Wetland Profile and Condition Assessment of the Laramie Plains Wetland Complex, Wyoming

FINAL REPORT

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EXECUTIVE SUMMARY

This report summarizes results of the first basin-wide assessment of wetlands in the Laramie Plains Wetland Complex (LPWC). The study was based on a rigorous field survey protocol applied within a robust sample of randomly-selected sites. The four objectives were: [1] create a landscape level wetland profile of the LPWC; [2] conduct a statistically valid, field-based assessment of wetland condition, [3] model the distribution of wetland conditions throughout the basin, and [4] determine key wetland habitat features and resources important to wetland-dependent wildlife species.

The landscape profile results show the importance of understanding linkages between land use, irrigation practices and wetlands in the LPWC. Wetlands comprise a third of the irrigated landscape. Over 60% of freshwater emergent wetlands, the most common type, are mapped as irrigated. Over 80% of wetlands are privately owned. Coordination with private landowners is essential to maintain the ecological integrity of wetland resources throughout the LPWC.

We developed a multi-level approach to estimate wetland condition within the LPWC. Ecological Integrity Assessment (EIA) methods were supplemented by measurements of anthropogenic and hydrologic disturbance, baseline characteristics of wetland vegetative communities, and hydrologic alteration. Level 2 wetland condition assessments using EIA methods were developed to measure the condition of wetlands in the basin. Metric scores can be used to convey a general overview of the condition of wetlands and to determine where there are large differences in conditions. A and B ranked wetlands indicate high potential for ecological integrity and conservation value. Management of these wetlands should focus on the prevention of further alteration. Lower-ranking wetlands have disturbance across multiple EIA metrics indicating that management would be needed to maintain or restore ecological attributes.

The four wetland subgroups identified within our sample frame were: riparian woodland and shrubland; emergent marsh; wet meadow; and playa and saline depressions. Our study found that all ecological subgroupings were dominated by B-ranked (slightly impacted) wetlands, meaning there was evidence of low levels of disturbance and a slight deviation from reference condition. We estimate 2% of wetlands were A-ranked (no or minimal impact), 67% B-ranked (slight impact), 27% C-ranked (moderate impact) and 4% D-ranked (significant impact). We used cumulative distribution function projections to extrapolate our results to the wetland population within the LPWC. Those extrapolations indicate 3% of wetlands in the LPWC are A-ranked, 67% B-ranked, 25% C-ranked and 5% D-ranked. These results closely resemble the results obtained from sampled wetlands and indicate approximately 30% of wetlands in the basin are moderately to significantly disturbed.

We collected data documenting stressors that may influence EIA attribute condition. Correlations between wetland condition and potential stresses can be used to direct management efforts. The most widespread disturbances (stressors) identified in our study were grazing by domestic and native herbivores and modified hydrology due to the presence of pumps, ditches, and diversions. Land management policies that discourage further human disturbance and encourage sustainable grazing management in and near wetlands will help to maintain wetland function and prevent further declines in condition.

Our results point to the challenge of quantitatively assessing ecological condition of wetlands in irrigated basins because many wetlands, regardless of ecological integrity, are influenced by hydrologic alterations. We developed a Landscape Hydrology Metric (LHM) that identified modified hydrology at 83% of sampled wetlands. Although irrigation and related agricultural activities are generally considered disturbance factors, water availability of many wetlands is also enhanced by these anthropogenic activities, especially in arid regions. Hydroperiod of many wetland basins is extended by nearby irrigation and other wetlands exist solely as a byproduct of irrigation runoff or seepage. These types of created and modified wetlands can be highly valuable habitat.

Our avian surveys confirmed *at least* 123 bird species are utilizing wetland habitat in the LPWC. Higher relative diversity of plant species was generally correlated with higher bird diversity. Although wet meadows consistently received lower EIA and LHM scores, bird diversity and abundance were generally higher. Wetlands influenced by hydrologic alterations, including inputs of water from flood irrigation and ditches, provide a stable water source and adequate habitat for wetland birds during dry summer months. These irrigation-induced wetlands have become critically important avian habitat within an otherwise arid region. Conversions from flood irrigation to center pivot irrigation and lined ditches could reduce runoff from return flows and lower groundwater levels, thereby decreasing the area of irrigation-supported or created wetlands.

The ecological challenges of conserving and managing hybrid and novel ecosystems are increasingly recognized. This recognition represents a shift from the traditional paradigm that pristine landscapes have the highest ecological value – wetlands within working landscapes do have their own intrinsic values. The wetland systems we studied constitute a novel or hybrid system resulting from anthropogenic alterations within the LPWC landscape. Understanding the functionality of entire landscapes, including the spectrum of historic to hydrologically influenced wetlands, will be necessary for effective decision-making and management of these novel systems. Traditional EIA metrics are biased in their assumption that anthropogenic disturbance is always equated with diminished condition and function. Recognizing this broad assumption may not necessarily hold true everywhere (e.g., on arid landscapes modified by agricultural irrigation), we included LHM, Mean C, and avian richness metrics in our analysis to better understand interactions and interrelationships between hydrology and habitat value.

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This study would not be possible without the permission granted by public land managers and private landowners to access wetlands on their lands. We extend our gratitude to landowners for their support of this project.

