WASHINGTON NATURAL HERITAGE PROGRAM

Assessment of Ecological Characteristics and Ecological Integrity of Wetlands in Northern Douglas County, Washington

Prepared for The Nature Conservancy, Wenatchee, WA

Prepared by
F. Joseph Rocchio and Rex C. Crawford

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Report Prepared for:
The Nature Conservancy
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EXECUTIVE SUMMARY

The northern portion of The Nature Conservancy's Moses Coulee Conservation Area contains numerous, small wetlands. Very little is known about these wetlands and their contribution to global and regional biodiversity. In order to improve conservation actions in this area, The Nature Conservancy contracted with the Washington Natural Heritage Program to collect information pertaining to the biodiversity and current ecological conditions associated with these wetlands. This knowledge will inform the development of strategies to conserve the biodiversity supported by these systems, prioritize and/or help stratify wetlands for further study and conservation action, and refine the methodology to remotely sense wetlands across the full Moses Coulee Conservation Area.

The Nature Conservancy is working with the University of Washington's Remote Sensing and Geospatial Laboratory (UW) to develop a remotely sensed map of wetlands in the project area. This work was initiated through mapping of a Pilot Assessment Area which is a 50,000 acre area in northern Douglas County. UW mapped wetlands into three categories: dry bed, open water, and emergent. For this project, 75 wetlands occurring on Washington Department of Natural Resource Trust Lands within the Pilot Assessment Area (project area) were randomly select and visited to collect on-the-ground ecological data. These data were then summarized to characterize the biodiversity supported by the wetlands in the project area. The following information was collected at each wetland: (1) classification of each site according to NatureServe's Ecological System's Classification (Comer et al. 2003); (2) rapid assessment of ecological condition using the Ecological Integrity Assessment method (Faber-Langendoen et al. 2006, 208, 2009); and (3) description of the biological and ecological characteristics of each wetland.

Most of the sites visited were classified as either Inter-Mountain Basin Alkaline Closed Depression (44%) or Columbia Plateau Wet Meadow (Provisional type; 30%). Based on observations from working in the project area, these proportions seem to reasonably represent the distribution of wetland types throughout the project area.

Field observations also suggest that the UW map rarely missed closed depressional wetlands which had salt flats, open water, or large areas of bare soil. However, some emergent zones within these wetlands were missed by the UW map. These areas seem to all share a similar color signature and were most often associated with the saltgrass (*Distichlis spicata*) communities. Often times, these missed areas occurred adjacent to a correctly mapped polygon.

Qualitative indicators of hydrology and salinity levels were noted for each of the surveyed wetlands. Given the qualitative nature of this dataset, care should be given to their use until future quantitative measures can confirm their accuracy. With that stated, over 80% of the wetland surveyed had an intermittently flooded hydrological regime. In other words, surface water in these wetlands can be present for variable periods without detectable seasonal periodicity and inundation is not predictable to a given season. A small number of wetlands had semi-permanently flooded hydrological regimes, meaning that in these sites surface water persists throughout the growing season in most years and the soil is normally saturated when water level drops below soil surface. These sites are mostly those that support marsh vegetation and in the project area are assumed to be associated with groundwater given the permanence of water levels.

Wetlands in the project area were predominantly more saline than fresh. The majority of wetlands surveyed had either saline (23%) or intermediately saline (48%) soil conditions, as indicated by the presence of halophytes growing at the site and salt crusts on the soil surface, plants, or other debris. Based on literature from the Great Plains prairie pothole region (Hayashi et al. 1998), the Washington Department of Ecology assumes that saline wetlands in eastern Washington are groundwater supported (Hruby et al. 2000). This is true of many playa wetlands across the Inter-Mountain West (as summarized in Rocchio 2006). However, some wetlands found in closed depressions may be saline due to the accumulation of solutes from overland flow, such as those found in the southern High Plains and southwestern U.S. The process of evaporation leaves behind an accumulation of solutes carried into these sites by overland flow which, with time, produces the alkaline/saline environment typically found in these wetlands. Based on rapid indicators, most wetlands in the project area appear to be less likely associated with groundwater than overland flow. The level of salinity associated with each of the groundwater dependence indicators also suggests that both fresh and saline wetlands may or may not be associated with groundwater discharge. Cook and Hauer (2007) found that groundwater played a minor role in the hydrology of Intermontane Prairie Pothole wetlands in western Montana, which are very similar in geological origin to those in the project area. Their research showed that these wetlands were primarily driven by surface and near-surface hydrological flow. They also concluded that soil salinity was a result of capillary flow moving solutes from ponded water (from overland flow) up toward the rooting zone located at the wetland margin (i.e., next highest zone). We observed this phenomenon at a few of the surveyed wetlands. At these sites, salt crusts were conspicuously present at the wetland margin (lower end of the lowest vegetation zone) but were seemingly absent from the lower, unvegetated portion of the wetland. Thus, the salinity of wetlands in Douglas County may not always be due to groundwater discharge.

Thirty three different plant associations were identified in the field. *Distichlis spicata*, *Hordeum jubatum*, *Juncus balticus*, and variations of *Leymus cinereus* types were the most common plant associations encountered during the project. However, future quantitative analysis may show that the the number of plant associations may be greater or fewer.

Field efforts were not targeted around optimal survey times for waterfowl, shorebirds, or other wildlife species that may be associated with the wetlands in the project area. Thus, our observations of wildlife were purely opportunistic and resulted in a paucity of observations. Those observations are found in the accompanying Microsoft Access database. However, data from the Washington Department of Fish and Wildlife (WDFW) indicate that the wetlands found in the Douglas County 'Pothole region' are important breeding habitat for waterfowl in Washington (Mikal Moore, personal communication). The aquatic invertebrate specimens collected for this project were not identified by WNHP. The specimens have been given to The Nature Conservancy. The identification of these specimens should be a high priority. Although only a few vernal pools were surveyed for this project, the invertebrate composition of other depressional wetlands in the project area is also not well-known and specimens collected for this project may assist in filling that information gap.

The overall ecological condition of each wetland is summarized by Ecological Integrity Assessment Ranks (EIA). All of the Columbia Plateau Vernal Pool, Inter-Mountain Basin Alkaline Closed Depression, and Inter-Mountain Basin Playa wetlands had an overall EIA rank of B (good integrity) while the Columbia Plateau Wet Meadow (Provisional) and North American Arid Freshwater Marsh sites also had quite an abundance of C ranked (fair integrity) sites. In terms of the underlying rank for Key Ecological Attributes, the Columbia Plateau Vernal Pool, Inter-Mountain Basin Alkaline Closed Depression, and Inter-Mountain Basin Playa wetlands had excellent (A) to good (B) ranks for all Key Ecological Attributes except Biotic Condition. North American Arid Freshwater Marsh and Columbia Plateau Wet Meadow (Provisional), however, had fair (C) and/or poor (D) ranks in each KEA.

Livestock grazing has resulted in the most common stressors associated with Landscape, Vegetation, Soils, and Hydrology attributes. These stressors appear to be having a negative effect on the ecological condition of wetlands in the project area. The most obvious effect resulting from grazing is a change in vegetation composition. These changes do not imply that all ecological services provided by these wetlands have been degraded or eliminated. However, from a biodiversity perspective, current grazing practices appear to be negatively impacting the integrity of the vegetation community. Impacts from grazing on aquatic invertebrates should be researched in the future.

The project area supports most of the wetland types found in the Columbia Basin of eastern Washington: Inter-Mountain Basin Alkaline Closed, Inter-Mountain Basin Playa, Columbia Plateau Wet Meadow (Provisional), Columbia Plateau Vernal Pool, and North American Arid Freshwater Marsh. The northern Waterville Plateau, because of its unique glacially-derived landforms, supports a unique collection of saline wetlands that resemble the prairie potholes wetlands found in western Montana mountain valleys (Cook and Hauer 2007) as well those found in the northern Great Plains. Currently, WNHP does not have Conservation Status Ranks assigned to Ecological Systems. However, the density of saline wetlands (e.g. Inter-Mountain Basin Alkaline Closed Depression and Playa Ecological Systems) found on the Waterville Plateau may be among the highest in the state and thus a very important region for the conservation of these saline wetland types.

Of the 33 plant associations identified in the field, nearly 25% (8) have a Global Rank between G1-G3Q while 33% (11) have a State Rank between S1-S3?. In other words, 25% of the plant associations are considered to be of global conservation significance while an additional 8% are of important conservation significance within the State of Washington. This indicates that the project area wetlands support numerous plant associations of higher conservation significance. Many of these plant associations are considered a conservation priority not because they are extremely rare on the landscape but rather because across their Global and State ranges most occurrences of these types have been heavily degraded by human-induced disturbances (NatureServe 2009).

No rare plants tracked by WNHP (WNHP 2009) were observed during the course of this project. However, field visits were not scheduled around the appropriate season for inventory for each of the potential rare plant species. Additional inventory work with consideration of each species' phenology is recommended.

WDFW's Wildlife Survey and Data Management Database or WNHP Biotics Database did not contain any records within the project area. No new observations of species tracked by these databases were documented during this project. As with the rare plants, animal observations were not the focus of scheduling field work and thus relied on opportunistic observations.

Until the aquatic invertebrate specimens are identified, their biodiversity significance remains unknown. However, given the rare and endemic species found in California and Oregon vernal pools, they should remain on the radar as a potential conservation target.

In summary, the wetlands of the project area occur in a unique geologic landscape which results in unique ecological characteristics and high biodiversity significance. The project area contains an unusual density of saline wetlands for Washington State, supports numerous rare wetland plant associations, and provides important waterbird habitat. The wetlands in the project area undoubtedly also provide a myriad of ecological services that were not addressed in this project.

Finally, the methods employed in this project were of a rapid and qualitative nature and were of a limited geographic focus. Because of these limitations, the following research is recommended in order to fully understand the ecological characteristics and biodiversity significance of wetlands in northern Douglas County:

- Continue inventory efforts on lands outside DNR ownership and throughout the Waterville Plateau and perhaps adjacent Grant and Okanogan Counties as well.
- Using vegetation plot data collected in this report and from additional inventory efforts, conduct a quantitative classification analysis of the plant associations occurring in northern Douglas County wetlands; such an analysis may reveal additional types not previously represented as well as provide additional data regarding regional variation of existing types
- Quantitatively characterize the hydrological regime of these wetlands, including a quantitative investigation of the relative contribution of groundwater and overland flow to the hydrological regime of these wetlands
- More focused and intensive survey effort for specific rare plants such as those listed in Table 5 and those associated with vernal pools
- Identify aquatic invertebrates that were collected for this project
- Conduct a quantitative analysis of livestock grazing impacts on biodiversity of wetlands in the project area.
- Work with WDFW to obtain site-specific data on use of wetlands by waterbirds

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1.0 Introduction

1.1 Project Objective

The northern portion of The Nature Conservancy's Moses Coulee Conservation Area (Figure 1) contains numerous, small wetlands. Very little is known about these wetlands and their contribution to global and regional biodiversity. In order to improve conservation actions in this area, The Nature Conservancy contracted with the Washington Natural Heritage Program to collect information pertaining to the biodiversity and current ecological conditions associated with these wetlands. This knowledge will inform the development of strategies to conserve the biodiversity supported by these systems, prioritize and/or help stratify wetlands for further study and conservation action, and refine the methodology to remotely sense wetlands across the full Moses Coulee Conservation Area (most of Douglas and northern Grant counties, Washington; over 1 million acres).

The Nature Conservancy is working with the University of Washington's Remote Sensing and Geospatial Laboratory (UW; http://depts.washington.edu/rsgal/) to develop a remotely sensed map of wetlands in the project area. This work was initiated through mapping of a Pilot Assessment Area which is a 50,000 acre area in northern Douglas County (Figure 1 & 2). UW mapped wetlands into three categories: dry bed, open water, and emergent (Figure 2). For this project, 75 wetlands occurring on Washington Department of Natural Resource Trust Lands within the Pilot Assessment Area (project area) were randomly select and visited to collect on-the ground ecological data. These data were then summarized to characterize the biodiversity supported by the wetlands in the project area. The following information was collected at each wetland: (1) classification of each site according to NatureServe's Ecological System's Classification (Comer et al. 2003); (2) rapid assessment of ecological condition using the Ecological Integrity Assessment method (Faber-Langendoen et al. 2006, 2008a, 2009); and (3) description of the biological and ecological characteristics of each wetland.

1.2 Study Area

The project area is located on the leeward side of the Cascade Range and encompasses approximately 50,000 acres in the northern portion of Douglas County, in the northeastern section of the Waterville Plateau (Figures 1 &2). The extent of the Waterville Plateau is delimited by the Columbia River to the north and west, Grand Coulee to the east and Quincy Basin to the south.

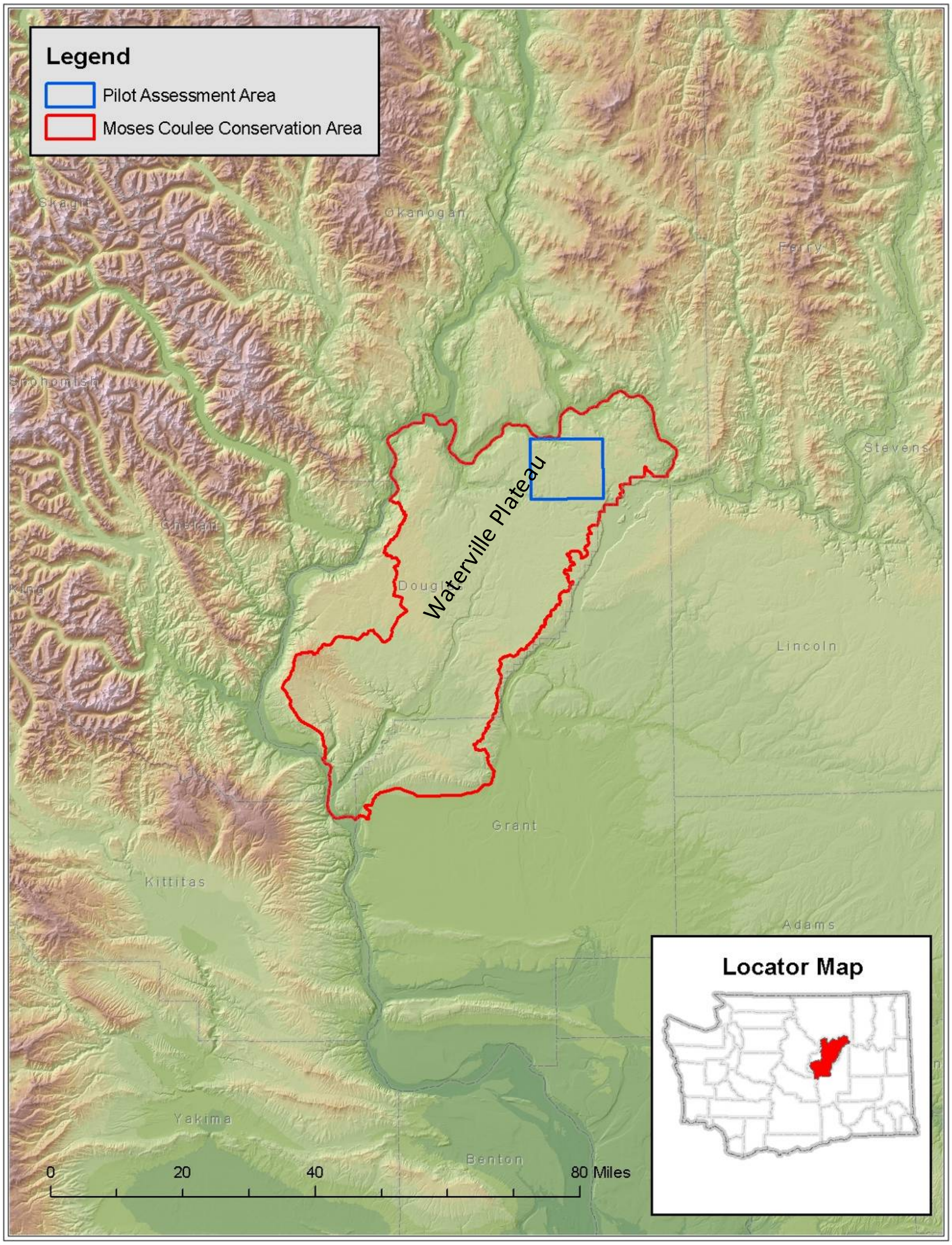


Figure 1. Moses Coulee Conservation Area and the location of the Pilot Assessment Area.

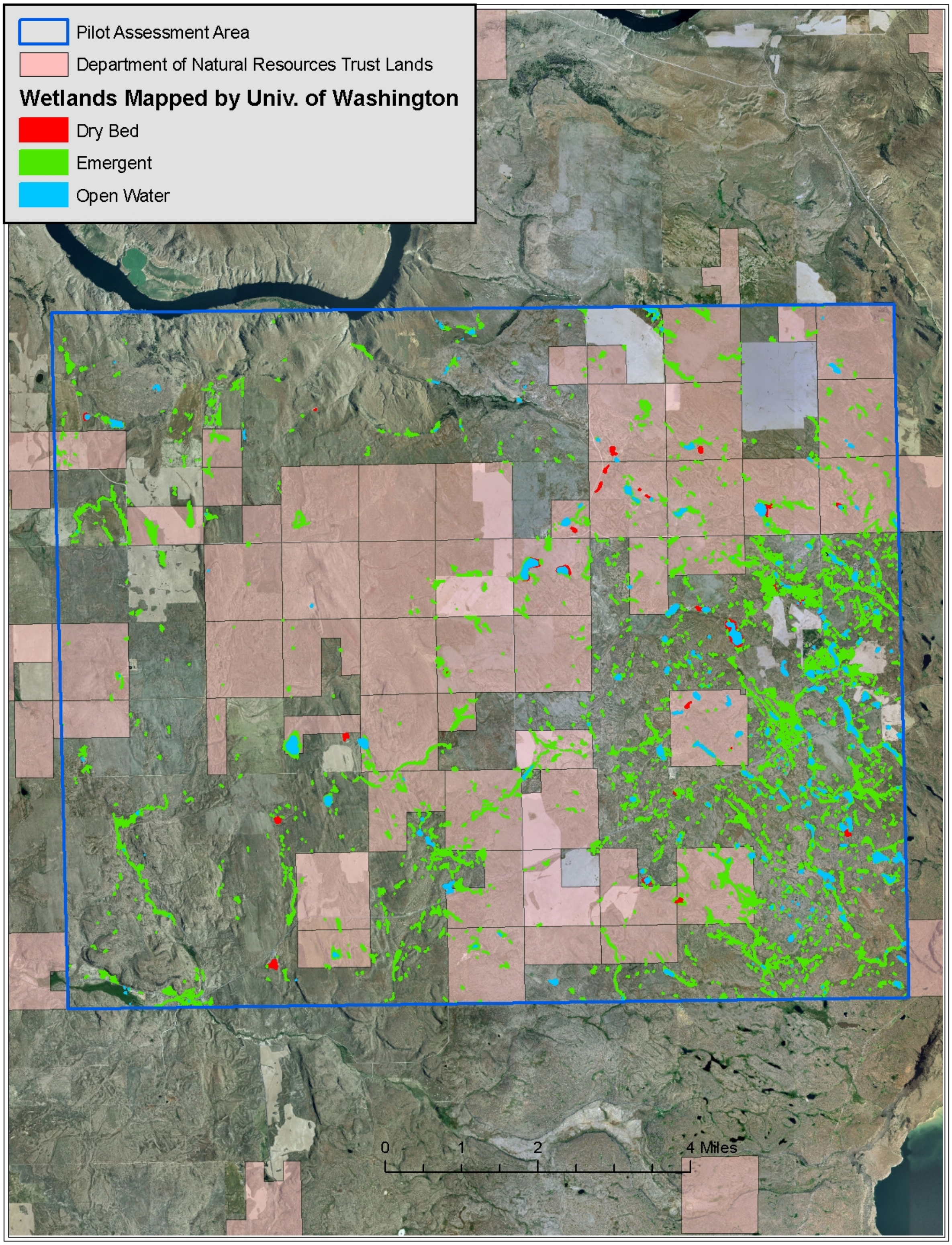


Figure 2. Wetlands Mapped by the University of Washington in the Pilot Assessment Area.
Note: Wetland polygon size exaggerated for viewing purposes.

1.2.1 Climate

The project area has hot, dry summers and cool, moist winters with an overall semi-arid climate. Annual precipitation in Douglas County ranges from 6 to 16 inches and is driest from July through September and wettest from November through February, mostly in the form of snow. Within the project area, annual precipitation is roughly > 10 inches/year, and tends to increase from west to east (USDA 1981; Western Regional Climate Center 2009). Annual snowfall varies from 40-80 inches across the Waterville Plateau and accumulations may be up to 20 inches (Foster Creek Conservation District 2004; Western Regional Climate Center 2009). Average maximum temperatures in January range from 28^{o} to 32^{o} F while minimum January temperatures range from 15^{o} to 20^{o} F. Average maximum temperatures in July range from 85^{o} to 90^{o} F while minimum July temperatures are in the lower 50's^{o} F. Occasionally temperatures can reach 100^{o} F or higher in the summer (up to 113^{o} F has been recorded on the Waterville Plateau). Thunderstorms occur on 10-15 days each summer. On the Waterville Plateau, the last freeze typically occurs in late May while the first freeze occurs in late September (Western Regional Climate Center, 2009)

Climate records for Waterville, WA (http://www.fostercreek.net/precipitation.htm), which is located approximately 30 southwest of the Pilot Assessment Area, indicates that in the past decade only two years (2005 and 2006) exceeded the long-term average of 11.22 inches/year (Table 1). Only one year (2001) was near the average indicating that the project area has received below average amounts of precipitation in the past decade. Local ranchers and the Natural Resource Conservation Service (Mark Bareither, personal communication) noted that many of the 'ponds' in the project area have dried up causing an increase in demand to install groundwater wells and/or irrigation piping to transport water from existing wells. The precipitation records seem to corroborate the lack of surface water in wetlands in the project area in the past 10 years.

