate is partially maritime-influenced. Average annual precipitation ranges from 14.6 to 28.1 inches (37 to 71 cm). Peak precipitation periods typically occur in May and June in the Blackfoot, and in November-January in the Swan. Highest maximum daily temperatures occur during July and August, with temperatures averaging 78° to 83° F (26° to 28° C). (Western Regional Climate Center 2015)

Relative effective annual precipitation (REAP) is an indicator of the amount of moisture available at a given location accounting for precipitation, slope, aspect, and soil properties. REAP ranges widely from 9 inches (24 cm) to 102 inches (260 cm), with the lowest values in the Blackfoot valley and highest values along the peaks of the Swan and Mission mountain ranges (Figure 3).

The major river in the project area is the Blackfoot River, which has its headwaters along the Continental Divide at Rogers Pass and flows southwesterly to its confluence with the Clark Fork River just east of Missoula. Other rivers include the Clearwater and Swan Rivers, separated by the gentle Clearwater Divide. The Clearwater flows south through a chain of lakes – including Seeley and Salmon Lakes – into the Blackfoot, and the Swan flows north into Swan Lake and

empties into Flathead Lake at the town of Bigfork, eventually joining the Flathead River. Other large lakes include Holland, Lindbergh, and Placid Lakes, but the landscape is dotted with many other smaller lakes and wetland features.

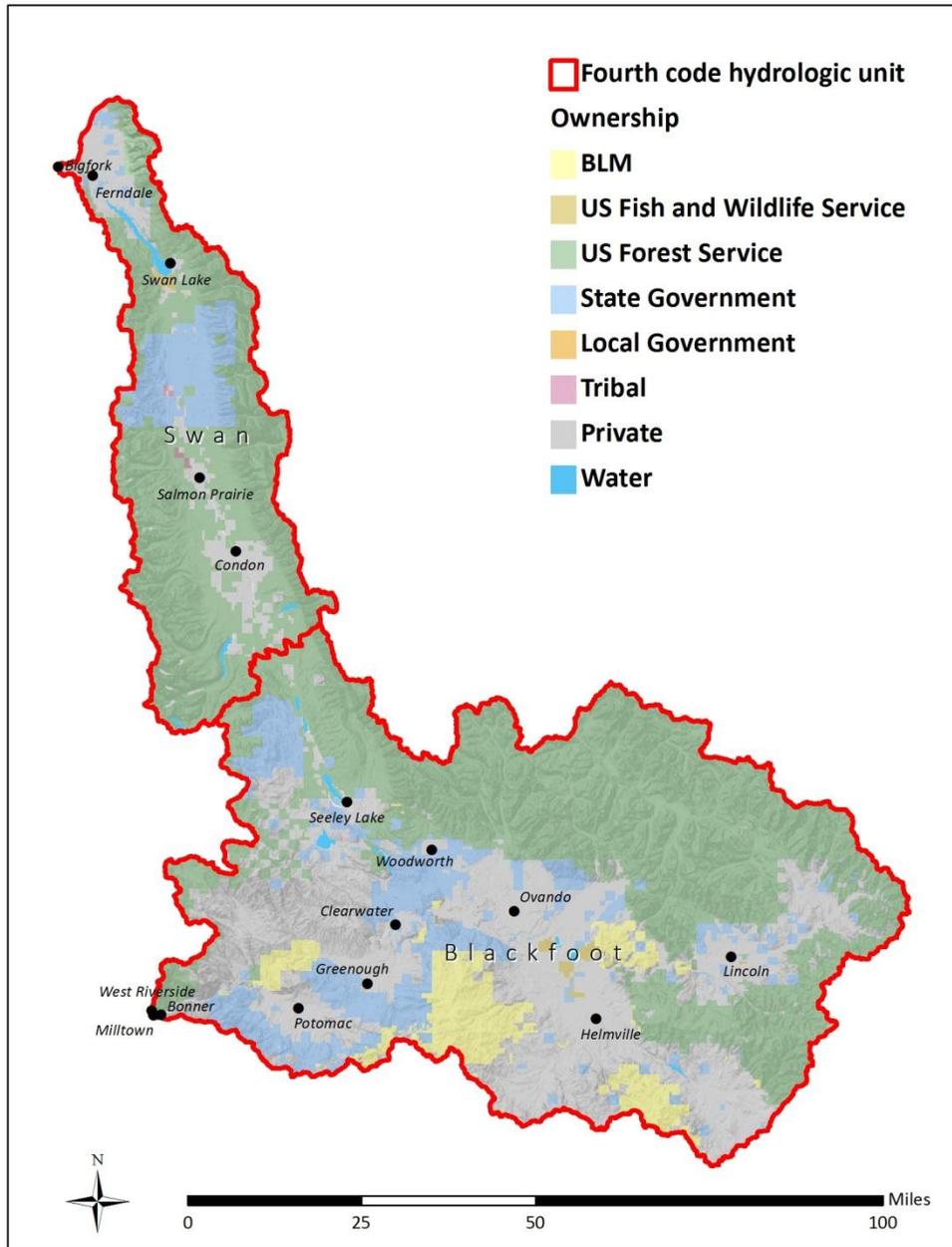


Figure 2. Land ownership within the Blackfoot-Swan Intensification Project area.

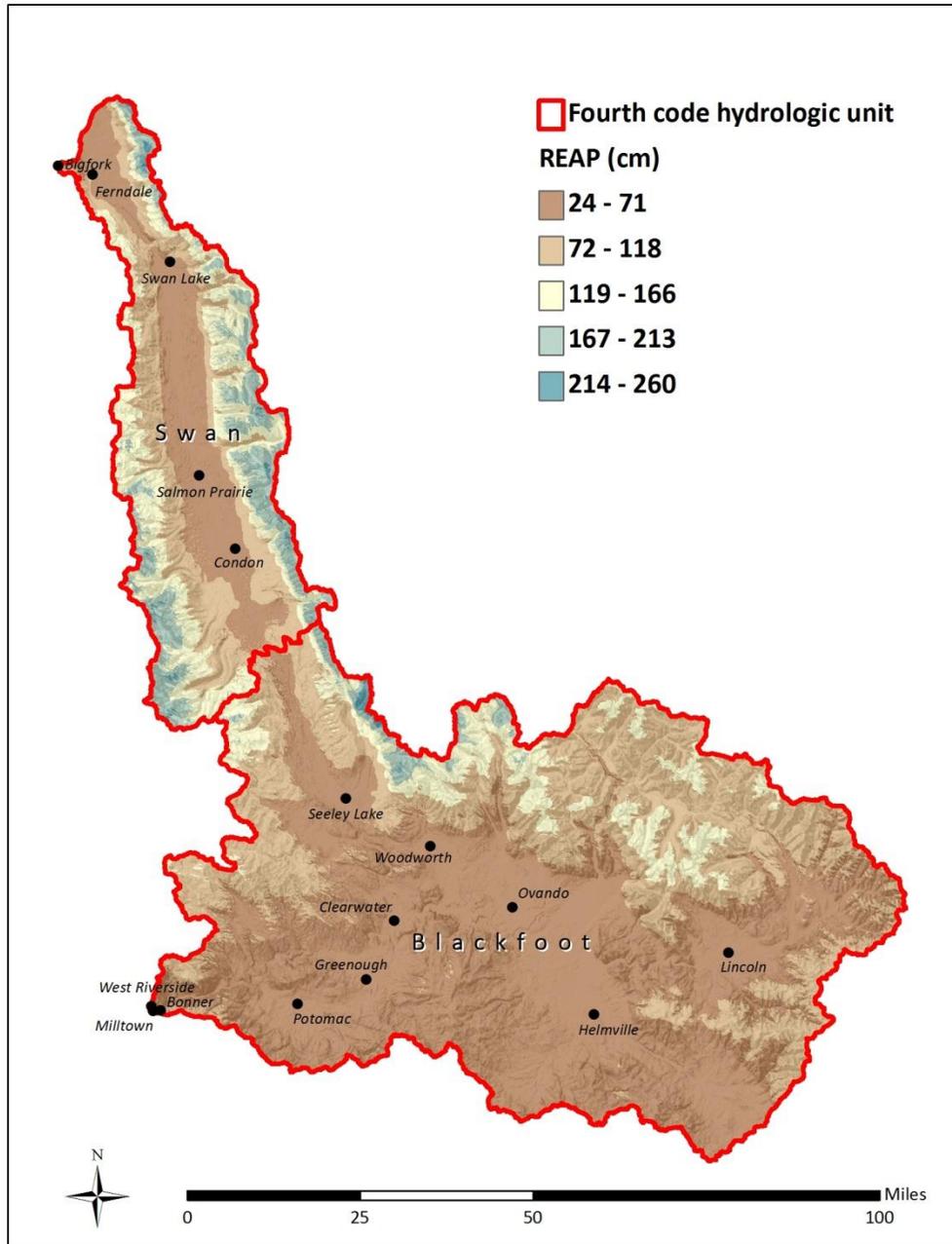


Figure 3. Relative effective annual precipitation (REAP) for the Blackfoot-Swan Intensification Project area.

2.3 Ecoregions and Vegetation

The project area falls within three Level III ecoregions (Omernik 1987). The Blackfoot watershed lies almost entirely within the Middle Rockies ecoregion, although the Swan and Mission mountain ranges in the northwestern corner are assigned to the Canadian Rockies, as they are in the Swan watershed to the north. The valley floor of the Swan falls within the Northern Rockies ecoregion.

Level IV ecoregions further subdivide the area into 12 different units based on geology and dominant vegetation (Table 2; Figure 4). Coniferous trees are the predominant vegetation, with grasslands and shrublands more common in the valleys and foothills of the Blackfoot (Figure 5). Subalpine fir (*Abies lasiocarpa*), Douglas-fir (*Pseudotsuga menziesii*), and ponderosa pine (*Pinus ponderosa*) forests occupy the mountains of the Blackfoot drainage, with foothill prairie vegetation in the Blackfoot Valley. In the moister Mission Mountains and Swan Range and in the valley that separates them, subalpine fir (*Abies lasiocarpa*) and Douglas-fir (*Pseudotsuga menziesii*) are joined by grand fir (*Abies grandis*) and Engelmann spruce (*Picea engelmannii*).

Table 2. Level IV ecoregions and their corresponding land area within the Blackfoot-Swan Intensification Project area.

Level IV Ecoregion Name	Code	Acres	Hectares	% Project Area
Crestal Alpine-Subalpine Zone	41b	40,402	16,350	2.08%
Deer Lodge-Philipsburg-Avon Grassy Intermontane Hills and Valleys	17ak	77,941	31,542	4.01%
Eastern Divide Mountains	17aj	10,821	4,379	0.56%
Flathead Thrust Faulted Carbonate-Rich Mountains	41e	3,295	1,333	0.17%
Flathead Valley	15c	37	15	0.00%
Foothill Potholes	17p	159,804	64,670	8.22%
Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire Mountains	17x	1,094,864	443,077	56.31%
Salish Mountains	15l	7,241	2,930	0.37%
Southern Carbonate Front	41d	467	189	0.02%
Southern Garnet Sedimentary-Volcanic Mountains	17al	32,297	13,070	1.66%
Stillwater-Swan Wooded Valley	15t	160,331	64,884	8.25%
Western Canadian Rockies	41c	356,949	144,453	18.36%

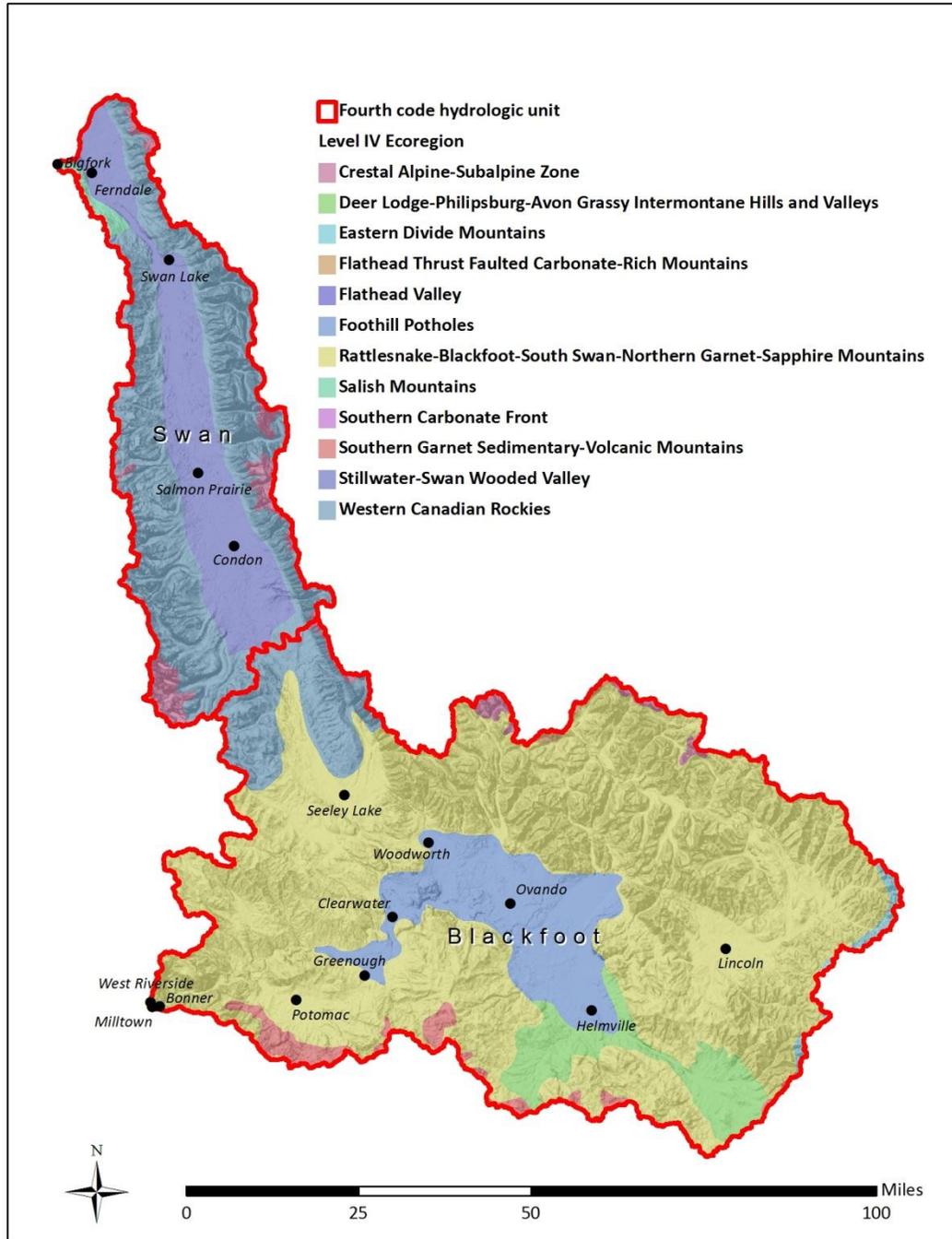


Figure 4. Level IV ecoregions within the Blackfoot-Swan Intensification Project area.

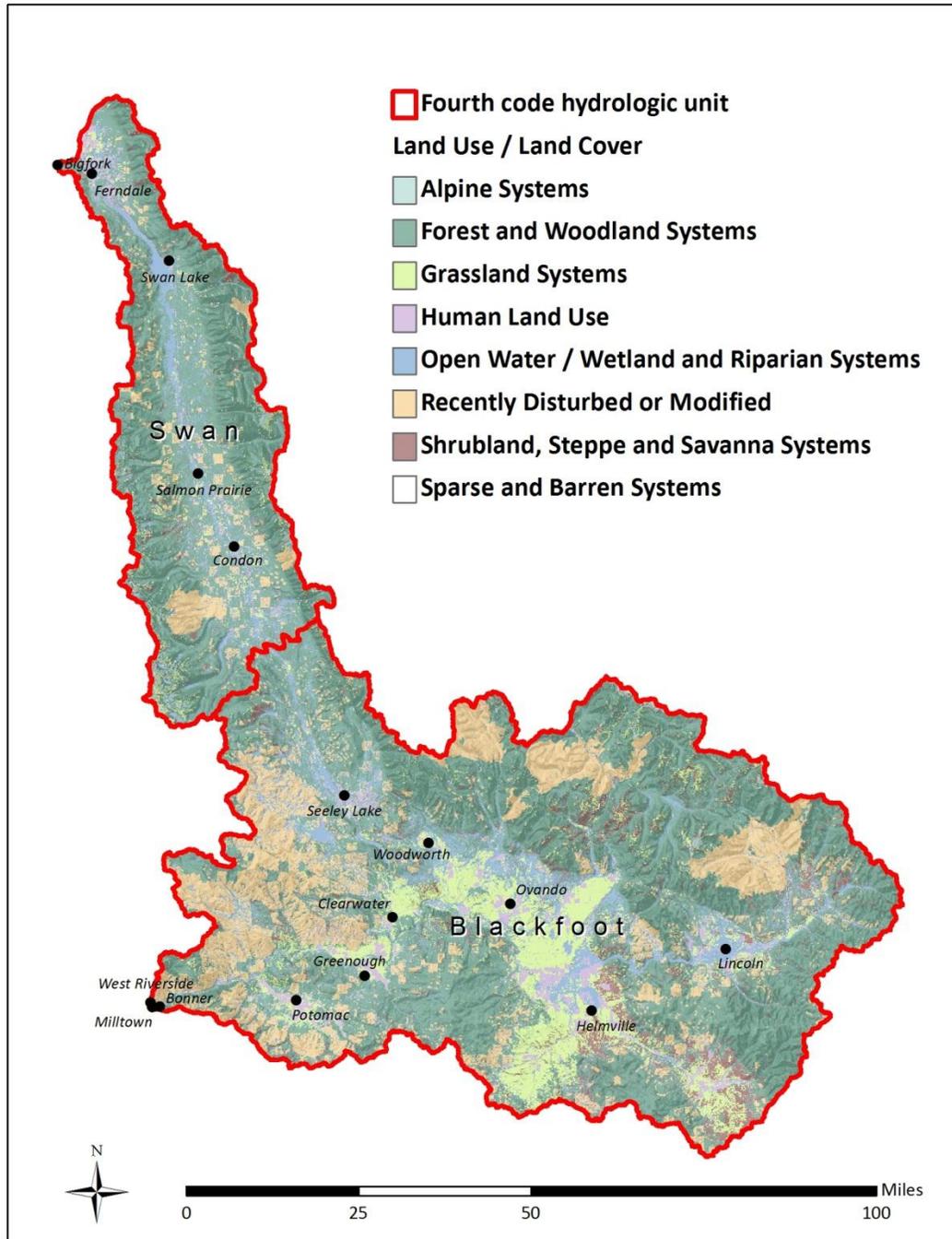


Figure 5. Broad land cover and land use classes of the Blackfoot-Swan Intensification Project area (MTNHP 2013). Areas classified as recently disturbed or modified represent areas burned by wildfires.

3.0 METHODS

3.1 Ecological Integrity Assessment Framework

The MTNHP uses an Ecological Integrity Assessment (EIA) framework to assess the condition of wetlands. This EIA framework is based on one developed by NatureServe and ecologists from several Natural Heritage Programs across the country (Faber-Langendoen et al. 2011). This framework also applies concepts from established wetland assessment methods, including the California Rapid Assessment Method for Wetlands (CWMW 2013) and the Ohio Rapid Assessment Method (Mack 2001). An EIA relies upon the identification of key ecological indicators or metrics and stressors that can be readily measured, monitored, or observed. The indicators reflect both the structure and function of the wetland. Metrics consist of narrative ratings and are scaled along a gradient reflecting wetland condition relative to a natural or undisturbed state (i.e., reference standard). Ideally, metrics should be unambiguous, mutually exclusive, and equally distributed along a disturbance gradient, allowing the observer to best describe the observed state (Sutula et al. 2006). Metric ratings are assigned on an ordinal scale, resulting in reduced measurement error and repeatable results. EIA metric ratings are integrated to produce overall scores for four attributes: 1) Landscape Context; 2) Vegetation; 3) Physicochemical; and 4) Hydrology. The ratings for these four attributes can be combined to produce an overall EIA score (Table 3).

We assessed wetland integrity at three levels. Level 1 GIS landscape analyses consist of: 1) wetland landscape profiles, which use digital wetland mapping to summarize information on wetland abundance, type, extent, and function across the watershed (Johnson 2005); and 2) a landscape characterization of the distribution of anthropogenic stressors such as roads and land use in relation to wetlands, as well as general information regarding wetland landscape context. Level 2 field-based assessments collect data on the general condition of individual wetlands. Level 3 assessments collect detailed quantitative data using indices of biological integrity.