1.0 INTRODUCTION

Freshwater wetland ecosystems are highly diverse, productive transitional habitats between aquatic and terrestrial ecosystems. Wetlands provide many vital ecosystem services including flood attenuation, stream flow maintenance, aquifer recharge, sediment retention, water quality improvement, production of food and goods for human use, and maintenance of biodiversity. The global economic value of ecosystem services provided by wetlands is estimated to be higher than that of lakes, streams, forests, and grasslands and second only to services provided by coastal ecosystems (Costanza et al. 1997). Wetland ecosystems support critical habitat for wildlife – more than a third of species listed as threatened or endangered in the United States live solely in wetlands and almost half use wetlands at some point in their life cycle (U.S. EPA 1995). In the Intermountain West, more than 140 bird species, 30 mammals, 36 amphibians, and 30 reptiles are either dependent on or associated with wetlands (Gammonley 2004). Approximately 90% of the wildlife species in Wyoming use wetland and riparian habitats daily or seasonally during their life cycle, and about 70% of Wyoming bird species are considered wetland or riparian habitat obligates (Nicholoff 2003).

Wetlands provide a host of ecosystem services, but remain highly threatened and subjected to pressures from many uses including agricultural, residential, and energy development. Dahl (1990) estimates 38% of wetlands that existed prior to European settlement in Wyoming were lost between 1780 and the mid-1980s. Recent studies identified wetlands as one of the habitat types most vulnerable to impacts of future development and climate change in Wyoming (Copeland et al. 2010, Pocewicz et al. 2014). In light of these threats and general lack of information about current status of wetlands in Wyoming, an evaluation of existing wetland conditions was needed to better inform conservation and management priorities.

Recent studies in Colorado (Lemly and Gilligan 2012), Montana (Newlon et al. 2013), and Wyoming (Tibbets et al. 2015) have utilized landscape profiles and rapid assessment methods (RAMs) to draw conclusions regarding the ecological integrity of wetland resources. Landscape profiles primarily utilize digital information or remote sensing data to provide a “desktop analysis” of wetlands at the landscape scale. Landscape profiles are used to quantify the distribution of resources, such as wetland types or area, and to develop strategic goals (Gwin et al. 1999). RAMs assess the condition of wetlands based on field surveys that measure abiotic and biotic indicators of ecological function and indicators of stress that have the potential to negatively impact wetlands. Together, landscape profiles and RAMs can be used to establish baseline wetland conditions, assess cumulative impacts, and prioritize protection and restoration efforts. This project was the second basin-scale wetland condition assessment within Wyoming, and builds upon a landscape profile and RAM completed within the Upper Green River Basin (Tibbets et al. 2015) as well as a previous statewide assessment (Copeland et al. 2010).

The Laramie Plains Wetland Complex (LPWC) is one of nine wetland complexes identified as a statewide conservation priority (Copeland et al. 2010) and one of eight focus areas identified by the USFWS Partners Program Strategic Plan (USFWS 2007) The LPWC is also among the 48 priority bird habitat conservation areas identified in the Intermountain West Joint Venture's (IWJV) Coordinated Implementation Plan (IWJV 2013), and a key habitat area identified in the State Wildlife Action Plan (SWAP) based on the presence of 39 vertebrate Species of Greatest Conservation Need (WGFD 2010). The LPWC provides important breeding, staging and stopover habitats for waterfowl, waterbirds, and numerous other avian species (WBHCP 2014). Based on surveys conducted from 1984-1999, the average density of duck breeding pairs within portions of the Laramie Plains complex ranked highest in the state (Wyoming Joint Ventures Steering Committee 2010).

1.1 Objectives

The four objectives of this project were: [1] create a landscape profile of the Laramie Plains Wetland Complex; [2] conduct a statistically valid, field-based assessment of wetland condition, [3] model the distribution of wetland types and their condition throughout the basin, and [4] determine key wetland habitat features and resources important to wetland-dependent wildlife inhabiting the region.

2.0 STUDY AREA

The LPWC study area is an intermountain basin located in Albany and Carbon counties in south-central Wyoming (Figure 1). The study area encompasses 947,171 acres (383,306 ha) with elevations ranging from 6,400-8000 feet. Human population estimates for Albany and Carbon counties combined totaled 52,184 (U.S. Census Bureau 2010). Land ownership within the study area is predominantly private and the dominant land use is agriculture. Principal agricultural uses are irrigated and dryland crops and native rangeland.

The basins of the Laramie and Medicine Bow rivers are the principal watersheds of the LPWC. Average annual precipitation in the study area ranges from 10-16 inches, with peak precipitation occurring in April-July (Curtis and Grimes 2004). Peak stream flows occur in May and June, corresponding with mountain snowmelt, and low flows occur in September and January (USGS 2015). Hydrology of the Laramie River is highly regulated by dams, diversions, and canals upstream and within the study area. Eight large reservoirs are located upstream or within the LPWC and have storage capacities ranging from 2,000-98,934 acre-feet. Hydrologic regulation has both eliminated and created wetlands. A 2001 study of 74 wetlands in the Laramie Basin determined that 65% of inflows were directly from flood irrigation (Peck and Lovvorn 2001). Runoff and seepage from flood irrigation of hayfields have created many temporary and permanent wetlands. Studies have indicated that changes to irrigation methods that increase irrigation efficiency would adversely affect wetland area in the LPWC (Peck and Lovvorn 2001, Peck et al. 2004)

The LPWC lies within the Wyoming Basin Level III Ecoregion (Chapman et al. 2004). Level IV ecoregions within the study area include the Laramie Basin and Rolling Sagebrush Steppe. Most of the study area is mixed-grass prairie community of blue gramma (*Bouteloua gracilis*), Indian ricegrass, western wheatgrass (*Pascopyrum smithii*), junegrass (*Koeleria macrantha*), Sandberg bluegrass (*Poa segunda*), needle-and-thread grass (*Hesperostipa comate*), fringed sage (*Artemisia frigida*), and various forb and shrub species. Upland plant communities in sagebrush steppe include Wyoming big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus sp.),* and various grass, forb, and shrub species.