1.2.2 Geology and Soils

The geology of the project area is primarily the result of three major geological events: (1) accumulation of massive amounts of Columbia River basalt flows; (2) modification by Pleistocene glaciation; and (3) massive glacial lake flooding (e.g. Spokane Floods). The Waterville Plateau is a broad concaved shaped basin which occurs at about 1,650 to 3,000 feet (Kovanen and Slaymaker 2004). Underlying bedrock of the Plateau is mostly of Miocene, horizontally bedded Columbia River Basalt which was extruded from cracks and fissures between 6 to 17 million years ago from southeast Washington. The basalt flowed north and east, forcing the Columbia River into its current route. These basalt flows are locally jointed and

Table 1. Precipitation Totals for Waterville Station (1998-2009). Data obtained from Foster Creek Conservation District web site: http://www.fostercreek.net/precipitation.htm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1999	1.89	1.68	0.72	T	0.86	0.03	0.03	T	T	0.4	1.35	0.77	**7.73**
2000	2.02	0.84	0.77	T	0.22	0.45	0.35	T	0.06	0.33	0.9	1.41	**7.35**
2001	0.41	0.83	0.87	0.81	0.16	1.28	0.97	0.2	0.15	0.16	2.72	1.48	**10.04**
2002	0.42	0.8	0.32	0.2	0.42	0.24	0.27	0.89	0.04	0.07	0.8	3.72	**8.19**
2003	2.72	0.47	0.24	1.02	0.19	0.35	0	0.03	0.1	0.69	0.27	1.81	**7.89**
2004	2.09	1.37	0.47	0.07	0.99	0.24	0.22	0.72	0.14	0.97	0.16	1.66	**9.1**
2005	1.49	0.03	0.83	0.33	3.13	0.83	0.23	0.21	0.12	1.09	2.86	2.83	**13.98**
2006	0.56	2.64	0.39	0.52	1.08	2.12	0	0	0.47	0.51	1.33	3.14	**12.76**
2007	0.2	1.89	0.06	0.05	1.35	0.34	0.37	0.08	0.31	0.95	0.79	2.91	**9.3**
2008	1.07	0.39	0.48	0.18	0.44	0.76	0	0.25	0	0.52	1.32	1.52	**6.93**
2009	0.64	0.86	0.98	0.17	0.61	0.5	0.33	0	0.55	1.19	0.66	N/A	**6.49**

fractured. Uplift associated with the Coulee Monocline raised the basalt into what is now known as the Waterville Plateau (Lillquist et al. 2009). During the late Pleistocene, the Okanogan Lobe of the Cordilleran Ice Sheet entered the northern portion of Douglas County, spreading across the Columbia River and flowing 30 miles south across the Waterville Plateau (Foster Creek Conservation District 2004).). Landforms created by the glacier include drumlins, kames, kettles, and eskers (USDA 1981). The Withrow moraine was the terminus of the Okanogan Lobe and is composed of irregular hills and depressions (Easterbrook and Rahm 1970). As the glacier advanced across the Plateau, glacial debris was lodged against the underlying bedrock, pushed up against hills, and deposited in valleys resulting in a veneer of ground moraine (or glacial drift) across much of the Waterville Plateau (Easterbrook and Rahm 1970). The glacial drift is composed of sand, silt, clay, cobbles, and boulders and is generally thin and discontinuously distributed in the project area (Foster Creek Conservation District 2004). Outcrops of the underlying basalt bedrock are common. Subglacial and proglacial meltwaters created fluvial landforms and deposited glacial outwash near the retreating edge of the glacier (Kovanen and Slaymaker 2004). Most of these areas seem to have been filled by glacial drift or more recent loess. The landscape left by the Okanogan Lobe includes numerous closed depressions and irregular fluvial channels, most of which terminate into closed basins (Lillquist et al. 2009).

A series of catastrophic flood events, known as the Missoula or Spokane Floods, occurred across much of eastern Washington during the late Pleistocene and early Holocene. Impacts from these floods are mostly limited to the southeast portion of the project area (northeast portion of the Waterville Plateau). In this area, the glacial floods eroded much of the overlying deposits left by the Okanogan Lobe and left its own fluvial deposits in some areas creating a landscape that is physically distinct from the other portion of the project area. Closed depressions and irregular fluvial patterns are still found in this area but rather than occurring atop glacial drift are instead located on basalt bedrock (Lillquist et al. 2009). Areas not impacted by the floods retained the overlying glacial drift or loess deposits.

1.2.3 Hydrology

Within the project area, there are numerous small lakes and intermittent ponds. These features occur in 'potholes' (e.g. kettles) left by the Okanogan Lobe. The small lakes are mostly supported by groundwater while the seasonal ponds appear to be a combination of seasonal groundwater discharge and overland flow from snow melt and rainfall via ephemeral streams. These potholes are the location of the more conspicuous wetlands in the project area. Interflow zones within the deep layers of basalt bedrock and coarse glacio-fluvial deposits are important sources of groundwater in the project area (Foster Creek Conservation District 2004).

As with prairie pothole wetlands in the Great Plains, winter precipitation appears to be the most significant factor related to the hydrology of wetlands in the project area (Lillquist et al. 2009). Because the drainage patterns in the project area are not naturally integrated, runoff from snowmelt and rainfall accumulates in the numerous depressions created by past glacial action (LaBaugh et al. 1998). Snowmelt and winter rains make their way to the potholes via infiltration into local groundwater and/or via overland flow which is concentrated by the morphology of each pothole's catchment basin. Significant winter snowpack may play a role in whether and/or how deep soils may freeze. With a persistent and deep snowpack, soils tend to not freeze allowing spring snowmelt to infiltrate into the soils and recharge local groundwater tables. With no or minimal snowpack, soils are more likely to freeze which prevents spring moisture from infiltrating and instead causes it to move overland toward depressional wetlands (Mark Bareither, personal communication). Evapotranspiration is the primary loss of water from wetlands in the project area.

Wetland hydrology is thus closely tied to late winter and spring snowmelt and groundwater discharge. Water levels or soil saturation in wetlands is variable and may last a few days, weeks, months or over many years depending on the size of the contributing catchment, whether groundwater discharge occurs at a site, and soil characteristics. Wetlands that hold water on a semi-permanent or permanent basis are likely tied to groundwater discharge whereas wetlands that dry up in late spring are likely associated with overland flow and/or shallow groundwater inputs. These hydrological differences have a significant impact on the vegetation and wildlife associated with each site.

1.2.4 Vegetation

The uplands in the project area are dominated by shrub steppe vegetation. According to NatureServe's Ecological System classification, the matrix of the upland vegetation would be considered Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland. The expression of this ecological system in the project area is that of a grassland dominated by cool-season perennial grasses such as Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Pseudoroegneria spicata*) along with patches of three-tip sagebrush (*Artemisia tripartita*). Also common in the uplands are Columbia Plateau Scabland Shrublands, which are lithosolic communities dominated by rigid sagebrush (*Artemisia rigida*), various buckwheats (*Eriogonum* spp.), and Sandberg's bluegrass (*Poa sandbergii*). The predominant upland plant associations are three-tip sagebrush/Idaho fescue and rigid sagebrush/Sandberg's bluegrass. Closed depressional wetlands are dominated by various grasses, bulrushes, sedges and rushes with composition varying according to hydrological fluctuations, land use, and salinity. Composition of wetlands will be discussed in more detail in the Results/Discussion section.

1.2.5 Land Use

Dryland agriculture and rangeland are the primary land uses occurring in the project area. Dryland agriculture mostly consists of a winter wheat crop which is grown in a fallow rotation (Foster Creek Conservation District 2004). Many areas in former agriculture production have been entered into the Conservation Reserve Program (CRP). In areas not suitable for dryland agriculture, livestock grazing is the most common land use. North of the Withrow Moraine and within the project area, ranching is the most common land use. Land use on Department of Natural Resource managed State Trust Lands (DNR Trust Lands) within the project area (the focus of this project) is primarily grazing and CRP.

2.0 Methods

2.1 Sample Site Selection

The 75 wetlands targeted for field surveys were randomly selected from the University of Washington's Pilot Assessment Project wetland map based on the following criteria:

- Occur within the 50,000 acre Wetlands Assessment Pilot Project area;
- Occur on Department of Natural Resources lands;
- Proportionally represented the distribution of the three University of Washington map classes (i.e.,i.e.,, Emergent, Dry Bed, and Open Water).

Additionally, representation of a human-induced disturbance gradient was sought so that the methodology used to assess ecological integrity could be calibrated. However, field observations indicated that this would not be possible as most sites were impacted by livestock grazing and adequate representation of the reference standard (i.e., sites with no or minimal human-induced disturbance) was not achievable on DNR Trust Lands.

Before randomly selecting polygons, the proportion of each wetland type was calculated for the project area. These proportions were then used to determine the number of wetlands to randomly select for each wetland type. The sites randomly selected are shown in Figure 3 and have been archived in GIS in the "Randomly Selected Wetlands" shapefile. Of these 75 sites, 33 were classified as Emergent, 25 as Open Water, and 17 as Dry Beds according to the University of Washington map. Field visits to these sites were prioritized by ensuring that each geographic portion of the project area was covered and that field travel times were minimized. Thus, some

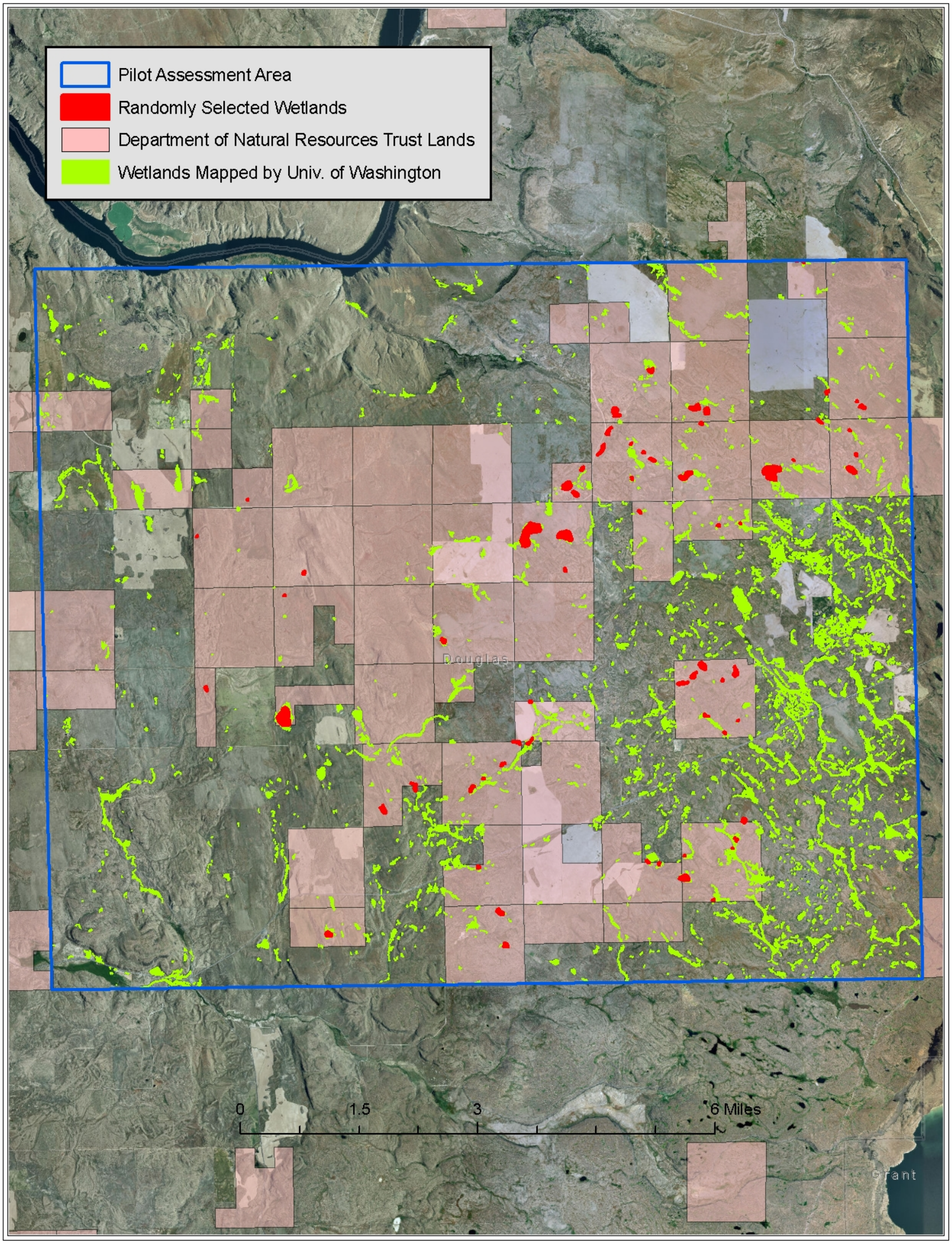


Figure 3. Randomly Selected Wetlands for Field Data Collection.

subjectivity was imposed on this random selection as field work progressed through the summer. In addition, a few sites encountered in the field that were not on the randomly selected list were sampled due to their unique nature (e.g. represented a type not yet encountered or appeared to be in better ecological condition than those already sampled). Fifty-three wetlands were surveyed plus reconnaissance points (see below), (Figure 4). The final list of sites surveyed can be viewed in GIS using the "Surveyed Wetlands" shapefile. Appendix B also lists these sites. The shapefile titled "Wetlands Mapped by UW" is a modification of the original shapefile provided by University of Washington. Additional attributes were added to the file to indicate which polygons were surveyed (labeled 09FJRxx) and which were sampled as reconnaissance points (labeled 09RCxx or Reconnaissance Point).

2.2 Reconnaissance Points

During field visits to randomly selected polygons, unmapped wetlands and mapped polygons that were not randomly selected were often encountered during travel between randomly selected sites. Forty four of these sites were documented with a GPS point (see associated GIS file titled "Reconnaissance Points" and the "Wetlands Mapped by UW" shapefile) and attributed with classification units (according to Washington Natural Heritage Program's Ecological System Classification) and a cursory assessment of the ecological condition of each wetland. A comprehensive inventory of unmapped wetlands was not conducted and these reconnaissance points only represent those unmapped or unselected wetlands that were encountered while hiking between randomly selected polygons. Thus, these represent opportunistically sampled polygons and were collected primarily with the intention of aiding the University of Washington in conducting a mapping accuracy assessment. No additional analysis of these sites is conducted in this report. The "Wetlands Mapped by UW" shapefile crosswalks with UW polygons that were not randomly selected were opportunistically documented as a reconnaissance point. This file differs from the "Reconnaissance Points" shapefile which is a comprehensive list of wetlands surveyed as reconnaissance points (i.e., it includes reconnaissance points mapped and not mapped by UW). Select metrics of biological condition (see EIA discussion below) were assessed for these reconnaissance points those data are included as attributes in the "Reconnaissance Points" shapefile. No analysis was conducted on the reconnaissance points. They are provided to assist in assessing mapping accuracy.

2.3 Field Methods

The following section provides an overview of methods and description of the types of data collected at each of the randomly selected polygons. The field forms used can be found in Appendix A. About ½ of the sites were visited by both Rex Crawford and Joe Rocchio (both

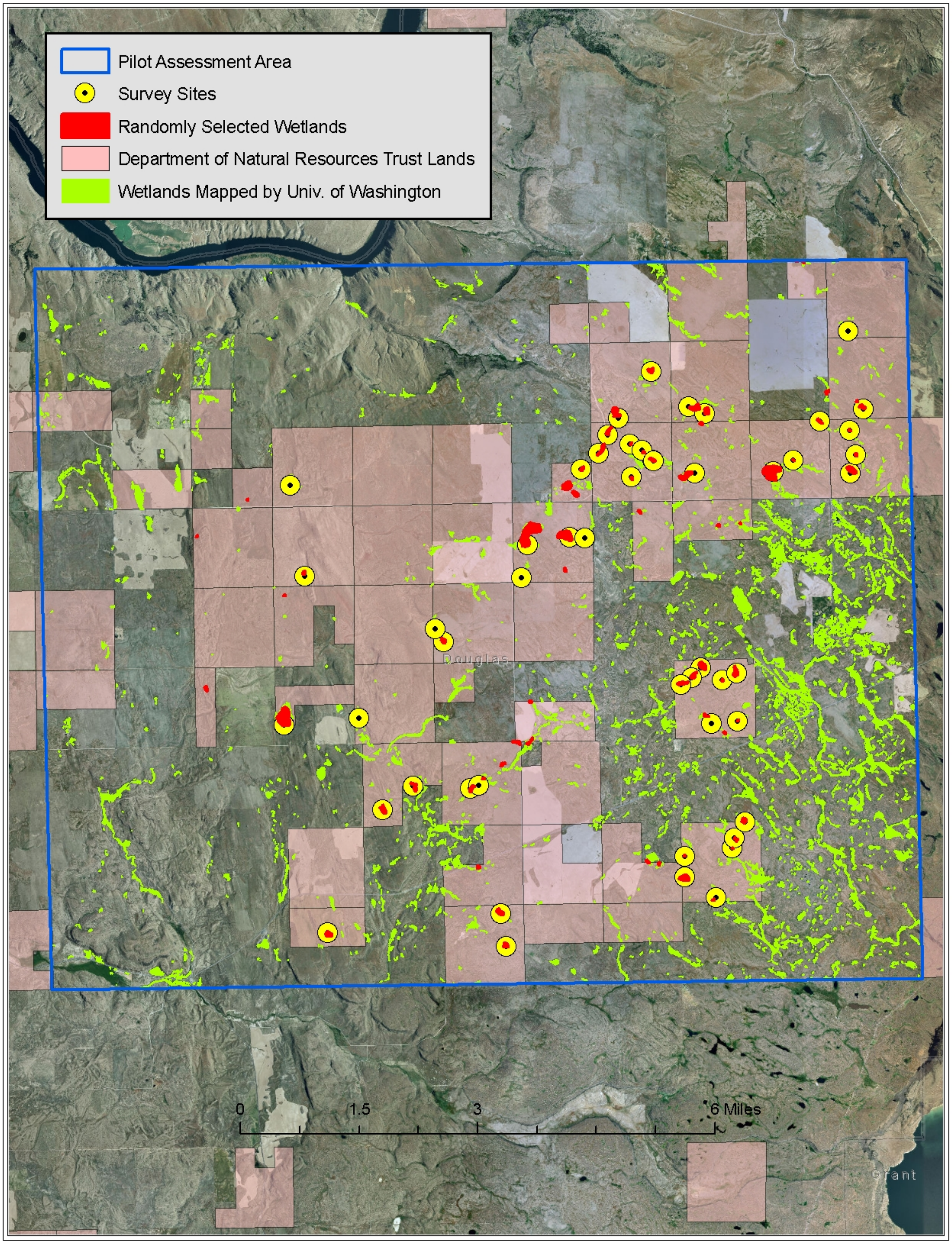


Figure 4. Wetland Surveyed for this Project.

Ecologists with the Washington Natural Heritage Program), while the remaining ½ were individually visited by either Rex or Joe.

2.3.1 Classification

Each polygon was typed according to three classification schemes: (1) Cowardin et al. (1979); (2) Hydrogeomorphic (HGM; Brinson 1993); and (3) Ecological Systems (Comer et al. 2003). Cowardin and HGM are the most common classification schemes used for wetlands. Cowardin is the basis for the National Wetland Inventory Maps and focuses on hydrological regime and physiognomic vegetation groups as the main classifiers. HGM is often used to categorize wetlands into hydrogeomorphic units which function similarly and is based on geomorphic position, water source, and hydrodynamics. The Ecological Systems classification incorporates elements of both Cowardin and HGM, although has a more explicit focus on the vegetation expression of sites with similar ecological characteristics. Plant associations are a fine-scale vegetation unit that reflects fine-scale ecological variability.

For this project, Ecological Systems and plant associations are used as the focus for analysis. HGM and Cowardin types are provided for each surveyed wetland in the accompanying database but are not discussed further since there was little variability of these types among surveyed wetlands (almost all were Palustrine (Cowardin) and Depressional (HGM) types).

Ecological Systems

Ecological systems integrate vegetation with natural dynamics, soils, hydrology, landscape setting, and other ecological processes. Ecological systems types facilitate mapping at meso-scales (1:24,000 – 1:100,000; Comer and Schulz 2007) and a comprehensive ecological systems map exists for Washington State. Ecological systems meet several important needs for conservation, management and restoration, because:

- they provide an integrated approach that is effective at constraining both biotic and abiotic variability within one classification unit.
- comprehensive maps of all ecological system types exist for the State of Washington.

The *Draft Field Guide to Washington's Ecological Systems* was used to identify the ecological system at each site (Rocchio and Crawford 2008).

Plant Associations

The International Vegetation Classification (IVC) covers all vegetation from around the world. In the United States, its national application is the U.S. National Vegetation Classification (NVC), supported by the Federal Geographic Data Committee (FGDC 2008), NatureServe (Faber-Langendoen et al. 2009c), and the Ecological Society of America (Jennings et al. 2009), with other partners. The IVC and NVC were developed to classify both wetlands and uplands, and identify types based on vegetation composition and structure and associated ecological factors. The NVC is hierarchical and consists of eight levels which are organized into three levels. At the highest level, physiognomic-ecological criteria are used; in the middle level physiognomic-floristic criteria are emphasized, and at the lower level floristic-ecological criteria are the primary classifiers (Faber-Langendoen et al. 2009c). The NVC levels allows for a link to NatureServe's Ecological Systems classification (described above). The NVC meets several important needs for conservation and resource management. It provides:

- a multi-level, ecologically based framework that allow users to address conservation and management concerns at scales relevant to their work.
- characterization of ecosystem patterns across the entire landscape or watershed, both upland and wetland.
- information on the relative rarity of types. Each association has been assessed for conservation status (extinction risk).
- relationships to other classification systems are explicitly linked to the NVC types (e.g. the Ecological System classification, Cowardin, and HGM (
- a federal standard for all federal agencies, facilitating sharing of information on ecosystem types (FGDC 2008).

The finest-scale unit of the NVC is the plant association, which represents diagnostic species which reflect topo-edaphic, climate, substrates, hydrology, and/or natural disturbance regimes. For this project, we attempted to classify the various plant associations contained within each surveyed wetland. Given the depressional nature of the project area wetlands, plant associations typically expressed themselves as distinct, concentric zones. Vegetation plot data was collected within each of these zones at each of the wetlands surveyed (data are in the accompanying Microsoft Access database). After collecting data, a preliminary plant association name was assigned in the field. However, limited time and funding precluded conducting a vegetation classification analysis for this project. Thus, the plant associations names assigned in this report are place-holders and should be used accordingly.

2.3.2 Ecological and Biological Characteristics

At each surveyed wetland, the following ecological attributes were documented or collected:

- Classification (see above)

- Location
- General description of wetland
- GPS location (HP iPaq 5915 units were used)
- Landform
- Plant species list by vegetation zone
    - 100m^2 releve plots were established in each zone; species nomenclature follows USDA PLANTS Database: http://plants.usda.gov/)
- Soil profile description
    - depth, color, texture, and structure of each horizon;
    - depth to water table, soil saturation, and impervious layer).
- Salinity
    - Assigned three qualitative categories: Fresh, Slightly Saline/Alkaline, or Saline based on soil and vegetation indicators.
- Shoreline complexity (assigned one of three qualitative categories)
- Hydrological indicators (noted signs of wetland hydrology)
- Hydrological regime (based on Cowardin (1979) categories)
- Drainage Class (based on NRCS categories: soils.usda.gov/technical/handbook/contents/part618.html)
- Groundwater dependence
    - used qualitative observations to assign High, Low, or Unknown categories of likelihood of groundwater dependence (Brown et al. 2007; see Appendix A for key)
- Evidence of use by vertebrate species, including amphibians, birds and mammals
    - no systematic surveys were conducted
    - opportunistic observations of species
    - observation of utilization indicators
- Ecological condition (using Ecological Integrity Assessment; see below)
- List of stressors, following NatureServe methodology (Master et al. 2009)
- Photographs (included as an Appendix)
- Aquatic invertebrates (see below)

2.3.3 Collection of Aquatic Invertebrates

Aquatic invertebrates were sampled at sites which had standing water at the time of the field visit. Sampling methods followed Merritt and Cummins (1995) suggestions for lentic habitats. The protocols was as follows: (1) at random locations around the perimeter of the shoreline, a dip net was used to make 10 sweeps through the surface sediments; (2) the sweeping 'events' were mostly within a few feet of the shoreline, however if water depth was minimal and the soils were solid enough, collection would also occur further toward the center of the wetland; (3) invertebrates captured with the dip net were sieved in the field and placed into a 95% ethanol solution in small containers; (3) each container was labeled with the Site ID value; (4) identification of collected invertebrates was not conducted as part of this project. However, all collections were provided to The Nature Conservancy so that a qualified aquatic ecologist can identify the specimens.