3.2 Wetland Classification

Natural variability occurs both within wetland classes (e.g., wet meadows can occur at either alpine or lower montane elevations, but differ in plant diversity and productivity) and among wetland classes (e.g., fens differ in hydrology, soils, and plant communities from freshwater marshes). Providing a classification framework to distinguish wetland systems helps reduce within class variability and enhance detection of differences in condition among wetlands. Common wetland classification systems include the Cowardin classification system (Cowardin et al. 1979) and the hydrogeomorphic (HGM) classification system (Brinson 1993). Standardized classifications have also been developed through the National Vegetation Classification (NVC; Grossman et al. 1998) and the Ecological Systems classification in the United States (Comer et al. 2003). For the purpose of this project, we used the Ecological Systems classification. This classification system provides a valuable means of classifying wetland systems because it uses

both biotic (e.g., vegetation physiognomy and floristics) and abiotic (e.g., geologic, hydrologic, elevation, edaphic) criteria to define landscape units. Ecological Systems can be crosswalked to other classification systems including the NVC, Cowardin, and HGM systems. Additionally, they capture the range of natural variability in wetlands while organizing them into manageable conceptual units.

Table 3. Ecological Integrity Assessment metrics and ecological attributes used in the Blackfoot-Swan Intensification Project.

Attribute	Metric
Landscape Context	Landscape Connectivity
	Buffer Width
	Buffer Length
	Buffer Condition
Vegetation	Relative Cover of Native Plant Species
	Relative Cover of Tolerant Native Plant Species
	Relative Cover of Noxious Plant Species
	Herbaceous Litter/Woody Debris Accumulation
	Interspersion of Plant Zones
	Woody Species Establishment and Regeneration
Physicochemical	Utilization of Trees and Shrubs
	Soil Surface Integrity
Hydrology	Water Quality: Algae, Plants, and Turbidity
	Water Inputs
	Water Outlets
	Hydroperiod
	Surface Water Connectivity

3.3 Sample Design

The MTNHP completed digital wetland mapping for the project area based on 2009 and 2013 aerial imagery with funding from this EPA Wetland Program Development Grant and prior funding from agency partners. This digital mapping was used to produce wetland landscape profiles for the project area. For the Level 1 landscape characterization and Level 2 and Level 3 wetland assessments, the target population included all mapped vegetated wetlands, but excluded lacustrine (deepwater lakes), riverine (deepwater habitats contained within the channel), and artificially flooded wetlands from the target population. We also excluded wetlands smaller than 0.1 ha. A list of NWI types included in the sample frame can be found in Appendix A. A list of NWI types excluded from the sample frame can be found in Appendices B and C.

The target number of sample sites was 1,000 wetlands for Level 1 landscape characterization; 100 wetlands for Level 1 and 2 assessments; and 30 wetlands for Level 3 assessment. We

followed a spatially balanced sampling approach (see Stevens and Olsen 2004, Stevens and Jensen 2007) to select wetlands for assessment. This approach allowed us to account for the spatial patterning inherent in ecological systems (e.g., sites in close proximity tend to be more similar than widely separated sites). Spatially balanced sampling is also more efficient than simple random sampling by minimizing the redundancy inherent in a simple random sample, which might select multiple proximate sites (Stevens and Jensen 2007). The sample design followed a Generalized Random Tessellation Stratified (GRTS) procedure for discrete objects with reverse hierarchical randomization, where polygons within the sample frame were the discrete objects and their locations were identified by their centroids. We selected approximately 1,000 wetlands, stratifying by Level IV ecoregion. GRTS sampling was performed using package `spsurvey` (Kincaid and Olsen 2009) in R (R Development Core Team 2009). After this initial site selection, we examined each selected wetland using aerial imagery in a GIS to ensure it still existed and was accessible until we had approximately 100 wetlands selected for Level 2 field assessments. We conducted intensive Level 3 assessments at approximately 30% of these 100 wetlands.

To support the description of Intermontane Potholes, we selected additional targeted sites through visual examination of aerial imagery and wetland mapping. These were confirmed in the field using the following criteria:

1. The wetland must have no hydrologic modifications (e.g., impoundments, ditches, etc.).
2. The HGM class must be Depressional.
3. The wetland should have clear wetland/vegetation zonation.
4. The surrounding upland within 200 m of the wetland perimeter must be primarily comprised of native prairie (e.g., *Festuca idahoensis*, *F. campestris*, *Agropyron spicatum*) or native sagebrush steppe vegetation (*Artemisia tridentata*, *A. tripartita*, and native grasses).
5. The majority of the water in the wetland must be less than 1 meter in depth.
6. There should be no evidence of heavy livestock use in the wetland or the surrounding 200 m envelope around the wetland (e.g., pugging, salt licks, wallows, water holes).
7. If the selected wetland does not meet the above criteria, or is unable to be sampled for other reasons, please note this and select another wetland with a similar hydrologic regime within the 200 meter envelope around the selected wetland.
8. When selecting a different site, try and select a wetland with a similar hydrologic regime to the wetland originally selected.

Thirty-one sites were assessed using Level 3 methods to collect detailed vegetation and hydrologic data; of these, 5 were Intermontane Potholes encountered during the probabilistic surveys and 26 were targeted sites.

3.4 Level 1-2-3 Assessments

3.4.1 Level 1 - Wetland Landscape Profiling: Using digital wetland mapping, we prepared a wetland landscape profile for the project area. A wetland landscape profile provides a broad landscape characterization of the wetlands within a particular area at the basin, watershed, or

subwatershed level. The profile summarizes wetland acreage by: Cowardin system, class, and hydrologic regime; land ownership; and the extent of wetlands that have been anthropogenically altered.

3.4.2 Level 1 - Landscape Characterization: Using our spatially balanced random sample of 1,000 palustrine wetlands from digital wetland mapping, we applied our recently developed Human Disturbance Index (Newlon 2015), to evaluate disturbance characteristics around these selected wetlands at three spatial scales: 100 m, 300 m, and 1,000 m.

3.4.3 Level 2 Rapid Assessments: Field methods for Level 2 assessments are detailed in the Montana Ecological Integrity Assessment Field Manual (MTNHP 2014). Level 2 assessments take half a day or less to complete. At each sample wetland point, we established an assessment area (AA) for sampling. The AA was established within a portion of the wetland representing the same Ecological System type within a 0.5 ha area around the sample point. Prior to field visits, we created a set of field maps for each targeted sample point. The field maps outlined the potential AA boundary and multiple radial buffers around the AA. These buffers are used in several of the landscape context metrics.

Once at the target sample point, field team members determined the extent of the AA by estimating the approximate boundaries of the wetland within the potential AA. Readily observable ecological criteria such as vegetation, soil, and hydrological characteristics were used to define wetland boundaries, regardless of whether they met jurisdictional criteria for wetlands regulated under the Clean Water Act (*sensu* U.S. Army Corps of Engineers 2010). Because certain field metrics vary by Ecological System, every attempt was made to include a single Ecological System in the AA. If the target sample point occurred at the edge of a wetland or at the edge of one Ecological System type, then field teams adjusted the point up to 60 m.

The EIA form also contains a list of observed stressors or disturbances commonly found in Montana (Table 4). Stressor lists can provide additional information when evaluating ecological integrity and can aid in further understanding of overall wetland condition. In some cases, stressors may be present at or near a site, but condition metrics may not reflect these impacts. This may be caused by a temporal lag between the impact and its effect on the biotic community, such as a very recent clear cut, or it may reflect stressors the current biotic metrics do not pick up. In the first case, the stressor list can be used to flag sites that may become degraded in the future. In the second case, the stressor list may indicate that adjustments should be made to the metrics.

Along with recording the occurrence of a stressor, the scope and severity of each stressor were also estimated (Faber-Langendoen et al. 2011; Table 5). Scope is defined as the proportion of the occurrence of an ecosystem that can be expected to be affected by the stress. Severity is the level of damage to the site from the stressor that can be expected with continuation of current circumstances. Stressor scope and severity scores are rolled up into an overall stressor impact score (Appendix D).

Table 4. Stressor metrics and associated disturbance categories.

Transportation Disturbances	Land Use Disturbances-Vegetation Removal
Paved surfaces (e.g., roads, parking lots)	Chemical vegetation control
Unpaved roads	Evidence of intentional burning
Railroads	Vegetation conversion
	Mechanical vegetation removal
Land Use Disturbances-Development or Recreation	Natural or Environmental Disturbances
Domestic or commercial development	Beetle-killed <i>Pinus</i> species
Intensively managed sports fields, golf courses	Other diseased conifers
Recreation or human visitation	Evidence of recent fire (<5 years)
Filling or dumping of sediment or fill	Beaver activity
Trash or refuse dumping	Evidence of prolonged drought
	Browsing of woody vegetation by native ungulates
Hydrologic Disturbances	Land Use Disturbances-Agriculture
Upstream spring box	Dryland farming
Impoundment of flowing water	Livestock grazing
Potential for agricultural runoff	Irrigated cropland
Potential for urban runoff	Irrigated hay pasture
Upstream dam	Permanent tree plantation
Reservoir/Stock pond	Disturbed fallow lands dominated by exotic species
Weir or drop structure	Haying of native grassland
Dredged inlet/outlet channel	Fallow fields (no human use in past 10 years)
Engineered channel (e.g., riprap)	Plowing or discing
Pumps, diversions, or ditches that move water into wetland	Irrigation ditches
Pumps, diversions, or ditches that move water out of wetland	Fences
Berms/dikes/levees	Land Use Disturbances-Resource Extraction
Culverts	Gravel pits, open pit mining
	Other mining activity or abandoned mines
	Resource extraction (oil and gas)
	Intensive logging (50-75% trees of >50 cm diameter removed)
	Selective logging (<50% of trees >50 cm diameter removed)

Table 5. Scope and severity ratings for stressors observed within the assessment area (AA) and within a 200-m envelope around the AA.

Scope of Disturbances	
5	Pervasive – Affects nearly all (>75%) of the envelope or AA.
4	Large – Affects most (>50-75%) of the envelope or AA.
3	Moderate – Affects much (>25-50%) of the envelope or AA.
2	Restricted – Affects some (>10-25%) of the envelope or AA.
1	Small – Affects a small (1-10%) portion of the envelope or AA.
0	Nil – Little or no observed effect (<1%) on the envelope or AA.
Severity of Disturbances	
4	Extreme – likely to extremely modify, degrade, destroy, or eliminate the wetland.
3	Serious – likely to seriously modify, degrade or reduce wetland function or condition.
2	Moderate – likely to moderately modify, degrade or reduce wetland function or condition.
1	Slight – likely to only slightly modify, degrade, or reduce wetland function or condition.

In addition to the EIA indicator metrics and observed stressors, we also collected standard site variables at each sample location. These included:

- UTM coordinates
- Elevation, slope, and aspect
- Ecological System classification (Comer et al. 2003)
- Dominant plant species
- HGM classification (Hauer et al. 2002)
- Cowardin classification (Cowardin et al. 1979)
- Nearby landforms (alluvial fans, narrow bedrock valley, alluvial valley, etc.)
- Description of onsite and adjacent ecological processes and land use
- Description of general site characteristics and a site drawing
- Selected soils data: depth and identification of soil horizons, texture, and color
- Water table depth

At least four photos were taken from the AA center at each site (Figure 6). Photos were taken 90° from each other, and the aspect was recorded to the nearest 5° at all photo points. Photo placards were placed in the corner of each photo. Additional photos were taken as needed to document the wetland and surrounding landscape.



Figure 6. Example photos from wetland condition assessments in the Blackfoot-Swan Intensification Project area.

At each sampling location, we collected detailed soil data by excavating a soil pit 45–60 cm in depth. For each horizon, we recorded depth, soil layers, matrix color, redoximorphic feature color and abundance (%), and soil texture. Soil color was determined using Munsell Soil Color Charts (Munsell Color Company 2000).

3.4.4 Level 3 Intensive Assessments: Field methods for Level 3 assessments are detailed in the Montana Ecological Integrity Assessment Field Manual (MTNHP 2014). We collected intensive Level 3 vegetation data at approximately 30% of randomly selected and at 26 targeted sites using a 20 m x 50 m relevé plot (Peet et al. 1998). This method, which takes approximately six hours per site, has been in use by the North Carolina Vegetation Survey for 15 years (Peet et al. 1998) and has been used to successfully develop a vegetation index of biotic integrity (VIBI) in Ohio (Mack 2004) and Colorado (Rocchio 2006; Rocchio 2007; Lemly and Rocchio 2009). The structure of the plot consists of ten 10 m x 10 m (100 m²) modules typically arranged in a 20 m x 50 m array (Figure 7). The plot was subjectively placed within the AA to maximize abiotic/biotic heterogeneity. Capturing heterogeneity within the plot ensures adequate representation of local variations produced by hummocks, water tracks, side-channels, pools, wetland edge, microtopography, etc. The following guidelines were used to determine plot locations within the AA:

- The plot was located in a representative area of the AA that incorporates as much microtopographic variation as possible.
- If the AA was homogeneous and there was no direction or orientation evident in the vegetation, the plot was laid out to run either N-S or E-W using the second hand on a watch to randomly determine direction (00–29 sec = N-S orientation; 30–59 sec = E-W orientation).
- If the AA was not homogeneous, was oddly shaped, or was directional (i.e., followed a stream), the plot was oriented to adequately represent all wetland features.
- If the wetland had an irregular shape and the 20 m x 50 m plot did not fit within the AA, the array of modules was restructured to accommodate the shape of the AA. For example, a 10 m x 50 m plot was used for narrow, linear areas and a 20 m x 20 m plot was used for small, circular sites.
- The plot captured the range of diversity within the AA, without crossing over into the upland. No more than 20% of the plot was located in upland areas beyond the wetland. If end modules crossed into the upland, they were not sampled as intensive modules.
- If a small patch of another wetland type was present in the AA (but not large enough to be delineated as a separate Ecological System), the plot was placed so at least a portion of the patch was in the plot.
- Localized, small areas of human-induced disturbance were included in the plot according to their relative representation of the AA.

Absolute cover of all vascular species was estimated within four of the 100 m² modules, referred to as intensive modules. When all species within a module had been identified, cover was visually estimated for the 100 m² module using the following cover classes (Peet et al. 1998):

- | | |
|---|-----------------------|
| Class 1 = trace (one individual or two individuals) | Class 6 \geq 10–25% |
| Class 2 $<$ 1% | Class 7 \geq 25–50% |
| Class 3 \geq 1–2% | Class 8 \geq 50–75% |
| Class 4 \geq 2–5% | Class 9 \geq 75–95% |
| Class 5 \geq 5–10% | Class 10 \geq 95% |

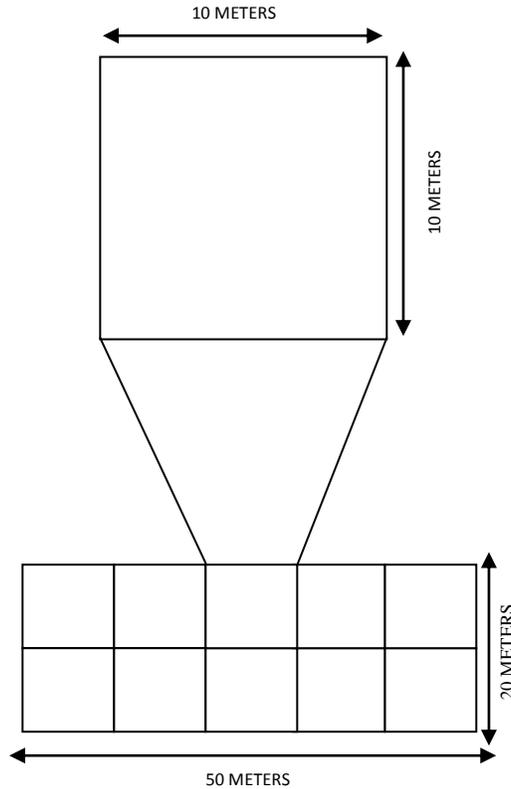


Figure 7. Reléve plot layout (adapted from Peet et al. 1998).

After sampling each of the intensive modules, the remaining, or residual, modules were walked to document presence of any species not recorded in the intensive modules. Percent cover of these species was estimated over the entire 1,000 m² plot.

In the field, vascular plants were identified using the Manual of Montana Vascular Plants (Lesica 2012) as well as ancillary dichotomous keys specific to certain plant genera (e.g., carices). The state-based nomenclature was crosswalked to nationally accepted nomenclature based on the USDA PLANTS Database (<http://plants.usda.gov>).

3.4.5 Intensive Assessment of Stressors: To capture the actual spatial extent of stressors observed within the 200-m envelope around the AA perimeter, we estimated the percent of the 200-m envelope affected by each stressor. For linear features such as roads, we estimated the length in meters of each stressor within the 200-m envelope.

3.5 Data Management

We created a relational database in Microsoft Access®. All EIA data and vegetation plot data were entered into the database after field data collection was complete. For vegetation data, plant species mean cover values were averaged across modules to get an average cover value for each plant species for the entire vegetation plot. Unknown species or ambiguous species (e.g., *Carex* sp.) were entered into the database, but these were not included in data analysis.

3.6 Data Analysis

3.6.1 Level 2 Assessments: Scores were calculated for each randomly selected site using metric narrative ratings and scoring formulas (Appendix E). A score was calculated for the site overall as well as separately for each major attribute.

We calculated descriptive statistics for and assessed the range and distribution of each metric by examining frequency histograms. We created correlation matrices using Spearman's correlation coefficients to investigate relationships and to evaluate any redundancy among metrics. Similarly, we calculated Spearman's correlation coefficients of attribute scores and final wetland condition scores to determine the amount of variability explained by each attribute and each metric.

3.6.2 Level 3 Vegetation Assessments: For the randomly selected sites (n=24), we calculated multiple vegetation metrics (Appendix F) to conduct a floristic quality assessment (FQA). The FQA accounts for the presence of both native and exotic species, as well as individual plant species' tolerance of disturbance (Cronk and Fennessy 2001, Miller and Wardrop 2006). Coefficients of conservatism (C-values) are assigned to taxa identified to species and represent the relative tolerance of a species to disturbance, ranging from 0 to 10 (after Andreas et al. 2004). Native species that exhibit high degrees of ecological specificity and sensitivity to disturbance have C-values of 9-10. Native species that are typical of well-established communities that have undergone minimal disturbance have C-values of 6-8. Native species that have some degree of habitat specificity but can tolerate moderate disturbance have C-values of 3-5. Widespread native species that occur in a variety of communities and are common in disturbed sites have values of 1-2. Finally, exotic species were assigned C-values of 0. C-values were recently assigned to most Montana wetland species by the Montana Natural Heritage Program (MTNHP 2015); these values were used in calculation of metrics.

We also calculated a wetland index that is based upon species' wetland indicator status from the National Wetland Plant List (Lichvar et al 2014). Each wetland indicator status category was assigned a value from +2 (UPL) to -2 (OBL), representing a coefficient of wetness for each taxa identified to species. These coefficients of wetness are averaged and the mean is considered a wetness index. A wetness index of zero or less indicates a predominance of wetland species. Only native species are considered in this calculation, as exotic species tend to skew the distribution of wetland indicators towards upland categories (Herman et al. 1997).

We calculated descriptive statistics for and assessed the range and distribution of vegetation metrics by examining frequency histograms. We created correlation matrices using Spearman's

correlation coefficients to investigate relationships and to evaluate any redundancy among metrics. We also used Spearman's correlation coefficients to evaluate the relationship of metrics to observed stressors as well as the ability of metrics to discriminate among wetland sites of varying condition.

3.6.3 Ecological System Descriptions. We reviewed academic and agency publications, as well as MTNHP records. We calculated descriptive statistics on plant species frequency across the sites as a whole and in relation to the different water regimes found in these ecological systems, using the Level 3 field assessment data from 31 sites. We identified apparent plant associations, and reviewed these against known associations in the MTNHP Ecological Community Lists (MTNHP 2002) and in the Draft National Vegetation Classification Standard (NatureServe *in preparation*). Following the format of our Montana Field Guide for Ecological Systems, we created a draft description of the Intermontane Prairie Pothole Ecological System.

3.6.4 Does water regime influence Floristic Quality Index scores? To ensure a sufficient sample, we combined the data from the randomly selected Level 3 sites in this project with Level 3 data from earlier studies to evaluate whether relative wetness is a predictive factor influencing the outcome of Floristic Quality Assessment (FQA) scoring. We began by calculating mean values of Coefficients of Conservatism (C-values) for 1,409 wetland plant species found in Montana, grouped according to their Wetland Indicator Status (WIS) assigned by Lichvar et al. (2014). Because Montana wetland plant species occur in two ACOE regions, we calculated these values separately for each region. Next, for each Level 3 assessment site included in the analysis, we examined the percentage of plant species that fell into either the Obligate Wetland Species (OBLW) or Facultative Wetland Species (FACW), using an Access query. FQAI scores and percentage of WIS scores were exported into R for further analysis. We used Spearman's correlation to identify the relationship between the percentage of wetland species and each FQA score. We also used descriptive statistics to summarize mean FQA scores and mean percentage of WIS by water permanence, based on field observations reported from each site.