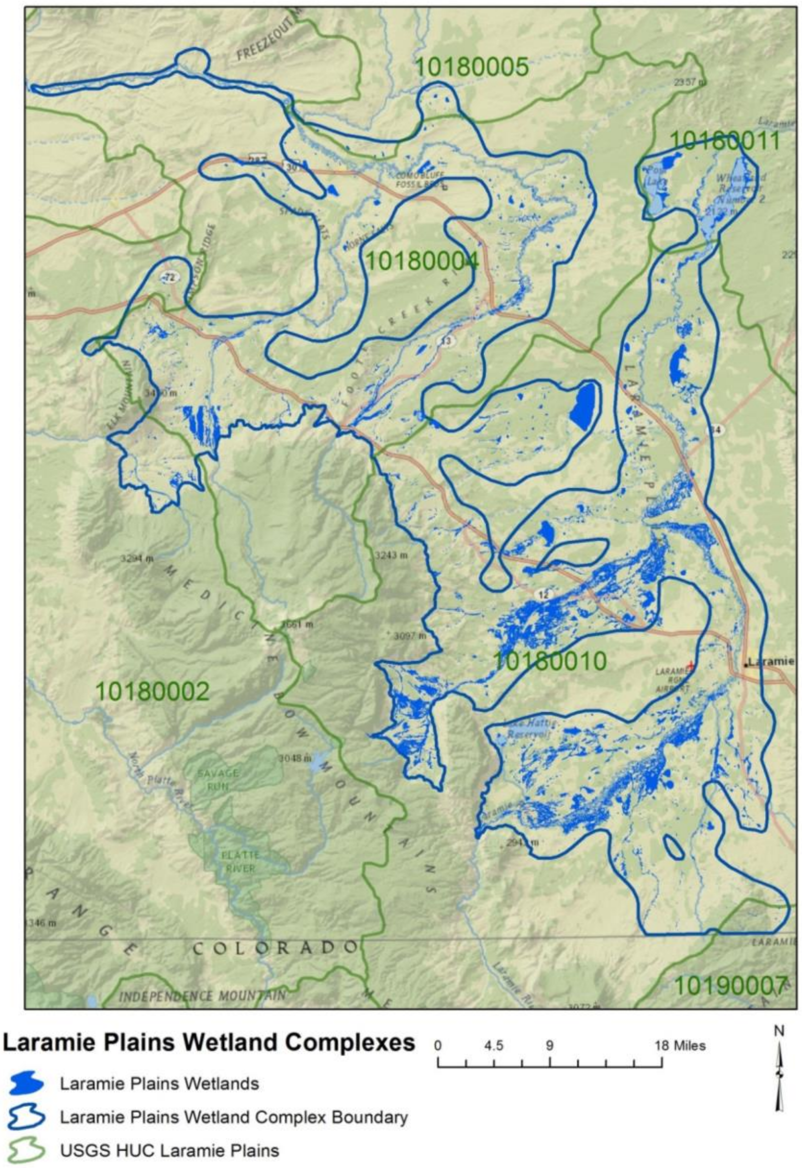

Figure 1. Laramie Plains Wetland Complex study area (HUC 8: 10180002, 10180004, 10180005, 10180010, 10180011) located in southeast Wyoming.

3.0 METHODS

3.1. Landscape Profile and Condition Assessment Framework

Landscape profiles and condition assessments can be effective methods to inventory and summarize the distribution and diversity of wetland resources, and can be used to establish baseline conditions, assess cumulative impacts to wetland condition and function, and inform the development of strategic conservation goals (Fennessy et al. 2007, Lemly and Gilligan 2012). A number of sampling methodologies have been developed in the past 15 years to monitor wetland condition at various spatial scales (US EPA Adamus 1993, DeKeyser et al. 2003, Jacobs et al. 2010, 2011, Lemly and Gilligan 2012, Vance et al. 2012). Currently, a "three-tiered" approach is recommended by the US Environmental Protection Agency (EPA), with each level increasing in the detail of data and information generated, accompanied by increasing degrees of effort, cost, and resolution:

- Level 1 assessments characterize land uses and distribution of resources such as wetland types over broad geographic areas. These assessments primarily rely on existing digital information or remote sensing data housed in Geographic Information Systems (GISs) to provide a "desktop analysis" of wetlands at the landscape scale.
- Level 2 assessments evaluate the condition of individual wetlands based on field sampling that focuses on indicators including anthropogenic disturbances, also known as stressors, which are rapid and easy to measure. Level 2 Rapid Assessment Methods (RAMs) are used throughout a number of regions in the US because they provide on-site assessments of wetland condition with comparatively limited effort (Fennessy et al. 2007). Common RAMs estimate the ecological condition of a wetland landscape by integrating metrics that focus primarily on hydrology, and on physical and biological structure. RAM metrics focus on observable stressors and disturbances known or presumed to degrade the ecological integrity of wetlands. Metric scores and stressor identification are incorporated into a wetland profile to provide information about the integrity of wetland resources within a basin.
- Level 3 assessments utilize more intensive methods that require specialized skill sets and usually a full day of measurement and data collection at each site. Example metrics include floristic quality assessments of the plant community, soil characterization, and water quality (Lemly and Gilligan 2012). Level 3 assessments are often used to provide more rigorous documentation of Level 2 assessment results and narrative ratings.