2.3.4 Ecological Integrity Assessments

Indicator-based (ecological endpoints) approaches to assessing and reporting on ecological integrity (Harwell et al. 1999, Young and Sanzone 2002, EPA 2002) are now being used by numerous organizations to assist with regulatory decisions (Mack 2004, USACE 2003, 2005, 2006), to set mitigation performance standards (Mack 2004, Faber-Langendoen et al. 2006, 2008a), and to set conservation priorities (Faber-Langendoen et al. 2008b).

NatureServe and the Natural Heritage Network have recently developed an approach for assessing ecological condition that is scaled both in terms of the scale of ecosystem type that is being assessed and the level of information required to conduct the assessment. This method is called the Ecological Integrity Assessment (Faber-Langendoen et al. 2006, 2008, 2009aa, 2009) and is now being implemented for a variety of small- and large-scale projects (Rocchio and Crawford 2009, Lemly and Rocchio *In Preparation*, Faber-Langendoen et al. 2009b, Tierney et al. 2009, Vance et al. *In Progress*).

The Ecological Integrity Assessment method (EIA) aims to measure the current ecological integrity of a site through a standardized and repeatable assessment of current ecological conditions associated with the structure, composition, and ecological processes of a particular ecological system. These conditions are then compared or ranked according to conditions expected in those sites operating within the bounds of their natural range of variation for that particular ecological system. The purpose of assigning an index of ecological integrity is to provide a succinct assessment of the current status of the composition, structure and function of occurrences of a particular ecosystem type and to give a general sense of conservation value, management effects, restoration success, etc. As such, the objectives of an EIA include: (1) assess ecological integrity on a fixed, objective scale; (2) compare ecological integrity of various occurrences of the same ecological systems; (3) determine the best examples and support selection of sites for conservation priority; (4) inform decisions on monitoring individual ecological attributes of a particular occurrence; and (5) provide an aggregated index of integrity to interpret monitoring data, including tracking the status of ecological integrity over time. The

EIA aims to standardize expert opinion and existing data up front so that a single, qualified ecologist could apply the EIA in a rapid manner to get an estimate of a site's ecological integrity. The EIA can improve an understanding of current ecological conditions which can lead to more effective and efficient use of available resources for ecosystem protection, management, and restoration efforts.

For this project, modified versions of EIAs developed by Faber-Langendoen et al. (2006) and (2008a) were used to rapidly assess the ecological integrity of each wetland. The metrics used in the EIA assessment are found in the field forms presented in Appendix A. Letter rankings were given numeric scores (A=5.0, B=4.0, C=3.0, D=1.0) which were then used to aggregate metric and Key Ecological Attribute (KEA) scores into higher level ranks through simple, weight-based algorithms. For example, metrics associated with each KEA were summed and divided by the total number of metrics (i.e., metrics were given equal weight). KEA scores were then given unique weights (Landscape Context = 0.25, Biotic Condition = 0.35, Abiotic Condition = 0.25, and Size = 0.15) according to their perceived importance. These weights were multiplied by the KEA score and added to arrive at an overall Ecological Integrity Assessment Score. This score was then converted back into a letter ranking.

2.4 Biodiversity Assessment

The Washington Natural Heritage program utilizes the Conservation Status Rank, which is an integral part of Natural Heritage Methodology, to determine conservation priorities. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global and S = State). The Global rank characterizes the relative rarity or endangerment of the element world-wide whereas the State rank characterizes the relative rarity or endangerment within the State of Washington. The number of occurrences and ecological integrity of known occurrences are considered when assigning the rank (other factors may be considered). Thus, an ecological element that is relatively common but most of the remaining occurrences are in fair to poor ecological condition might have the same Global or State rank as another ecological element that is rare but extant occurrences remain in good ecological condition. The ranks have the following meaning:

- **G1 or S1** = Critically imperiled throughout its range or in the state because of extreme rarity or other factors making it especially vulnerable to extirpation from the state. (Typically 5 or fewer occurrences or very few remaining individuals or acres)
- **G2** or **S2** = Imperiled throughout its range or in the state because of rarity or other factors making it very vulnerable to extirpation from the state. (Typically 6 to 20 occurrences or few remaining individuals or acres)

- **G3 or S3** = Rare or uncommon throughout its range or in the state. (Typically 21 to 100 occurrences)
- **G4 or S4** = Widespread, abundant, and apparently secure throughout its range or in state, with many occurrences, but the taxon is of long-term concern. (Usually more than 100 occurrences)
- **G5 or S5** = Demonstrably widespread, abundant, and secure throughout its range or in the state; believed to be ineradicable under present conditions.
- **GH** or **SH** = Historical occurrences only are known, perhaps not verified in the past 20 years, but the taxon is suspected to still exist throughout its range or in the state.
- **GNR** or **G?** or **SNR** or **S?** = Not yet ranked. Sufficient time and effort have not yet been devoted to ranking of this taxon.
- **GX or SX** = Believed to be extirpated throughout its range or from the state with little likelihood that it will be rediscovered.

Conservation Status Ranks will be used as the primary measure of biodiversity significance of the wetlands in the project area.

3.0 RESULTS AND DISCUSSION

3.1 ECOLOGICAL CHARACTERISTICS OF NORTHERN DOUGLAS COUNTY WETLANDS

A summary of the ecological characteristics of the wetlands surveyed in this report are presented in Appendix B. All of the data collected for this project are found in the accompanying Microsoft Access Database that was delivered to The Nature Conservancy with this report. Some of the key ecological characteristics are discussed below.

3.1.1 CLASSIFICATION AND RELATION TO MAPPING UNITS

Ecological System Classification

The University of Washington's wetland map documented 2,779 polygons in the project area. Although the 53 sites we visited represents only 2% of this total, field observations suggest that the data collected for this project adequately represent the types of wetlands found in the project area. As shown in Figure 5, most of the sites we visited were classified as either Inter-Mountain Basin Alkaline Closed Depression (44%) or Columbia Plateau Wet Meadow (Provisional type; 30%). Based on observations from working in the project area, these proportions seem to reasonably represent the distribution of wetland types throughout the project area.

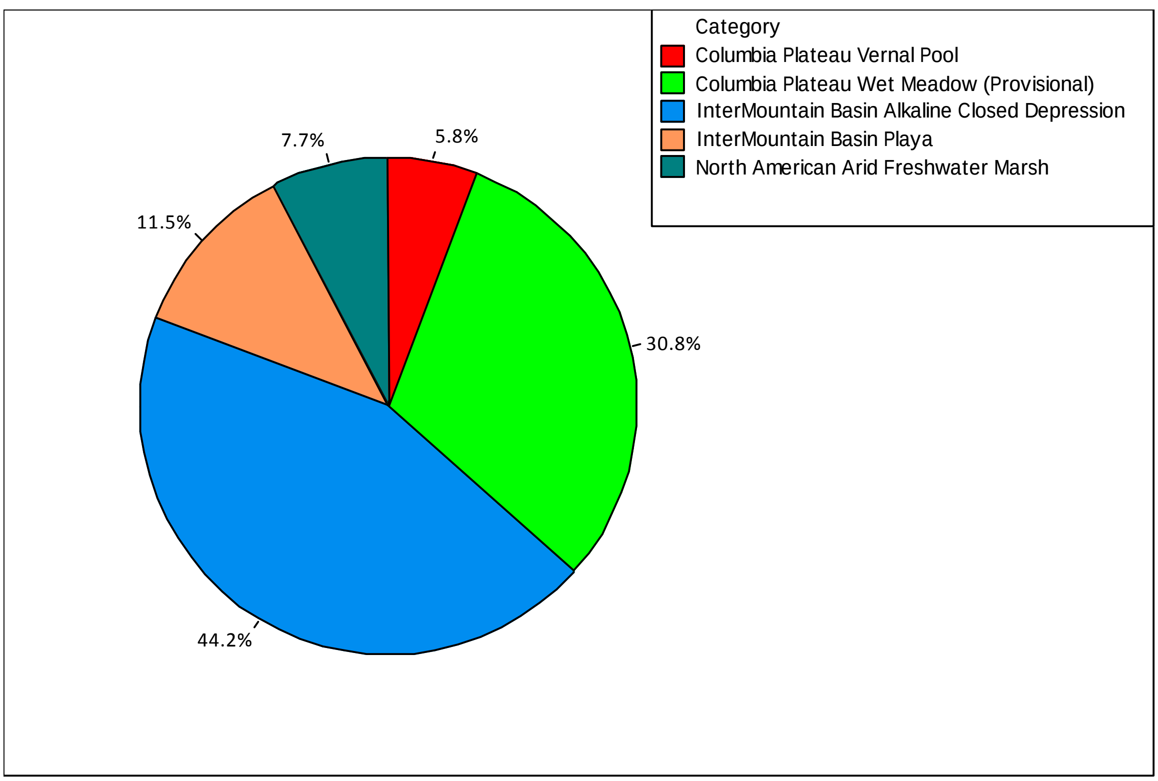


Figure 5. Classification of Surveyed Wetlands

Comparison to Mapping Units

Table 2 shows the correlation between the University of Washington (UW) map units that were mapped and the Ecological System classification assigned during field work. Often more than one UW polygon associated was with a surveyed wetland, which is why the totals in Table 2 exceed 53 (total polygons evaluated). The scale at which the UW polygons and Ecological Systems are mapped is not the same (i.e., the UW units are finer-scale than Ecological Systems). For example, the closed depressional wetlands found in the project area have distinct, concentric vegetation zones commonly surrounding the lowest point in the wetland. The UW polygons mostly distinguished zones or at least a portion of zones associated with a wetland. In contrast, Ecological Systems would lump all the vegetation zones into one classification type. For example, an Inter-Mountain Basin Alkaline Closed Depression may contain an open water zone at the lowest point, then an 'emergent' zone dominated by saltgrass (*Distichlis spicata*), followed by a zone dominated by Baltic rush (*Juncus balticus*) and finally the most driest zone might dominated by Great Basin wild rye (*Leymus cinereus*). The UW polygons were more likely to be associated with one of these zones. Because the various vegetation zones or plant associations occur in multiple Ecological System types, the UW map would be difficult to use to map Ecological Systems. However, if the algorithm could be designed to consider the type of adjacent polygons (e.g. dry bed next to emergent = Inter-Mountain Basin Alkaline Closed Depression or Playa) then typing Ecological Systems may be possible. The UW polygons, however, do show promise for mapping at the plant association scale.

Table 2. Comparison of University of Washington Map Units and Ecological System Classification

	Inter-Mountain Basin Alkaline Closed Depression	**Columbia Plateau Wet Meadow (Provisional)**	**Inter-Mountain Basin Playa**	**North American Arid Freshwater Marsh**	**Columbia Plateau Vernal Pool**	**Total**
Emergent	32	16	8	12	1	69
Open Water	18	1	3	2		24
Dry Bed	10	2	2		1	15
Total	60	19	13	14	2	108

Most vegetated zones of the wetlands encountered in the project area would not be considered "emergent" vegetation by wetland scientists The North American Arid Freshwater Marsh Ecological Systems is the only type that supports defined emergent vegetation. The intent of the map label "emergent" for this project was to indicate vegetated/non-upland polygons associated with wetlands or "wetland vegetation.

Field observations also suggest that the UW map rarely missed closed depressional wetlands which had salt flats, open water, or large areas of bare soil. However, some emergent zones within these wetlands were missed by the UW map. These areas seem to all share a similar color signature and were most often associated with the saltgrass (*Distichlis spicata*) communities. Often times, these missed areas occurred adjacent to a correctly mapped polygon. Often mapped polygons with open water were dry during the time of the field visit, which complicates the mapping classification scheme since open water vs. dry bed could simply be a matter of seasonality as opposed to any difference in wetland type.

3.1.2 Landform

The majority of wetlands surveyed were located in a closed depression (i.e., kettle or pothole) (Figure 6). The next most common landform were swales, which somewhat resemble intermittent streams but without a defined channel and no exposure of bedrock, cobbles, or stones. The swales were confined sloping areas with deep loamy soils. Many sites were also found in small depressions located in the upland matrix, well above the kettles or potholes. These sites were classified as being in a swale landform given the similarity in soils and hydrological regime. A few sites were found in a riverine channel environment. These areas were mostly intermittent streams with exposed bedrock and had a more clearly defined

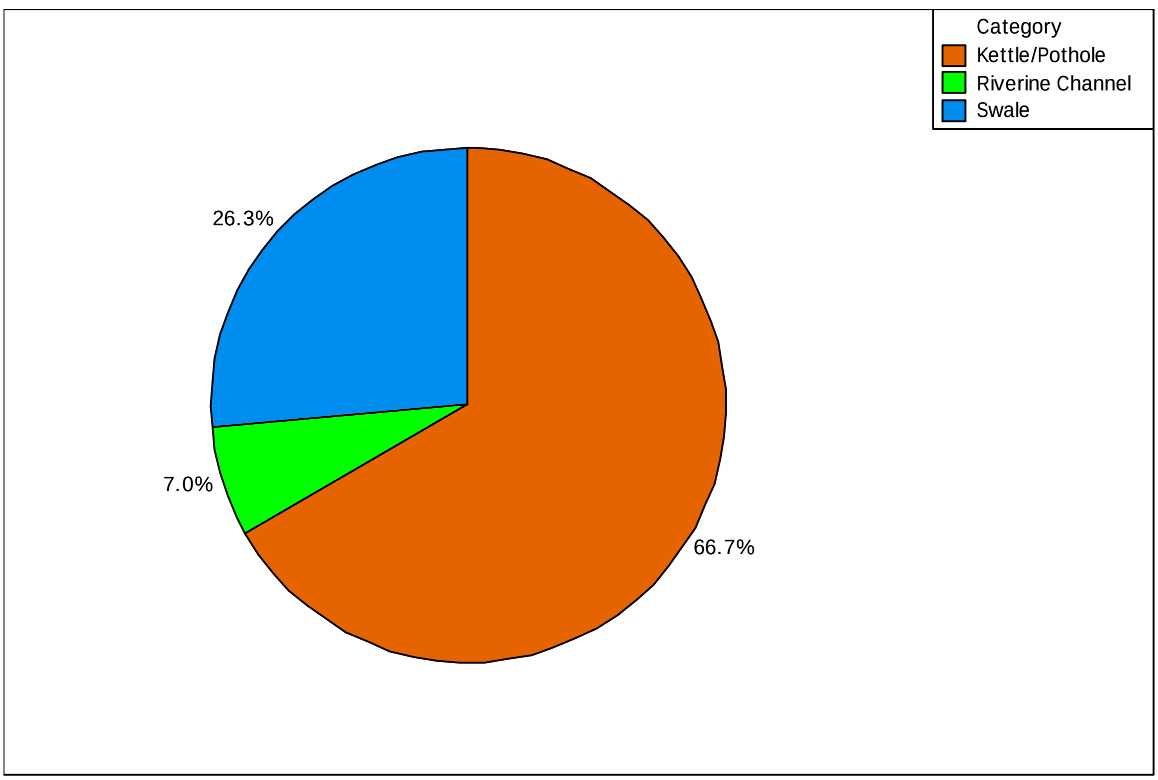


Figure 6. Distribution of Surveyed Wetlands by Major Landform

channel than the swales. The riverine channel wetlands were located in the portion of the project area subjected to erosion from the Spokane floods or in glacial outwash. Wetlands in the project area occur on four major geological substrates: (1) undifferentiated glacial drift (i.e., ground moraine); (2) glacial till; (3) glacial outwash; and (3) Columbia River basalts (Figure 7). Subglacial and proglacial meltwater-induced erosion from these moraines have created landforms where many contemporary wetlands are found (i.e., the linear wetland features found on glacial drift in Figure 7). Wetlands in the southeastern portion of the project area occur within scablands scoured by the Spokane Floods. No obvious patterns of occurrence were found between Ecological System types and geological substrate (Figure 7). However, a more thorough assessment of this relationship is warranted as Lillquist et al. (2009), in a study of wetland change on the Waterville Plateau, found that wetlands on glacial drift exhibited different hydrological fluctuations than those on basalt.

3.1.2 Hydrology and Salinity

Surface Hydrology

Rapid, qualitative indicators of hydrology and salinity levels were noted for each of the surveyed wetlands. Given the qualitative nature of this dataset, care should be given to their use until quantitative measures can confirm their accuracy. Over 80% of wetlands surveyed had an intermittently flooded hydrological regime. In other words, surface water in these wetlands can be present for variable periods without detectable seasonal periodicity and inundation is not predictable to a given season (Figure 8). Preliminary research at the University of Washington suggests that the probability of any given pond holding water in a given year is difficult to predict (Meghan Halabisky, personal communication 2009). For those ponds that are inundated any given year, Lillquist et al. (2009) found that water levels reached their maximum depth in March and April while lowest levels occurred between June and August. Data collected by the Washington Department of Fish and Wildlife (Mikal Moore, personal communication, 2009) since the late 1970’s suggest that the number of ponds that hold water in any given year has fluctuated on a decadal interval since the late 1970’s (Figure 9). The number of ponds with open water seems to follow annual precipitation levels, although the trend isn’t apparent between 1988 and 1998 (Figure 9). There also seems to be a slight delay in response of pond water levels relative to annual precipitation (Figure 9). The amount of frozen ground in the uplands surrounding any given wetland may be a good predictor of whether and how much surface water may be present in that wetland (Mark Bareither, Natural Resources Conservation Service, Waterville, personal communication). The length and depth of snowpack determines whether the soil is frozen at the time of spring snowmelt. Frozen soil restricts the amount of water that can infiltrate into local soils and instead moves overland toward depressional wetlands. If soils are not frozen, then spring snowmelt infiltrates into the local soil profile, most

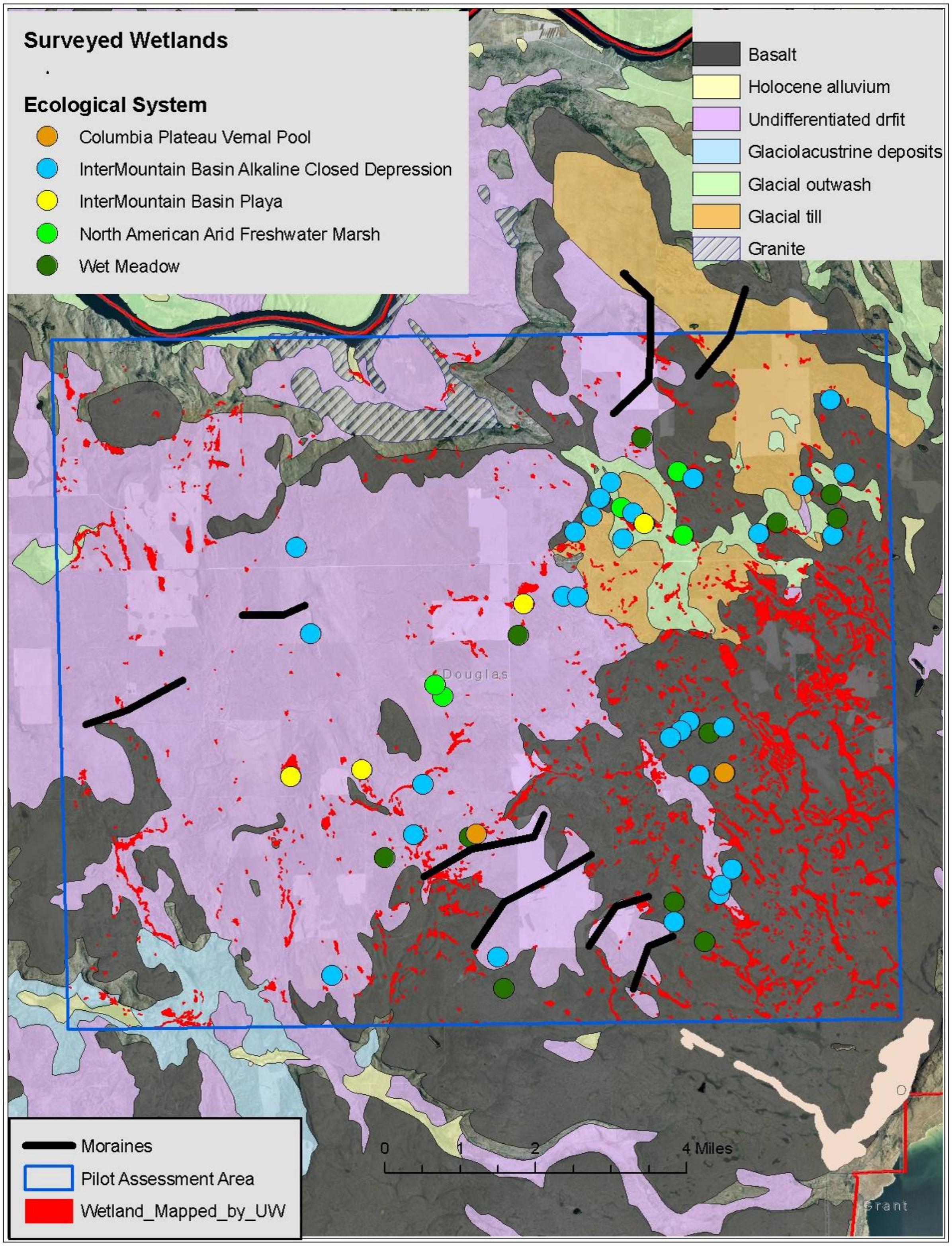


Figure 7. Distribution of Wetlands on Geological Substrates. Approximate location of moraines from Kovanen and Slaymaker (2004)

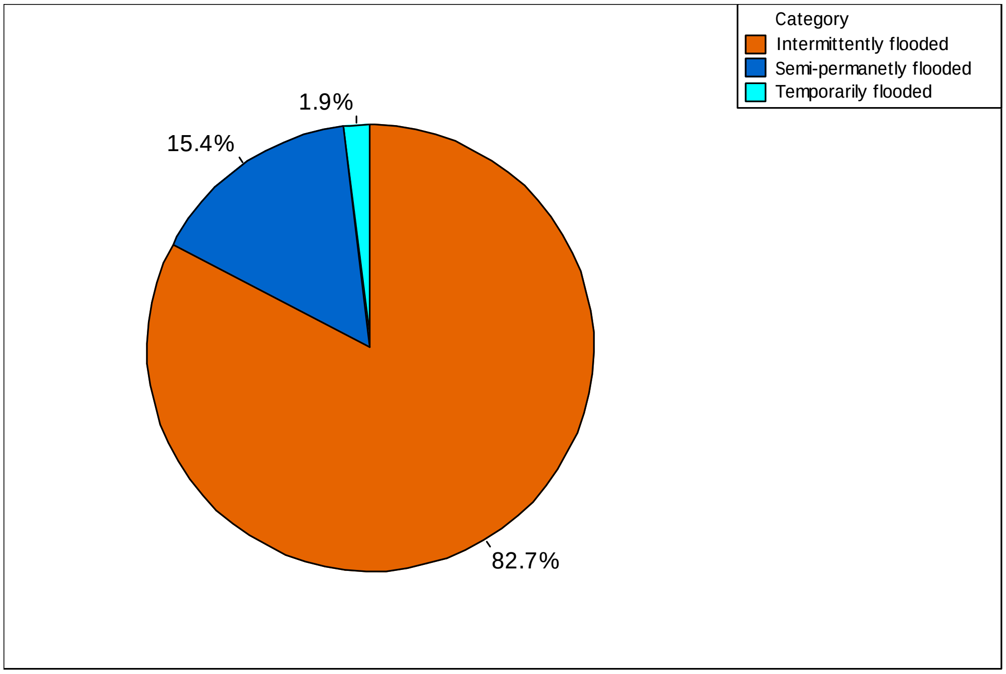


Figure 8 Hydrological Regime of Surveyed Wetlands

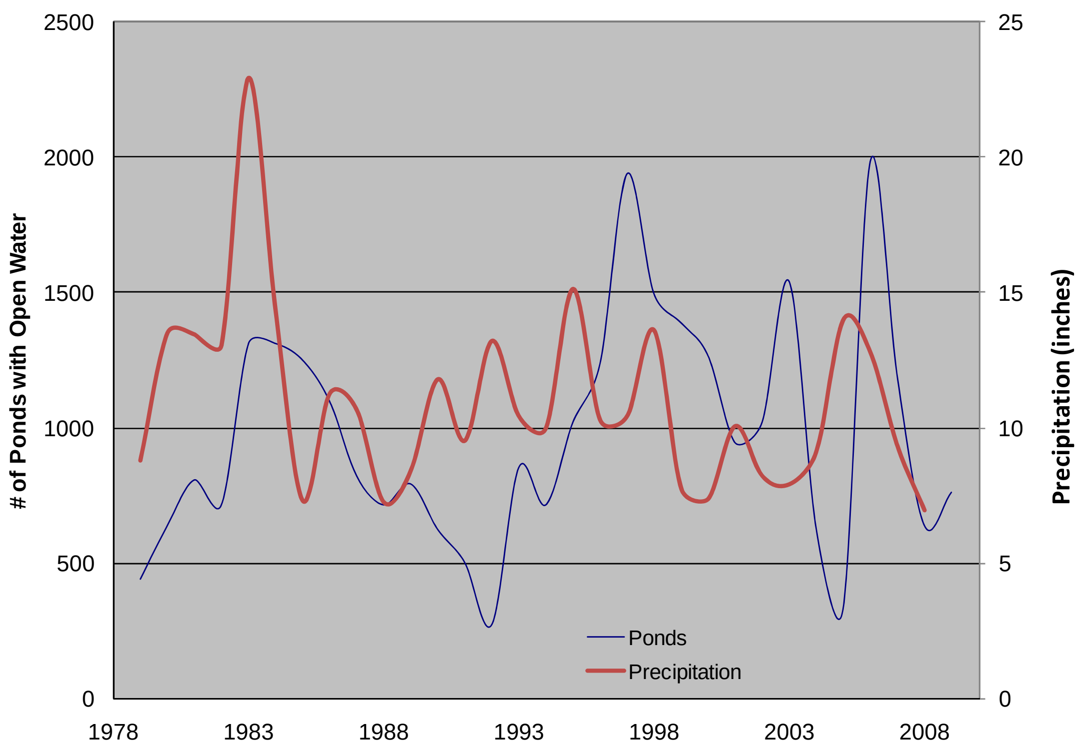


Figure 9. Annual Precipitation Compared to Pond Inundation. Pond data from Washington Department of Fish and Wildlife's Douglas County Potholes Breeding Waterfowl Survey Route. Precipitation data from Waterville Station.

of which is utilized by upland vegetation (van der Kamp and Hayashi 1998). Thus, with more frozen soil across the landscape, it is likely that more ponds will have water while the reverse may also be true (Mark Bareither, personal communication). Such interactions have also been found in the prairie pothole region of the northern Great Plains (as summarized in Lillquist et al. 2009). Additional analysis of air and soil temperatures, snowfall and snowpack, and rainfall data needs to be conducted to confirm whether these dynamics occur in the project area.