4.0 RESULTS

4.1 Wetland Landscape Profile

Based on digital mapping, wetlands and other water bodies within the study area totaled 97,847 acres (39,597 hectares). These totals include deepwater areas such as lakes and river channels, which provide critical aquatic habitat and other valuable ecosystem services but are not considered wetlands. By system, the majority (76%) of the mapped acres are palustrine wetlands (Figure 8). By class, freshwater emergent wetlands make up the largest proportion (41%) of wetland acres (Figure 9). By water regime, temporarily and seasonally flooded wetlands are the most common (Figure 10). These wetlands typically have surface water for a few days or weeks during the growing season but dry down later in the season.

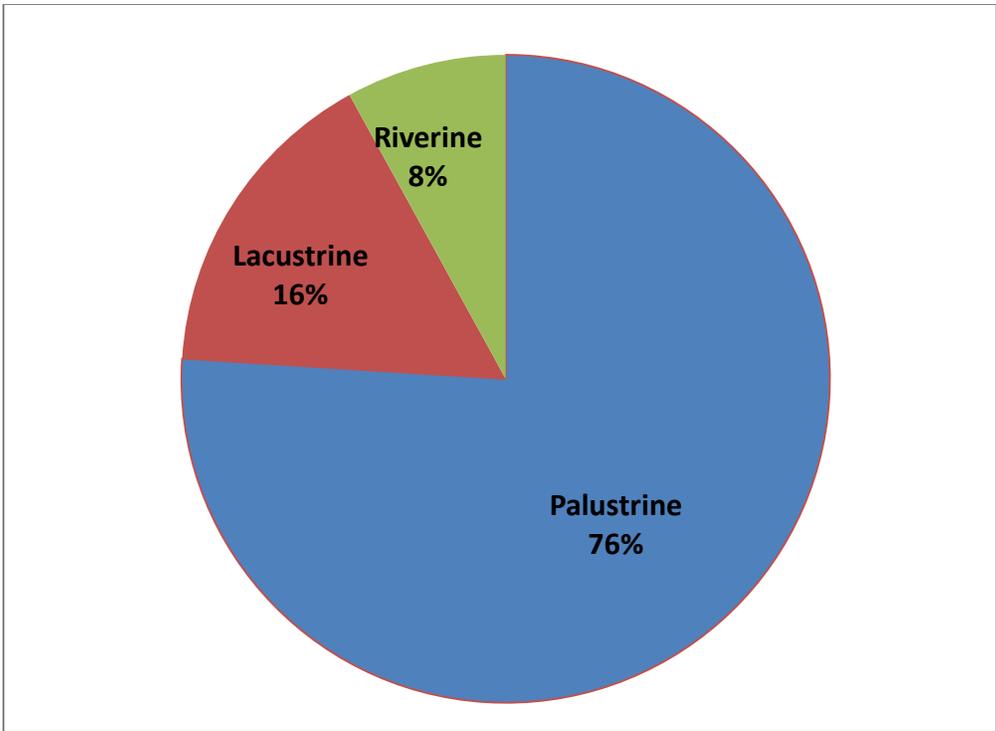


Figure 8. Percent of mapped wetland acres by Cowardin system in the Blackfoot-Swan Intensification Project area.

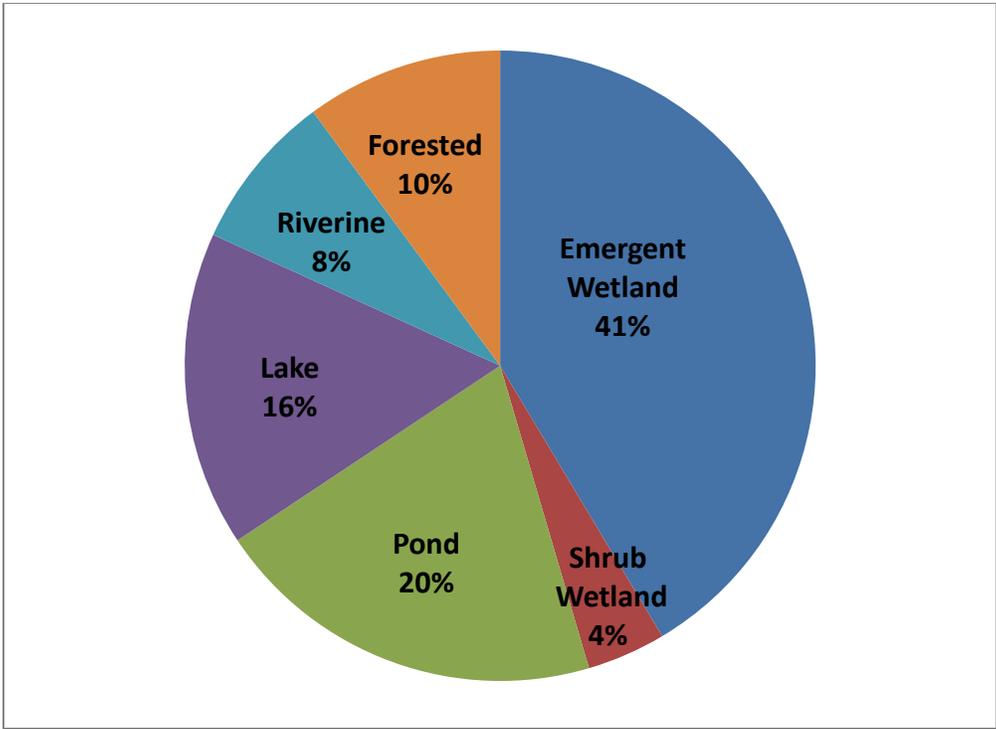


Figure 9. Percent of mapped wetland acres by Cowardin class in the Blackfoot-Swan Intensification Project area.

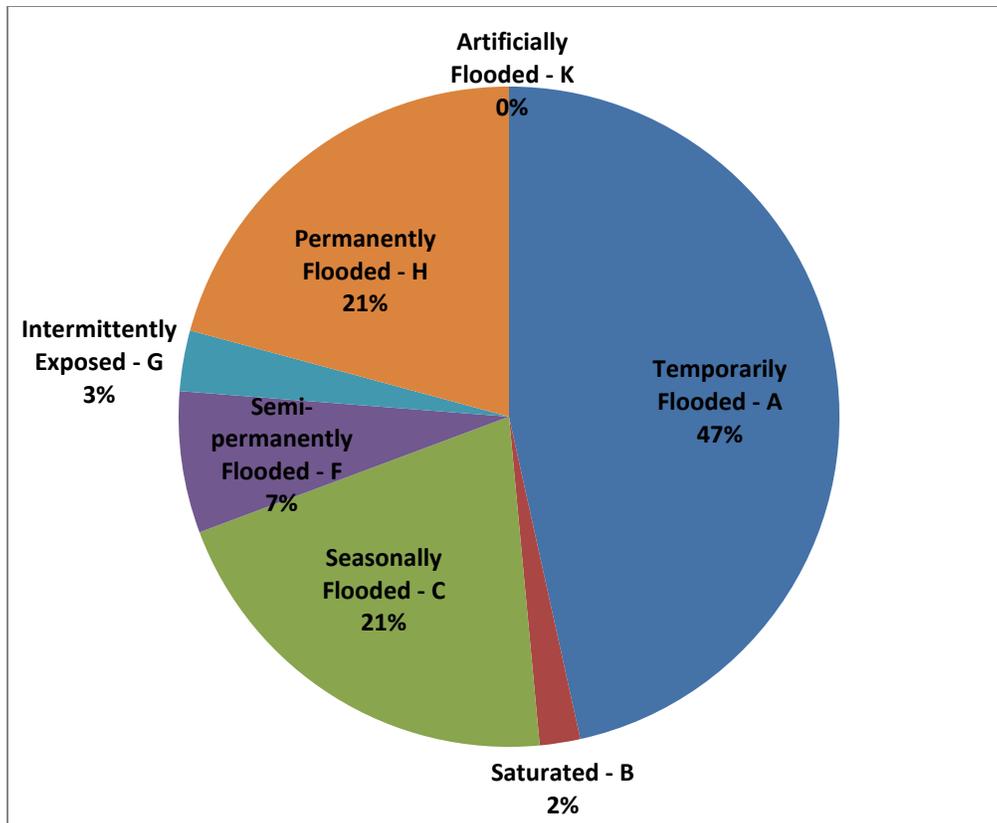


Figure 10. Percent of mapped wetland acres by Cowardin water regime in the Blackfoot-Swan Intensification Project area.

Most anthropogenically altered wetlands in the project area fell into the Palustrine System, as these mapped wetland types represent reservoirs created by stream impoundments or excavated wetlands (Figure 11). Altered lacustrine wetlands represent large reservoirs created by stream impoundments. The spatial distribution of palustrine wetlands by watershed is included in Appendix G.

4.2 Level 1 Landscape Characterization

Mean human disturbance index (HDI) scores (Figure 12) were relatively consistent across all three envelopes (100 m, 300 m, and 1000 m) for wetland types in the Blackfoot and Swan subbasins (Table 6), suggesting moderate levels of disturbance.

We calculated human disturbance index (HDI) scores separately for surveyed and non-surveyed wetlands. Although we used a GRTS approach to select candidate wetlands from all ownership classes for our surveys, the candidates were further screened for accessibility. Therefore, surveyed wetlands were more likely to be near roads than were randomly chosen wetlands. Similarly, although our randomly selected wetlands included both privately owned wetlands and

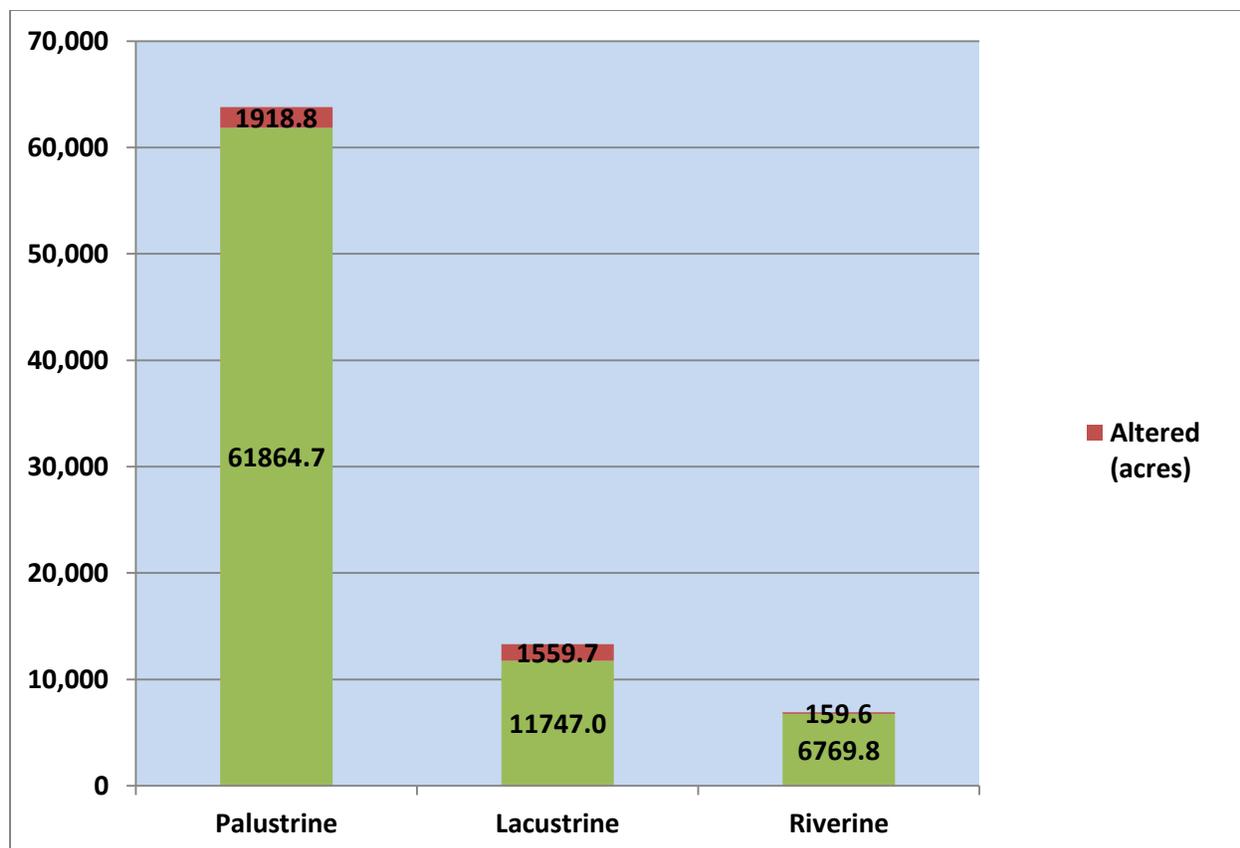


Figure 11. Proportion of mapped wetlands classified as anthropogenically altered by Cowardin system in the Blackfoot-Swan Intensification Project area.

wetlands on public land, we were frequently denied access by landowners. As a result, surveyed wetlands were disproportionately on public land. Because these two populations of wetlands – randomly chosen, and randomly chosen then screened—differed in these two ways, we hypothesized that there would be differences in the HDI scores. This proved to be the case. For wetlands which were randomly selected (and not surveyed in the field) for Level 1 landscape characterization, mean HDI scores were lower for public lands than they were for private lands (Table 7; $P < 0.001$ in all instances), indicating fewer disturbances on public lands. In contrast, for those wetlands surveyed for Level 2 assessment, no statistically significant differences were found between HDI scores for public versus private lands (Table 7). Across all wetland sites, mean HDI scores were lower for Level 2 sites than they were for randomly selected sites; these differences were significant at 100 m and 300 m, but not at 1000 m (Table 8). Again, we surmise that this reflects a public land effect.

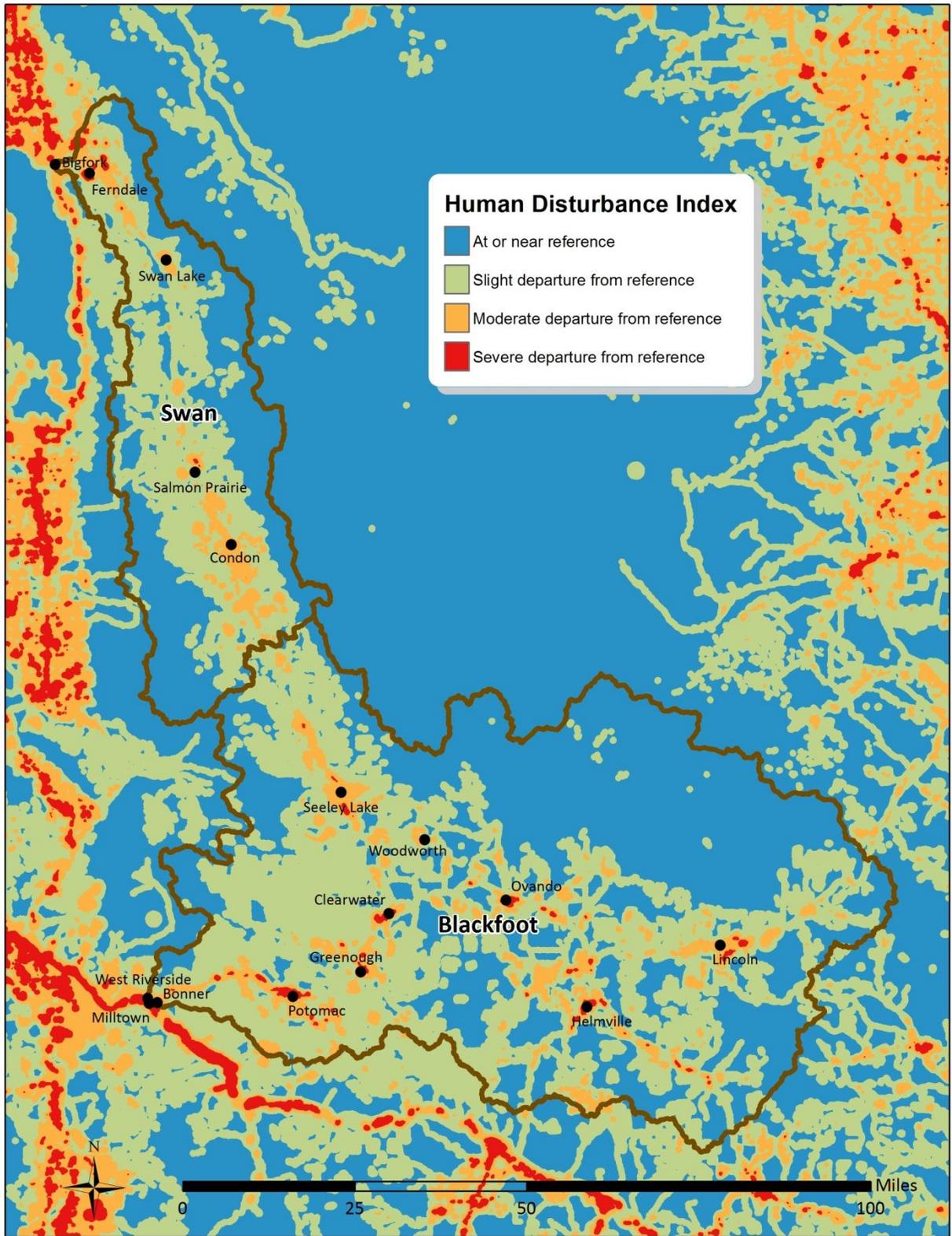


Figure 12. Human disturbance index for the Blackfoot-Swan Intensification Project and surrounding areas.

Table 6. Mean, standard deviation (SD), minimum, and maximum values for mean human disturbance index (HDI) by wetland type within 100 m, 300 m, and 1,000 m envelopes around Level 2 surveyed wetlands (n = 119) and randomly selected wetlands (n = 881) in the Blackfoot and Swan subbasins. Results are also presented for 7 sites surveyed to help characterize the Intermontane Potholes ecological system) at Ninepipe National Wildlife Refuge in the Lower Flathead subbasin. Note: all wetland types are freshwater, e.g., Freshwater Emergent.

	n	mean	Human Disturbance Index										
			100 m envelope			300 m envelope				1,000 m envelope			
			SD	min	max	mean	SD	min	max	mean	SD	min	Max
Blackfoot													
<i>Level 2</i>													
Emergent	44	323.60	342.75	0	1523.07	340.45	337.27	0	1492.97	409.84	312.46	0	1292.86
Forested/Shrub	8	452.53	207.44	108.92	711.08	448.56	184.52	170.78	682.82	421.62	148.22	152.52	609.21
Pond	14	282.49	395.82	0.02	1471.02	293.38	387.68	0.31	1459.44	379.26	325.33	33.11	1228.51
<i>Random</i>													
Emergent	245	578.20	541.06	0	2370.73	574.39	523.27	0	2283.76	550.17	433.13	0	2006.70
Forested	22	478.96	501.89	0	1621.73	475.50	502.71	0	1685.46	442.95	458.89	0	1688.19
Pond	13	632.68	469.95	0	1340.20	629.92	476.17	0.06	1377.47	595.88	458.59	25.41	1550.21
Scrub-shrub	154	609.42	456.08	0	1918.62	605.03	441.41	0	1855.86	565.14	369.21	0	1690.39
Swan													
<i>Level 2</i>													
Emergent	29	417.24	379.58	0	1256.71	427.11	370.13	0	1244.18	449.77	350.73	0	1294.12
Forested/Shrub	21	537.66	469.36	1.30	1616.49	527.80	447.35	3.02	1564.67	473.52	337.96	65.62	1178.82
Pond	3	222.60	341.83	3.14	616.45	241.44	342.09	7.71	634.08	389.82	314.61	84.50	712.96
<i>Random</i>													
Emergent	220	412.46	462.49	0	1609.01	415.09	460.88	0	1588.45	424.71	449.80	0	1574.07
Forested	33	237.11	363.51	0	1342.49	241.97	367.34	0	1299.48	253.45	344.71	0	1149.58
Pond	58	367.85	480.23	0	2268.13	365.77	468.90	0	2199.92	358.12	406.26	0	1705.74
Scrub-shrub	136	306.42	415.33	0	1824.21	308.19	409.21	0	1775.82	322.73	390.17	0	1534.37
Ninepipe													
Emergent	6	623.71	381.92	287.87	1179.59	636.39	390.58	284.28	1202.34	745.77	303.22	401.44	1139.31
Pond	1	1004.65	0	--	--	970.25	0	--	--	969.57	0	--	--

Table 7. Comparison of mean human disturbance index (HDI) values within 100 m, 300 m, and 1000 m envelopes around wetland sites under public and private ownership in the Blackfoot and Swan subbasins.