Depending on resource availability and study scope, approaches from different assessment levels may be combined to produce the required detail of data and information.

3.1.1 Ecological Integrity Assessment Framework

We assessed wetland condition using protocols from all 3 levels and based on the Ecological Integrity Assessment (EIA) framework. The overarching goal of the EIA framework is to provide a rapid, repeatable, scientifically-defensible evaluation of the ecological condition of a wetland. EIA methods were developed by NatureServe to assess the condition of wetlands across larger landscapes (Faber-Langendoen et al. 2011) and have been refined by several regional wetland programs to specifically address wetland conditions in the Intermountain West (Rocchio 2007, Lemly and Gilligan 2012, Vance et al. 2012).

We developed a Landscape Hydrology Metric (LHM), an assessment of alteration to hydrologic regime. The LHM incorporates Level 1 landscape-scale data on hydrologic alterations and water source with Level 3 field data on wetland soils.

We applied Level 2 field metrics based largely on the EIA methods developed by Lemly et al. (2012). Field indicators or metrics were evaluated at each wetland based on narrative ratings of 4 attributes: Landscape Context, Hydrologic Condition, Physicochemical Condition, and Biotic Condition. The field metrics were assumed to represent measurable qualities of a wetland ecosystem's complex ecological structure and function. Separate stressor metrics focused heavily on identifying the severity of anthropogenic disturbance or "stressors" associated with degradation of wetland ecosystems. Metric scores for each of the four attributes were combined into an overall EIA score that can be used to describe wetlands in relation to a reference condition.

Level 3 field protocols including methods for floristic quality assessments, soil characterization, and water quality were incorporated from Colorado's EIA framework (Lemly and Gilligan 2012).

3.1.2 Wildlife Habitat Assessment

We utilized two field-based methods to identify key habitat features for wetland-dependent avian species: 1) Avian Richness Evaluation Method (AREM – Adamus 1993) and 2) bird surveys. Bird surveys were carried out the year following wetland condition assessments to better understand the relationship between species diversity and wetland condition. In addition, we adapted the AREM for use in Wyoming (Adamus 1993). AREM is a Level 2 assessment of wetland habitat suitability and avian species richness. Information from the bird surveys, AREM, and other field metrics were used to link habitat quality, wetland condition, and avian biodiversity.

3.2 Landscape Profile for Laramie Plains Wetland Complex

A landscape profile was created using digital wetland mapping data available from the U.S. Fish and Wildlife Service's (USFWS) National Wetland Inventory (NWI). This digital data layer shows wetlands as polygon features, and was produced by digitizing of NWI wetland maps that were drawn in the 1970s and 1980s from aerial photographs. Additional data layers included irrigated lands and land ownership within the LPWC study area. The landscape profile describes water features throughout the study area based on the following attributes: wetland and waterbody type; hydrologic regime; extent modified/irrigated (Wyoming Wildlife Consultants 2007); and land management/ownership (Bureau of Land Management 2010). The landscape profile identifies all wetland types and waterbodies according to categories based on codes and modifiers defined by Cowardin et al. (1979). The landscape profile provides a broad description of ALL wetland and waterbody features in the LPWC, whereas a subset of NWI codes were used to identify the wetland features that make up the target population for this condition assessment (Section 3.3 or Table 1). We present information in the landscape profile for all wetland and waterbodies, and the target population to capture these differences.

3.3 Survey Design and Site Selection for Wetland Condition Assessment

3.3.1 Target Population

Our wetland target population for the condition assessment included all palustrine wetlands within the LPWC, and excluded non-wetland features such as deepwater lakes and stream channel bottoms. Palustrine wetlands can be situated shoreward of lakes or river channels, on floodplains, in locations isolated from water bodies, in depressions, or on slopes. We also set a minimum size criterion of at least 0.1 hectare and a minimum width of 10 m.

3.3.2 Sample Frame

We used the digital NWI polygon dataset to identify our sample frame (US FWS 1984). Table 1 describes the Cowardin hydrologic codes and modifiers used to define the sample frame and exclude non-wetland features from the dataset. NWI polygons that originated in the study area and extended beyond the boundary were included in the sample frame. The study area boundary was re-delineated to include these wetland polygons.

Our sample frame consists of four wetland subgroups based on Cowardin, Hydrogeomorphic (HGM), and Ecological System classes: 1) riparian woodland and shrubland; 2) freshwater emergent marsh; 3) wet meadows; and 4) playa and saline depressions. Table 1 provides a detailed description of the four wetland subgroups that were included in the study.

Table 1. Wetland subgroups classified by Cowardin, Hydrogeomorphic (HGM), and Ecological Systems used in the Laramie Plains Wetland Complex.