A small number of wetlands had semi-permanently flooded hydrological regimes, meaning that in these sites surface water persists throughout the growing season in most years and the soil is normally saturated when water level drops below soil surface (Figure 8). These sites are mostly those that support marsh vegetation and in the project are assumed to be associated with groundwater given the permanence of water levels. An even smaller percentage of wetlands had a temporary flooded regime (Figure 8). Surface water in these sites is present for brief periods during growing season, but water table usually lies well below soil surface.

Salinity and Groundwater Hydrology

In arid and semi-arid regions, where evaporation exceeds precipitation, soluble salts are not leached from the soil profile and thus cause these soils to become saline. In the arid west, salinity is only second to water as being the most critical factor affecting plant growth and vegetation distribution in wetlands (Laubhan 2004). Saline, alkali, saline-alkali, and saline-sodic were terms often used to describe soils affected by soluble salts, high pH, and exchangeable soils (Soil Science Society of America 2005). Saline soils are those containing sufficient amounts of soluble salts (e.g., conductivity is > 4.0 mS/cm) able to adversely affect plant growth (Soil Science Society of America 2005; Sposito 1989). Saline soils often have white crusts on the surface and their chemical characteristics are based on the amount and type of salts present (USDA 1954). Saline soils have an exchangeable sodium percentage less than 15 and a pH less than 8.5 (USDA 1954). Alkali soils have a pH of 8.5 or higher and an exchangeable sodium percentage greater than 15. We did not collect any chemical data to discern if soils of wetlands in the project area were saline versus alkaline. However, the term saline is used in this report to encompass both possibilities.

As indicated by the presence of halophytes growing at the site and salt crusts on the soil surface, plants, or other debris ,wetlands in the project area were predominantly more saline than fresh (Figure 10). The majority of wetlands surveyed had either saline (23%) or intermediately saline (48%) soil conditions. Based on literature from the Great Plains prairie pothole region (Hayashi et al. 1998), the Washington Department of Ecology assumes that

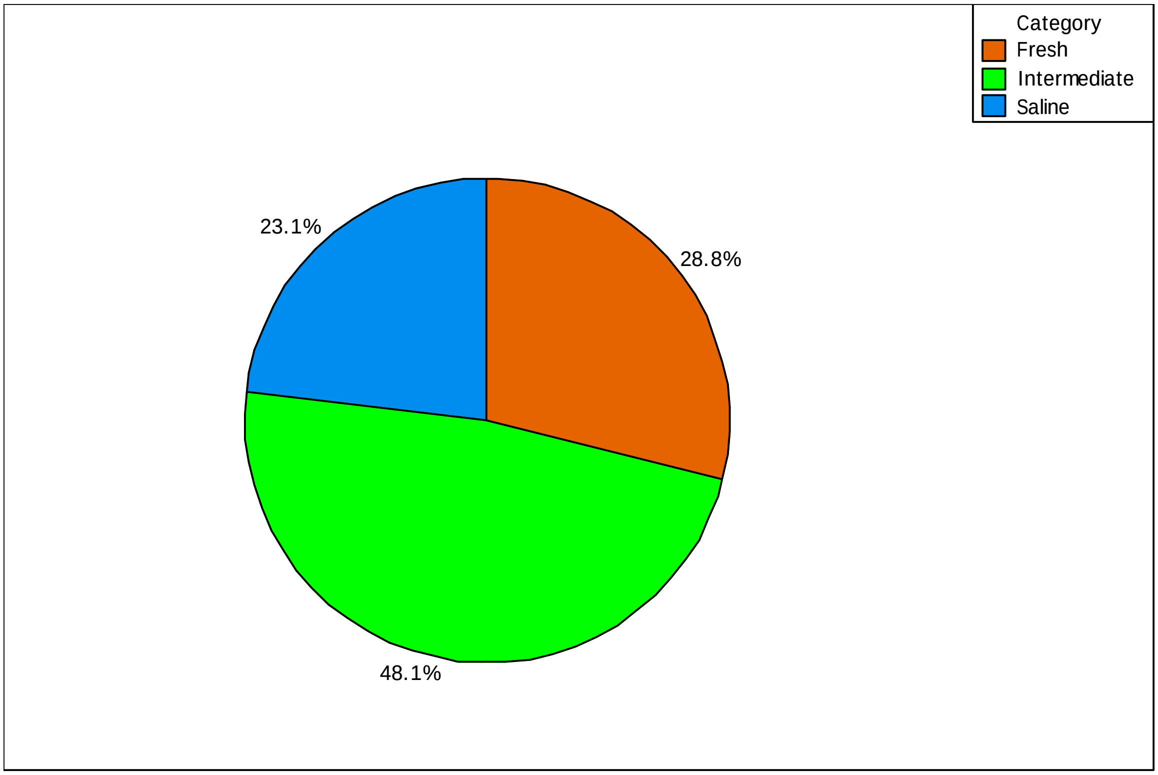


Figure 10. Salinity of Ponds

saline wetlands in eastern Washington are groundwater supported (Hruby et al. 2000). This is true of many playa wetlands across the Inter-Mountain West (as summarized in Rocchio 2006). However, some wetlands found in closed depressions may be saline due to the accumulation of solutes from overland flow, such as those found in the southern High Plains and southwestern U.S. These sites are often terminal closed depressions associated with a local network of intermittent channels. Overland flow moves through the channels as sheetflow across upland surfaces and accumulates in these basins. Because of the fine-texture soils in these basins, water infiltration is limited and instead perches on the soil surface. The semi-arid climate results in high evaporation loss causing these sites to dry by mid- to late-summer (Lichvar et al. 2002). The process of evaporation leaves behind an accumulation of solutes carried into the site by overland flow which, with time, produces the alkaline/saline environment typically found in these wetlands.

Based on observations from this project, most wetlands in the project area appear to be less likely associated with groundwater than overland flow (Figure 11). However, these observations are not substantiated with groundwater well or piezometer data. Field indicators such as impervious layers, presence/absence of seeps and springs, surface flow patterns, etc. were used to assign each wetland a likelihood rating that it is associated with groundwater discharge.

The level of salinity associated with each of the groundwater dependence indicators also suggests that both fresh and saline wetlands may or may not be associated with groundwater discharge (Figure 12). Cook and Hauer (2007) found that groundwater played a minor role in the hydrology of Intermontane Prairie Pothole wetlands in western Montana, which are very similar in geological origin as those in the project area. Their research showed that these wetlands were primarily driven by surface and near-surface hydrological flow. They also concluded that soil salinity was a result of capillary flow moving solutes from ponded water (from overland flow) up toward the rooting zone located at the wetland margin (i.e., next highest zone). We observed this phenomenon at a few of the surveyed wetlands where salt crusts were conspicuously present at the wetland margin (lower end of the lowest vegetation zone) but were seemingly absence from the lower, unvegetated portion of the wetland. Thus, the salinity of wetlands in Douglas County may not always be due to groundwater discharge.

Salt crusts were occasionally encountered on unvegetated soil surfaces as well. Their presence in these locations can be very helpful in determining whether groundwater discharge is occurring at site. For example, in places where the groundwater table is close enough to the soil surface to be affected by the capillary fringe, salts can accumulate in the upper soils horizons and on the soil surface. Under such conditions, the salt crusts tend to have a fluffy, snow-like appearance (Boettinger 1997). Such crusts can be a useful indicator of the presence of groundwater, of course after considering the scenario described by Cook and Hauer (2007). When the soil surface is inundated or ponded and then subsequently dries, the soils tend to form a brittle, flat salt crust (Boettinger 1997). Since ponding in these situations may occur due to elevated groundwater levels or overland flows, these types of crust are less useful for discerning water source. Regardless, because almost every wetland surveyed had been recently or heavily grazed, intact salt crusts were rarely encountered and thus were not useful indicators of water source.

3.1.3 Dominant Vegetation Types

Plant Associations

Although a classification analysis was not conducted, a cursory cross-walk between plant associations assigned in the field and those previously classified in the Columbia Basin (Crawford 2003) or listed on NatureServe Explorer (NatureServe 2009) is presented in Table 3. It is important to note that this cross-walk is based on expert opinion and not a quantitative analysis of the data. The latter should be a focus of future work.

Thirty three different plant associations were identified in the field. *Distichlis spicata*, *Hordeum jubatum*, *Juncus balticus*, and variations of *Leymus cinereus* types were the most common plant associations encountered during the project (Table 3). However, future quantitative analysis may show that the the number of plant associations may be greater or fewer.

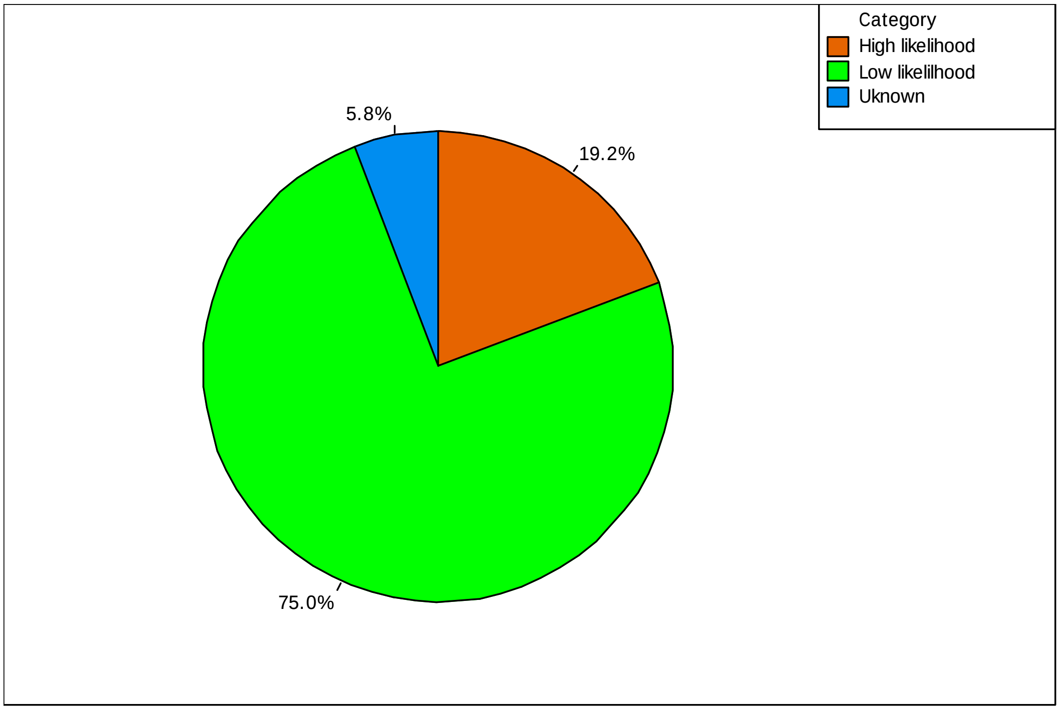


Figure 11. Groundwater Likelihood

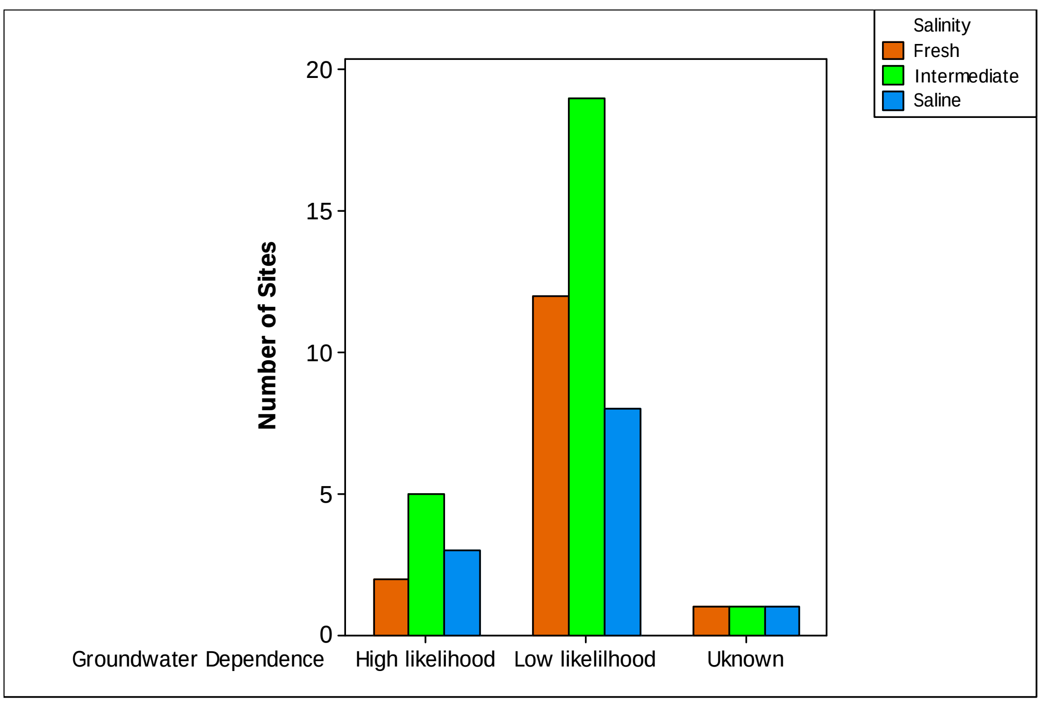


Figure 12. Salinity Levels by Groundwater Dependence

Table 3. Plant Associations Found in Each Ecological System

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
Columbia Plateau Vernal Pool	1	*Allium geyeri*	1	None		GU	SU
		Polygonum polygaloides	1	None		GU	SU
	2	*Allium geyeri*	1	None		GU	SU
		Deschampsia danthonioides	1	Deschampsia danthonioides Seasonally Flooded Herbaceous Vegetation	Crawford (2003); WNHP Biotics Database	G2	S1
		Distichlis spicata	1	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
	3	*Grindelia squarrosa*	1	Deschampsia danthonioides Seasonally Flooded Herbaceous Vegetation	Crawford (2003); WNHP Biotics Database	G2	S1
		Hordeum jubatum	1	Hordeum jubatum Herbaceous Vegetation	NatureServe (2009)	G4	SU
		Juncus balticus-Poa pratensis	1	None		GU	SU
	4	*Poa pratensis*	1	None in wetland environments in the Columbia Basin		Nonnative	Nonnative
Columbia Plateau Wet Meadow (Provisional)	1	*Argentina anserina - Juncus balticus*	2	Juncus balticus - Argentina anserina	Crawford (2003)	GU	SU
		Carex praegracilis	1	Carex praegracilis Herbaceous Vegetation	NatureServe (2009)	G3G4	SU
		Carex praegracilis - Juncus balticus	1	Maybe part of Carex praegracilis or Juncus balticus Herbaceous Vegetation	NatureServe (2009)	GU	SU
		Hordeum jubatum	2	Hordeum jubatum Herbaceous Vegetation	NatureServe (2009)	G4	SU

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
		Juncus balticus	2	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU
		Juncus balticus-Poa pratensis	2	None		GU	SU
		Leymus cinereus - Carex praegracilis	1	Leymus cinereus Bottomland Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G1	S1
		Leymus cinereus - Juncus balticus	3	Leymus cinereus Bottomland Herbaceous Vegetation	NatureServe (2009)	G1	S1
		Leymus cinereus - Poa secunda (juncifolia)	1	Leymus cinereus Bottomland Herbaceous Vegetation	NatureServe (2009)	G1	S1
		Schoenoplectus americanus	1	Schoenoplectus americanus Western Herbaceous Vegetation	NatureServe (2009)	G3Q	S1?
	2	*Carex praegracilis - Juncus balticus*	1	Maybe part of Carex praegracilis or Juncus balticus Herbaceous Vegetation	NatureServe (2009)	GU	SU
		Distichlis spicata	1	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
		Eleocharis palustris	1	Eleocharis palustris Herbaceous Vegetation	NatureServe (2009)	G5	S3?
		Juncus balticus	1	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU
		Juncus balticus-Poa pratensis	1	None		GU	SU
		Leymus cinereus - Carex praegracilis	3	Leymus cinereus Bottomland Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G1	S1

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
		Leymus cinereus - Distichlis spicata	1	Leymus cinereus - Distichlis spicata Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G3G4	S1
		Schoenoplectus americanus - Puccinellia lemmonii	1	May be transitional or variation of Schoenoplectus americanus Western Herbaceous Vegetation or a Puccinellia lemmonii type		GU	SU
	3	*Carex praegracilis - Argentina anserina*	1	May be transitional or variation of Carex praegracilis Herbaceous Vegetation		GU	SU
		Distichlis spicata - Argentina anserina	1	May be transitional or variation of Distichlis spicata Herbaceous Vegetation		GU	SU
		Leymus cinereus - Carex praegracilis	1	Leymus cinereus Bottomland Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G1	S1
	4	*Juncus balticus*	1	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU
		Rosa woodsii	1	Rosa woodsii Shrubland	Crawford (2003); NatureServe (2009)	G5	SU
Inter-Mountain Basin Alkaline Closed Depression	1	*Distichlis spicata*	1	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
		Eleocharis palustris	1	Eleocharis palustris Herbaceous Vegetation	NatureServe (2009)	G5	S3?
		Hordeum jubatum	6	Hordeum jubatum Herbaceous Vegetation	NatureServe (2009)	G4	SU

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
		Mudflat/Salt Crust	8	N/A	N/A	N/A	N/A
		Open Water	5	N/A	N/A	N/A	N/A
		Schoenoplectus americanus	1	Schoenoplectus americanus Western Herbaceous Vegetation	NatureServe (2009)	G3Q	S1?
	2	*Argentina anserina - Juncus balticus*	1	Juncus balticus - Argentina anserina	Crawford (2003)	GU	SU
		Carex praegracilis - Juncus balticus	1	May be transitional or variation of Carex praegracilis or Juncus balticus Herbaceous Vegetation		GU	SU
		Distichlis spicata	7	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
		Hordeum jubatum	3	Hordeum jubatum Herbaceous Vegetation	NatureServe (2009)	G4	SU
		Juncus balticus	1	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU
		Kochia sp.	1	None		Nonnative	Nonnative
		Leymus cinereus - Juncus balticus	1	Leymus cinereus Bottomland Herbaceous Vegetation	NatureServe (2009)	G1	S1
		Mudflat/Salt Crust	1	N/A	N/A	N/A	N/A
		Puccinellia lemmonii	1	None		GU	SU
		Schoenoplectus acutus	1	Schoenoplectus acutus Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G5	S4
		Schoenoplectus americanus	3	Schoenoplectus americanus Western Herbaceous Vegetation	NatureServe (2009)	G3Q	S1?