<i>Envelope</i>	<i>n</i>	<i>Level 2 Surveyed Sites</i>							<i>Randomly Selected Sites</i>							
		<i>Public</i>			<i>Private</i>				<i>t-test</i>	<i>P</i>	<i>Public</i>			<i>Private</i>		
		<i>mean</i>	<i>sd*</i>	<i>n</i>	<i>mean</i>	<i>sd</i>					<i>n</i>	<i>mean</i>	<i>sd</i>	<i>n</i>	<i>mean</i>	<i>sd</i>
Blackfoot	63			3					208			226				
100 m		333.86	346.57		260.10	200.71	0.5956	0.593		373.17	365.75		781.65	540.82	9.2803	<0.001
300 m		347.49	338.99		261.19	174.78	0.7876	0.488		373.09	354.72		774.10	523.07	9.4113	<0.001
1000 m		409.39	302.81		307.94	113.80	1.3354	0.253		375.72	309.83		713.11	430.46	9.4251	<0.001
Swan	49			4					342			105				
100 m		423.03	406.32		832.60	398.17	-1.9751	0.120		213.29	321.91		844.07	456.81	13.1802	<0.001
300 m		426.66	389.38		822.04	402.95	-1.8916	0.155		214.14	318.39		849.50	443.61	13.6373	<0.001
1000 m		428.50	319.41		790.08	434.69	-1.6281	0.202		220.46	304.94		867.26	369.12	16.3263	<0.001

*sd = standard deviation; t-test = t statistic from two-sample t-test assuming unequal variances; P is two-tailed.

Table 8. Comparison of mean human disturbance index (HDI) values for 100 m, 300 m, and 1000 m envelopes around Level 2 surveyed sites and randomly selected sites.

<i>Envelope</i>	<i>Level 2 Surveyed Sites (n = 119)</i>		<i>Randomly Selected Sites (n = 881)</i>		<i>t-test</i>	<i>P, two-tail</i>
	<i>mean</i>	<i>sd*</i>	<i>mean</i>	<i>sd</i>		
100 m	385.48	379.69	472.02	490.44	2.246037467	0.025945272
300 m	393.87	367.37	471.04	480.30	2.065499298	0.040324933
1000 m	427.50	315.75	460.59	426.98	1.023706089	0.307332861

* sd = standard deviation.

4.3 Level 2 Assessments

We visited 126 sites during the summers of 2013 and 2014: 66 in the Blackfoot, 53 in the Swan, and 7 at Ninepipe National Wildlife Refuge in the Lower Flathead subbasin (Figure 13). The Ninepipe sites, as well as 19 sites in the Blackfoot drainage, were part of a target sampling effort to aid in the characterization of the newly-defined Intermontane Potholes ecological system.

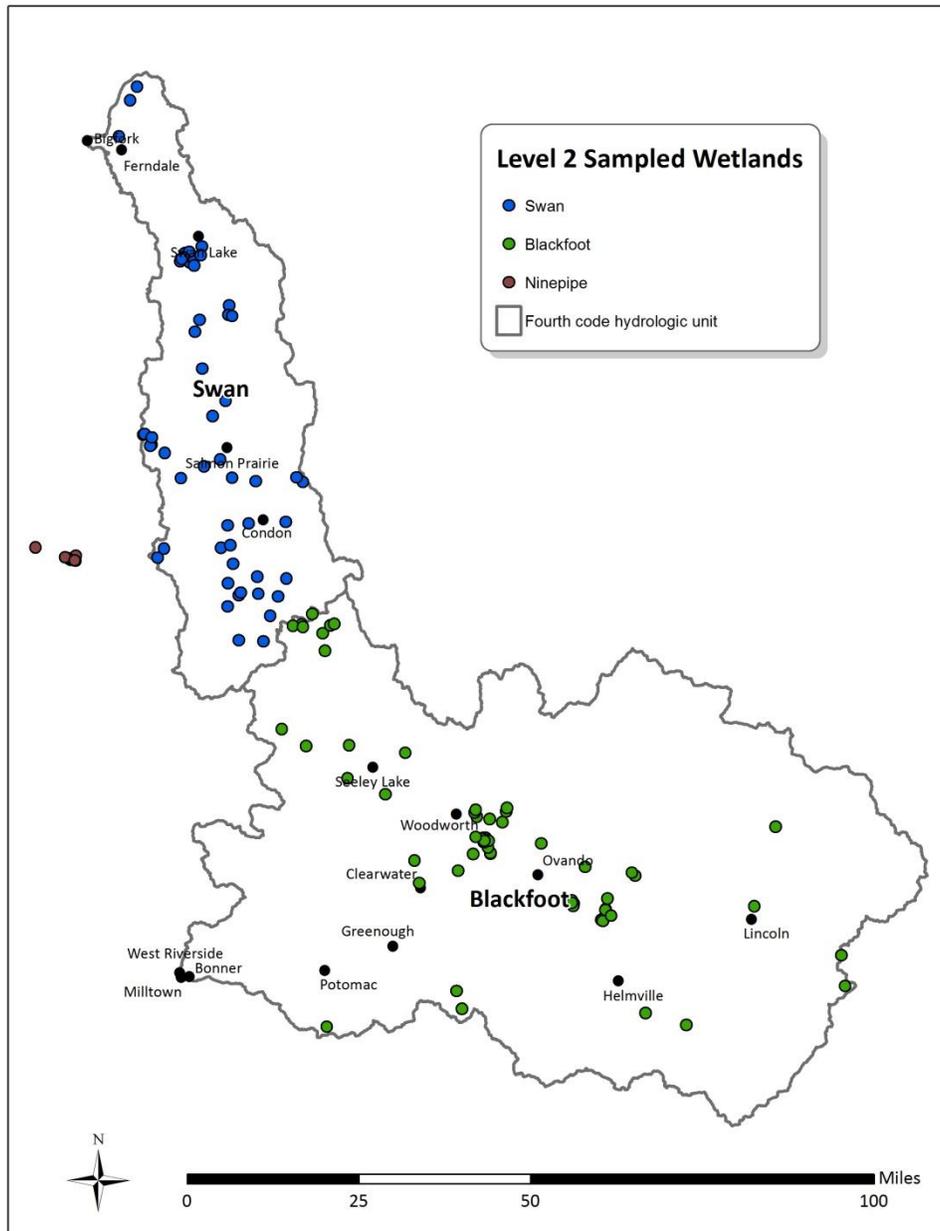


Figure 13. 126 wetland sites that were sampled for Level 2 assessment in the Blackfoot-Swan Intensification Project area.

Sixty-one percent of the sampled sites are on federal lands, with the remainder held by the state of Montana (33%) or under private ownership (6%) (Figure 14).

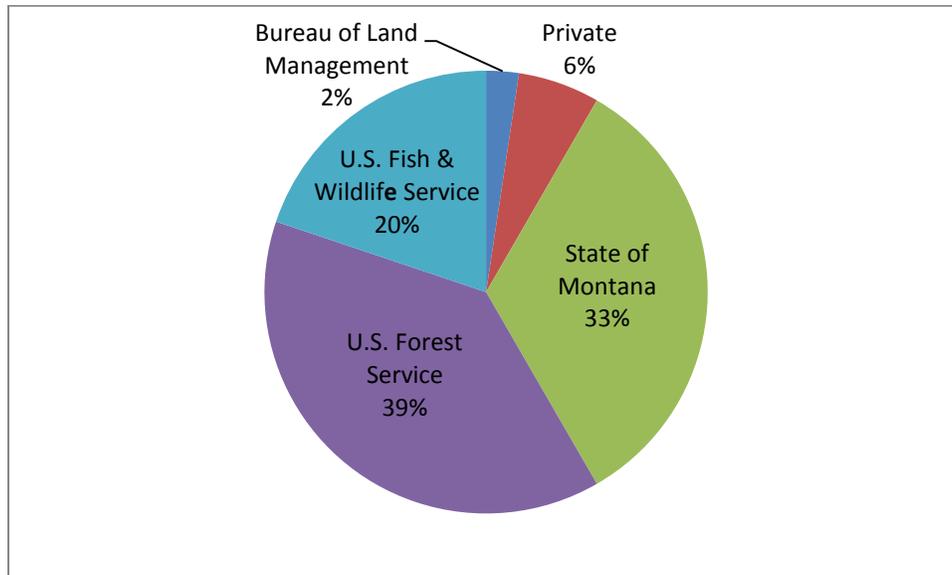


Figure 14. Sampled wetlands by land ownership in the Blackfoot-Swan Intensification Project area.

Sampled wetlands represented nine ecological systems (Table 9). Intermontane Potholes were the most commonly sampled type, followed by Rocky Mountain Subalpine-Montane Fens and Rocky Mountain Alpine-Montane Wet Meadows. Together, these three ecological systems represented 68% of the sites. Representative photos are included below (Figures 15-23).

Table 9. Sampled wetlands by Ecological System in the Blackfoot-Swan Intensification Project area.

Ecological System	Number of Sites Surveyed
Intermontane Pothole	37
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	16
Northern Rocky Mountain Conifer Swamp	2
Northern Rocky Mountain Wooded Vernal Pool	3
Rocky Mountain Alpine-Montane Wet Meadow	23
Rocky Mountain Subalpine-Montane Fen	26
Rocky Mountain Subalpine-Montane Riparian Shrubland	10
Rocky Mountain Subalpine-Montane Riparian Woodland	1
Western North American Emergent Marsh	8
Total	126



Figure 15. An Intermontane Prairie Pothole sampled as part of the Blackfoot-Swan Intensification Project.



Figure 16. A Western North American Emergent Marsh sampled as part of the Blackfoot-Swan Intensification Project.



Figure 17. A Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland sampled as part of the Blackfoot-Swan Intensification project.



Figure 18. A Northern Rocky Mountain Conifer Swamp sampled as part of the Blackfoot-Swan Intensification project.



Figure 19. A Rocky Mountain Subalpine Shrubland sampled as part of the Blackfoot-Swan Intensification project.



Figure 20. A Northern Rocky Mountain Wooded Vernal Pool sampled as part of the Blackfoot-Swan Intensification project.



Figure 21. A Northern Rocky Mountain Subalpine-Montane Riparian Woodland sampled as part of the Blackfoot-Swan Intensification project.



Figure 22. A Rocky Mountain Subalpine-Montane Wet Meadow sampled as part of the Blackfoot-Swan Intensification Project.



Figure 23. A Rocky Mountain Subalpine-Montane Fen sampled as part of the Blackfoot-Swan Intensification project.

Wetlands sampled were also classified by hydrogeomorphic (HGM) system in the field. The slope HGM class was assigned most frequently (61 sites), although depressional wetlands were also common (53 sites; Table 10). Hydrology of these slope wetlands was largely dominated by seeps and springs.

Table 10. Sampled wetlands by hydrogeomorphic system in the Blackfoot-Swan Intensification Project area.

Hydrogeomorphic System	Number of Sites Surveyed
Depressional	53
Lacustrine Fringe	1
Riverine	11
Slope	61
Total	126

Level 2 condition scores were calculated for all 126 wetlands sampled. Scores ranged from 52-100 out of a possible range of 21.5-100. We divided our assessment scores into four categories defined relative to their departure from reference standard: 1) at or near expected reference standard (scores = 90-100); 2) slight departure from expected reference standard (scores = 80-89); 3) moderate departure from expected reference standard (scores = 70-79); and 4) severe departure from expected reference standard (scores < 70). Most sites were either at or near the reference standard, or slightly departed from reference (Figure 24, Table 11).

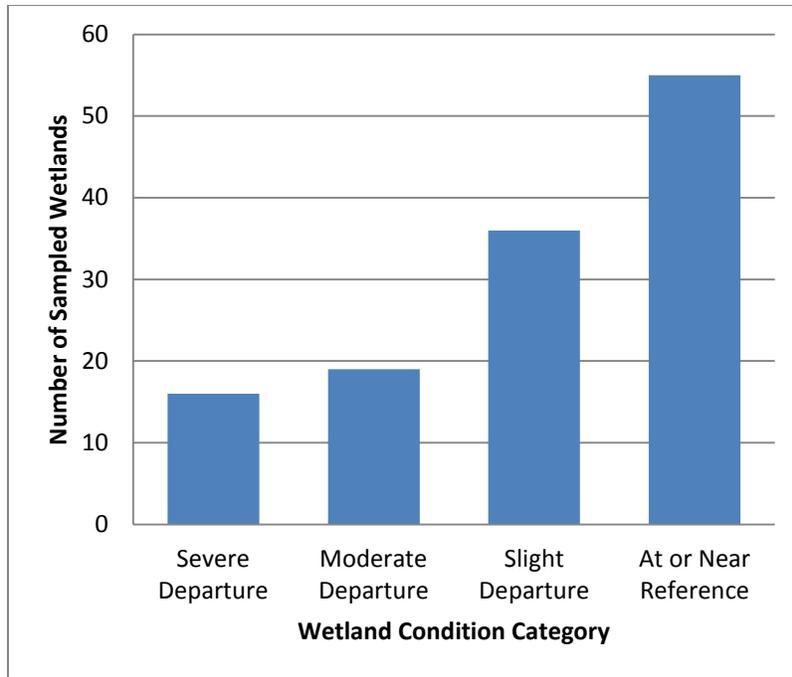


Figure 24. Level 2 assessment condition categories for wetlands assessed as part of the Blackfoot-Swan Intensification Project. Condition categories are relative to reference standard.

Table 11. Wetland condition category by wetland ecological system for 126 sampled wetlands in the Blackfoot-Swan Intensification Project area. Condition categories are interpreted as at or near reference standard and slight, moderate, and severe departure from reference standard.

Ecological System	Wetland Condition Category			
	At or Near Reference	Slight Departure	Moderate Departure	Severe Departure
Intermontane Pothole	8	15	6	8
Northern RM* Lower Montane Riparian Woodland and Shrubland	4	6	5	1
Northern RM Conifer Swamp	1		1	
Northern RM Wooded Vernal Pool		2		1
RM Alpine-Montane Wet Meadow	12	5	3	3
RM Subalpine-Montane Fen	22	3	1	
RM Subalpine-Montane Riparian Shrubland	3	4	2	1
RM Subalpine-Montane Riparian Woodland	1			
Western North American Emergent Marsh	4	1	1	2
Totals	55	36	19	16

The scores for each of the four attributes comprising the overall condition score (Landscape Context, Vegetation, Physicochemical, and Hydrologic attributes) showed variable patterns (Table 12). Sites were most likely to be at or near reference conditions for the Hydrologic attribute, followed by the Landscape Context attribute.

Table 12. Ecological Integrity Assessment (EIA) attribute condition category by wetland ecological system for the Blackfoot-Swan Intensification Project area. Condition categories are interpreted as at or near reference standard and slight, moderate, and severe departure from reference standard.

	Condition Category			
	At or Near Reference	Slight	Moderate	Severe
<i>Landscape Context Attribute</i>	68	17	17	24
Intermontane Pothole	21	2	5	9
Northern RM Lower Montane Riparian Woodland and Shrubland	3	4	5	4
Northern RM Conifer Swamp	1		1	
Northern Rocky Mountain Wooded Vernal Pool		1	1	1
Rocky Mountain Alpine-Montane Wet Meadow	17	1		5
Rocky Mountain Subalpine-Montane Fen	17	6	2	1
Rocky Mountain Subalpine-Montane Riparian Shrubland	4	2	2	2
Rocky Mountain Subalpine-Montane Riparian Woodland	1			
Western North American Emergent Marsh	4	1	1	2
<i>Vegetation Attribute</i>	37	47	21	21
Intermontane Pothole	7	10	11	9
Northern RM Lower Montane Riparian Woodland and Shrubland	5	6	2	3
Northern RM Conifer Swamp		1		1
Northern Rocky Mountain Wooded Vernal Pool		2		1
Rocky Mountain Alpine-Montane Wet Meadow	5	11	2	5
Rocky Mountain Subalpine-Montane Fen	14	8	4	
Rocky Mountain Subalpine-Montane Riparian Shrubland	2	4	2	2
Rocky Mountain Subalpine-Montane Riparian Woodland	1			
Western North American Emergent Marsh	3	5		
<i>Physicochemical Attribute</i>	51	25	17	33
Intermontane Pothole	4	7	7	19
Northern RM Lower Montane Riparian Woodland and Shrubland	7	3	1	5
Northern RM Conifer Swamp	1		1	
Northern Rocky Mountain Wooded Vernal Pool		2		1
Rocky Mountain Alpine-Montane Wet Meadow	10	5	4	4
Rocky Mountain Subalpine-Montane Fen	21	2	1	2
Rocky Mountain Subalpine-Montane Riparian Shrubland	4	4	1	1
Rocky Mountain Subalpine-Montane Riparian Woodland		1		
Western North American Emergent Marsh	4	1	2	1
<i>Hydrologic Attribute</i>	103	7	6	10
Intermontane Pothole	35			2
Northern RM Lower Montane Riparian Woodland and Shrubland	12	2		2
Northern RM Conifer Swamp	1	1		
Northern Rocky Mountain Wooded Vernal Pool	3			
Rocky Mountain Alpine-Montane Wet Meadow	17	2	1	3
Rocky Mountain Subalpine-Montane Fen	23	2	1	
Rocky Mountain Subalpine-Montane Riparian Shrubland	6		4	
Rocky Mountain Subalpine-Montane Riparian Woodland	1			
Western North American Emergent Marsh	5			3

Although most of the Intermontane Pothole sites were at or near reference conditions for the Hydrologic attribute, their scores were much more variable for the other attributes, most notably the Physicochemical attribute (with 19 of 37 sites showing a severe departure from reference conditions). This was largely due to reduced soil surface integrity caused by heavy grazing, especially near the drier sites. The Rocky Mountain Subalpine-Montane Fens tended toward relatively high scores across all four attributes, whereas scores were more variable for Rocky Mountain Alpine-Montane Wet Meadows.

4.3 Stressors

The scope and severity of each observed stressor were recorded both within the AA and within a 200-m envelope around the AA to help identify potential impacts to wetland condition. Fewer stressors were recorded in the AA than in the 200-m envelope around the AA (Table 13). This is partially attributable to the requirement that at least 90% of the AA be placed within a wetland, so stressors like paved roads cannot be included in an AA. Thirty-eight of the 126 sites had no observed stressors in the AA, and 17 sites had no observed stressors within the 200-m envelope. Most stressor impact ratings fell into the Minimal to No Impact and Low Impact categories at both scales (Tables 14 and 15). No site's impact rating was categorized as Very High, although five sites (two in the AA and three in the 200-m envelope) received High impact ratings. When examined by EIA attribute, impact scores tended to be highest for the Landscape Context and Vegetation attributes within both the AA and the 200-m envelope (Tables 16 and 17). The Physicochemical attribute made the least contribution to higher impact scores, with nearly all sites falling in the No Impact and Low Impact categories.

Recreation/human visitation and livestock grazing were the most common stressors potentially impacting Landscape Context within the AA. While they were also common within the 200-m envelope, unpaved roads were the most observed stressor there. Intensive or selective logging was also noted at many sites, as were beetle-killed *Pinus* and other diseased conifers. Vegetation stressors included browsing by native ungulates, livestock grazing, and beaver activity. Beaver activity was also the most common Hydrologic stressor, along with impoundments. Trash or refuse dumping was the most common Physicochemical stressor.

Table 13. Stressors observed in the assessment area (AA) and the 200-m envelope around the AA and the corresponding number of sampled wetland sites, categorized by Ecological Integrity Assessment (EIA) attribute. Note that some stressors are considered to impact more than one attribute.

<i>Landscape Context</i>	Number of Sites	
	AA	200 m
Paved surfaces	--	13
Unpaved roads	7	55
Domestic or commercial development	--	5
Recreation or human visitation	22	41
Livestock grazing	31	35
Irrigated cropland	--	1
Irrigated hay pasture	1	2
Irrigation ditches	--	1
Disturbed fallow lands dominated by exotic species	--	1
Fallow fields (no human use in past 10 years)	--	1
Fences	4	5
Intensive logging	8	21
Selective logging	12	26
Beetle-killed <i>Pinus</i> species	2	12
Other diseased conifers	5	22
Recent fire (<5 years)	1	1
Potential for agricultural runoff	1	1
Potential for urban runoff	3	3
<i>Vegetation</i>		
Livestock grazing	31	35
Vegetation conversion	1	1
Mechanical vegetation removal	--	1
Recent fire (<5 years)	1	1
Evidence of intentional burning	1	2
Browsing of woody vegetation by native ungulates	52	58
Beaver activity	17	16
<i>Physicochemical</i>		
Filling or dumping of sediment or fill	1	2
Trash or refuse dumping	4	13
Gravel pits, open pit mining	1	1
Other mining activity	--	1
Chemical vegetation control	--	1
Mechanical vegetation removal	--	1
<i>Hydrologic</i>		
Impoundment of flowing water	9	15
Culvert	4	6
Upstream dam	1	2
Engineered channel (e.g., riprap)	--	1
Pumps, diversions, or ditches that move water into wetland	2	3
Pumps, diversions, or ditches that move water out of wetland	4	6
Berms/Dikes/Levees	5	5
Beaver activity	17	16

Table 14. Count of overall assessment area (AA) stressor impact ratings by wetland ecological system for the Blackfoot-Swan Intensification Project area.