Wetland Subgroups	HGM Class	NWI Cowardin Class	Ecological System
Riparian Woodland and Shrubland	Riverine	PSSA/PSSAh/PSSB/PSSC/ PSSCb/PSSCh/PFO/ Any PEM Class (non-irrigated with ES Riverine)/ All special modifier = 'b' (beaver)	Western Great Plains Riparian and Floodplain
Emergent Marshes	Depression	PEMF/PEMFh/PEMFb/PEM Fd/L2ABF/L2ABFh/PABHh/ PABG/PABGh/PABF/PABFh	Open Freshwater Depression
Wet meadows (including irrigated hayfields)	Slope	PEMA/PEMAd/PEMAh/PEM B/PEMC and PEMF/PEMFh (Irrigated)	Pasture/Hay; Introduced Riparian and Wetland Vegetation
Playa and saline depressions	Depression	L2ABF/L2ABFh/L2ABG (temporary only-permanent with open water ES were removed); /L2USA/L2USAh/L2USC/L2 USCh/ PUSA/PUSAd/PUSAd/PUSA h/PUSC/PUSCd/PUSCh	Saline Depression; Aklaline Closed Depression; Intermountain Basin Playa

Sample sites were randomly selected from the sample frame by using a generalized random tessellation stratified survey design for a finite resource (Stevens and Olsen 2004, Stevens and Jensen 2007). The target sample size was 80 sites with 20 sites expected in each of the four wetland subgroups. After potential sample sites were selected, and prior to field sampling, a desktop site evaluation was performed to determine: 1) whether the presence of a wetland meeting the sample criteria was likely based on examination of aerial imagery (USDA Farm Service Agency 2009); and 2) land ownership/management status (private, state, federal). Permission was then sought to access sample sites located on private and State lands. Potential sample sites that met one of the following conditions were withdrawn from the sample:

1. Size: the wetland area did not meet the minimum area or width requirements for sampling.

2. Minimum distance: the wetland was within 500 meters of another sample location of the same subpopulation.
3. Access issues: the landowner granted permission but the point could not be safely accessed at the time of sampling.
4. Depth: the wetland exceeded the maximum depth criterion of 1 meter and the point could not be repositioned to a location that met our size criterion.
5. Hayed before sampling: all of the vegetation was cropped from the site prior to sampling, such that plant identification was not possible.
6. Not a wetland: The sample location did not contain a wetland due to mapping error, or a wetland may have been present but the location no longer met our operational definition of a wetland.

The operational definition of wetlands used in this project is based on the definition adopted by the U.S. Fish and Wildlife Service (USFWS) and used in the National Wetland Inventory (Cowardin et al. 1979):

> *"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."*

However, it is important to note that standard wetland delineation techniques are based on a different definition used by the U.S. Army Corps of Engineers (ACOE) and the Environmental Protection Agency (EPA) for regulatory purposes under Section 404 of the Federal Clean Water Act: (ACOE 2008):

> *"[Wetlands are] those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."*

The primary difference between the two definitions is the ACOE/EPA definition requires positive identification of all three wetland parameters (hydrology, vegetation, and soils), whereas the USFWS definition requires only one characteristic must be present. We used the USFWS definition of a wetland for this survey. Non-vegetated areas and deep water habitats that would be considered wetlands under the USFWS definition were excluded.

If a site was withdrawn, it was replaced with an "oversample" site from the random survey design. In addition, seven wetlands were hand-selected and sampled as potential reference sites representing "least disturbed" condition based on professional judgment of regional wildlife managers.

3.4 Field Methods

In June-August 2013, 86 wetlands (78 randomly selected and 8 reference sites) were sampled to assess ecological condition and wildlife habitat value. Field methods were based on EIA protocols developed by Lemly et al. (2012). In addition, we collected data on soils, water quality, vegetation, and avian diversity and habitat suitability to supplement the EIA protocol. These assessments required a half a day or less to complete at each site. Detailed field data forms are included in Appendix B. Bird surveys were also conducted at 46 wetland study sites in April-June 2014. Field methods are described in detail in the following sections.

3.4.1 Wetland Assessment Area (AA)

The field crew applied the EPA's National Wetland Condition Assessment methodology to identify the assessment area (AA) at each wetland site (US EPA 2011). When possible a standard 40 m radius circular AA was established. If the site configuration did not accommodate a circular AA of this size, the crew adjusted the AA to a rectangular or irregular shape of at least 1000 m^2 and 10 m wide. The AA boundary was marked with flagging to aid with data collection. A 500-m buffer was established from the perimeter of each AA. Standard descriptions of each wetland included: UTM coordinates, wetland classification, presence or signs of wildlife, and photos of the buffer and AA.

3.4.2 Ecological Integrity Assessment (EIA)

After the AA was established, each wetland was assessed based on the EIA manual and field forms adapted from Lemly et al. (2012). A copy of the field forms is included in Appendix B and the manual can be obtained on request. The principal attributes and metrics that were measured in this study are summarized in Table 2.

Table 2. EIA attributes and field metrics used for wetland assessments in the Laramie Plains Wetland Complex.

Attributes	Indicators and Metrics
Landscape Context	• Landscape Fragmentation • Buffer Extent • Buffer Width • Buffer Condition
Hydrologic Condition*	• Water Source • Hydrologic Connectivity • Alteration of Hydroperiod
Physicochemical Condition	• Water Quality • Algal Growth • Substrate/soil Disturbance
Biological Condition	• Relative Cover of Native Plant Species • Absolute Cover of Noxious Weeds • Absolute Cover of Aggressive Native Species • Mean C • Structural Complexity

*Field data for hydrology metrics were collected, however, scores for the Landscape Hydrologic Metric were used in place of the field scores for EIA scoring.