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
		Schoenoplectus americanus - Puccinellia lemmonii	1	May be transitional or variation of Schoenoplectus americanus Western Herbaceous Vegetation or a Puccinellia lemmonii type		GU	SU
	3	*Argentina anserina - Juncus balticus*	2	Juncus balticus - Argentina anserina	Crawford (2003)	GU	SU
		Distichlis spicata	5	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
		Distichlis spicata - Carex praegracilis	1	Distichlis spicata - Carex praegracilis	Crawford (2003)	GU	SU
		Hordeum jubatum	1	Hordeum jubatum Herbaceous Vegetation	NatureServe (2009)	G4	SU
		Juncus balticus	8	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU
		Leymus cinereus - Distichlis spicata	1	Leymus cinereus - Distichlis spicata Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G3G4	S1
		Puccinellia lemmonii	1	None		GU	SU
		Sarcobatus vermiculatus / Distichlis spicata	1	Sarcobatus vermiculatus / Distichlis spicata Shrubland	Crawford (2003); NatureServe (2009)	G4	S2?
		Schoenoplectus americanus	1	Schoenoplectus americanus Western Herbaceous Vegetation	NatureServe (2009)	G3Q	S1?
	4	*Distichlis spicata*	3	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
		Juncus balticus	3	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
		Leymus cinereus - Carex praegracilis	2	Leymus cinereus Bottomland Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G1	S1
		Leymus cinereus - Distichlis spicata	1	Leymus cinereus - Distichlis spicata Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G3G4	S1
		Leymus cinereus - Juncus balticus	2	Leymus cinereus Bottomland Herbaceous Vegetation	NatureServe (2009)	G1	S1
		Poa secunda (juncifolia)	1	None		GU	SU
	5	*Leymus cinereus - Juncus balticus*	1	Leymus cinereus Bottomland Herbaceous Vegetation	NatureServe (2009)	G1	S1
Inter-Mountain Basin Playa	1	*Mudflat/Salt Crust*	3	N/A	N/A	N/A	N/A
		Open Water	1	N/A	N/A	N/A	N/A
	2	*Distichlis spicata*	1	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
		Puccinellia lemmonii	1	None		GU	SU
		Schoenoplectus americanus	1	Schoenoplectus americanus Western Herbaceous Vegetation	NatureServe (2009)	G3Q	S1?
		Suaeda sp.	2	None		GU	SU
	3	*Distichlis spicata*	2	Distichlis spicata Herbaceous Vegetation	NatureServe (2009)	G5	S1?
		Puccinellia lemmonii	2	None		GU	SU
		Schoenoplectus acutus	1	Schoenoplectus acutus Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G5	S4
	4	*Juncus balticus*	1	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
		Puccinellia lemmonii	1	None		GU	SU
		Sarcobatus vermiculatus / Distichlis spicata	1	Sarcobatus vermiculatus / Distichlis spicata Shrubland	Crawford (2003); NatureServe (2009)	G4	S2?
		Schoenoplectus americanus	1	Schoenoplectus americanus Western Herbaceous Vegetation	NatureServe (2009)	G3Q	S1?
North American Arid Freshwater Marsh	1	*Eleocharis palustris*	1	Eleocharis palustris Herbaceous Vegetation	NatureServe (2009)	G5	S3?
		Open Water	1	N/A	N/A	N/A	N/A
		Schoenoplectus acutus	1	Schoenoplectus acutus Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G5	S4
	2	*Alisma gramineum*	1	None		GU	SU
		Argentina anserina - Juncus balticus	1	Juncus balticus - Argentina anserina	Crawford (2003)	GU	SU
		Schoenoplectus acutus	1	Schoenoplectus acutus Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G5	S4
		Schoenoplectus acutus - Schoenoplectus americanus	1	May be transitional or variation of Schoenoplectus americanus Western or Schoenoplectus acutus Herbaceous Vegetation		GU	SU
	3	*Juncus balticus*	1	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU
		Leymus cinereus - Carex praegracilis	1	Leymus cinereus Bottomland Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G1	S1

Ecological System	Zone	Plant Association Name Assigned in the Field	Frequency in Ecological System	Potential Synonym	Synonym Source	Global Rank	State Rank
		Schoenoplectus maritimus	1	Schoenoplectus maritimus Herbaceous Vegetation	NatureServe (2009)	G4	S1?
		Wet Juncus balticus	1	Juncus balticus Herbaceous Vegetation	NatureServe (2009)	G5	SU
	4	*Schoenoplectus acutus*	2	Schoenoplectus acutus Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G5	S4
	5	*Juncus balticus-Poa pratensis*	1	None		GU	SU
		Schoenoplectus acutus	1	Schoenoplectus acutus Herbaceous Vegetation	Crawford (2003); NatureServe (2009)	G5	S4
	6	*Argentina anserina - Juncus balticus*	1	Juncus balticus - Argentina anserina	Crawford (2003)	GU	SU

3.1.4 Wildlife Observed

Field efforts were not targeted around optimal survey times for waterfowl, shorebirds, or other wildlife species that may be associated with the wetlands in the project area. Thus, our observations of wildlife were purely opportunistic and resulted in a paucity of observations. Those observations are found in the accompanying Microsoft Access database.

The Washington Department of Fish and Wildlife (WDFW) has conducted an annual breeding waterfowl survey in the Douglas County “Potholes” since the early 1960’s. Mikal Moore, State Waterfowl Specialist with WDFW, indicated that the waterfowl breeding pair counts take place each May. Observers follow a road route and count all waterfowl within a ¼ mile buffer. Roughly, the road route extends from Elbow Lake, east to Wilson Lake, northeast to School Creek, south to Hwy. 174 (past Smith Lake), west along Hwy. 174 to Del Rio Road, and north back to Elbow Lake. These counts are then expanded by a factor of 15.26 to extrapolate to the total substrata area. The observers also count potholes with water along the route for an index of available breeding habitat (this is the source of data for Figure 9). The results from over 50 years of data collection are shown in Figure 13. WDFW indicated that the wetlands found in the Douglas County ‘Pothole region’ are important breeding habitat for waterfowl in Washington (Mikal Moore, personal communication). Although shorebirds were generally not the focus of the WDFW surveys, the wetlands in northern Douglas County are likely an important habitat for them as well.

3.1.5 Aquatic Invertebrates

Isolated wetlands such as vernal pools often support rare and endemic invertebrate species (Keeley and Zedler 1998). Numerous endemic and rare invertebrates have found in California and Oregon vernal pools (USFWS 2005). The vernal pools of eastern Washington are thought to be very similar to the vernal pools in California and Oregon (Keeley and Zedler 1998; Bjork 1997). Recent floristic analysis has shown that Washington vernal pools support numerous rare plants (Bjork 1997, WNHP 2009) but very little work has focused on identifying the composition of the invertebrate communities which occur in eastern Washington’s vernal pools (Kulp and Rabe 1984).

The aquatic invertebrate specimens collected for this project were not identified by WNHP. The specimens have been given to The Nature Conservancy. The identification of these specimens should be a high priority. Although only a few vernal pools were surveyed for this project, the invertebrate composition of other depressional wetlands in the project area is also not well-known and specimens collected for this project may assist in filling that information gap.

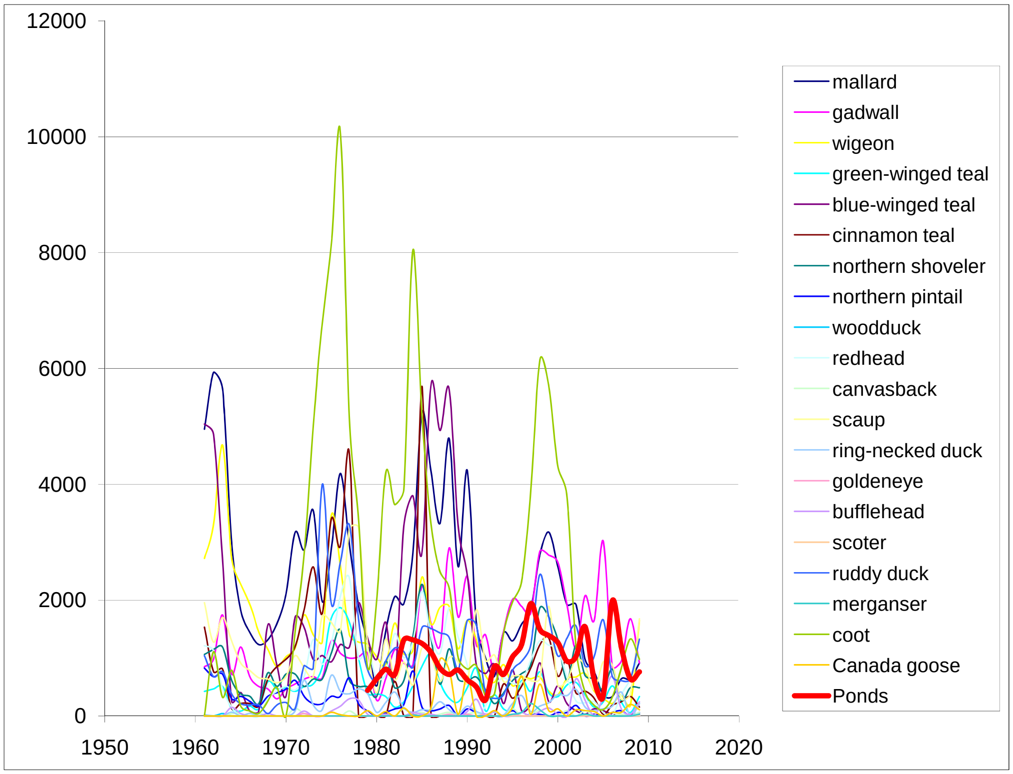


Figure 13. Number of Waterfowl Breeding Pairs Associated with Wetlands in Northern Douglas County. Data source: WDFW

3.1.6 Overall Ecological Condition

The overall ecological condition of each surveyed wetlands is summarized in this section. The reconnaissance points were excluded from this analysis since only cursory Ecological Integrity Assessment (EIA) data were collected from them. Some basic information regarding the biological condition of the reconnaissance points is documented in the attached GIS file called "Wetlands Mapped by UW".

The overall EIA rank represents an aggregation of the ranks associated with four key ecological attributes (KEA): (1) Landscape Context; (2) Biotic Condition; (3) Abiotic Condition; and (4) Size. The ranks for each of the KEAs are derived from a roll-up of underlying metric ranks associated with each KEA. Each level of rank (overall EIA rank down to a metric rank) is suited for specific prioritization or analysis objectives. For example, metric ranks are most useful for assessing and monitoring specific ecological characteristics associated with an Ecological System while the

KEA and EIA rank provide a more useful rank for prioritizing conservation and management actions. KEA and EIA ranks for wetlands surveyed in this project are presented in Figures 14-18 while metric ranks are presented in Table 4.

All of the Columbia Plateau Vernal Pool, Inter-Mountain Basin Alkaline Closed Depression, and Inter-Mountain Basin Playa wetlands had an overall EIA rank of B (good integrity) while the Columbia Plateau Wet Meadow (Provisional) and North American Arid Freshwater Marsh sites also had quite an abundance of C ranked (fair integrity) sites (Figure 14). The majority of wetlands had a Landscape Context rank of B (good), although ½ of the sites classified as North American Arid Freshwater Marsh had a C (fair) or D (poor integrity) rank (Figure 15). The Biotic Condition of most surveyed wetlands had a C (fair) or D (poor) rank and ½ of all the Columbia Wet Meadow (Provisional) type were in poor (D) ecological condition (Figure 16). In contrast to Biotic Condition, Abiotic Condition ranks were generally excellent (A) to good (B) for most sites although nearly 20% of the Columbia Plateau Wet Meadow (Provisional) were ranked as poor (D) and 25% of North American Arid Freshwater Marsh as fair (C) (Figure 17). Most surveyed wetlands had excellent (A) to good (B) ranks for Size (Figure 18). However, 25% of North American Arid Freshwater Marsh sites had a poor (D) rank.

The frequency of metric ranks across Ecological Systems is shown in Table 4. These ranks provide further detail and explanation of the underlying reasons of each of the KEA ranks.

In summary, the Columbia Plateau Vernal Pool, Inter-Mountain Basin Alkaline Closed Depression, and Inter-Mountain Basin Playa wetlands had excellent (A) to good (B) ranks for all KEAs except Biotic Condition. North American Arid Freshwater Marsh and Columbia Plateau Wet Meadow (Provisional), however, had fair (C) and/or poor (D) ranks in each KEA. Anthropogenic stressors potentially associated with degraded ecological conditions are explored in the next section.

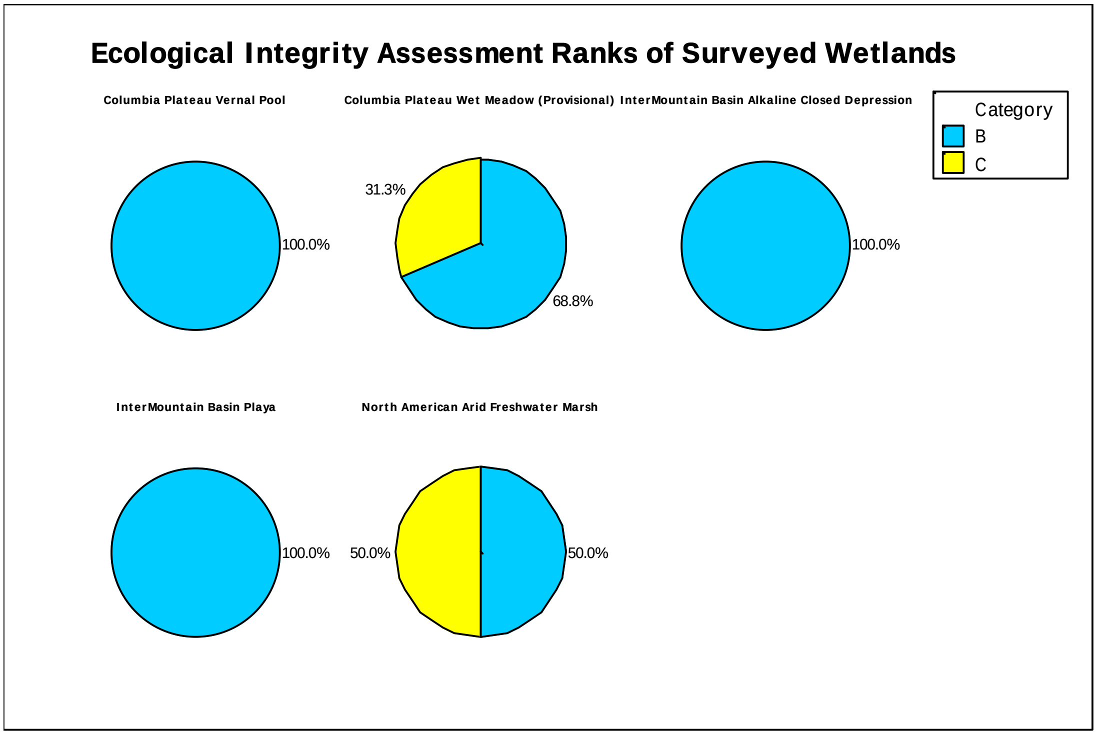


Figure 14. Overall Ecological Integrity Assessment Ranks for Each Ecological System. Note: A = Excellent Integrity; B = Good Integrity; C = Fair Integrity; and D = Poor Integrity.

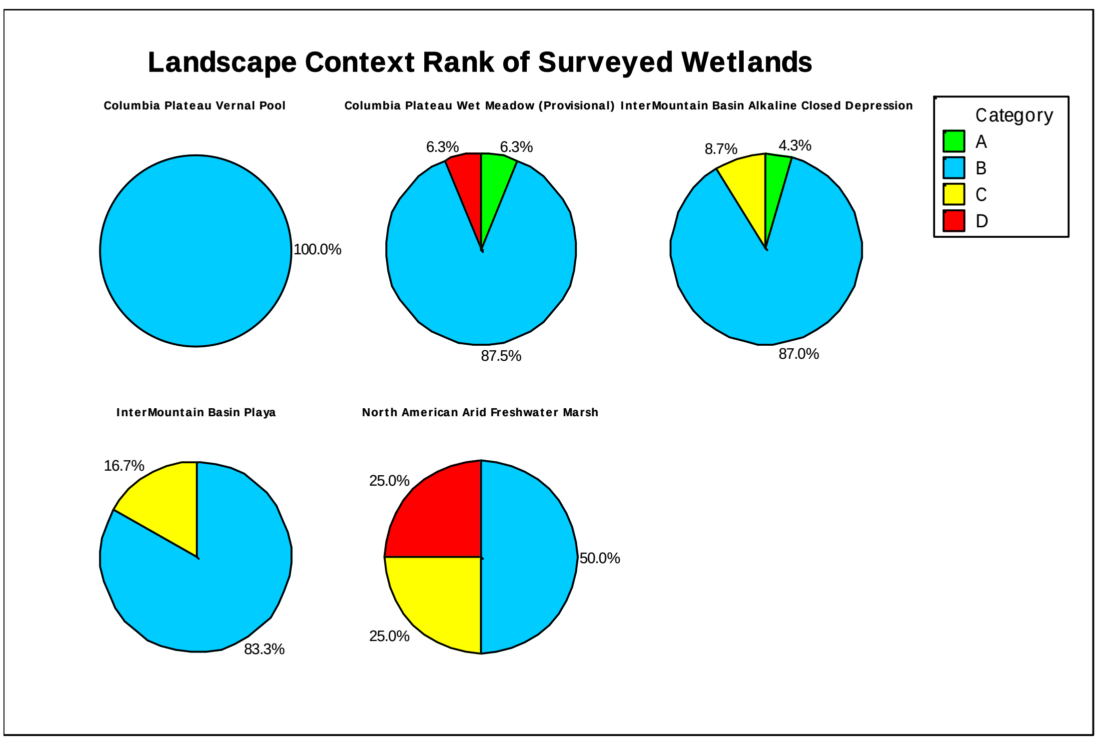


Figure 15. Landscape Context Ranks for Each Ecological System. Note: A = Excellent Integrity; B = Good Integrity; C = Fair Integrity; and D = Poor Integrity.

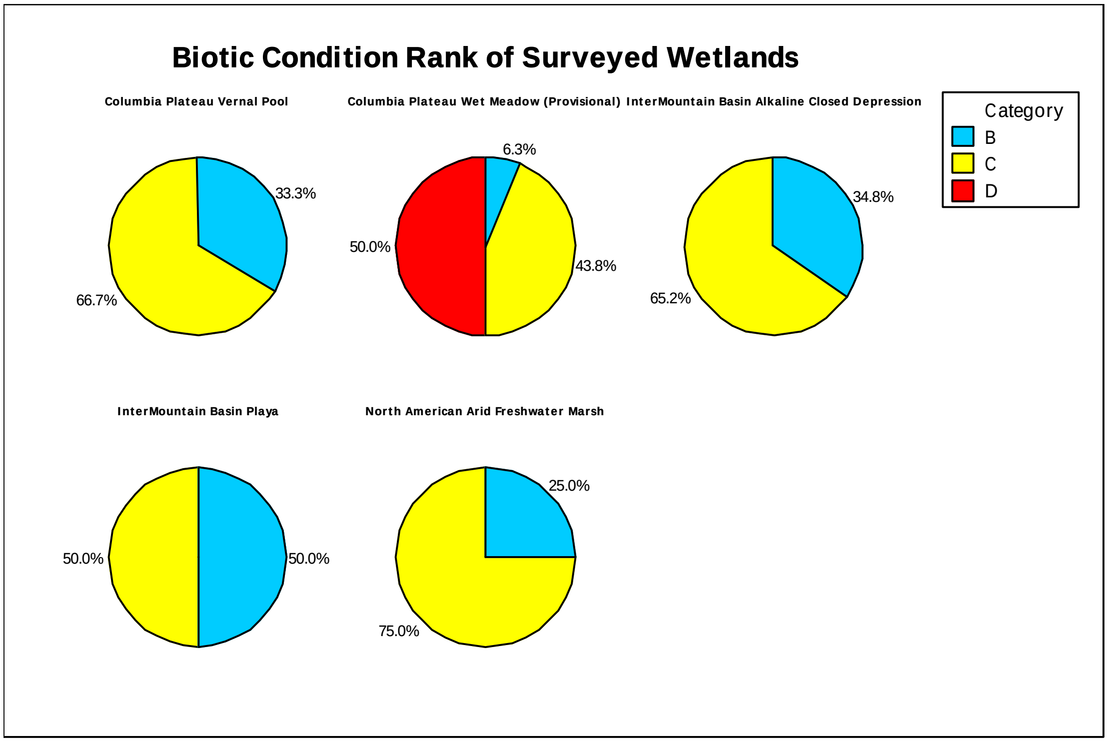


Figure 16. Biotic Condition Ranks for Each Ecological System. Note: A = Excellent Integrity; B = Good Integrity; C = Fair Integrity; and D = Poor Integrity.

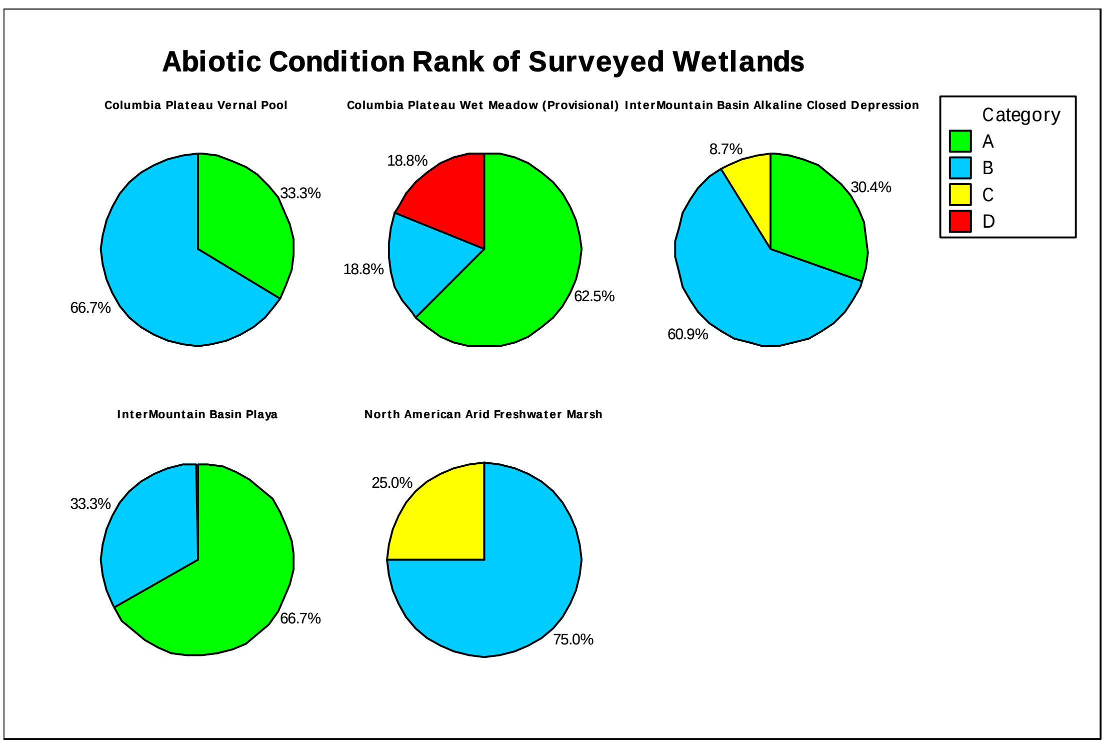


Figure 17. Abiotic Condition Ranks for Each Ecological System. Note: A = Excellent Integrity; B = Good Integrity; C = Fair Integrity; and D = Poor Integrity.