	Impact Rating ^a					# Sites
	Minimal to No Impact	Low	Medium	High	Very High	
Intermontane Pothole	29	6	1	1		37
Northern RM Lower Montane Riparian Woodland and Shrubland	10	5	1			16
Northern RM Conifer Swamp	1	1				2
Northern RM Wooded Vernal Pool	3					3
RM Alpine-Montane Wet Meadow	15	6	1	1		23
RM Subalpine-Montane Fen	21	4	1			26
RM Subalpine-Montane Riparian Shrubland	4	4	2			10
RM Subalpine-Montane Riparian Woodland			1			1
Western North American Emergent Marsh	5	1	2			8

^a Overall impact rating values were rounded to create five classes.

Table 15. Overall stressor impact rating within the 200-m envelope around the assessment area (AA) by wetland ecological system for the Blackfoot-Swan Intensification Project area.

	Impact Rating ^a					# Sites
	Minimal to No Impact	Low	Medium	High	Very High	
Intermontane Pothole	21	13	3			37
Northern RM Lower Montane Riparian Woodland and Shrubland	8	7	1			16
Northern RM Conifer Swamp		2				2
Northern RM Wooded Vernal Pool	2	1				3
RM Alpine-Montane Wet Meadow	13	8		2		23
RM Subalpine-Montane Fen	17	8	1			26
RM Subalpine-Montane Riparian Shrubland		8	1	1		10
RM Subalpine-Montane Riparian Woodland		1				1
Western North American Emergent Marsh	2	3	3			8

^a Overall impact rating values were rounded to create five classes.

Table 16. Ecological Integrity Assessment (EIA) attribute stressor impact rating within the assessment area (AA) by wetland ecological system for the Blackfoot-Swan Intensification Project area. RM = Rocky Mountain.

	Impact Rating				
	No Impact	Low	Medium	High	Very High
Landscape Context Attribute					
Intermontane Pothole	11	18	4	2	2
Northern RM Lower Montane Riparian Woodland and Shrubland	12	1	2	1	
Northern RM Conifer Swamp	2				
Northern Rocky Mountain Wooded Vernal Pool	2	1			
Rocky Mountain Alpine-Montane Wet Meadow	15	5	2	1	
Rocky Mountain Subalpine-Montane Fen	17	7	1	1	
Rocky Mountain Subalpine-Montane Riparian Shrubland	4	6			
Rocky Mountain Subalpine-Montane Riparian Woodland		1			
Western North American Emergent Marsh	4	4			
Vegetation Attribute					
Intermontane Pothole	13	17	3	2	2
Northern RM Lower Montane Riparian Woodland and Shrubland	7	3	5	1	
Northern RM Conifer Swamp		2			
Northern Rocky Mountain Wooded Vernal Pool	2	1			
Rocky Mountain Alpine-Montane Wet Meadow	10	10	1	1	1
Rocky Mountain Subalpine-Montane Fen	13	8	2	2	1
Rocky Mountain Subalpine-Montane Riparian Shrubland		6	1	1	2
Rocky Mountain Subalpine-Montane Riparian Woodland					1
Western North American Emergent Marsh	4	3		1	
Physicochemical Attribute					
Intermontane Pothole	36	1			
Northern RM Lower Montane Riparian Woodland and Shrubland	16				
Northern RM Conifer Swamp	2				
Northern Rocky Mountain Wooded Vernal Pool	3				
Rocky Mountain Alpine-Montane Wet Meadow	22	1			
Rocky Mountain Subalpine-Montane Fen	26				
Rocky Mountain Subalpine-Montane Riparian Shrubland	9	1			
Rocky Mountain Subalpine-Montane Riparian Woodland	1				
Western North American Emergent Marsh	7	1			
Hydrologic Attribute					
Intermontane Pothole	35	1		1	
Northern RM Lower Montane Riparian Woodland and Shrubland	11	1	1	1	2
Northern RM Conifer Swamp	1		1		
Northern Rocky Mountain Wooded Vernal Pool	3				
Rocky Mountain Alpine-Montane Wet Meadow	15	3	1	1	3
Rocky Mountain Subalpine-Montane Fen	23	1	1		1
Rocky Mountain Subalpine-Montane Riparian Shrubland	5	1	1	1	2
Rocky Mountain Subalpine-Montane Riparian Woodland					1
Western North American Emergent Marsh	3	2		1	2

Table 17. Ecological Integrity Assessment (EIA) attribute stressor impact rating within the 200-m envelope around the assessment area (AA) by wetland ecological system for the Blackfoot-Swan Intensification Project area. RM = Rocky Mountain.

	Impact Rating				
	No Impact	Low	Medium	High	Very High
Landscape Context Attribute					
Intermontane Pothole	7	12	12	4	2
Northern RM Lower Montane Riparian Woodland and Shrubland	3	6	5	2	
Northern RM Conifer Swamp		2			
Northern Rocky Mountain Wooded Vernal Pool		2	1		
Rocky Mountain Alpine-Montane Wet Meadow	5	10	4	3	1
Rocky Mountain Subalpine-Montane Fen	4	15	2	4	1
Rocky Mountain Subalpine-Montane Riparian Shrubland		3	5	1	1
Rocky Mountain Subalpine-Montane Riparian Woodland		1			
Western North American Emergent Marsh	3		3	1	1
Vegetation Attribute					
Intermontane Pothole	13	11	8	3	2
Northern RM Lower Montane Riparian Woodland and Shrubland	7	5	3	1	
Northern RM Conifer Swamp		2			
Northern Rocky Mountain Wooded Vernal Pool	2	1			
Rocky Mountain Alpine-Montane Wet Meadow	9	10	2	1	1
Rocky Mountain Subalpine-Montane Fen	11	11	1	2	1
Rocky Mountain Subalpine-Montane Riparian Shrubland		7	1	2	
Rocky Mountain Subalpine-Montane Riparian Woodland		1			
Western North American Emergent Marsh	3	1	1	3	
Physicochemical Attribute					
Intermontane Pothole	36	1			
Northern RM Lower Montane Riparian Woodland and Shrubland	15		1		
Northern RM Conifer Swamp	1	1			
Northern Rocky Mountain Wooded Vernal Pool	3				
Rocky Mountain Alpine-Montane Wet Meadow	19	4			
Rocky Mountain Subalpine-Montane Fen	25	1			
Rocky Mountain Subalpine-Montane Riparian Shrubland	6	2	1		1
Rocky Mountain Subalpine-Montane Riparian Woodland	1				
Western North American Emergent Marsh	4	4			
Hydrologic Attribute					
Intermontane Pothole	35			1	1
Northern RM Lower Montane Riparian Woodland and Shrubland	9	4	1		2
Northern RM Conifer Swamp	1		1		
Northern Rocky Mountain Wooded Vernal Pool	3				
Rocky Mountain Alpine-Montane Wet Meadow	16	3	2		2
Rocky Mountain Subalpine-Montane Fen	20	4	2		
Rocky Mountain Subalpine-Montane Riparian Shrubland	5	2	1	2	
Rocky Mountain Subalpine-Montane Riparian Woodland		1			
Western North American Emergent Marsh	3	1	1	2	1

4.4 Level 3 Assessments

We completed 24 Level 3 intensive assessments within the project area, encountering 309 plant taxa. Of these, 282 taxa were identified to the species level. Of the 309 total plant taxa encountered, 125 species were encountered at only one site and 49 species were encountered at only two sites. The average number of species encountered per site was 34 (range 7-76). Of the 282 taxa identified to species, 260 (92%) were native species and 19 (7%) were exotic species. Two species were classified as “native/exotic” (*Prunella vulgaris* and *Poa palustris*), and one was classified as “unknown/undetermined” (*Chenopodium watsonii*).

The most commonly encountered plant species was common beaked sedge (*Carex utriculata*; Table 18). This species is an obligate wetland species that inhabits a variety of wetland systems in the northern half of North America.

Table 18. Most commonly encountered plant species during Level 3 intensive assessments in the Blackfoot-Swan Intensification Project area.

Scientific Name	Common name	Number of Sites Encountered	C-Value	Wetland Indicator Status	Native Status
<i>Carex utriculata</i>	common beaked sedge ^a	20	3	OBL	Native
<i>Salix drummondiana</i>	Drummond’s willow	11	5	FACW	Native
<i>Symphoricarpos albus</i>	common snowberry	10	3	UPL	Native
<i>Fragaria virginiana</i>	Virginia strawberry	10	3	FACU	Native
<i>Eleocharis palustris</i>	creeping spikerush	10	4	OBL	Native
<i>Picea engelmannii</i>	Engelmann spruce	10	4	FAC	Native
<i>Galium triflorum</i>	sweet-scent bedstraw	10	6	FACU	Native
<i>Smilacina stellata</i>	starry false Solomon’s-seal	10	4	FACU	Native
<i>Cirsium arvense</i>	Canada thistle	10	0	FACU	Exotic
<i>Phalaris arundinaceae</i>	reed canarygrass	10	0	FACW	Exotic
<i>Angelica arguta</i>	Lyall’s angelica	10	5	NA	Native

^a Alternate common name Northwest Territory sedge

4.5 Floristic Quality Assessment

We calculated floristic quality assessment (FQA) metrics for all 24 Level 3 assessment sites (Table 19). These metrics can be used as a measure of biotic condition. Mean C-value across these sites was $4.91 + 0.76$ SD (range 3.44 – 6.34). Most C-values for native species encountered fell between 3 and 8 (Figure 25). Species at the lower end of that range are found in a range of habitats with little to moderate disturbance, while those at the higher end tend to be habitat specialists or have low tolerance for disturbance.

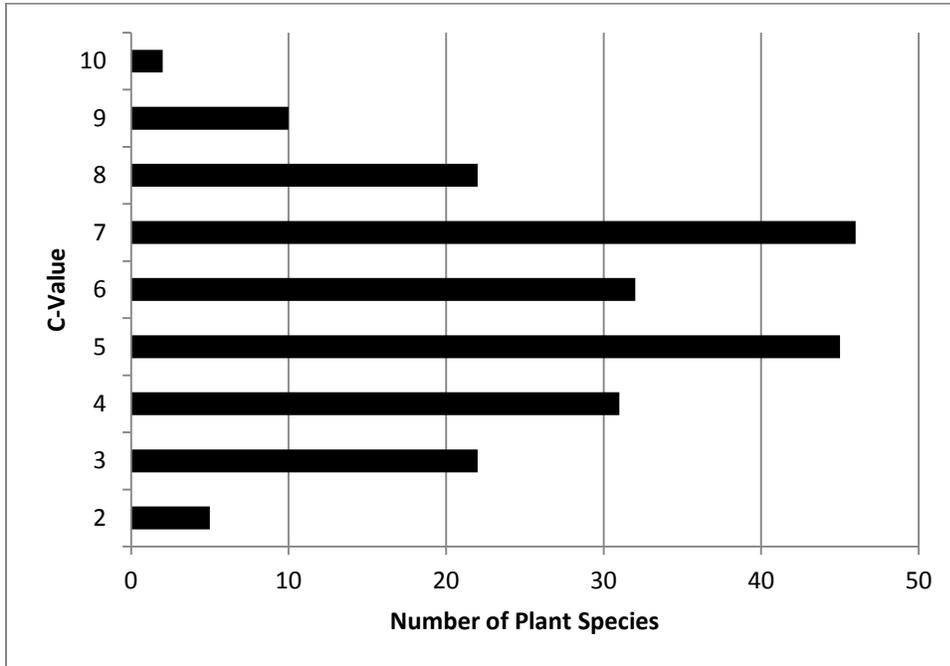


Figure 25. Frequency distribution of C-values of native plant species encountered during Level 3 assessments in the Blackfoot-Swan Intensification Project area.

4.6 Comparisons of Level 2 & 3 Results

To understand the effectiveness of this assessment framework in determining the condition of wetlands in the Blackfoot-Swan Intensification Project area, we compared Level 3 assessment results with Level 2 assessment results.

Impact ratings within the AA and within the 200-m envelope around the AA showed moderate correlations with overall Level 2 assessment scores ($r = 0.36$ and $r = 0.38$, respectively; Tables 20 and 21). The Landscape Context and Hydrologic attribute scores were most strongly correlated with overall impact rating for both the AA and the 200-m envelope (with r values ranging from 0.35-0.54). In general, the Landscape Context and Hydrologic attribute scores tended toward stronger correlations with impact scores calculated within the 200-m envelope than with those calculated within the AA itself. The reverse was true for the Vegetation and Physicochemical attributes, although the trend was not as strong or consistent.

Table 19. Means and standard deviations of all floristic quality assessment (FQA) metrics considered by Ecological System for Level 3 assessments completed in the Blackfoot-Swan Intensification Project area.

	Inter- montane Pothole (n = 1)	Western North American Emergent Marsh (n = 1)	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland (n = 4)		Rocky Mountain Alpine-Montane Wet Meadow (n = 5)		Rocky Mountain Subalpine- Montane Fen (n = 11)		Rocky Mountain Subalpine- Montane Riparian Shrubland (n = 2)	
	Value	Value	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total species richness ^a	32	16	44.50	16.82	29.00	11.58	31.18	20.75	50.50	0.71
Native species richness	23	15	39.25	16.74	27.80	12.01	29.91	19.36	47.50	2.12
Non-native species richness	8	1	4.75	0.96	1.67	0.58	2.17	1.47	3	2.83
Cover of native graminoids	0.94	6.10	0.71	0.52	2.09	1.72	2.48	1.61	0.72	0.71
Mean C-value of all species	3.48	5.19	4.33	0.64	4.91	1.06	5.27	0.49	4.71	0.47
Mean C-value of native species	4.65	5.53	5.07	0.37	5.24	0.70	5.44	0.45	5.03	0.18
Cover-weighted Mean C-value of all species	3.03	3.91	2.50	1.20	3.40	2.06	5.36	0.61	4.04	0.60
Cover-weighted Mean C-value of native species	3.76	4.73	4.17	1.30	4.37	1.31	5.45	0.67	4.26	0.31
FQI of all species	19.71	20.75	28.76	7.82	26.63	9.55	27.91	10.70	33.49	3.09
FQI of native species	22.31	21.43	31.17	7.21	27.35	8.89	28.46	11.07	34.69	2.01
Cover-weighted FQI of all species	17.16	15.65	17.09	10.12	19.53	13.17	28.10	9.88	28.71	4.09
Cover-weighted FQI of native species	18.06	18.31	26.37	10.58	23.61	10.18	28.14	10.06	29.40	2.81
Adjusted FQI of native species	39.44	53.58	47.20	4.68	50.89	8.65	53.53	4.64	48.83	3.17
Adjusted cover-weighted FQI of native species	31.92	45.77	39.12	13.10	42.62	13.90	53.62	6.58	41.39	4.24
Average Wetness Index	-1.60	-1.30	-0.13	0.66	-0.36	0.27	-1.06	0.66	-0.55	0.07
Percent of Total Species FAC or OBL	68.75	81.25	36.91	21.23	49.94	6.80	71.95	19.65	53.49	3.55

^a For a very few species, nativity has not been determined. As a result, in this table, native species richness + non-native species richness does not always equal total species richness.

Table 20. Spearman's correlation coefficients of Impact Category scores calculated within the assessment area (AA) with Level 2 assessment attribute and overall scores.

Impact Category	Level 2 Assessment Scores				
	Landscape Context	Vegetation	Physico-chemical	Hydrologic	Overall Condition
Landscape Context	0.35	0.16	0.41	0.14	0.37
Vegetation	0.17	0.22	0.07	0.17	0.16
Physicochemical	0.17	0.09	0.02	0.52	0.20
Hydrologic	0.19	0.07	0.03	0.15	0.15
Overall Impact Rating	0.35	0.25	0.22	0.40	0.36

Table 21. Spearman's correlation coefficients of Impact Category scores calculated within a 200-m envelope of the assessment area with Level 2 assessment attribute and overall scores.

Impact Category	Level 2 Assessment Scores				
	Landscape Context	Vegetation	Physico-chemical	Hydrologic	Overall Condition
Landscape Context	0.64	0.19	0.27	0.47	0.47
Vegetation	0.24	0.21	0.14	0.26	0.24
Physicochemical	0.23	0.04	-0.04	0.65	0.21
Hydrologic	0.28	<0.01	0.03	0.42	0.20
Overall Impact Rating	0.48	0.17	0.15	0.54	0.38

We evaluated 16 vegetation metrics in the FQA. Several of these metrics were highly correlated ($r \geq 0.9$) with each other (Table 22). Most of the vegetation metrics showed some degree of correlation with either stressors or overall wetland condition (Table 23), but none of the correlations was strong. The strongest correlation was observed between mean C-value of native species and overall condition score ($r = 0.54$). Non-native species richness was negatively correlated with stressor impact scores and overall condition scores, meaning that as impact and condition scores increased toward their maximum values (indicating reference conditions on the ground), the number of non-native species decreased.

FQA metrics that were correlated with overall condition scores also were correlated with one or more individual Level 2 attribute scores (Table 24). Not surprisingly, nearly all FQA metrics showed moderate correlation with the Vegetation attribute. Again, non-native species richness was negatively correlated with all four attributes, meaning that as EIA attribute scores increased toward 100 (reference conditions), non-native species richness decreased.

Table 22. Spearman's correlation coefficients of metrics included in the floristic quality assessment (FQA) for the Blackfoot-Swan Intensification Project. Correlation coefficients of 0.90 or greater are in bold.

	Total species richness	Native species richness	Non-native species richness	Cover of native graminoids	Mean C-value, all species	Mean C-value, native species	Cover-weighted mean C-value, all species	Cover-weighted mean C-value, native species	FQI, all species	FQI, native species	Cover-Weighted FQI, all species	Cover-Weighted FQI, native species	Adjusted FQI	Adjusted cover-weighted FQI	Wetness index	Percent of total species FAC or OBL
Total species richness	1.00															
Native species richness	0.99	1.00														
Non-native species richness	0.46	0.37	1.00													
Cover of native graminoids	-0.42	-0.38	-0.66	1.00												
Mean C-value of all species	-0.13	-0.04	-0.77	0.56	1.00											
Mean C-value of native species	0.10	0.16	-0.38	0.33	0.83	1.00										
Cover-weighted mean C-value of all species	-0.08	-0.01	-0.56	0.51	0.63	0.36	1.00									
Cover-weighted mean C-value of native species	-0.13	-0.08	-0.43	0.29	0.57	0.51	0.79	1.00								
FQI of all species	0.85	0.89	0.07	-0.19	0.33	0.52	0.12	0.09	1.00							
FQI of native species	0.90	0.93	0.21	-0.25	0.21	0.43	0.06	0.02	0.98	1.00						
Cover-weighted FQI of all species	0.61	0.66	-0.14	0.10	0.44	0.41	0.63	0.38	0.71	0.68	1.00					
Cover-weighted FQI of native species	0.82	0.85	0.14	-0.23	0.26	0.44	0.35	0.39	0.86	0.86	0.83	1.00				
Adjusted FQI	-0.06	0.03	-0.65	0.52	0.97	0.91	0.58	0.59	0.41	0.30	0.45	0.35	1.00			
Adjusted cover-weighted FQI	-0.16	-0.11	-0.50	0.37	0.62	0.51	0.85	0.99	0.08	0.01	0.41	0.36	0.63	1.00		
Wetness index	0.50	0.56	0.22	-0.30	-0.14	-0.08	-0.34	-0.37	0.45	0.48	0.12	0.30	-0.09	-0.38	1.00	
Percent of total species FAC or OBL	-0.52	-0.55	-0.36	0.41	0.29	0.21	0.46	0.47	-0.40	-0.45	-0.03	-0.25	0.24	0.49	-0.97	1.00

Table 23. Vegetation metrics included in the floristic quality assessment (FQA), and their response to stressors within the assessment area (AA), within the 200-m envelope surrounding the AA, and their relationship with overall wetland condition scores. Response categories are defined as follows: **poor correlation** refers to metrics with weak correlation ($r < 0.3$) with stressors at either scale and/or overall condition scores, and **correlated** indicates metrics that show a response ($r \geq 0.3$) to either stressors and/or overall wetland condition scores. FQA metrics that were highly correlated ($r \geq 0.9$) with other FQA metrics were not considered.

Metric	Response	Response to stressors (AA)	Response to stressors (200 m)	Overall Condition Score
Non-native species richness	negatively correlated	-0.42	-0.33	-0.41
Cover of native graminoids	correlated	0.44	0.21	0.43
Mean C-value of native species	correlated	0.38	0.44	0.54
Cover-weighted Mean C-value of all species	correlated	0.43	0.21	0.33
FQI of native species	correlated	0.08	0.25	0.30
Cover-weighted FQI of native species	poor correlation	0.14	0.21	0.17
Adjusted cover-weighted FQI of native species	correlated	0.31	0.18	0.18
Wetness index	poor correlation	-0.05	0.15	-0.02

Table 24. Spearman's correlation coefficients of floristic quality assessment (FQA) metrics with Level 2 assessment attribute scores for the Blackfoot-Swan Intensification Project. FQA metrics that were highly correlated ($r \geq 0.9$) with other FQA metrics were not considered.