3.4.3 Plant Community

We used a plotless sample design to collect vegetation data using methods described in Lemly et al. (2012). Species searches were limited to no more than one hour at each site. Vascular plant species were identified using Dorn (2001) and regional keys including Johnston (2001), Skinner (2010), and Culver and Lemly (2013). Species names are taken from the U.S. Department of Agriculture (USDA) Plants database. Unknown plant specimens were pressed in the field and cataloged for later identification. The percent cover of each species, including that of unidentified specimens, was estimated over the entire AA.

3.4.4 Soils

We dug 2-4 soil pits within each AA. One pit was placed within each community type excluding those covered completely by water. We recorded a GPS waypoint at each soil pit and then marked the location on a map. Pits were dug to a depth of 40 cm (about 1 shovel length) when possible. The core was removed and laid next to the pit, ensuring all horizons were intact and in order. We recorded the following information about each horizon: 1) color of the matrix (based on a Munsell Soil Color Chart) and any redoximorphic concentrations (mottles and oxidized root channels) and depletions; 2) soil texture; and 3) any other specifics about the concentration of roots, the presence of gravel or cobble, or other unusual soil features. Hydric soil indicators were identified based on guidance from the Interim Regional Supplement to the Corps of

Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (2008) and the Natural Resources Conservation Service (NRCS) Field Indicators of Hydric Soils in the United States and Hydric Soil Indicators in the Mountain West (NRCS 2010).

3.4.5 Water Quality

We estimated percent cover and interspersion (patch complexity) of open water within the AA. The water depth range and average were recorded within the AA. Common water chemistry parameters (pH, salinity, conductivity, total dissolved solids and temperature) were recorded from permanent, undisturbed standing water closest to the center point of the AA.

3.4.6 Avian Richness Evaluation Method

We assessed habitat characteristics of all wetlands by completing the Avian Richness Evaluation Method (AREM) field forms (Appendix B). Habitat characteristics were assessed within a 200 m buffer surrounding the AA (Adamus 1993).

3.4.7 Bird Surveys

During April-June, 2014, a Wyoming Game and Fish Department (WGFD) biologist conducted bird surveys at 46 of the wetland study sites sampled in 2013. Data were used to estimate bird diversity and abundance. Each location was visited once in the evening and once in the morning during the breeding season. The observer walked to the center point (or close to it), noting species and numbers of all birds seen or heard for a total of 25 minutes. The observer then relocated 40 meters north, and walked in a 40-m radius around the center point noting all bird species observed. Surveys were suspended under any of the following conditions: rain, fog, or smoke impaired visibility; wind velocity exceeded 12 mph (18 mph in open regions); or cold or wet weather that inhibited bird song activity. Survey methods were adjusted in open habitats (those lacking forested vegetation structure) because birds tended to flush from afar. Surveys in open habitats were done from the best available vantage point and at varying distances that did not disturb the birds present. In a number of instances, the surveys were done from a vehicle.

3.5 Data Management

All data were entered into relational databases that were developed using Microsoft Access and/or ArcGIS 10.1 platforms. Data were then proofed to correct any errors prior to analysis. The data are housed on a TNC data server that is backed up nightly and stored off-site weekly.

3.6 Data Analysis

3.6.1. Ecological Integrity Assessment

To increase efficacy, ecological assessment metrics should provide information about the integrity of major ecological attributes in relation to a gradient of disturbance or stressors. We evaluated performance of each EIA metric based on methods used to refine aquatic condition indices (Stoddard et al. 2006, Jacobs et al. 2010, Faber-Langendoen et al. 2011). Evaluation of EIA methods and scoring was a vital step to ensure the EIA methods we selected were relevant and effective for assessing wetland condition in Wyoming. The applicable range of each metric was determined by examining histograms depicting ranges and distributions of scores. We evaluated metric redundancy by calculating Spearman's rank correlation coefficients among all metrics. None of the metrics within an attribute category were found to be highly correlated (as determined by a coefficient value of $r > 0.8$).

3.6.2. Landscape Hydrology Metric (LHM)

Hydrology is broadly characterized as the movement, distribution, timing, and quality of water across the landscape. Hydrology is the primary driver of the processes that establish and maintain wetlands, including ecological, physical, and chemical processes that sustain ecosystem functions and associated services and values to people (Mitch and Gosselink 2000). Therefore, it is important to identify alterations to the natural hydrologic regime that may affect the structure and function of a wetland. Identifying alterations to natural wetland hydrology can be a challenge because significant alterations such as major dams or ditches may not be evident during a single site visit or are located outside the 500m buffer surrounding the AA. In addition, it can be difficult to identify the water source to a wetland when it is supported or created by hydrologic alterations, such as leaky dams or canals.

We based the hydrology component of the EIA scoring formula on scores from the Landscape Hydrology Metric (LHM), an assessment of alteration to hydrologic regime. LHM incorporates landscape-level data identifying alterations to hydroperiod and water source, along with field data characterizing wetland soils. Tibbets et al. (2015) found that the LHM was more effective at identifying features potentially affecting wetland hydrology, such as ditches and small dams or impoundments compared to field site visits. Moreover, LHM scoring provides more specific information about how a wetland is influenced by anthropogenic water sources because it estimates the proportions of natural versus human-mediated water inputs. In contrast, EIA hydrology subscores combine several field RAM metrics, which eliminates the capability to categorize wetlands based on specific types of hydrologic alteration. LHM relies on descriptive criteria from submetrics to assign a categorical score from 5 to 0 (Table 3). Historic wetlands (score = 5) were defined in this study as wetlands without evidence of hydrologic alteration, whereas created wetlands (score = 0) are dependent on hydrologic alteration.