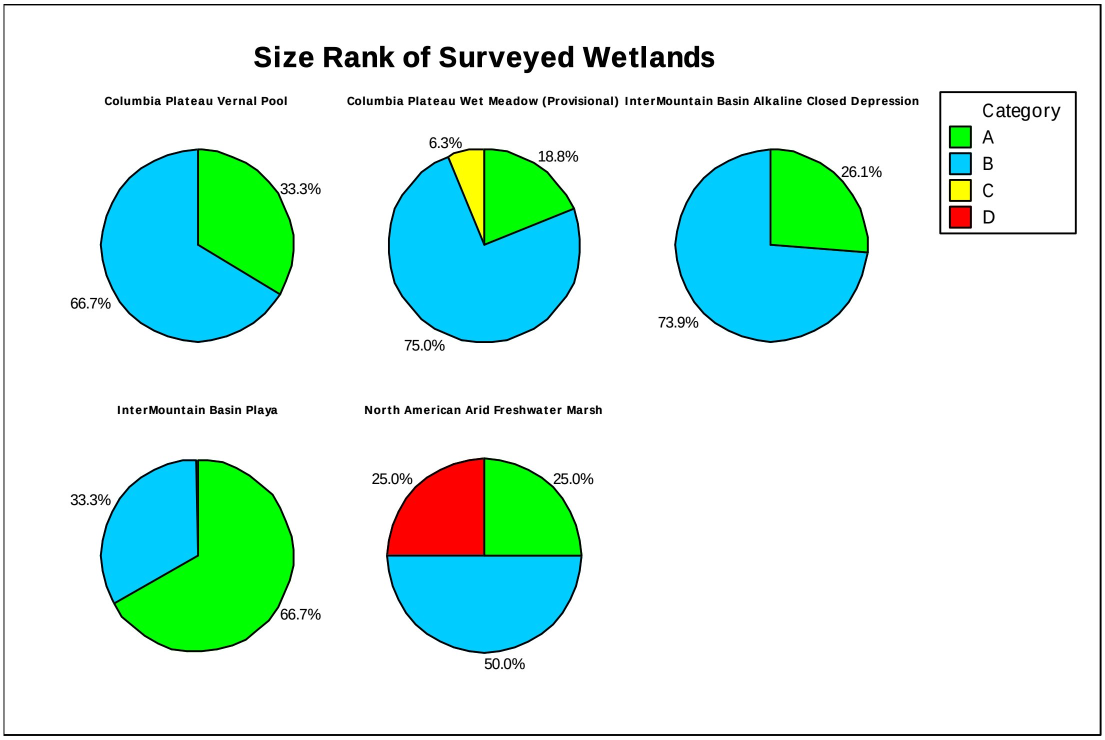


Figure 18. Size Ranks for Each Ecological System. Note: A = Excellent Integrity; B = Good Integrity; C = Fair Integrity; and D = Poor Integrity.

Table 4. Distribution of Metric Ranks Across Ecological Systems

Key Ecological Attribute	Metric	Rank	Columbia Plateau Vernal Pool	Columbia Plateau Wet Meadow (Provisional)	Inter-Mountain Basin Alkaline Closed Depression	Inter-Mountain Basin Playa	North American Arid Freshwater Marsh	Grand Total
Landscape Context	Landscape Connectivity	A	2	3	1	5		11
		AB		1		2		3
		B		14	1	3		18
		BC	1		1	2	1	5
		C		5	3	4	2	14
		D					1	1
	Buffer Width	A	3	13	3	13	1	33
		B		5	2	2	1	10
		C		5	1		1	7
		D				1	1	2
	Buffer Condition	AB		1		1		2
		B	3	6		6		13
		BC		2	1	1	1	5
		C		14	5	7	2	28
		D				1	1	2
	Adjacent Land Use	A				1		1
		B	1	2		3		6
		C	2	20	6	10	4	42
		D		1		2		3
	Buffer Length	A	3	20	4	13	2	42
		B		1	2	1	1	5
		C		2		1	1	4
		D				1		1
Biotic Condition	Native Plant Cover	A						0
		B	1	19	5	8	1	33
		BC		1				1

Key Ecological Attribute	Metric	Rank	Columbia Plateau Vernal Pool	Columbia Plateau Wet Meadow (Provisional)	Inter-Mountain Basin Alkaline Closed Depression	Inter-Mountain Basin Playa	North American Arid Freshwater Marsh	Grand Total
		C	2	3	1	8	3	17
		D						0
	Onsite Land Use	A			1	1		2
		B	1	1		2	1	5
		C	2	14	3	11	1	31
		D		8	2	2	2	14
	Invasive Plant Cover	A						0
		B		12	3	3	1	19
		BC		1				1
		C	1	7	3	7		18
		CD				1		1
		D	2	3		5	3	13
	Typha Dominance	A		3	1		3	7
		B						0
		C						0
		D						0
		N/A	3	20	5	16	1	45
	Vegetation Composition	A						0
		AB			1			1
		B				1		1
		BC	1	9	1	1	1	7
		C	2	13	4	11	2	32
		CD		1		1		2
		D				2	1	3
	Patch Richness	A						0
		AB	1					1
		B	1	3	2		2	8
		BC					1	1

Key Ecological Attribute	Metric	Rank	Columbia Plateau Vernal Pool	Columbia Plateau Wet Meadow (Provisional)	Inter-Mountain Basin Alkaline Closed Depression	Inter-Mountain Basin Playa	North American Arid Freshwater Marsh	Grand Total
		C	1	19	4	5	1	30
		CD				1		1
		D		1		10		11
	Patch Interspersion	A	1					1
		B	2	10	4	2	2	20
		C		13	2	4	2	21
		D				10		10
	Cryptogamic Crust Cover	A						0
		B						0
		C						0
		CD	1					1
		D	2					2
	Increaser Plant Cover	A			2	1		3
		B	2	2	1	1		6
		BC		3				3
		C		12	3	5	4	24
		D	1	6		9		16
Abiotic Condition	Water Source	A	2	23	6	15	4	50
		AB				1		1
		B	1					1
		C						0
		D						0
	Hydroperiod	A	1	17	5	10	2	35
		AB		2		1		3
		B	2	3	1	4		10
		C		1			2	3
		D						0

Key Ecological Attribute	Metric	Rank	Columbia Plateau Vernal Pool	Columbia Plateau Wet Meadow (Provisional)	Inter-Mountain Basin Alkaline Closed Depression	Inter-Mountain Basin Playa	North American Arid Freshwater Marsh	Grand Total
	Hydrological Connectivity	A	3	19	6	15	4	47
		B		2				2
		C				1		1
		D						0
	Soil Disturbance	A	1		2	3		6
		B		6		5		11
		BC					1	1
		C	2	15	4	8	2	31
		CD		1				1
		D		1			1	2
	Water Quality	A	1	2	2	2		7
		B	1	5		2		8
		BC	1	4			1	6
		C		5	2	1	2	10
		D					1	1
Size	Patch Size	A		1				1
		B	1	5	4	4	1	15
		BC		1				1
		C	2	16	1	10	2	31
		CD			1			1
		D				2	1	3
	Relative Size	A	3	21	6	14	2	46
		B		2		1	1	4
		C				1	1	2
		D						

3.1.7 STRESSORS

Stressors associated with four ecological attributes were documented at each site using NatureServe's Stressor checklist methodology (Master et al. 2009; Appendix A). These categories are (1) Landscape Stressors; (2) Vegetation Stressors; (3) Soil Stressors; and (4) Hydrology Stressors.

The most common stressor associated the surrounding landscape of surveyed wetlands was ranching (i.e., livestock grazing) of either moderate (~40%) or low (~22%) density (Figure 19). Untreated populations of invasive species and CRP (conservation reserve program) were the next most common stressors encountered in the surrounding landscape. Only two stressors were identified for Vegetation and ranching (or grazing) was by far the most common (78%) while populations of untreated invasive species constituted the remaining 22% (Figure 20). These two stressors are the primary reason that the biological condition of most wetlands (see previous Section) was degraded. Many of the Biotic Condition metrics (Table 4) are well known to be correlated to livestock grazing (Kauffman and Krueger 1984; Elmore and Kauffman 1994; Belsky et al. 1999; Rocchio 2007). Physical disturbance (e.g. trampling), also related to livestock grazing, was the overwhelming dominant stressor (~95% of wetlands) for Soils (Figure 21).

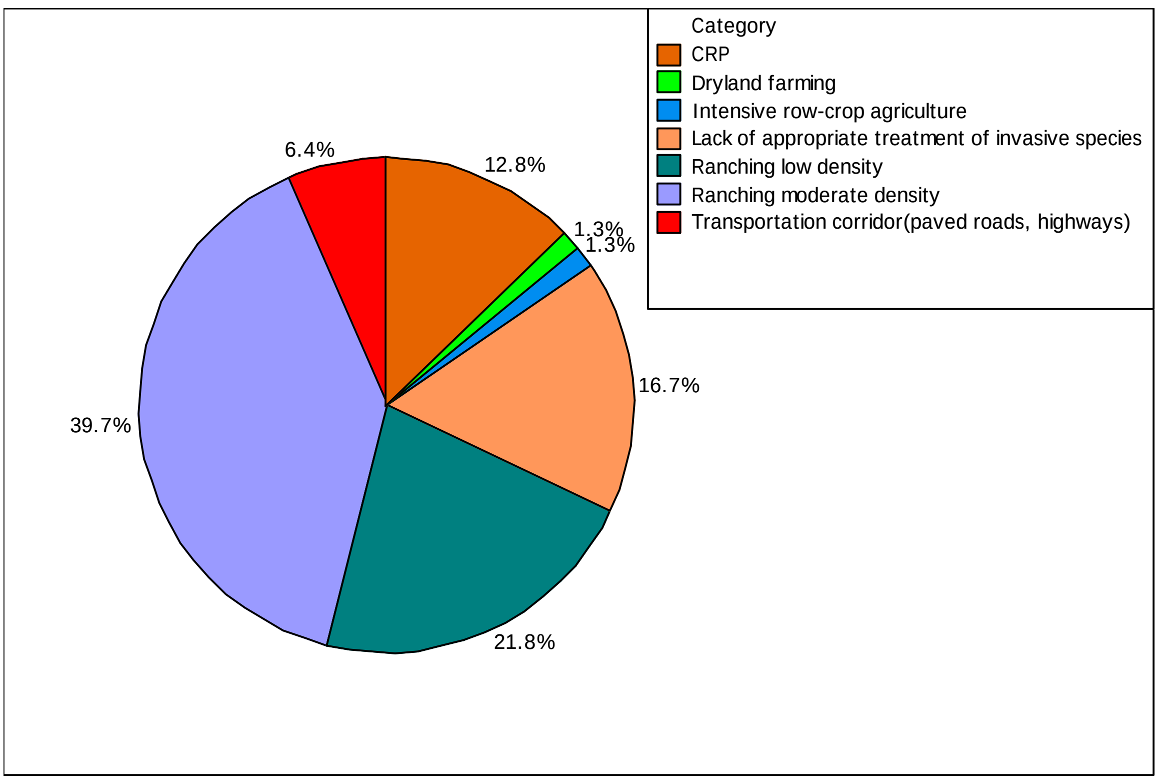


Figure 19. Landscape Stressors

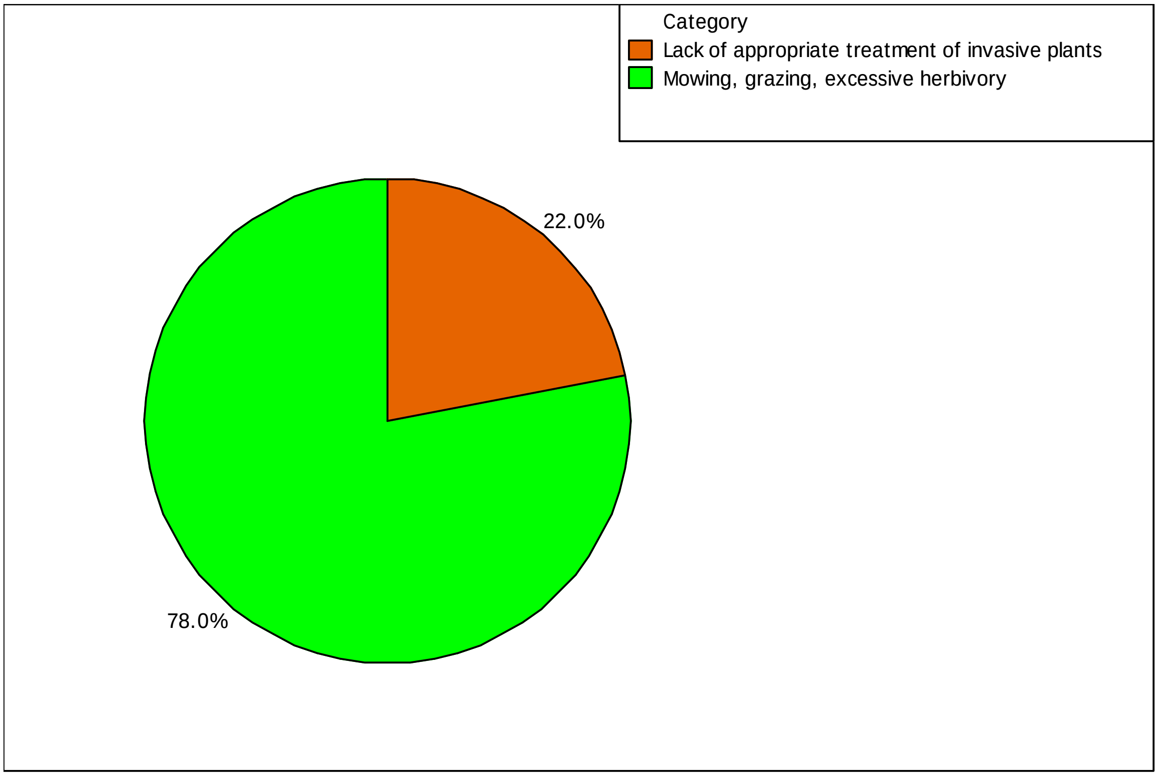


Figure 20. Vegetation Stressors

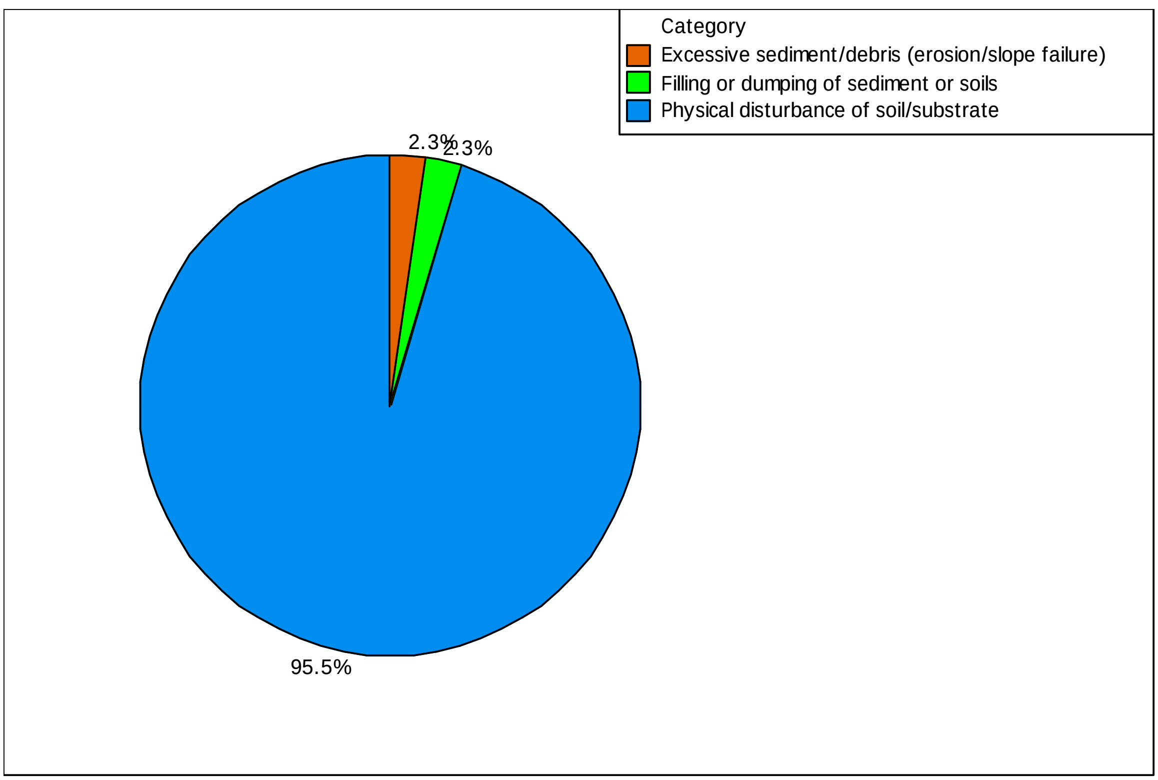


Figure 21. Soil Stressors

Hydrology stressors are a bit more diverse, although nonpoint source discharge constitutes ~65% of the hydrological stressors documented in the project area (Figure 22). This stressor refers to the abundance of 'cow pies' found at nearly every wetland. Livestock excrement was so abundant that cover of 'cow pies' was a variable noted while collecting vegetation plots for this project. Livestock excrement has a negative effect on water quality due to bacteria and nutrients introduced into water bodies (Belsky et al. 1999) which is why it was documented as a nonpoint source discharge stressor. Groundwater extraction was the second most common hydrological stressor, although it was only noted at 11% of site. However, conversations with local ranchers and the Natural Resource Conservation Service (Mark Bareither, personal communication) indicated that interest in installing groundwater wells is increasing with local farmers and ranchers, especially given that many of the closed depression wetlands have not held as much water in recent years as in the past.

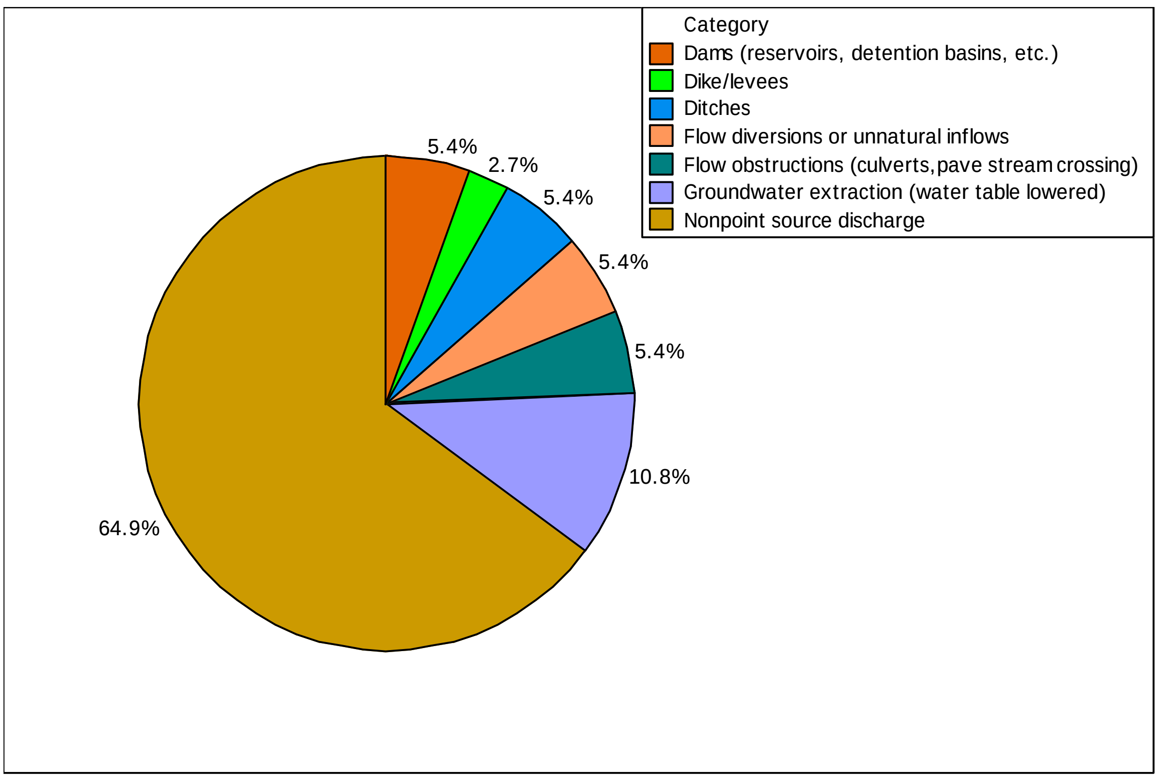


Figure 22. Hydrology Stressors

In summary, livestock grazing has resulted in the most common stressors associated with Landscape, Vegetation, Soils, and Hydrology attributes. These stressors appear to be having a negative effect on the ecological condition of wetlands in the project area. The most obvious effect resulting from grazing is a change in vegetation composition. These changes do not imply that all ecological services provided by these wetlands have been degraded or eliminated.

However, from a biodiversity perspective, current grazing practices appear to be negatively impacting the integrity of the vegetation community. Impacts from grazing on aquatic invertebrates should be researched in the future.

One positive outcome of the heavy grazing observed in the project wetlands is that because livestock tend to congregate in wetlands and riparian areas due to the relative abundance of forage and availability of water, the uplands surrounding many of the wetlands in the project area were in much better ecological condition than likely would like be the case without the presence of the wetlands to draw the attention of the livestock.

3.2 Biodiversity Significance

The contribution of wetlands in the project area toward regional and global biodiversity is summarized below. This is a cursory assessment based on rapid measures of presence/absence of elements of biodiversity and ecological condition. In order to provide a more comprehensive assessment of the biodiversity values of these wetlands, additional inventory and assessment should be conducted throughout the Waterville Plateau to provide a better estimate of overall ecological condition and elements of biodiversity that these wetlands support. Nonetheless, the data collected in this project provide a good first measure of biodiversity significance of wetlands in northern Douglas County.

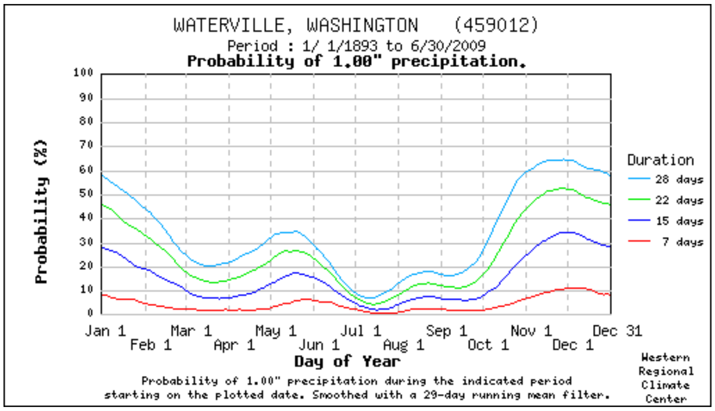
3.2.1 Elements of Conservation Concern

Ecological Systems

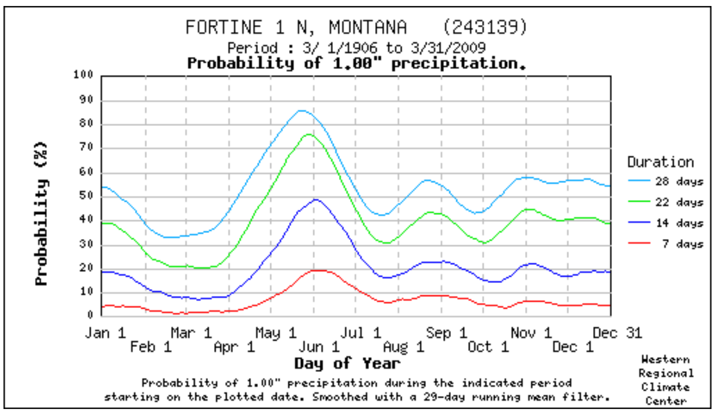
Except for the Columbia Basin Foothill Riparian Woodland and Shrubland and Northern Columbia Plateau Basalt Pothole Ponds Ecological Systems, which were not encountered during field work for this project, the project area supports most of the wetland types found in the Columbia Basin of eastern Washington: Inter-Mountain Basin Alkaline Closed, Inter-Mountain Basin Playa, Columbia Plateau Wet Meadow (Provisional), Columbia Plateau Vernal Pool, and North American Arid Freshwater Marsh. Currently, WNHP does not have Conservation Status Ranks assigned to Ecological Systems. However, their contribution to regional biodiversity is explored below.