	Landscape Context	Vegetation	Physico-Chemical	Hydrologic
Non-native species richness	-0.35	-0.38	-0.34	-0.38
Cover of native graminoids	0.23	0.40	0.49	0.36
Mean C-value of native species	0.38	0.56	0.45	0.32
Cover-weighted mean C-value of all species	-0.07	0.47	0.42	0.13
FQI of native species	<0.01	0.35	0.13	0.02
Cover-weighted FQI of native species	-0.08	0.29	0.08	-0.04
Adjusted cover-weighted FQI of native species	-0.04	0.37	0.30	0.12
Wetness index	<0.01	-0.29	0.02	0.07

4.7 Intermontane Prairie Pothole Descriptions

Field observation and analysis of assessment scores indicate that Intermontane Prairie Potholes (IPP) are similar to Great Plains Prairie Potholes (GPP) in terms of size, water regime, and graminoid dominance. However, because of differences in underlying substrates and in climatic influences, species composition and distribution are different. These differences support designation of IPPs as a separate Ecological System (Comer et al. 2003) in Montana. The final description of the Intermontane Prairie Potholes can be found in Appendix H.

4.8 Wetland Indicator Species and Floristic Quality Assessments

Coefficients of Conservatism (C-values) are assigned to an individual plant species based on the plant's tolerance to natural and/or human disturbance and its affinity to a specific, unimpaired habitat in a given geographical area. The C-value is a foundational component of Floristic Quality Assessment Index (FQAI) metrics, but is sometimes used alone.

Collectively, the C-values (of a given site) can be used to: 1) identify and prioritize the riparian and wetland sites to conserve, 2) develop baseline conditions, 3) monitor the development of wetland and riparian habitats, 4) determine the species to retain or to plant at a restoration project, and 5) set the restoration targets that achieve a certain quality of habitat. In Montana, C-values range from 0 to 10, with 0 representing non-native species, 1 indicating species with broad habitat affinity and high disturbance tolerance, and 10 representing native species with the strongest affinity to unimpaired habitat in specific areas. The mean C-value for all species that are included in the ACOE's WIS list (and that have an assigned C-value) is 4.17, suggesting that Montana's wetland species are generally tolerant of a moderate range of conditions.

When the WIS list is subset into Wet (OBL and FACW) and Dry (FAC, FACU and UPL), mean C-values are seen to be higher for hydrophytic species. Using values assigned by the National Wetland Plant List for the Great Plains, the mean C-value for OBL and FACW species is 5.55, while for FAC, FACU and UPL species it is 3.45, reflecting the broader range and higher tolerance of upland species compared to hydrophytes. Using the National Wetland Plant List for the Western Mountains and Valleys, there is a greater difference; the mean C-value for OBL and FACW species is 5.83, while for FAC, FACU and UPL species it is 2.87.

The next step in our analysis was to identify any correlations between the percentage of wetland species at a given site and individual FQAI metrics. In this study, Table 24 shows a moderate negative correlation (-0.55) between the percentage of FACW or OBL species at a site and its overall native plant richness, and a slightly weaker correlation between the unadjusted FQI of native species and the percentage of hydrophytes (-0.45). Scores on the Adjusted Cover-weighted FQI are moderately and positively correlated (0.49) with the proportion of hydrophytes. Mean C and Mean C of native species show no significant linear relationship (0.21 and 0.29 respectively) with the percentage of wetland species.

When we analyzed correlations across the larger suite of Level 3 sites assessed in the past five years (n=189), we saw a stronger positive correlation between Mean C and Mean C of native species (0.55 and 0.54, respectively, Table 25). To ensure that this result was not being skewed by the number of fens in previous studies¹, we removed fens from the dataset and reran the analysis. Again, Mean C and Mean C of native species were moderately correlated with the proportion of FACW and OBL (0.58 and 0.46). We noted, too, that in both cases there was a moderate negative correlation between the proportion of hydrophytes and the number of exotic species. We also saw a moderate correlation between the Adjusted FQI for native species and the proportion of FACW and OBL species at a site.

¹ Fens are typically saturated and therefore have more hydrophytic species than drier sites. Moreover, fen-obligate species tend to have higher C-values than more widespread wetland plants.

Table 25. Spearman's correlation coefficients of metrics included in the floristic quality assessment (FQA) for the current study and previous studies in Montana (n=189), and with fens excluded (n=89). Strong correlations are in bold.

	PctWet All	PctWet No fens
TotalSpp	-0.59	-0.55
NativeSppTotal	-0.50	-0.42
ExoticSppTotal	-0.66	-0.65
AvgCovNativeGrams	0.17	-0.12
MeanCAll	0.55	0.58
MeanCNative	0.44	0.46
CovWMeanC	0.59	0.63
CovWMeanCNative	0.43	0.39
FQIAll	-0.18	-0.08
FQINative	-0.27	-0.20
CWFQIAll	-0.07	0.03
CWFQINative	-0.17	-0.11
AdjustedFQINative	0.51	0.52
AdjCovWFQINative	0.41	0.31

Correlations between FQAI metrics and the percentage of hydrophytes at a site do not necessarily indicate that wetter sites are “better” than drier sites, or that the presence of water at a given site predicts its FQAI scores. To evaluate relationships between the presence of water and the proportion of hydrophytes, we used descriptive statistics to summarize mean C by water permanence and by the percentage of standing water in the AA. We expected that sites with widespread standing water or an assignment of “permanent” or “semi-permanent” inundation would have a greater proportion of FACW and OBL species than drier sites, and higher mean C values. Only part of this expectation was borne out by the data. While there appears to be a clear relationship between the percent of standing water and proportion of FACW and OBL species, there does not appear to be any linear relationship between the percent of standing water and Mean C, except for the driest sites (Table 26).

Table 26. Mean C and proportion of FACW and OBL species by percentage of standing water in the AA.

AAWater	All sites		All sites, no fens	
	Mean C	Pct Wet	Mean C	Pct Wet
1-25%	5.16	61.32	4.51	46.21
26-50%	4.90	57.75	4.38	42.56
51-75%	5.01	70.20	4.87	70.85
76-100%	5.42	77.41	4.64	69.90
none	4.54	53.83	3.81	47.59

DISCUSSION

Wetlands are abundant in this study area compared to other parts of the state, largely because of the sizeable snowpack that forms during winter months. They also tend to exhibit more ecological integrity than do wetlands in eastern and southwestern Montana, and to be subject to fewer stressors. We attribute this to several factors. First, most of the areas sampled are in public ownership, where steep terrain, difficult or no road access and a harsh climate limit public use. Second, the climate promotes lush vegetation growth, so that even though exotic species colonize disturbed areas such as logging sites, they have more difficulty establishing in sites that are already vegetated. Third, the wetlands are more abundant. Even in areas where livestock range freely, the sheer number of wetlands appears to spread out the disturbance, in contrast to what we sometimes see in eastern Montana, where water scarcity tends to concentrate impacts near wetlands.

Private land access continues to be a challenge in aquatic resource monitoring (Leibowitz et al. 1991, Fellows and Buhl 1995, Adamus et al. 2001). Only 7% of the sites surveyed in the field were privately owned, despite our randomized sampling approach, because we were repeatedly denied access. In our analysis of Human Disturbance Index (HDI) scores, we saw that wetlands on private land tend to have a greater number of stressors within their buffer area, but lack of access prevented us from evaluating this result in the field. Therefore, conclusions drawn from our Level 2 and Level 3 surveys should be taken as indicating the condition of wetlands on public land, rather than all wetlands in the study area subbasins. And indeed, because our sampling was, of necessity, limited to sites within close enough proximity to roads that they could be accessed by crews, the overall condition of public land wetlands may be even better than reported.

In previous studies, we observed poor correlations between FQA metrics and wetland condition as reflected in Level 2 attribute scores (McIntyre et al. 2011, Newlon and Vance 2011, Newlon 2012). Here, we found stronger (although still moderate) correlations. This suggests that wetland plant species in our study area are adapted to a narrower range of climatic conditions and disturbance regimes, and thus are less tolerant to disturbance than their counterparts in other parts of the state. However, we note that FQA metrics may covary with both environmental variation and anthropogenic disturbances, limiting the utility of these metrics in assessing wetland condition (Wilcox et al. 2002, Euliss and Mushet 2011).

In this study area, we saw little correlation between Mean C and the proportion of wetland plants at a site, while in the larger group of sites assessed over the past few years, the correlation was present. We surmise that this is due, in part, to the relatively high Mean C observed in the Blackfoot-Swan project area, and the general conditions which support hydrophytic plants. We also believe that regional variation may play out in other conclusions. For example, analyzing the larger data set, we found that while there appears to be a clear relationship between the percent of standing water and proportion of FACW and OBL species, there does not appear to be any linear relationship between the percent of standing water and Mean C, except at the driest sites. Because of differences in database structures, our analysis was limited to sites assessed during our most recent rotating basin studies, which meant that sites from the northern Glaciated Plains,

and particularly the Prairie Pothole region, were not included. Due to the fluctuating water regimes experienced by wetlands in that region, we suspect that we would see different results there, but this will require empirical investigation before we can draw conclusions.

Finally, based on our field observations, we were satisfied with our identification of Intermontane Prairie Potholes as a new Ecological System in the glaciated valleys of northern Montana. While it is similar to several marsh systems – notably the Boreal Freshwater Emergent Marsh and the North-Central Interior Freshwater Marsh found in southern Canada and the U.S. Midwest – we feel that the grassland matrix in which it occurs distinguishes it from these other glacial pothole systems, which are typically found in more woody environments. More research will be necessary to determine if the potholes which have been casually observed on benches and toe slopes in the mountains are examples of this system, one of the marsh systems, or some other system altogether.

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Appendix A. National Wetland Inventory (NWI) attribute codes included in the Blackfoot-Swan Intensification Project wetland assessment sample frame.

Attribute	System	Class	Regime	Modifier
PABF	Palustrine	Aquatic Bed	Semipermanently Flooded	
PABFb	Palustrine	Aquatic Bed	Semipermanently Flooded	Beaver
PABFh	Palustrine	Aquatic Bed	Semipermanently Flooded	Diked/Impounded
PABFx	Palustrine	Aquatic Bed	Semipermanently Flooded	Excavated
PABG	Palustrine	Aquatic Bed	Intermittently Exposed	
PABGb	Palustrine	Aquatic Bed	Intermittently Exposed	Beaver
PABGh	Palustrine	Aquatic Bed	Intermittently Exposed	Diked/Impounded
PEMA	Palustrine	Emergent	Temporarily Flooded	
PEMA d	Palustrine	Emergent	Temporarily Flooded	Partially Drained/Ditched
PEMAh	Palustrine	Emergent	Temporarily Flooded	Diked/Impounded
PEMAx	Palustrine	Emergent	Temporarily Flooded	Excavated
PEMB	Palustrine	Emergent	Saturated	
PEMBb	Palustrine	Emergent	Saturated	Beaver
PEMC	Palustrine	Emergent	Seasonally Flooded	
PEMCh	Palustrine	Emergent	Seasonally Flooded	Diked/Impounded
PEMCx	Palustrine	Emergent	Seasonally Flooded	Excavated
PEMF	Palustrine	Emergent	Semipermanently Flooded	
PEMFh	Palustrine	Emergent	Semipermanently Flooded	Diked/Impounded
PEMFx	Palustrine	Emergent	Semipermanently Flooded	Excavated
PFOA	Palustrine	Forested	Temporarily Flooded	
PFOAh	Palustrine	Forested	Temporarily Flooded	Diked/Impounded
PFOAx	Palustrine	Forested	Temporarily Flooded	Excavated
PFOB	Palustrine	Forested	Saturated	
PFOBb	Palustrine	Forested	Saturated	Beaver
PSSA	Palustrine	Scrub-Shrub	Temporarily Flooded	
PSSAh	Palustrine	Scrub-Shrub	Temporarily Flooded	Diked/Impounded
PSSAx	Palustrine	Scrub-Shrub	Temporarily Flooded	Excavated
PSSB	Palustrine	Scrub-Shrub	Saturated	
PSSBb	Palustrine	Scrub-Shrub	Saturated	Beaver
PSSBd	Palustrine	Scrub-Shrub	Saturated	Partially Drained/Ditched
PSSC	Palustrine	Scrub-Shrub	Seasonally Flooded	
PSSCh	Palustrine	Scrub-Shrub	Seasonally Flooded	Diked/Impounded

Appendix B. Palustrine National Wetland Inventory (NWI) attribute codes excluded from the Blackfoot-Swan Intensification Project wetland assessment sample frame.

Attribute	System	Class	Regime	Modifier
PABKx	Palustrine	Aquatic Bed	Artificially Flooded	Excavated
PUBF	Palustrine	Unconsolidated Bottom	Semipermanently Flooded	
PUBFx	Palustrine	Unconsolidated Bottom	Semipermanently Flooded	Excavated
PUBG	Palustrine	Unconsolidated Bottom	Intermittently Exposed	
PUSA	Palustrine	Unconsolidated Shore	Temporarily Flooded	
PUSAh	Palustrine	Unconsolidated Shore	Temporarily Flooded	Diked/Impounded
PUSAx	Palustrine	Unconsolidated Shore	Temporarily Flooded	Excavated
PUSC	Palustrine	Unconsolidated Shore	Seasonally Flooded	
PUSCd	Palustrine	Unconsolidated Shore	Seasonally Flooded	Partially Drained/Ditched
PUSCh	Palustrine	Unconsolidated Shore	Seasonally Flooded	Diked/Impounded
PUSCx	Palustrine	Unconsolidated Shore	Seasonally Flooded	Excavated

Appendix C. Lacustrine and riverine National Wetland Inventory (NWI) attribute codes excluded from the Blackfoot-Swan Intensification Project wetland assessment sample frame.

Attribute	System	Subsystem	Class	Regime	Modifier
L1UBG	Lacustrine	Limnetic	Unconsolidated Bottom	Intermittently Exposed	
L1UBH	Lacustrine	Limnetic	Unconsolidated Bottom	Permanently Flooded	
L1UBHh	Lacustrine	Limnetic	Unconsolidated Bottom	Permanently Flooded	Diked/Impounded
L2ABF	Lacustrine	Littoral	Aquatic Bed	Semipermanently Flooded	
L2ABFh	Lacustrine	Littoral	Aquatic Bed	Semipermanently Flooded	Diked/Impounded
L2ABG	Lacustrine	Littoral	Aquatic Bed	Intermittently Exposed	
L2ABGh	Lacustrine	Littoral	Aquatic Bed	Intermittently Exposed	Diked/Impounded
L2UBF	Lacustrine	Littoral	Unconsolidated Bottom	Semipermanently Flooded	
L2UBG	Lacustrine	Littoral	Unconsolidated Bottom	Intermittently Exposed	
L2USA	Lacustrine	Littoral	Unconsolidated Shore	Temporarily Flooded	
L2USAh	Lacustrine	Littoral	Unconsolidated Shore	Temporarily Flooded	Diked/Impounded
L2USC	Lacustrine	Littoral	Unconsolidated Shore	Seasonally Flooded	
L2USCh	Lacustrine	Littoral	Unconsolidated Shore	Seasonally Flooded	Diked/Impounded
R2UBG	Riverine	Lower Perennial	Unconsolidated Bottom	Intermittently Exposed	
R2UBH	Riverine	Lower Perennial	Unconsolidated Bottom	Seasonally Flooded	
R2USA	Riverine	Lower Perennial	Unconsolidated Shore	Temporarily Flooded	
R3UBF	Riverine	Upper Perennial	Unconsolidated Bottom	Semipermanently Flooded	
R3UBFx	Riverine	Upper Perennial	Unconsolidated Bottom	Semipermanently Flooded	Excavated
R3UBG	Riverine	Upper Perennial	Unconsolidated Bottom	Intermittently Exposed	
R3UBH	Riverine	Upper Perennial	Unconsolidated Bottom	Seasonally Flooded	
R3USA	Riverine	Upper Perennial	Unconsolidated Shore	Temporarily Flooded	
R3USC	Riverine	Upper Perennial	Unconsolidated Shore	Seasonally Flooded	
R4SBA	Riverine	Intermittent	Streambed	Temporarily Flooded	
R4SBC	Riverine	Intermittent	Streambed	Seasonally Flooded	
R4SBCx	Riverine	Intermittent	Streambed	Seasonally Flooded	Excavated
R4USA	Riverine	Intermittent	Unconsolidated Shore	Temporarily Flooded	

Appendix D. Scoring procedure for calculating stressor impact ratings (sensu Faber-Langendoen et al. 2011).

Table 1. Stressor impact ratings calculations.

		Scope					
		Pervasive	Large	Restricted	Moderate	Small	Nil
Severity	Extreme	Very High	High	Medium	Medium	Low	Low
	Serious	High	High	Medium	Medium	Low	Low
	Moderate	Medium	Medium	Low	Low	Low	Low
	Slight	Low	Low	Low	Low	Low	Low

Table 2. Stressor impact rating numerical conversions.

		Scope					
		5	4	3	2	1	0
Severity	4	20	16	12	8	4	0
	3	15	12	9	6	3	0
	2	10	8	6	4	2	0
	1	5	4	3	2	1	0

Table 3. Rollup procedure for calculating an overall stressor impact rating.

Impact Values of Stressor Categories	Overall Stressor Rating
1 or more Very High Stressors, OR 2 or more High, OR 1 High + 2 or more Medium	Very High (1)
1 High Stressor, OR 3 or more Medium, OR 2 Medium + 2 or more Low, OR 1 Medium, + 3 or more Low	High (2)
1 Medium Stressor + 5 or more Low, OR 8 or more Low	Medium (3)
1 Medium Stressor + 1-4 Low, OR 1-7 Low Stressors	Low (4)
0 Stressors	Absent (0)

Appendix E. Scoring formulas for Level 2 attribute and overall wetland condition scores.

1. For each metric, convert narrative rating score (1, 2, 3, 4, and 5) into the corresponding metric score: 1=12, 2=9, 3=6, 4=3, and 5=1. If metric has only four narrative ratings, then 1=12, 2=9, 3=6, 4=3. If metric had only three narrative ratings, then 1=12, 2=6, and 3=1.
2. Each final attribute score was calculated according to the following:

Landscape Context (LC) Attribute Score:

Raw score = $\left[\frac{\text{Buffer Condition_Plants} + \text{Buffer Condition_Soils} + \text{Buffer Condition_Trash}}{3} \times (\text{Buffer width} \times \text{Buffer length})^{1/2} \right]^{1/2} + \text{Landscape Connectivity}$

Final Attribute score = $\frac{\text{Raw Landscape Context Score}}{\text{Total possible points allowed (24)}} \times 100$

Vegetation Attribute Score:

Raw score = $\left[\frac{(\text{Invasive native} + \text{Native} + \text{Noxious})}{3} \right] + \text{Litter or woody debris accumulation} + \text{Patch Interspersion} + \left[\frac{(\text{Woody vegetation} + \text{Browse})}{2} \right]$

Final Attribute Score = $\frac{\text{Raw Biotic Score}}{\text{Total possible points allowed (48)}} \times 100$

Physicochemical Attribute Score:

Raw score = $\left[\frac{\text{Soil Surface Integrity} + (\text{Water Quality_Algae} + \text{Water Quality_Plants} + \text{Water Quality_Turbidity})}{3} \right]$

Final Attribute Score = $\frac{\text{Raw Physicochemical Score}}{\text{Total possible points allowed (24)}} \times 100$

Hydrology Attribute Score:

Raw score = $\left[\frac{(\text{Hydrologic Input} + \text{Hydrologic Output})}{2} \right] + \text{Hydroperiod} + \text{Surface Water Connectivity scores}$

Final Attribute Score = $\frac{\text{Raw Hydrology Score}}{\text{Total possible points allowed (36)}} \times 100$

3. Final AA Score = Final LC + Final Vegetation + Final Physico + Final Hydro/4

Appendix F. Terminology, description, and calculation of the floristic quality assessment metrics.

N_n = count of native species, N_a = count of all species, N_e = count of non-native species, C_i = index of conservatism for the i^{th} species, x_i = percent cover for the i^{th} species, W = coefficient of wetness.