LHM Submetric 1: Hydroperiod alteration

We used high-resolution (0.3 meter) satellite imagery obtained from Digital Globe to conduct a desktop assessment of potential stressors to hydrology and hydroperiod alterations affecting each wetland AA. We recorded evidence of hydroperiod alteration such as the presence of irrigation ditches and canals, dams and berms, or points of diversion at a higher position in the watershed from each AA. Major dams or reservoirs were noted if they were located upstream or near a site. A major dam is defined as one that's located on the main-stem of a river, 50 feet tall, and having a storage capacity of at least 5,000 acre feet, or a dam of any height with a storage capacity of at least 25,000 acre feet (US ACOE 2006). Mapped GIS data from the US Geological Survey's National Hydrologic Dataset (USGS NHD high-resolution version) were used to confirm or support satellite imagery interpretations.

LHM Submetric 2: Evidence of a natural water source

We used GIS data available from USGS NHD, and satellite imagery to conduct a desktop evaluation of natural surface water sources that could influence the hydrology at each sampled site. A site was considered to have a natural water source if a permanent or intermittent stream was within 50 meters or the site was within a natural playa. We also evaluated the likelihood of groundwater influence by identifying locations where groundwater is within 20 feet from the surface based on an existing GIS model of depth to groundwater (WYDEQ 2005). The site was also considered to have a natural water source if histic soils were identified in the field.

LHM Submetric 3: Calculation of wetness

We applied the Compound Topographic Index (CTI) to identify wet areas. CTI is a steady state wetness index model available in a toolbox provided with ArcGIS 10.1 (Evans et al. 2014). The CTI is a function of both the slope and ratio of the upstream contributing area to width measured at right angle to the flow direction. CTI was derived for the entire study area based on a "filled" 30-m National elevation dataset (USGS 2009). We applied a 90m x 90m smoothing focal mean filter to the resulting CTI model and then partitioned model results into 10 equal area classes. Final CTI pixel values were assigned to sample sites (0=driest and 10=wettest).

LHM Submetric 4: Evidence of historic saturated conditions from soils data

Soil profile data were collected in the field and used to identify sites with a histic epipedon (surface organic matter $\geq$ 20 cm thick) or a histosol (organic soil, with $\geq$ 40 cm of organic matter). Presence of these organic soil layers indicates long-term saturated conditions and provides hydrologic evidence that the site historically supported wetland conditions.

LHM Scoring Criteria

Based on the LHM criteria outlined above, we identified four categories of wetland hydrology ranging from low to high degrees of alteration: historic, hybrid, supported and created. Hybrid and supported wetlands were further classified based on influence from local and basin-wide alterations including major dams and diversion structures. Wetlands were assigned to a hydrologic category and given a LHM score based on the metric criteria outlined in Table 3.

Table 3. Landscape Hydrology Metric scoring criteria.

Hydrologic Category	LHM Score	Landscape Hydrology Metric Criteria
Historic Wetland	5	No alterations to hydrology identified, natural water source or no observed natural water source but histic layer present.
Hybrid Wetland in landscape with site-level hydrologic alterations	4	Site-level hydrologic alteration, natural water source identified or no observed natural water source but histic layer present.
Hybrid Wetland in landscape with basin-wide hydrologic alterations	3	Basin-wide hydrologic alteration (major dam present) and direct hydrologic connectivity to natural water source observed. No histic layer observed.
Supported Wetland with natural water source	2	Basin-wide hydrologic alteration (major dam present), landscape position is in depression with natural water source potential, however, dominant water source is unclear due to presence of large canals. No histic layer observed.
Supported Wetland- Irrigation Dependent Depression	1	Hydrologic alteration identified, landscape position is in depression. Irrigation is likely dominant water source. No histic layer observed.
Created Wetland - Irrigation Dependent	0	Hydrologic alteration identified, no natural water source identified. Irrigation is exclusive water source. No histic layer observed.

3.6.3. Floristic Quality Assessment (FQA)

Floristic Quality Assessment (FQA) uses plant community composition as an indicator of ecological condition. The FQA method assesses the degree of human caused disturbance based on the proportion of "conservative" plants present. "Coefficients of conservatism" (C-values) are the foundation of FQA. C values range from 0 to 10 and represent an estimated probability that a plant is likely to occur in a landscape relatively unaltered from conditions that existed before European settlement (Swink and Wilhelm 1979, 1994). A C-value of 10 is assigned to plant species obligate to high-quality natural areas and having low tolerance for habitat degradation, whereas a 1 is assigned to plant species with a wide tolerance to human disturbance (Rocchio 2007). Non-native species are assigned a 0. Once C-values have been assigned for a given region or area, they can then be used to calculate a number of FQA indices such as the average C-value of a site (Mean C) and the Floristic Quality Assessment Index (FQAI) (Swink and Wilhelm 1979, 1994). Formalized C-values are not currently available for Wyoming. TNC staff developed a series of rules to assign surrogate C-values to species on the USDA list of wetland plants in Wyoming (~1500 species) based on existing C-value data from Colorado, Nebraska, the Dakotas and Montana (Appendix C).