Due to unique geology, the density of Inter-Mountain Basin Alkaline Closed Depression and Playa wetlands found on the Waterville Plateau (and north of the Columbia River between Soap Lake Mountain and Omak Lake, on the Colville Indian Reservation) may be the highest in the state and thus a very important region for the conservation of these saline wetland types. Although found throughout the Columbia Basin, the density of the Columbia Plateau Wet Meadow (Provisional) Ecological System in the project areas is also very high suggesting that this region may also be of importance to the conservation of this wetland type in Washington. The Columbia Plateau Vernal Pool Ecological System appears to occur at high densities in the Cheney-Palouse tract, Davenport tract, and Grand Coulee areas of the channel scablands which are located further to the east of the project area (Bjork 1997). The North American Arid Freshwater Marsh Ecological System is found throughout the Columbia Basin, although appears to occur at the highest densities along perennial stream/river reaches and in the Potholes Reservoir area (National Wetland Inventory maps), where natural groundwater found in the Quincy Basin coupled with irrigation 'wastewater' and management of the reservoir which have created an abundance of marshes which historically were absent, support large numbers of wetlands.

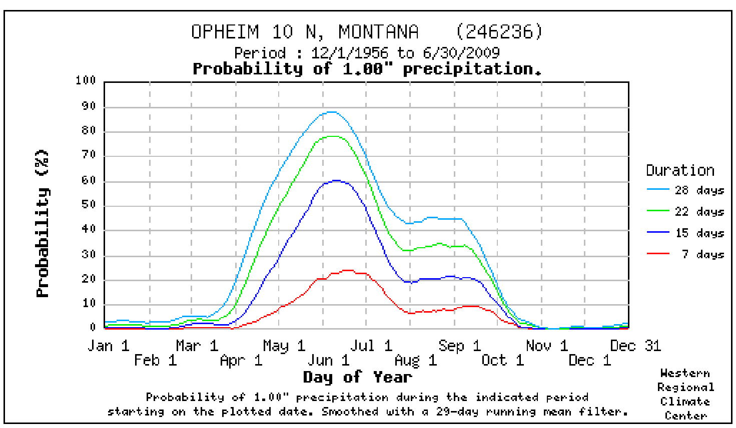
The Waterville Plateau, because of its unique glacially-derived landforms, supports a regionally significant collection of saline wetlands which resemble the prairie potholes wetlands found in western Montana mountain valleys (Cook and Hauer 2007) as well those found in the northern Great Plains. The Columbia Plateau Prairie Pothole region differs in its winter-spring precipitation and summer drought pattern in contrast to the summer rain pattern of the Great Plains Prairie Pothole region (Figure 23). A primary difference between Washington's 'prairie pothole' wetlands and those located further east, is the distribution of freshwater versus saline vegetation. Washington's prairie potholes are primarily saline while those in the Great Plains and in Montana have a greater abundance of freshwater vegetation (Cook and Hauer 2007; Hauer et al. 2002; Stewart and Kantrud 1971). Freshwater vegetation associated with Washington's prairie potholes are primarily associated with loess filled channels and depressions which support the Columbia Plateau Wet Meadow (Provisional) type or the semi-permanent ponds which support the North American Arid Freshwater Marsh type. Washington's saline prairie pothole wetlands are primarily classified as either Inter-Mountain Basin Playa or Inter-Mountain Basin Alkaline Closed Depression Ecological System types. The difference between these two, which can be difficult to distinguish especially in Washington, is that playas are sparsely vegetated while alkaline depressions have a higher cover of vegetation. In addition, playas are thought to be more saline than alkaline closed depressions (NatureServe 2009). However, these distinctions were often not readily apparent in the project area. Thus, we suggest that these two Ecological Systems be lumped and considered to be one conservation target.



Columbia Plateau Pothole



NW Montana Pothole



Great Plains Pothole

Figure 23 Seasonal precipitation differences across the prairie potholes region. Western Regional Climate Center,wrcc@dri.edu

Plant Associations

Of the 33 wetland plant associations identified in the field, nearly 25% (8) have a Global Rank between G1-G3Q while 33% (11) have a State Rank between S1-S3? (Figures 24 and 25, respectively). This indicates that 25% of the plant associations are considered to be of global conservation significance while an additional 8% are of important conservation significance within the State of Washington. However, this analysis is based on the cursory cross-walk conducted for this report. Future quantitative analysis of the vegetation data may change the distribution of conservation status ranks for plant associations in the project area. For example, 42% of the plant associations had a GU rank and 58% had a SU rank, indicating that additional classification work is needed to better understand the conservation significance of the full suite of plant associations that occur in the project area.

Nonetheless, the data presented here suggest that the project area wetlands support numerous plant associations of higher conservation significance. Many of these plant associations are considered a conservation priority not because they are extremely rare on the landscape but rather because across their Global and State ranges most occurrences of these types have been heavily degraded by human-induced disturbances (NatureServe 2009).

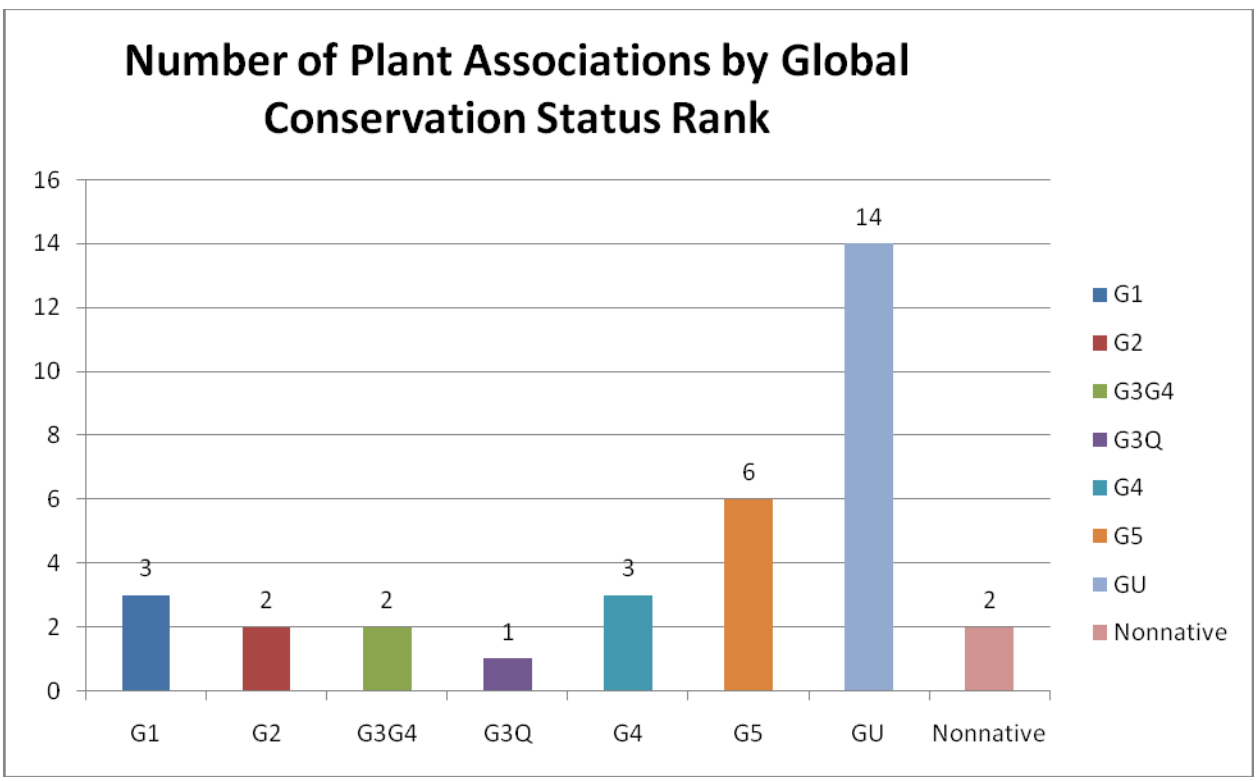


Figure 24. Number of Plant Associations According to Global Conservation Status Ranks

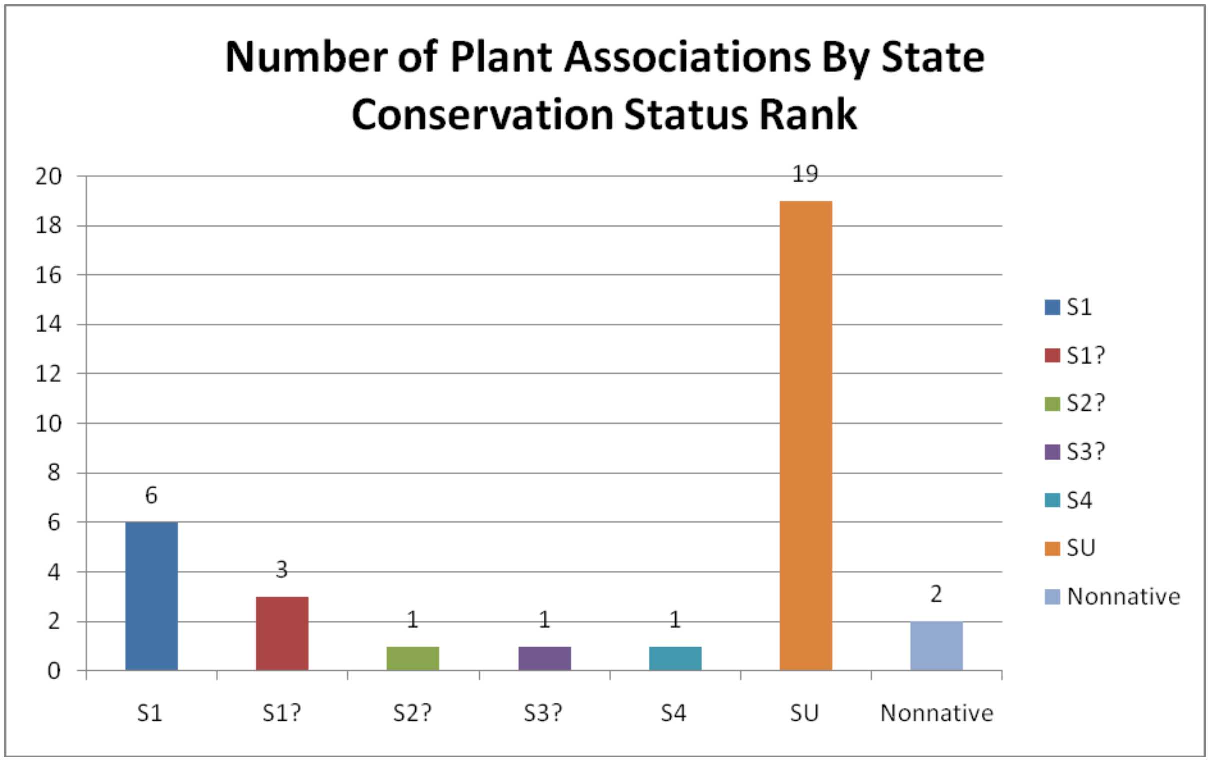


Figure 25. Number of Plant Associations According to State Conservation Status Ranks

Rare Plants

No rare plants tracked by WNHP (WNHP 2009) were observed during the course of this project. However, field visits were not scheduled around the appropriate season for inventory for each of the potential rare plant species. Additional inventory work with consideration of each species' phenology is recommended. Rare species with potential to occur in wetlands on the Waterville Plateau are listed in Table 5. This list was constructed by consulting the Douglas County rare plant list (WNHP 2009) and determining which of those species may occur in wetlands. Not listed here is the full suite of rare species that are associated with Columbia Plateau Vernal Pools (Caplow 2005; Bjork 1997). These species should also be a focus of future inventory work.

Table 5. Rare Plants with Potential to Occur in Douglas County Wetlands.

SNAME	Global Rank	State Rank	State Status	Federal Status	Habitat
Allium constrictum	G2	S2	Sensitive		vernally moist lithosols
Camissonia pygmaea	G3	S1S2	Sensitive		unstable soil or gravel, washes, river banks
Delphinium viridescens	G2	S2	Threatened	Species of Concern	wet meadows in dry forest
Eleocharis rostellata	G5	S1	Sensitive		Salt flats, alkaline
Juncus tiehmii	G4	S1	Threatened		Along streams, in seeps
Juncus uncialis			Sensitive		Vernal pools, swales
Mimulus suksdorfii	G4	S2	Sensitive		Dry or open seeps
Monolepis pusilla	G5	S1	Threatened		Alkaline, edges of vernal pools
Nicotiana attenuata	G4	S2	Sensitive		dry sandy areas, valley bottoms
Ophioglossum pusillum	G5	S1S2	Threatened		Wet areas
Phacelia tetramera	G4T4	S1	Sensitive		Alkaline, vernal pools
Potamogeton filiformis var. occidentalis	G5T5	S1S2	Review Group 1 (additional field work needed before statu is assigned)		Aquatic
Sisyrinchium montanum	G5	S1	Threatened		Moist meadows and streambanks
Thelypodium sagittatum ssp. sagittatum	G4T4	S1	Sensitive		Moist swales in shrub-steppe
Trichostema oblongum	G5	SNR	Review Group 1 (additional field work needed before statu is assigned)		Alkaline, vernally wet

Rare Animals

WDFW's Wildlife Survey and Data Management Database contains information on documented point observations for state and federal listed species including those designated as endangered, threatened, sensitive, candidate, and monitor. Additionally, data for other species considered a priority by Washington Department of Fish & Wildlife are included. This database represents observations from 1881 to the present. Scope of the database is statewide and encompasses over 230 species. WDFW's Wildlife Survey and Data Management Database or WNHP Biotics Database did not contain any records within the project area. No new observations of species tracked by these databases were documented during this project. As with the rare plants, animal observations were not the focus of scheduling field work and thus relied on opportunistic observations.

3.2.2 Waterbird Habitat

As noted above, wetlands on the Waterville Plateau support important waterbird habitat for breeding waterfowl species in Washington State (Mikal Moore, personal communication). The relationship between the quality of waterfowl habit and EIA measures should be explored to determine to what extent, if any, the integrity of the vegetation community affects the ability of these wetlands to provide suitable and high quality habitat.

3.2.3 Aquatic Invertebrates

Until the aquatic invertebrate specimens are identified, their biodiversity significance remains unknown. However, given the rare and endemic species found in California and Oregon vernal pools, they should remain on the radar as a potential conservation target.

3.3 Synthesis and Future Research

In summary, the wetlands of the project area occur in a unique geologic landscape which results in unique ecological characteristics and high biodiversity significance. The project area contains an unusual density of saline wetlands for Washington State, supports numerous rare wetland plant associations, and provides important waterbird habitat. The wetlands in the project area undoubtedly also provide a myriad of ecological services that were not addressed in this project.

The methods employed in this project were of a rapid and qualitative nature. In addition, the geographic focus of this project represents only a portion of the extent of these wetlands and field efforts were limited to wetlands occurring on DNR managed State Trust Lands. Because of these limitations, the following research is recommended in order to fully understand the ecological characteristics and biodiversity significance of wetlands in northern Douglas County:

- Continue inventory efforts on lands outside DNR ownership and throughout the Waterville Plateau
- Using vegetation plot data collected in this report and from additional inventory efforts, conduct a quantitative classification analysis of the plant associations occurring in northern Douglas County wetlands; such an analysis may reveal additional types not previously represented as well as provide additional data regarding regional variation of existing types

- Quantitatively characterize the hydrological regime of these wetlands, including a quantitative investigation of the relative contribution of groundwater and overland flow to the hydrological regime of these wetlands
- More focused and intensive survey effort for specific rare plants such as those listed in Table 5 and those associated with vernal pools
- Identify aquatic invertebrates that were collected for this project
- Conduct a quantitative analysis of livestock grazing impacts on biodiversity of wetlands in the project area.
- Work with WDFW to obtain site-specific data on use of wetlands by waterbirds
- Synthesize data from these efforts, along with data collected in this report, into a regional conservation strategy for wetlands on the Waterville Plateau.

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APPENDIX A - FIELD FORMS

General Information		
Site ID	Photos	USGS Quad(s)
Plot ID(s)	Ownership	Elevation (m/ft)
UW Polygon Number(s)	TRS	Slope (deg)
Date	Weather Conditions	Aspect
Observers	Directions and Access Comments	

Impervious Substrate & Depth	
Claypan	
Hardpan	
Basalt	

Soil Texture

Hydrological Features (circle all that apply)	
Water marks above water surface	Open water
	soil cracks
Springs	Slope break discharge
Seeps	Inlet
Salt crust	Outlet

Landform (circle all that apply)			
Erosional		Depositional	
Glacial	Swale	Till	Floodplain
Valley	Slope	Outwash	Dune
Alluvial	Kettle	Alluvial	Loess
Channel	Pothole	Colluvial	Moraine
Plateau	Oxbow	Esker	Terrace
Flat	Canyon	Other	

GPS
UTM E
UTM N
Accuracy

Site Type (circle all that apply)					
spring	seep	aquatic	point bar	1st terrace	2nd terrace
swale	topes	streambank	toeslope	mid slope	high slope
wet basin	moist basin	channel	dry wash	edge	saddle
ridgetop	lake/pond	flat	concave	convex	undulating

Hydrologic Regime (circle one)		
permantely flooded	semi-permanately flooded	temporarily flooded
occasionally flooded	intermittently flooded	saturated

Drainage Class (circle one)		
excessively drained	well drained	moderately well drained
somewhat poorly drained	poorly drained	very poorly drained

Water Source(s) (circel all that apply; indicate relative % of each)		
surface flow	groundwater	anthropogenic

Classification
Ecological System
Plant Association
HGM Class
Cowardin Class

Groundwater Dependent (see keys)		
High likelihood	Low likelihood	Uknown

<table>
<tr><td>overland flow/ precipitation</td><td>Other</td><td colspan="3">Salinity</td></tr>
<tr><td colspan="2" rowspan="2">Other</td><td>Saline
(salt crusts & halophytes present)</td><td>Saline/ Alkaline</td><td>Fresh</td></tr>
<tr><td colspan="3">Shoreline Complexity</td></tr>
<tr><td colspan="2"></td><td>Simple</td><td>Somewhat irregular</td><td>Complex</td></tr>
<tr><td colspan="5">Site Drawing (add north arrow)</td></tr>
<tr><td colspan="5">Horizontal Drawing</td></tr>
<tr><td colspan="5">Vertical Drawing</td></tr>
<tr><td colspan="5">Site Description and Comments</td></tr>
<tr><td colspan="5"></td></tr>
</table>

Vegetation Data

UW Polygon						
Vernal Pools/Playas →		Zone 1	Zone 2	Zone 3	Zone 4	Other
Marsh/Pothole Pond/Seep & Springs →		Open Water	Deep Emergent	Shallow Emergent	Wet Meadow	
Riparian		Below Bankfull	Bankfull / Streambank	Floodplain	Second Terrace	
Cover Classes **1**: trace **2**: 0–<1% **3**: 1–<2% **4**: 2–<5% **5**: 5–<10% **6**: 10–<25% **7**: 25–<50% **8**: 50–<75% **9**: 75–<95% **10**: >95%						
Species	**Coll #**					
Water						
Bare Ground						
Litter						
Cryptogamic Crust						
Thatch						
Annual Species						
Perennial Species						

Wildlife Species List

Vernal Pools/Playas →		Zone 1	Zone 2	Zone 3	Zone 4	Other
Marsh/Pothole Pond/Seep & Springs →		Open Water	Deep Emergent	Shallow Emergent	Wet Meadow	
Riparian		Below Bankfull	Bankfull / Streambank	Flood plain	Second Terrace	
When possible, indicate # of individuals observed within each Zone						
Wildlife Species Observed						
Aquatic Invertebrate Collection?	Yes/No					
Comments about Aquatic Invertebrates						

Soil Pit (s)	Center of Wetland + additional pits, if needed						
Depth to Impervious Layer (cm)		Depth to Saturated Soils (cm)		Depth to Water Table (cm)		Thickness of Peat (cm)	
Pit 1	Pit 2	Pit 1	Pit 2	Pit 1	Pit 2	Pit 1	Pit 2

Horizon		Range (depth in cm)		Texture		Color (Matrix and Mottle)		Structure		% Coarse		Comments	
Pit 1	Pit 2	Pit 1	Pit 2	Pit 1	Pit 2	Pit 1	Pit 2	Pit 1	Pit 2	Pit 1	Pit 2	Pit 1	Pit 2

Ecological Integrity Assessment

1. Landscape Context and Buffer Condition - Circle the applicable letter score

1a. Landscape Connectivity	
Nonriverine: Intact: Embedded in 90-100% natural habitat of around wetland, preferably within the watershed **Riverine:** Combined length of all non-buffer segments is less than 200 m (<10%) for wadable (2-sided) sites, 100 m (<10%) for non-wadable (1-sided) sites.	**A**
Nonriverine: Variegated: Embedded in 60-90% natural habitat **Riverine:** Combined length of all non-buffer segments is between 200 m and 800 m (10-40%) for "2-sided" sites; between 100 m and 400 m (10-40%) for "1-sided" sites.	**B**
Nonriverine: Fragmented: Embedded in 20-60% natural habitat **Riverine:** Combined length of all non-buffer segments is between 800 and 1800 m (40-90%) for "2-sided" sites; between 400 m and 900 m (40-90%) for "1-sided" sites.	**C**
Nonriverine: Relictual: Embedded in < 20% natural habitat **Riverine:** Combined length of all non-buffer segments is greater than 1800 m for "2-sided" (>90%) sites, greater than 900 m f or "1-sided" sites (>90%).	**D**

1b. Average Buffer Width	
Average buffer width of occurrence is > 200 m	**A**
Average buffer width is 100 – 199 m	**B**
Average buffer width is 50 – 99 m	**C**
Average buffer width is < 49 m	**D**

1c. Buffer Condition	
Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND little or no trash or refuse.	**A**
Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils, moderate or lesser amounts of trash or refuse, OR minor intensity of human visitation or recreation.	**B**
Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption, moderate or greater amounts of trash or refuse, OR moderate intensity of human visitation or recreation.	**C**
Dominant (>50%) cover of non-native plants, barren ground and highly compacted or otherwise disrupted soils, moderate or greater amounts of trash or refuse, moderate or greater intensity of human visitation or recreation, OR no buffer at all.	**D**

1d. Adjacent Land Use (100 m Buffer)	
Land Use Score ≥95	**A**
Land Use Score = 80 to <95	**B**
Land Use Score = 40 to <80	**C**
Land Use Score <40	**D**

1e. Onsite Land Use (Assessment Area)	
Land Use Score ≥95	**A**
Land Use Score = 80 to <95	**B**
Land Use Score = 40 to <80	**C**
Land Use Score <40	**D**

Land Use Categories	**Coefficient**	**100 m Buffer**		**Assessment Area**	
		% Area	**Score**	**% Area**	**Score**
Paved roads / parking lots	0.00				
Domestic or commercially developed buildings	0.00				
Gravel pit operation	0.00				
Unpaved Roads (e.g., driveway, tractor trail, 4-wheel drive roads)	0.10				
Mining (other than gravel mining)	0.10				
Agriculture (tilled crop production)	0.20				
Heavy grazing by livestock	0.30				
Intense recreation (ATV use / camping / popular fishing spot, etc.)	0.30				
Logging or tree removal with 50-75% of trees >50 cm dbh removed	0.40				
Hayed pasture	0.50				
Moderate grazing	0.60				
Moderate recreation (high-use trail)	0.70				

Selective logging or tree removal with <50% of trees >50 cm dbh removed	0.80				
Light grazing	0.90				
Light recreation (low-use trail)	0.90				
Fallow with no history of grazing or other human use in past 10 yrs	0.95				
Natural area / land managed for native vegetation	1.00				
Total Land Use Score					

2. Biotic & Abiotic Condition – Circle the applicable letter score

1d. Buffer Length	
Buffer is > 75 – 100% of occurrence perimeter.	**A**
Buffer is > 50 – 74% of occurrence perimeter.	**B**
Buffer is 25 – 49% of occurrence perimeter.	**C**
Buffer is < 25% of occurrence perimeter.	**D**

2a. Cover Native Plant Species	
Cover of native plants = 100%.	**A**
Cover of native plants 90 to <100%.	**B**
Cover of native plants 50 to <90%.	**C**
Cover of native plants <50%.	**D**

2b. Cover Invasive Species	
None present.	**A**
Invasive species present, but sporadic (<3% cover).	**B**
Invasive species prevalent (3–10% absolute cover).	**C**
Invasive species abundant (>10% absolute cover).	**D**

2c. Cattail, Phragmites, Phalaris Dominance	
Typha, *Phragmites*, or *Phalaris* absent OR occupy <10% of the wetland.	**A**
Typha, *Phragmites*, or *Phalaris* occupy 10–25% of the wetland.	**B**
Typha, *Phragmites*, or *Phalaris* occupy 25–75% of the wetland.	**C**
Typha, *Phragmites*, or *Phalaris* occupy >75% of the wetland.	**D**

2e. Vegetation Structure **RIPARIAN**	
Average tree cover generally > 25%; mixed age	**A**
Largely heterogeneous in age or size; some gaps and variation in tree sizes AND overall density moderate and greater than 25% tree cover.	**B**
Somewhat homogeneous in density and age, AND canopy cover >90% OR <25%	**C**
Canopy extremely homogeneous, sparse, or absent (<10% cover).	**D**

2f. Native Sapling and Seedling **RIPARIAN**	
Saplings and/or seedlings present in expected amounts; obvious regeneration;	**A**
Saplings and/or seedlings present but less than expected	**B**
Saplings and/or seedling present but low amounts; little regeneration	**C**
No reproduction of woody species.	**D**

2g. Vegetation Composition	
Species diversity/abundance at or near reference standard condition in species present and their proportions. Native species sensitive to anthropogenic degradation are present, functional groups indicative of anthropogenic disturbance (ruderal or “weedy” species) are absent to minor, and full range of diagnostic / indicator species are present.	**A**
Species diversity/abundance close to reference standard condition. Some native species reflective of past anthropogenic degradation present. Some indicator/ diagnostic species may be absent.	**B**
Species diversity/abundance is different from reference standard condition in, but still largely composed of native species characteristic of the type. This may include ruderal (“weedy”) species. Many indicator/diagnostic species may be absent.	**C**
Vegetation severely altered from reference standard. Expected strata are absent or	**D**

2h. Biotic and Abiotic Patch Richness	
Vernal Pools/Playas ≥9 patch types Vernal Pool Systems ≥6 Marshes ≥6 Riparian ≥13	**A**
Vernal Pools/Playas ≥5-8 Vernal Pool Systems ≥4-5 Marshes ≥4-5 Riparian ≥9-12	**B**
Vernal Pools/Playas ≥2-4 Vernal Pool Systems ≥2-3 Marshes ≥2-3 Riparian ≥4-8	**C**
<2 patch types present (<4 for riparian areas)	**D**

2i. Interspersion of Patches	
Complex array of patches with no single dominant patch type.	**A**
Moderate array of patches with no single dominant patch type.	**B**
Simple array of patches.	**C**
One dominant patch type	**D**

dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species. Most or all indicator/diagnostic species are absent.	