Indices	Description	Calculation
Total species richness	Number of plant species observed	N_a
Native species richness	Number of native plant species observed	N_n
Non-native species richness	Number of non-native plants	N_e
Cover of native graminoids	Sum of cover of native graminoids (grasses, sedges, and rushes)	$\sum_{i=1}^n x_i$
Mean C	Average C-value of all plants	$\sum_{i=1}^n \frac{C_i}{N_a}$
Mean C_{nat}	Average C-value of only the native plants	$\sum_{i=1}^n \frac{C_i}{N_n}$
Cover-weighted Mean C	Sum of each species C-value multiplied by its cover values, then divided by the sum of cover values for all species	$\frac{\sum_{i=1}^n x_i C_i}{\sum_{i=1}^n x_i}$
Cover-weighted Mean C_{nat}	Sum of each native species C-value multiplied by its cover values, then divided by the sum of cover values for native species	$\frac{\sum_{i=1}^n x_i C_i}{\sum_{i=1}^n x_i}$
FQI	Mean C of all species multiplied by the square-root of the number of all plant species	$\left(\sum_{i=1}^n C_i / N_a \right) \times \sqrt{N_a}$
FQI _{nat}	Mean C of native plant species multiplied by the square-root of the number of native plants	$\left(\sum_{i=1}^n C_i / N_n \right) \times \sqrt{N_n}$
Cover-weighted FQI	Cover-weighted Mean C for all species multiplied by the square-root of all species	$\left(\frac{\sum_{i=1}^n x_i C_i}{\sum_{i=1}^n x_i} \right) \times \sqrt{N_a}$
Cover-weighted FQI _{nat}	Cover-weighted Mean C for native plants multiplied by the square-root of native plants	$\left(\frac{\sum_{i=1}^n x_i C_i}{\sum_{i=1}^n x_i} \right) \times \sqrt{N_n}$
Adjusted FQI _{nat}	Mean C of native plants divided by 10 multiplied by square-root of native plants divided by the square-root of number of all plants multiplied by 100	$\left(\frac{\sum_{i=1}^n C_i / N_n}{10} \times \frac{\sqrt{N_n}}{\sqrt{N_a}} \right) \times 100$
Adjusted cover-weighted FQI _{nat}	Cover-weighted Mean C for native plants divided by 10 multiplied by square-root of native plants divided by the square-root of number of all plants multiplied by 100	$\left(\frac{\sum_{i=1}^n x_i C_i / \sum_{i=1}^n x_i}{10} \times \frac{\sqrt{N_n}}{\sqrt{N_a}} \right) \times 100$
Wetness Index	Average coefficient of wetness for native species	$\bar{W} = \sum W / N_n$
Percent of Total Species of at least FAC	Proportion of total species observed that have a wetland indicator status of FAC or wetter	W_i / N_a

Appendix G. Wetland landscape profile for palustrine wetlands in the Blackfoot-Swan Intensification Project area.

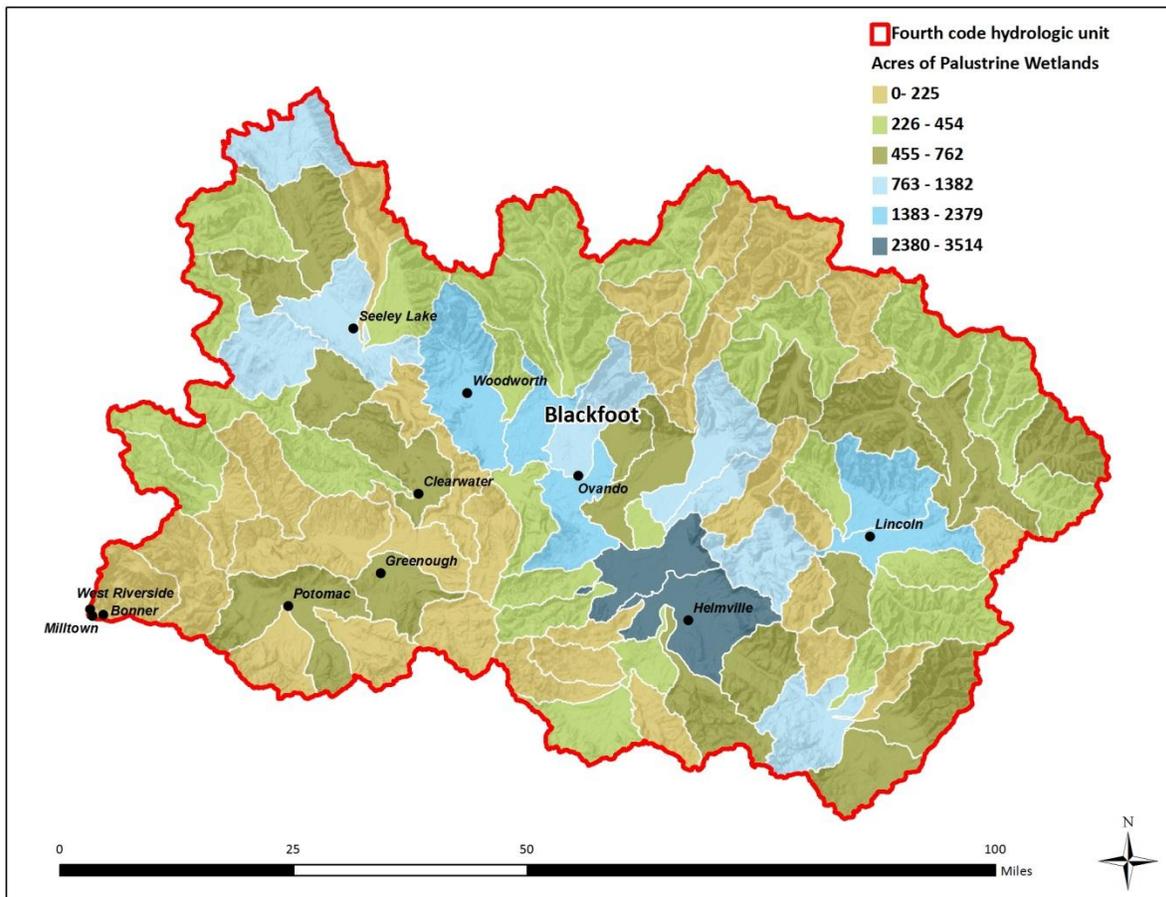


Figure 1. Acres of palustrine wetland by sixth code hydrologic unit in the Blackfoot watershed.

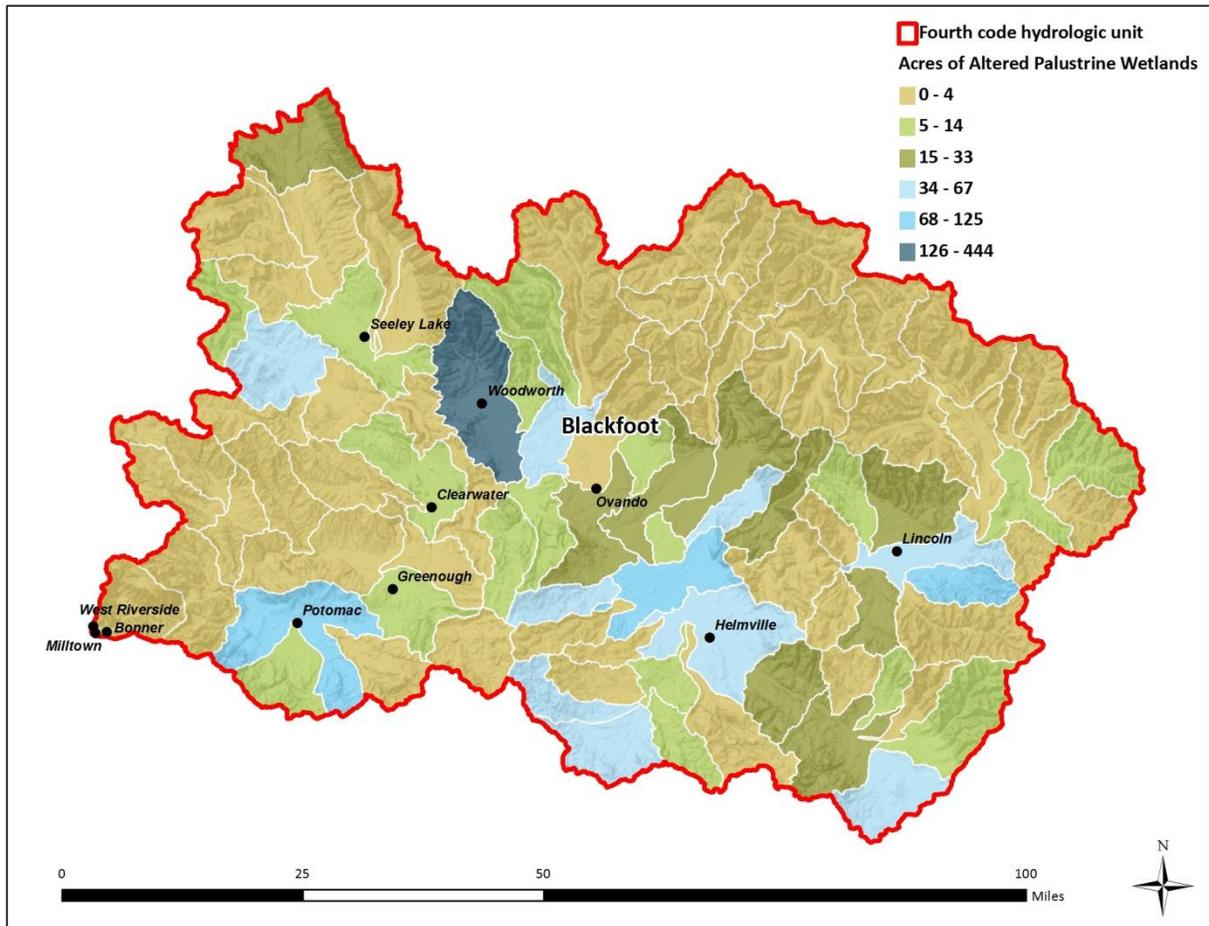


Figure 2. Acres of anthropogenically altered palustrine wetlands (i.e., ditched, drained, impounded, excavated, farmed) by sixth code hydrologic unit in the Blackfoot watershed.

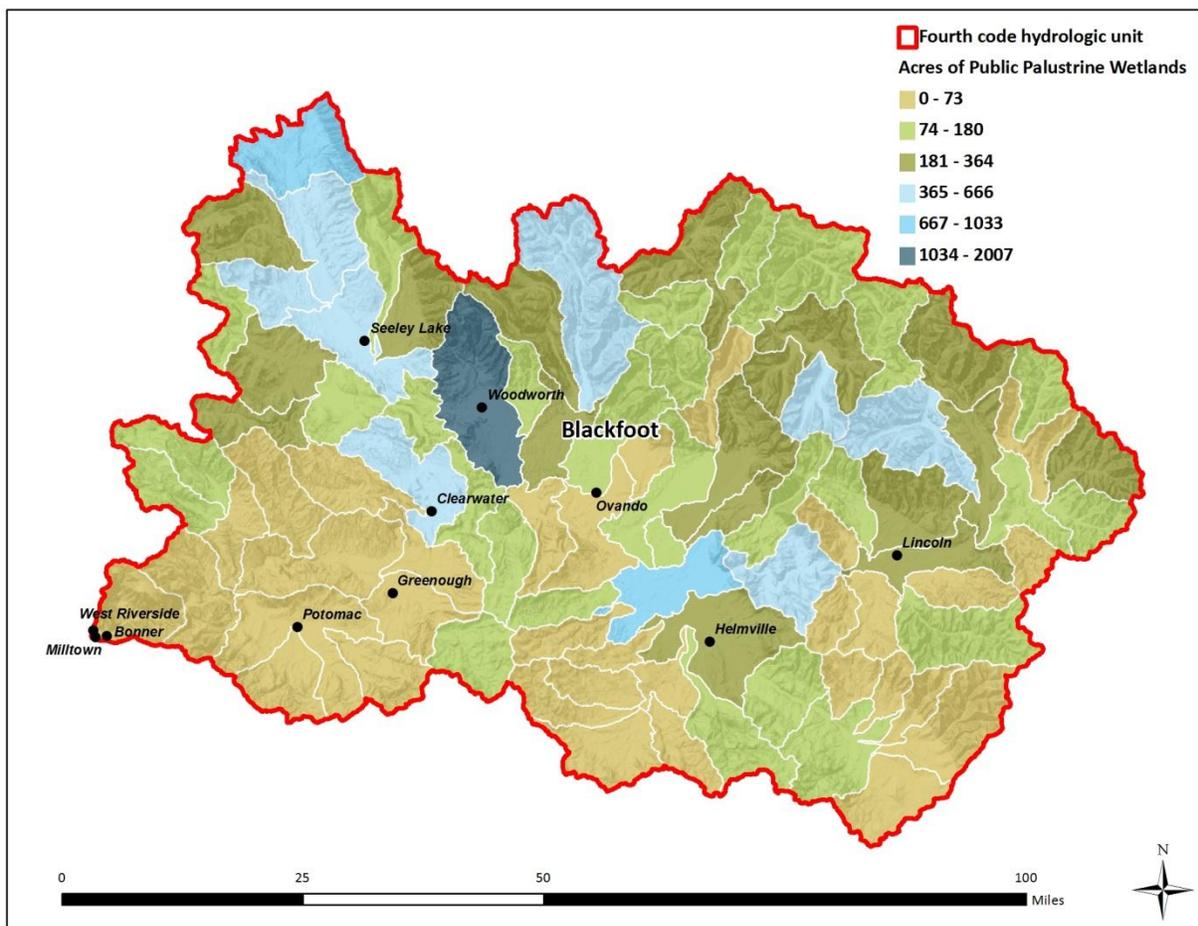


Figure 3. Acres of palustrine wetlands on publicly owned lands by sixth code hydrologic unit in the Blackfoot watershed.

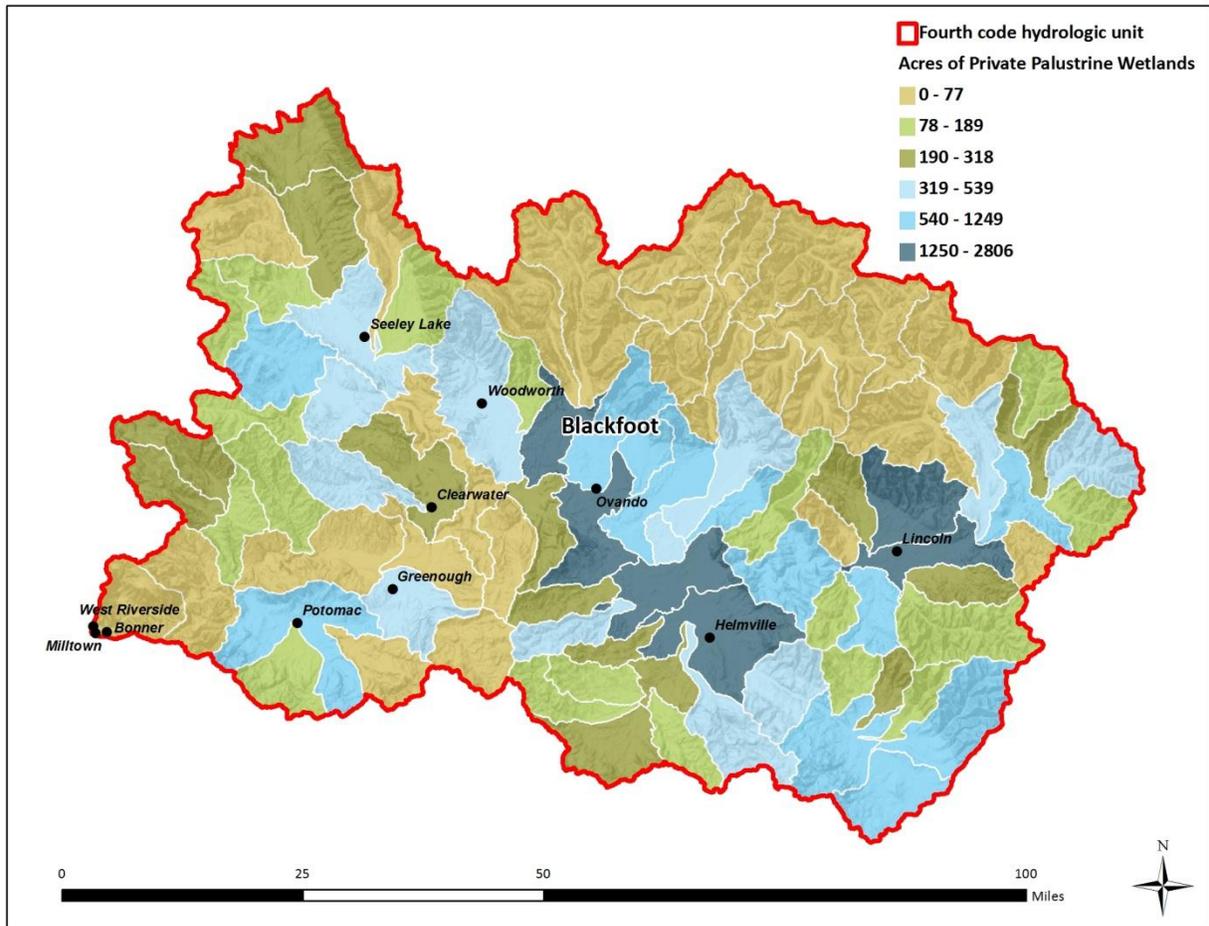


Figure 4. Acres of palustrine wetlands on privately owned lands by sixth code hydrologic unit in the Blackfoot watershed.

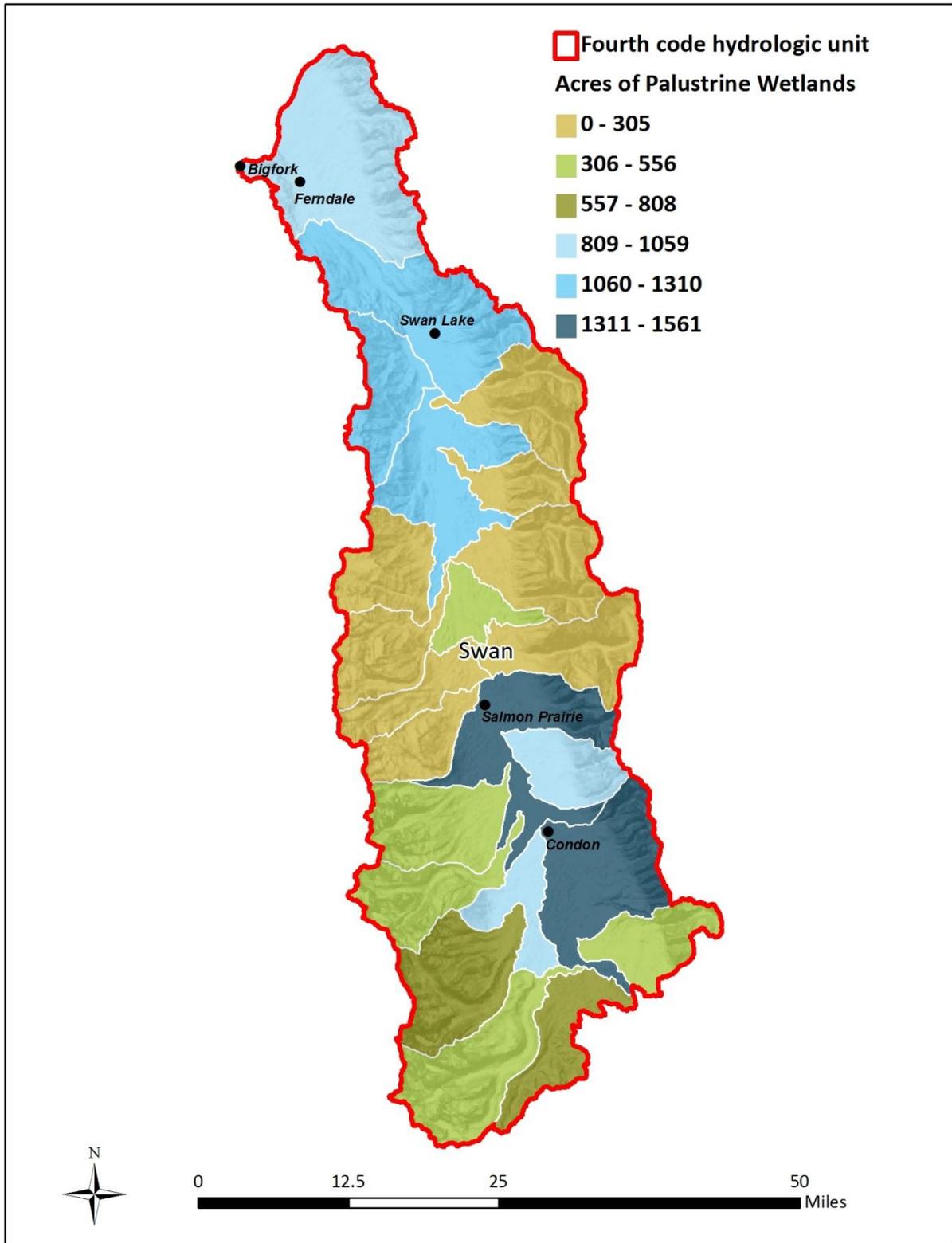


Figure 5. Acres of palustrine wetland by sixth code hydrologic unit in the Swan watershed.

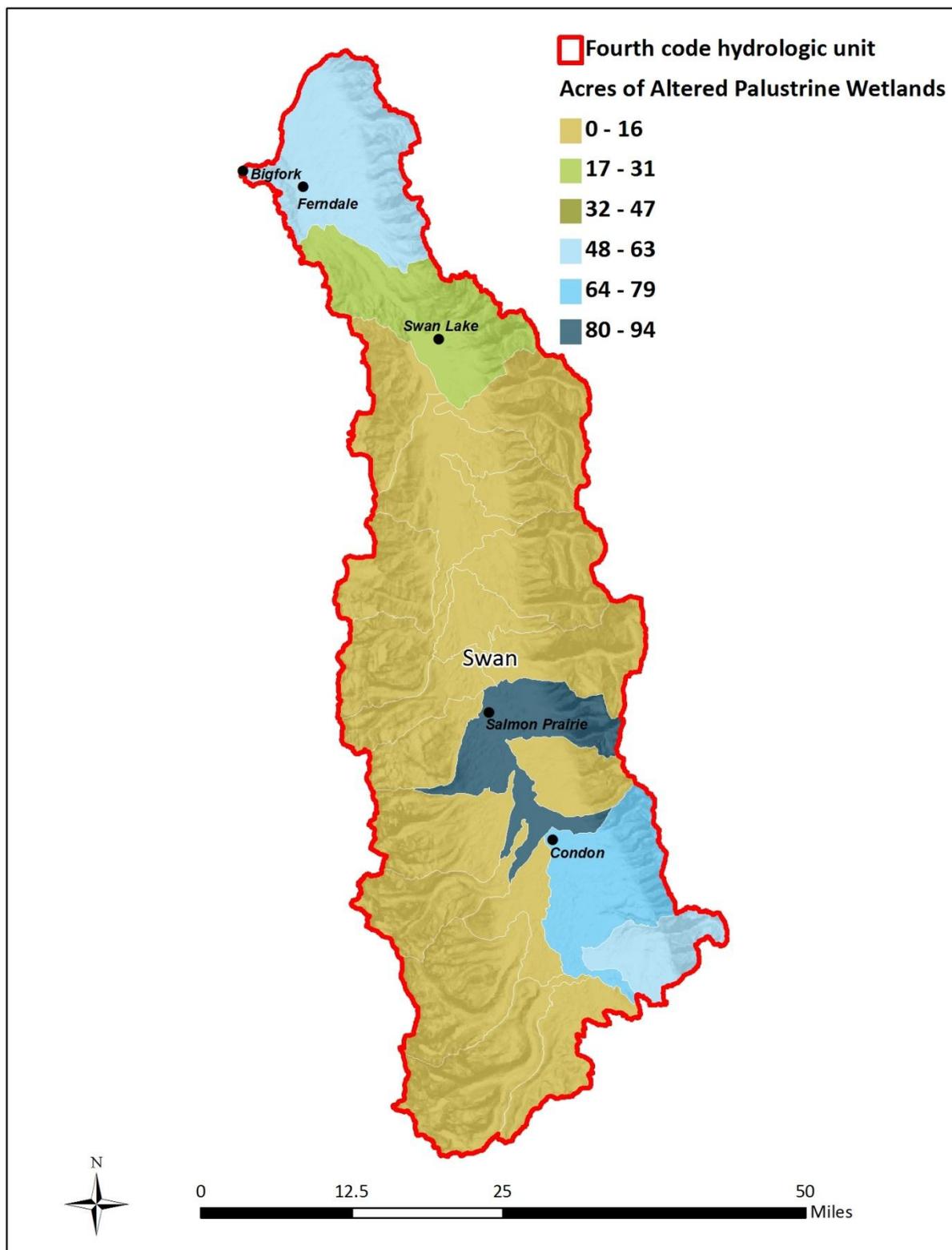


Figure 6. Acres of anthropogenically altered palustrine wetlands (i.e., ditched, drained, impounded, excavated, farmed) by sixth code hydrologic unit in the Swan watershed.

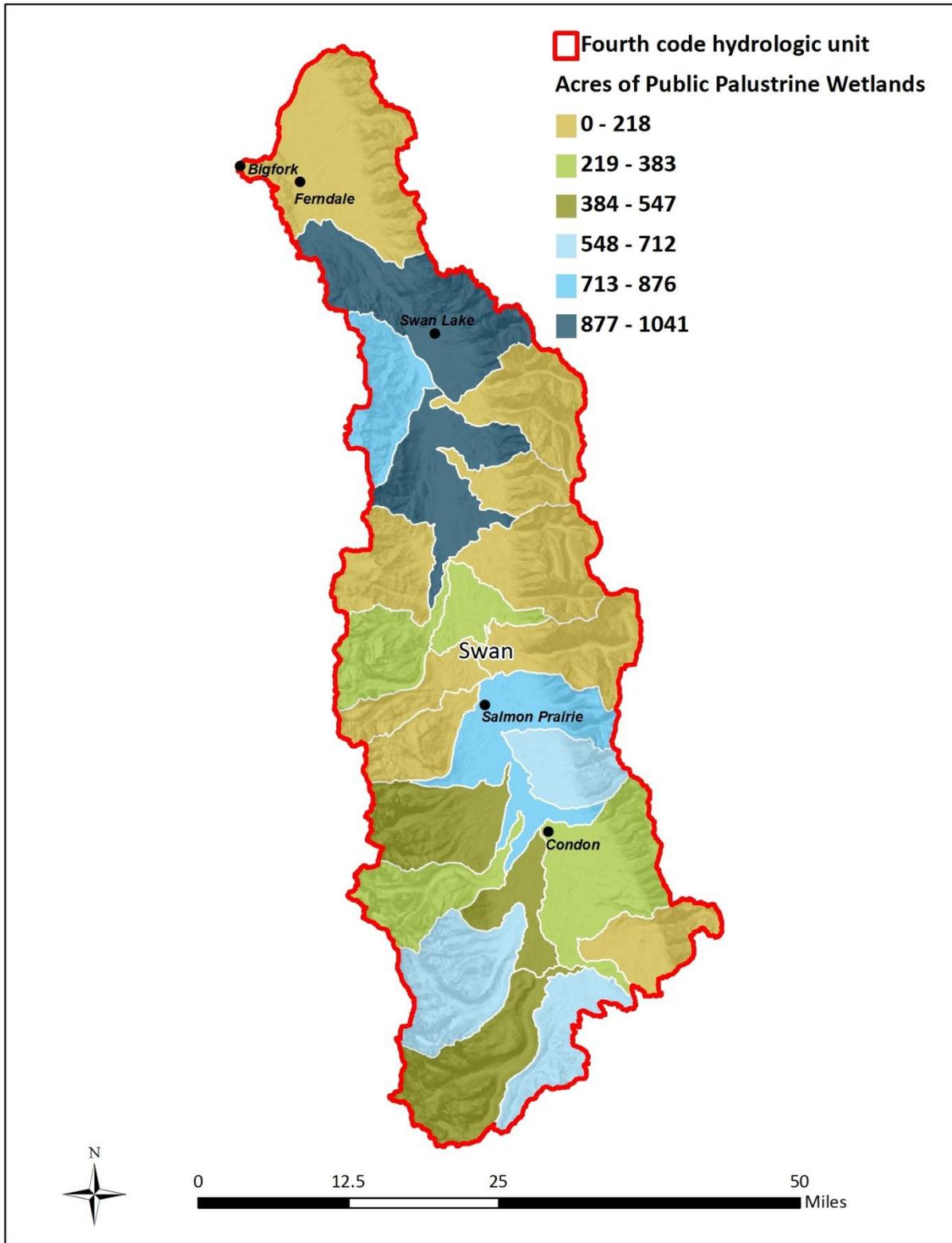


Figure 7. Acres of palustrine wetlands on publicly owned lands by sixth code hydrologic unit in the Swan watershed.

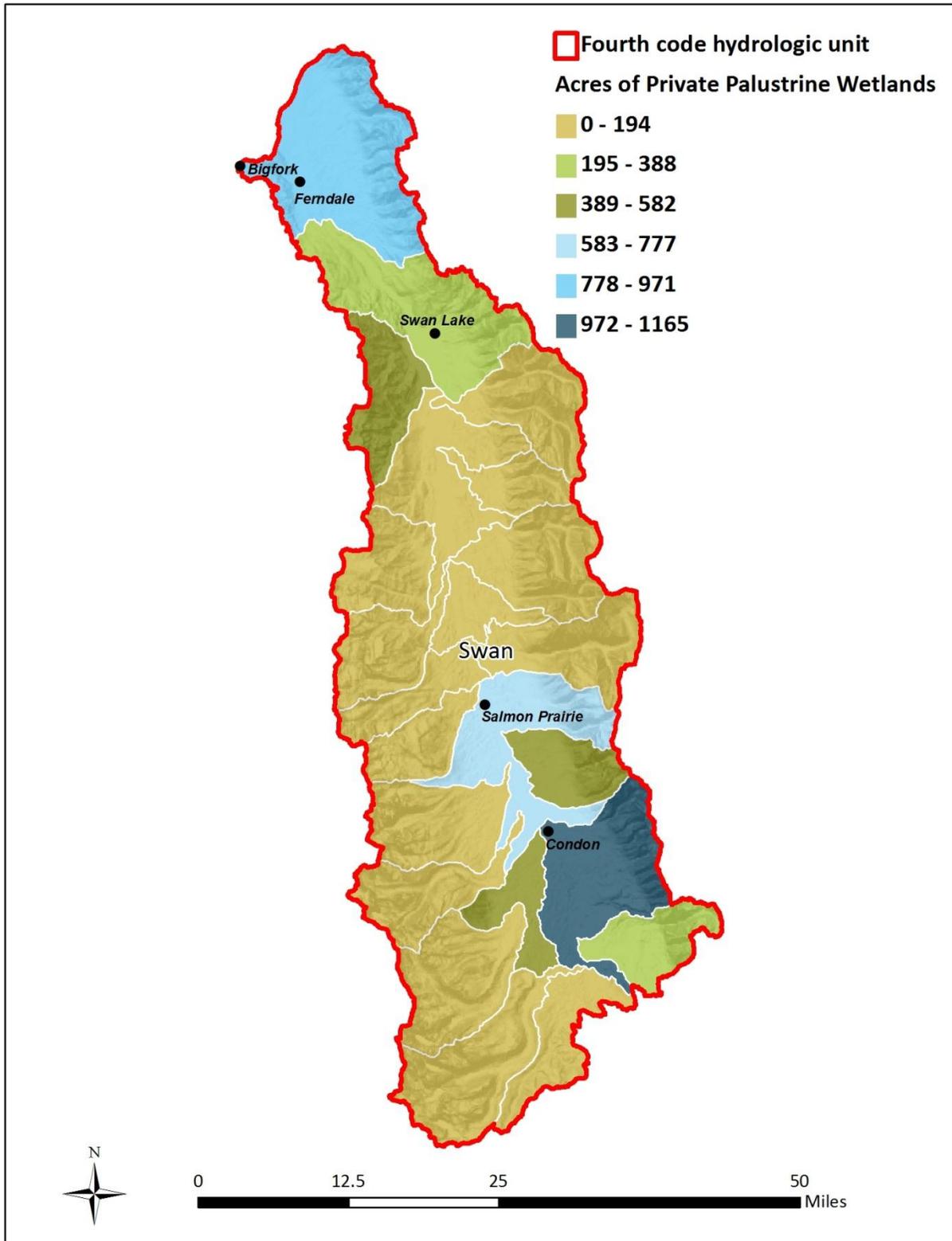


Figure 8. Acres of palustrine wetlands on privately owned lands by sixth code hydrologic unit in the Swan watershed.

Appendix H. Intermontane Prairie Pothole Ecological System description



Provisional State Rank: S3

General Description

The Intermontane Prairie Pothole ecological system occurs in depressions in glaciated valleys of the ecoregions of northwestern Montana, with the highest concentrations found in the Foothill Potholes Level 4 ecoregion north of Ovando and in the Southern Flathead Valley. This system is typically part of a matrix within the Rocky Mountain Lower Montane, Foothill, and Valley Grassland ecosystem. This system is distinguished from the Great Plains Prairie Pothole ecosystem by its location, by its floristic composition, and by hydrology. Unlike wetlands of the Great Plains Prairie Pothole ecosystem, both isolated and connected wetlands within the Intermontane Prairie Pothole ecosystem have only minimal influences from or to local groundwater, and are more likely to exchange water with surrounding uplands than with each other. Water permanence varies depending on wetland size, depth and landscape position, and wetlands of this system can range from temporarily to permanently inundated, although even permanent wetlands may have significant drawdown by the end of the growing season. Vegetation composition varies according to water permanence, but these wetlands are usually dominated by emergent graminoids such as spikerushes (*Eleocharis* species), sedges (*Carex* species), rushes (*Juncus* species) and often, cattails (*Typha* species) and bulrushes (*Schoenoplectus* species). In the Flathead valley, reed canarygrass (*Phalaris arundinacea*) is common, and can become invasive in some wetlands. Zonation is characteristic, with all Intermontane Prairie Potholes having a Low Prairie and Wet Meadow zone, and wetter examples also having a Shallow Marsh, and occasionally, a Deep Marsh zone (*sensu* Stewart and Kantrud 1971). Because of their limited distribution and their presence on the landscape as wetland-grassland complexes, wetlands in this ecological system should be regarded as **Wetlands of Special Significance**.

Diagnostic Characteristics

Herbaceous, depression, depressional, flooded or saturated soils, partially isolated

Similar Systems

- North-Central Interior Freshwater Marsh
- Boreal Freshwater Emergent Marsh
- Alpine-Montane Wet Meadow
- Great Plains Prairie Pothole

Range

The Intermontane Prairie Pothole ecosystem occurs in depressions in glaciated valleys of the ecoregions of northwestern Montana, with the highest concentrations found in the Foothill Potholes Level 4 ecoregion north of Ovando and in the Ninepipe area of the Southern Flathead Valley. Similar potholes can be found on grassy benches along the North Fork of the Sun River, the Rocky Mountain Front, toe slopes of the Pintler Mountains and in other glaciated valleys where climate favors development of short-grass prairie; however, more field work and analysis will be required to determine whether these similar potholes fall into the current Ecological System

Spatial Pattern

Matrix

Environment

Intermontane Prairie Potholes occur in the colluvium and glacial till mantle of valleys in the northwestern Montana mountain ranges. Although the main glacial advance from the cordilleran ice sheet ended in the Flathead Valley, smaller valley glaciers from local mountains formed thick trunk glaciers in these valleys (Hauer et al. 2002). Ice blocks were deposited by retreating glaciers in the Flathead Valley area, forming the kettle depressions in the Ninepipe area, while glacial disintegration created the hummocks and depressions common in the foothill potholes near Ovando. The fine glacial sediments underlying these wetlands consist of glacial “flour” or fine clay, and are generally impermeable. Although the deeper Intermontane Prairie Potholes generally intersect the water table, seasonal and temporary ones are characteristically perched above it (Cook and Hauer 2007). Elevations in the Ninepipe area of the Flathead Valley and the Foothill Potholes ecoregion range from 900 meters to 1,350 meters. Climate is characterized by long, cold winters and moist springs. In the Ninepipe area, climate is distinctly maritime-influenced, with the highest precipitation falling between November and January, while the Ovando area receives the greatest amount of precipitation in May and June.

Vegetation

Permanently and semipermanent flooded Intermontane Prairie Potholes generally consist of three to four distinct vegetation zones (*sensu* Stewart and Kantrud 1971): Low Prairie, Wet Meadow, Shallow Marsh, and Deep Marsh. The Deep Marsh zone is characterized by submerged aquatic plants in the open water zone including common hornwort (*Ceratophyllum demersum*), horned pondweed (*Zannichellia palustris*), greater bladderwort (*Utricularia macrorhiza*), and milfoil species (*Myriophyllum spp.*), as well as floating-leaved plants including lesser duckweed (*Lemna minor*) and star duckweed (*Lemna trisulca*), floating pondweed (*Potamogeton natans*), and slender pondweed (*Potamogeton pusillus*). The Shallow Marsh zone is typically dominated by hardstem bulrush (*Schoenoplectus acutus*), cattails (*Typha* species), narrowleaf bur-reed (*Sparganium angustifolium*), water smartweed (*Polygonum amphibium*), common mare's tail (*Hippuris vulgaris*) and hemlock water-parasit (*Sium suave*). The Wet Meadow zone, found in all Intermontane Prairie Potholes, is typically dominated by graminoids including creeping spikerush (*Eleocharis palustris*), least spikerush (*Eleocharis acicularis*), common beaked sedge (*Carex utriculata*), awned sedge (*Carex atherodes*), foxtail barley (*Hordeum jubatum*), and boreal mannagrass (*Glyceria borealis*). In the Ninepipe area, as in many wet meadows in the Flathead Valley, reed canarygrass (*Phalaris arundinacea*) frequently dominates the wet meadow zone, outcompeting other species. The drier Wet Prairie zone features a mix of graminoids and forbs such as clustered field sedge (*Carex praegracilis*), tufted hairgrass (*Deschampsia cespitosa*), wild mint (*Mentha arvensis*) and silverweed cinquefoil (*Argentina anserina*). Because many Intermontane Prairie Potholes occur in close proximity to pastures and hayfields, exotic grasses such as intermediate wheatgrass (*Elymus hispidus*) are common in the Wet Prairie zone.

Alliances and Associations

Alliances

- A3807. *Eleocharis palustris* - *Eleocharis acicularis* - *Eleocharis rostellata* Herbaceous Alliance
- A2642. *Argentina anserina* Low Forb Wet to Dry Meadow Alliance

Associations

- CEGL001833 *Eleocharis palustris* Herbaceous Vegetation
- CEGL005825 *Argentina anserina* Ruderal Herbaceous Vegetation

Dynamic Processes

Unlike the Great Plains, intermontane valleys like the Flathead and the Blackfoot did not experience a high degree of natural disturbance by large herbivores. However, periodic flooding events, wet-dry climatic cycles and occasional fires operate on both pothole systems in the same

ways. In dry years, when the aquatic bottoms of shallow water zones are exposed, seeds from both annuals and perennials germinate. When subsequent precipitation floods the depressions, the annuals drown and the perennials survive. Over a series of years the perennials dominate. In the southern Flathead Valley, dry conditions favor the expansion of *Phalaris arundinacea* into shallow marsh zones; similarly, wet conditions allow it to expand into the Low Prairie zone. In general, species richness can vary considerably among individual intermontane potholes depending on the number of zones present and the degree of grazing in the Low Prairie and Wet Meadow zones.

In contrast to pothole wetlands in the Great Plains, Intermontane Potholes have low ground-water connectivity. Topographic low points on the landscape allow shallow surface-water connections between some wetlands, while high points lead to isolation for others. In both cases, however, Deep and Shallow Marsh areas of these wetlands tend to discharge to the Low Prairie zone in spring, and in summer, as ponded water depth declines, are recharged by water from near-shore soils (Cook and Hauer 2007). Connected wetlands store water longer into the growing season, and show greater primary productivity than isolated wetlands, but there are no notable differences in species diversity, although some species appear to have a greater affinity for connected or isolated wetlands (Cook and Hauer 2007).

Management

Changes will occur in the plant communities due to climatic conditions and/or management activities as well as the spread of *Phalaris arundinacea*. Grazing influences at margins or throughout the wetland in drier years can alter the characteristic plant communities. Similarly, agricultural practices may contribute to the spread of exotic species into the Low Prairie zone, and occasionally, into the Wet Meadow zone.

Restoration Considerations

Intermontane Prairie Potholes in the Ovando area occur mostly in closed basins where the undulating landform does not favor draining or ditching. In other areas, where draining or diversion has occurred, restoration will require reestablishment of the original hydrology, generally by blocking outlets. Once water levels are restored, regrowth and recolonization from dormant rhizomatous root systems of common emergent species can occur within a few years. Livestock grazing should be controlled to allow regrowth, recolonization and resprouting from existing root systems. In areas where *Phalaris arundinacea* is a problem, aggressive action may be necessary to restore native plant communities. *Phalaris arundinacea* is undeterred — and in fact may be increased — by burning or mowing. Where flooding can be manipulated, a combination of tillage and flooding may help to control it. Left alone, *P. arundinacea* will colonize the areas where sedges and other graminoids would otherwise establish, precluding their successful growth.

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Version Date

11/15/2015

Other Classifications:

National Vegetation Classification Standard

Class

2. Shrub & Herb Vegetation

Subclass

2.B Temperate & Boreal Grassland & Shrubland

Formation

2.B.2 Temperate Grassland & Shrubland

Division

D031. Western North American Freshwater Shrubland, Wet Meadow & Marsh

Macrogroup

M075. Western North American Montane-Subalpine Wet Shrubland & Wet Meadow

Group

G521. Vancouverian & Rocky Mountain Montane Wet Meadow & Marsh

Cowardin Classification System:

Palustrine Aquatic Bed Permanently Flooded (PABH)

Palustrine Aquatic Bed Semipermanently Flooded (PABF)

Palustrine Aquatic Bed Intermittently Exposed (PABG)

Palustrine Emergent Semipermanently Flooded (PEMF)

Palustrine Emergent Seasonally Flooded (PEMC)

Palustrine Emergent Temporarily Flooded (PEMA)

References

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Hauer, F.R., B.J. Cook, M.C. Gilbert, E.J. Clairain Jr., and R.D. Smith. 2002. A regional guidebook for assessing the hydrogeomorphic approach to assessing wetland functions of intermontane prairie pothole wetlands in the Northern Rocky Mountains. U.S. Army Engineer Research and Development Center, ERDC/EL TR-02-7, Vicksburg, MS.

Stewart, R. E., and H.A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Resource Publication 92, Washington, DC.