Patch Codes:

2j. Cryptogamic Crust Cover **VERNAL POOL**	
intact, >80% of interspace; high diversity	**A**
well-developed, >60% of interspace; diverse (at least 3-4 species);	**B**
>30% cover of interspace (monotypic early-successional moss may be abundant); diversity low; lichens low percent cover	**C**
degraded or absent , <30% cover of interspace; crust often low diversity	**D**

2k. Cover of Increasers	
Absent or incidental	**A**
Present; <10% total cover and <20% relative dominance in the herb layer;	**B**
Common; <20% total cover and <30% relative dominance in the herb layer;	**C**
Dominant; >20% total cover and >30% relative dominance in the herb layer;	**D**

3a. Water Source	
Source is natural or naturally lacks water in the growing season. No indication of direct artificial water sources	**A**
Source is mostly natural, but site directly receives occasional or small amounts of inflow from anthropogenic sources	**B**
Source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology	**C**
Water flow has been substantially diminished by human activity	**D**

3b. Hydroperiod **NON-RIPARIAN**	
Natural patterns of filling/inundation and drying or drawdown.	**A**
Filling/inundation is of > magnitude and <or > duration than natural conditions, but site naturally drawdowns or dries.	**B**
Filling/inundation under natural conditions but subject to more rapid or extreme drawdown or drying,; OR Vice Versa	**C**
Both the filling/inundation and drawdown/drying deviate (< or>) from natural conditions	**D**

3c. Channel Stability **RIPARIAN**	
Natural channel; no evidence of severe aggradation or degradation	**A**
Most of the channel has some aggradation or degradation, none of which is severe	**B**
Evidence of severe aggradation or degradation of most of the channel	**C**
Concrete, or artificially hardened, channels through most of the site	**D**

3d. Hydrological Connectivity **NONRIPARIAN**	
No obstructions to the lateral movement of water.	**A**
Lateral movement is partially restricted; but < 25% of the site is restricted by barriers to drainage back to wetland.	**B**
Lateral movement is partially restricted; **and** 25-75% of the site is restricted by barriers to drainage back to wetland.	**C**
Essentially no hydrologic connection to uplands. Most water stages contained, or > 75% of wetland is restricted by barriers to drainage back to wetland.	**D**

3e. Floodplain Interaction	
Completely connected to floodplain; No geomorphic modifications made to contemporary floodplain.	**A**
Minimally disconnected from floodplain; Up to 25% of streambanks are affected.	**B**
Moderately disconnected from floodplain due to multiple geomorphic modifications; 25 – 75% of streambanks are affected.	**C**
Extensively disconnected from floodplain; > 75% of streambanks are affected.	**D**

3f. Substrate / Soil Disturbance	
Bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails.	**A**
Some bare soil due to human causes but the extent and impact is minimal. The depth of disturbance is limited to only a few inches and does not show evidence of ponding or channeling water.	**B**
Bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts.	**C**
Bare soil areas substantially & contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded.	**D**

3g. Water Quality	
No evidence of degraded water quality. Water is clear; no strong green tint or sheen.	**A**
Some negative water quality indicators are present, but limited to small and localized areas. Water may have a minimal greenish tint or cloudiness, or sheen.	**B**
Negative indicators or wetland species that respond to high nutrient levels are common. Water may have a moderate greenish tint, sheen or other turbidity with common algae.	**C**
Widespread evidence of negative indicators. Algae mats may be extensive. Water may have a strong greenish tint, sheen or turbidity. Bottom difficult to see during due to surface algal mats and other vegetation blocking light to the bottom.	**D**

3. Size – Circle the applicable letter score

4a. Patch Size	
Very large compared to other examples of the same type (e.g., top 10% based on known and historic occurrences, or area-sensitive indicator species very abundant within occurrence).	**A**
Large compared to other examples of the same type (e.g. within 10-30%, based on known and historic occurrences, or most area-sensitive indicator species moderately abundant within occurrence).	**B**
Moderate compared to other examples of the same type, (e.g., within 30-70% of known or historic sizes; or many area-sensitive indicator species are able to sustain a minimally viable population, or many characteristic species are sparse but present).	**C**
Too small to sustain full diversity and full function of the type. (e.g., smallest 30% of known or historic occurrences, or both key area-sensitive indicator species and characteristic species are sparse to absent).	**D**

4b. Relative Patch Size	
Occurrence is at, or only minimally reduced from, its full original, natural extent (<95%), and has not been artificially reduced in size.	**A**
Occurrence is only modestly reduced from its original natural extent (80-95% or more).	**B**
Occurrence is substantially reduced from its original, natural extent (50-80%).	**C**
Occurrence is heavily reduced from its original, natural extent (>50%).	**D**

Other?	

LANDSCAPE CONTEXT STRESSORS CHECKLIST	Scope	Severity	Impact
Urban residential			
Industrial/commercial			
Military training/Air traffic			
Transportation corridor (paved roads, highways)			
Dryland farming			
Intensive row-crop agriculture			
CRP			
Orchards/nurseries			
Dairies			
Commercial feedlots (high density livestock)			
Ranching, moderate density livestock (enclosed livestock grazing or horse paddock)			
Rangeland, low density livestock (livestock rangeland also managed for native vegetation)			
Sports fields and urban parklands (golf courses, soccer fields, etc.)			
Passive recreation (bird-watching, hiking, etc.)			
Active recreation (off-road vehicles, mountain biking, hunting, fishing)			
Physical resource extraction, mining, quarrying (rock, sediment, oil/gas)			
Biological resource extraction (aquaculture, commercial fisheries, horticultural and medical plant collecting)			
Lack of appropriate treatment of invasive plant species in surrounding area			
Overall Landscape Context Stressor Impact			
Comments			
VEGETATION (BIOTA) STRESSORS CHECKLIST	**Scope**	**Severity**	**Impact**
Mowing, grazing, excessive herbivory (within occurrence)			
Excessive human visitation			
Predation and habitat destruction by non-native vertebrates, including feral introduced naturalized species, such as feral livestock, exotic game animals, pet predators (e.g., Virginia possum, oryx, pigs, goats, burros, cats, dogs).			
Tree / sapling or shrub removal (cutting, chaining, cabling, herbiciding)			
Removal of woody debris			
Lack of appropriate treatment of invasive plant species in the area			
Damage caused by treatment of non-native and nuisance plant species			

Pesticide application or vector control			
Lack of fire or too frequent fire			
Lack of floods or excessive floods for riparian areas			
Biological resource extraction or stocking (e.g., aquaculture, commercial fisheries, horticultural and medical plant collecting)			
Excessive organic debris (for recently logged sites)			
Other lack of vegetation management to conserve natural resources [please specify]			
Overall Vegetation (Biota) Stressor Impact			
Comments			
SOIL (& SUBSTRATE) STRESSORS CHECKLIST	**Scope**	**Severity**	**Impact**
Filling or dumping of sediment or soils **(N/A for restoration areas)**			
Grading/ compaction **(N/A for restoration areas)**			
Plowing/Discing **(N/A for restoration areas)**			
Resource extraction (sediment, gravel, mineral, oil and/or gas)			
Impact of vegetation management on soils /substrate (e.g., terracing, pitting, drilling seed, chaining, root plowing)			
Excessive sediment or organic debris (e.g. excessive erosion, gullying, slope failure)			
Physical disturbance of soil / substrate by recreational vehicle tracks, livestock, logger skidding, etc.			
Pesticides or toxic chemicals (PS or Non-PS pollution) (on-site evidence)			
Trash or refuse dumping			
Overall Soil / Substrate Stressor Impact			
Comments			
HYDROLOGY STRESSORS CHECKLIST	**Scope**	**Severity**	**Impact**
Point Source (PS) Discharges (POTW, other non-stormwater discharge)			
Non-point Source (Non-PS) Discharges (urban runoff, farm drainage on to site)			
Flow diversions or unnatural inflows (restrictions and augmentations)			
Dams (reservoirs, detention basins, recharge basins)			
Flow obstructions (culverts, paved stream crossings)			
Weir/drop structure, tide gates			
Dredged inlet/channel			
Engineered channel (riprap, armored channel bank, bed)			
Dike/levees			

Groundwater extraction (water table lowered)			
Ditches (borrow, agricultural drainage, mosquito control, etc.)			
Actively managed hydrology (e.g. lake levels controlled)			
Overall Hydrology Stressor Impact			
Comments			

Threat Scope (typically assessed within a 10-year time frame)
Pervasive = Affects all or most (71-100%) of total occurrence
Large = Affects much (31-70%) of the total occurrence
Restricted = Affects some (11-30%) of the total occurrence
Small = Affects a small (1-10%) proportion of the total occurrence
Threat Severity (within the scope. *Assessed within max of 10 yrs)*
Extreme = likely to extremely degrade/destroy or eliminate occurrence (71-100%)
Serious = likely to seriously degrade/reduce occurrence (31-70%)
Moderate = likely to moderately degrade/reduce occurrence (11-30%)
Slight = likely to only slightly degrade/reduce occurrence (1-10%)

Threat Impact Calculation		**Scope**			
		Pervasive	Large	Restricted	Small
Severity	Extreme	Very High	High	Medium	Low
	Serious	High	High	Medium	Low
	Moderate	Medium	Medium	Low	Low
	Slight	Low	Low	Low	Low

Threat Impact
A = Very High
B = High
C = Medium
D = Low

Guidelines for assigning an overall impact value.

Impact Values of Stressor Categories	**OVERALL THREAT IMPACT**
1 or more Very High, OR 2 or more High, OR 1 High + 2 or more Medium	**Very High**
1 High, OR 3 or more Medium, *OR* 2 Medium + 2 Low, *OR* 1 Medium + 3 or more Low	**High**
1 Medium, or 4 or more Low	**Medium**
1 to 3 Low	**Low**

Key to Likelihood of GW Dependence

Read in order in which indicators are presented.

Wetland Indicators	Likelihood	Riverine Indicators	Likelihood	Lake Indicators	Likelihood
Wetland is seasonal	Low	Not a perennial stream	Low	Lake located on hardpan soils OR on relatively impermeable geologic deposits	Low
Wetland occurs at slope break OR intersection of a confined aquifer with a slope OR stratigraphic change	High	Springs are present in the drainage near the stream AND summer precipitation is not a significant source of water	High	Springs visibly discharge into the lake OR sections of the lake are ice-free in winter	High
Wetland is associated with a seep/spring	High	Snowfields or glaciers are NOT present in the headwaters AND summer precipitation is NOT a significant source of water	High	Lake is located high in the watershed (headwaters)	High (local inputs)
Wetland lacks surface flow indicators	High	NONE OF THE ABOVE	Low	Lake is NOT located high (headwaters area) in the watershed	High (local and regional inputs
Soils are organic; either muck or peat	High			NONE OF THE ABOVE	Low
Wetland remains saturated after surface inputs become dry & extended periods of no precipitation AND soils are clay, hardpan, or impermeable	High				
NONE OF THE ABOVE	Low				

APPENDIX B - ECOLOGICAL CHARACTERISTICS OF SURVEYED WETLANDS

Site ID	Date Visited	Ecological System	HGM Class	Cowardin System	Elevation	LAT	LONG	Hydrological Regime	Drainage Class	Groundwater Dependence	Salinity
09FJR01	5/18/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	698.2	47.927	119.352	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR02	5/19/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	739.4	48.022	119.251	Semi-permanently flooded	Poorly drained	High likelihood	Slightly Saline/ Alkaline
09FJR03	5/19/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	736.8	48.021	119.247	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR04	5/19/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	694.3	48.018	119.273	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR05	5/19/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	701.7	48.014	119.275	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR06	5/20/2009	Inter-Mountain Basin Playa	Depression	Palustrine	722.2	48.013	119.261	Intermittently flooded	Poorly drained	Low likelihood	Saline
09FJR07	5/20/2009	Inter-Mountain Basin Playa	Depression	Palustrine	717.6	48.013	119.261	Intermittently flooded	Poorly drained	Low likelihood	Saline

Site ID	Date Visited	Ecological System	HGM Class	Cowardin System	Elevation	LAT	LONG	Hydrological Regime	Drainage Class	Groundwater Dependence	Salinity
09FJR08	5/20/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	726.8	48.015	119.264	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR09	5/20/2009	North American Arid Freshwater Marsh	Depression	Palustrine	720.1	48.016	119.267	Semi-permanently flooded	Poorly drained	High likelihood	Fresh
09FJR10	5/21/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	722.2	48.010	119.267	Intermittently flooded	Somewhat poorly drained	Uknown	Fresh
09FJR11	5/21/2009	North American Arid Freshwater Marsh	Depression	Palustrine	719.3	48.010	119.250	Semi-permanently flooded	Poorly drained	High likelihood	Slightly Saline/ Alkaline
09FJR12	6/2/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	676.7	48.009	119.360	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR13	6/3/2009	Columbia Plateau Wet Meadow (Provisional)	Riverine	Palustrine	694.9	47.953	119.312	Intermittently flooded	Moderately well drained	Low likelihood	Fresh
09FJR14	6/3/2009	Columbia Plateau Vernal Pool	Depression	Palustrine	707.1	47.953	119.309	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR15	6/4/2009	Inter-Mountain Basin Alkaline Closed	Depression	Palustrine	757.3	48.010	119.207	Semi-permanently flooded	Very poorly drained	Low likelihood	Slightly Saline/ Alkaline

Site ID	Date Visited	Ecological System	HGM Class	Cowardin System	Elevation	LAT	LONG	Hydrological Regime	Drainage Class	Groundwater Dependence	Salinity
		Depression									
09FJR16	6/4/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	773.8	48.013	119.206	Intermittently flooded	Somewhat poorly drained	Low likelihood	Fresh
09FJR17	6/4/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	773.1	48.020	119.216	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR18	6/4/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	783.5	48.018	119.207	Intermittently flooded	Poorly drained	Low likelihood	Fresh
09FJR19	6/16/2009	Columbia Plateau Vernal Pool	Depression	Palustrine	768.9	47.965	119.239	Intermittently flooded	Somewhat poorly drained	Low likelihood	Fresh
09FJR20	6/16/2009	Inter-Mountain Basin Playa	Depression	Palustrine	754.9	47.973	119.239	Intermittently flooded	Poorly drained	Low likelihood	Saline
09FJR21	6/16/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	764.9	47.972	119.243	Intermittently flooded	Somewhat poorly drained	Low likelihood	Fresh
09FJR22	6/16/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	750.2	47.975	119.249	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline

Site ID	Date Visited	Ecological System	HGM Class	Cowardin System	Elevation	LAT	LONG	Hydrological Regime	Drainage Class	Groundwater Dependence	Salinity
09FJR23	6/16/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	745.4	47.973	119.251	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR24	6/16/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	746.2	47.972	119.255	Intermittently flooded	Poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR25	6/17/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	736.4	47.933	119.246	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR26	6/17/2009	Inter-Mountain Basin Playa	Depression	Palustrine	735.4	47.936	119.254	Intermittently flooded	Poorly drained	Low likelihood	Saline
09FJR27	6/17/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	743.3	47.940	119.254	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR28	6/17/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	746.1	47.943	119.240	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR29	6/17/2009	Columbia Plateau Vernal Pool	Depression	Palustrine	746.5	47.941	119.241	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR31	6/17/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	747.3	47.946	119.238	Intermittently flooded	Poorly drained	Low likelihood	Fresh

Site ID	Date Visited	Ecological System	HGM Class	Cowardin System	Elevation	LAT	LONG	Hydrological Regime	Drainage Class	Groundwater Dependence	Salinity
09FJR32	6/18/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	693.4	47.992	119.357	Intermittently flooded	Poorly drained	Uknown	Slightly Saline/ Alkaline
09FJR33	6/18/2009	Inter-Mountain Basin Playa	Depression	Palustrine	648.5	47.965	119.363	Semi-permanently flooded	Poorly drained	High likelihood	Saline
09FJR34	6/19/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	696.9	47.950	119.336	Intermittently flooded	Moderately well drained	Low likelihood	Fresh
09FJR35	6/19/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	694.1	47.954	119.328	Intermittently flooded	Poorly drained	Low likelihood	Saline
09FJR36	6/19/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	701.2	47.930	119.304	Intermittently flooded	Somewhat poorly drained	High likelihood	Slightly Saline/ Alkaline
09FJR37	6/19/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	700	47.924	119.303	Intermittently flooded	Poorly drained	Low likelihood	Fresh
09FJR38	6/3/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	744.8	47.965	119.246	Intermittently flooded	Somewhat poorly drained	High likelihood	Slightly Saline/ Alkaline
09FJR39	7/13/2009	Columbia Plateau Wet Meadow	Depression	Palustrine	699	47.924	119.303	Intermittently flooded	Poorly drained	Low likelihood	Saline

Site ID	Date Visited	Ecological System	HGM Class	Cowardin System	Elevation	LAT	LONG	Hydrological Regime	Drainage Class	Groundwater Dependence	Salinity
		(Provisional)									
09FJR40	7/14/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	761.9	48.036	119.208	Intermittently flooded	Poorly drained	High likelihood	Saline
09FJR41	7/14/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	731.5	48.010	119.228	Semi-permanently flooded	Poorly drained	High likelihood	Saline
09FJR42	7/14/2009	Columbia Plateau Wet Meadow (Provisional)	Riverine	Palustrine	753.7	48.012	119.223	Intermittently flooded	Moderately well drained	Low likelihood	Slightly Saline/ Alkaline
09FJR43	7/14/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	788.7	48.022	119.204	Intermittently flooded	Poorly drained	Uknown	Saline
09FJR44	7/15/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	696.5	47.998	119.296	Semi-permanently flooded	Poorly drained	High likelihood	Slightly Saline/ Alkaline
09FJR45	7/14/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	695.6	47.999	119.284	Intermittently flooded	Poorly drained	Low likelihood	Saline

Site ID	Date Visited	Ecological System	HGM Class	Cowardin System	Elevation	LAT	LONG	Hydrological Regime	Drainage Class	Groundwater Dependence	Salinity
09FJR46	7/15/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	707.5	47.992	119.297	Intermittently flooded	Moderately well drained	Low likelihood	Fresh
09FJR47	7/15/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Palustrine	697.6	48.000	119.281	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR48	7/15/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	745.3	48.029	119.262	Intermittently flooded	Moderately well drained	Low likelihood	Fresh
09FJR49	7/15/2009	Inter-Mountain Basin Alkaline Closed Depression	Depression	Lacustrine	698.2	48.020	119.270	Intermittently flooded	Somewhat poorly drained	Low likelihood	Slightly Saline/ Alkaline
09FJR50	7/14/2009	North American Arid Freshwater Marsh	Depression	Palustrine	703.4	47.982	119.321	Semi-permanently flooded	Poorly drained	High likelihood	Fresh
09FJR51	7/15/2009	North American Arid Freshwater Marsh	Depression	Palustrine	703.9	47.963	119.319	Intermittently flooded	Poorly drained	Low likelihood	Fresh
09FJR52	7/16/2009	Inter-Mountain Basin Playa	Depression	Palustrine	675.6	47.967	119.343	Temporarily flooded	Poorly drained	Low likelihood	Saline
09FJR53	7/15/2009	Columbia Plateau Wet Meadow (Provisional)	Depression	Palustrine	696.2	47.963	119.326	Intermittently flooded	Moderately well drained	Low likelihood	Fresh

Appendix C - Microsoft Access Database

Database contains all the raw data collected for the project. For table descriptions, right-click a table and choose table properties and the description will be visible.

Appendix D - GIS Files

GIS files included are:

(1) "Wetland Mapped by UW" – entire set of polygons mapped by the University of Washington throughout the project area; also includes attributes information about which of these polygons are linked to surveyed wetlands and reconnaissance points.
(2) Randomly Selected Wetlands – displays the 75 sites randomly selected from the University of Washington Wetland Map of the Pilot Assessment Area.
(3) "Surveyed Wetlands" –
(4) "Reconnaissance Points" – a comprehensive list of wetlands surveyed as reconnaissance points (i.e., it includes reconnaissance points mapped and not mapped by UW)

Appendix E - Photographs

Photographs accompanied this report in a separate file. Images are organized by Site ID.