We calculated Mean C, total species richness, and the numbers of native and non-native species based on the species lists compiled at each wetland site. Mean C is calculated by summing the C-values of the plant species found at each site, and then dividing by the number of species. We also calculated Spearman's rank correlation coefficients to evaluate relationships among FQA metrics, disturbance indices, and stressors metrics.

3.6.3. Ecological Integrity Assessment Scores

We calculated EIA scores and thresholds based on EIA methods used in Colorado (Lemly and Gilligan 2012, 2013) . Refer to Appendix D for a detailed description of scoring formulas and thresholds used to rank from A-D. Ideally, wetlands ranked "A" are in minimally disturbed condition (MDC) and represent the best approximation of naturalness or a high degree of biological integrity on the landscape (Stoddard et al. 2006). Reference wetland condition in the LPWC is defined as least disturbed condition (LDC), meaning "in the best available physical, chemical and biological habitat conditions given today's state of the landscape" (Stoddard et al. 2006). Because LDC can differ from MDC, the biological integrity of our A-ranked sites may not reflect the sites' fullest potential for biological integrity.

Cumulative distribution function (CDF) analysis was used to estimate the percent of the target population (i.e., all wetlands in the LPWC) that is less than or equal to a particular EIA score (Whittier et al. 2002). A site weight was calculated from the probability sample design to estimate the number of wetlands each sample site represented across the total target population. Percent and standard error of number of wetlands within each ranking category were calculated. We generated CDF estimates using R software package version 3.1.0 (R Development Core Team 2014) and the "spsurvey" library.

3.6.4. Assessment of Wildlife Habitat

The AREM database and models were migrated from the MS-DOS platform to Microsoft Access. Habitat indicators for 261 wetland and riparian bird species were entered. The list of birds included all species (excluding rare species) that use wetlands, riparian areas and irrigated lands in Wyoming (Orabona et al. 2012). The final list was further narrowed by considering professional opinion of WGFD nongame bird biologists (S. Patla, personal communication), regional abundance information, and checklists (WGFD 2008, Faulkner 2010). Data were analyzed using the AREM database and models for birds present during the breeding season in SE Wyoming (WGFD 2008). The model assigns "habitat suitability" scores, ranging from 0 (least suitable) to 1 (most suitable), for each species potentially present based on site-specific habitat data collected at each wetland. A bird species is included in a list of species for each site based on thresholds of habitat suitability scores defined by the AREM user. For example, if the habitat suitability threshold is set at 0.75, a bird species with a habitat suitability score of 0.65 would not be included in the list of species for consideration. Species richness estimates for the LPWC were also calculated at each wetland site based on the 0.75 threshold, because this threshold successfully predicted presence of wetland bird species on the Colorado Plateau (Adamus 1993).

4.0 RESULTS

4.1 Landscape Profile for Laramie Plains Wetland Complex

The exterior boundary of the LPWC encompasses 947,171 acres within southeastern Wyoming. All wetlands and waterbodies total 88,477 acres of the LPWC (Table 4). This figure includes non-wetland features such as deep water lakes and excavated features that comprise 4,849 acres or less than 1% of the area. The remaining 83,629 acres are comprised of wetlands, representing approximately 9% of the study area.

Freshwater emergent wetlands are the most common wetland type, totaling 65,778 acres or 79% of the wetland area within the LPWC (Table 4). Freshwater emergent wetlands include irrigated hayfields, wet meadows, and emergent vegetation zones surrounding more permanent water features such as rivers and ponds. Lakes are the second most common wetland type, totaling 7,439 acres or 9% of the wetland area. Wetlands mapped as lakes include freshwater emergent zones along permanent water sources or intermittently flooded playas. Shrub wetlands are the third most common type, representing 7% of the wetland area. Many shrub wetlands are distributed along river floodplains or are associated with beaver activity.

Seasonally and temporarily flooded wetlands are the two most common hydrologic regimes in the study area (Table 5). Seasonally flooded wetlands account for 25% of the wetland area. Seasonally flooded wetlands hold surface water for extended periods during the growing season, but are dry by the end of the growing season in most years. They include wetlands with hydrology dependent on alluvial groundwater and seasonal flooding along rivers and streams. Temporarily flooded wetlands hold surface water for shorter periods during the growing season. Temporarily flooded wetlands account for 68% of the wetland area. Semi-permanently flooded water bodies, such as playa lakes and riverine oxbows, total 9,107 acres or 6% of the wetland area.

Water bodies influenced by man-made and natural alterations are identified by modifier codes on NWI maps. No modifier codes are identified for over 93% of mapped wetlands in the LPWC (Table 6). Approximately 900 acres of wetlands are influenced by beaver activity.   These consist predominantly of freshwater emergent wetlands and ponds. Impoundments and dikes are the most prevalent anthropogenic modifications and influence over 5% of the wetland area. Approximately 230 acres of excavated features are also present in the LPWC.

Irrigation was not explicitly identified as a wetland modifier in the NWI mapping codes, even though much of land within the LPWC is irrigated for agricultural production. Fourteen percent (136,016 acres) of the LPWC study area is mapped as irrigated land (Wyoming Wildlife Consultants 2007) (Table 8). Thirty-three percent (41,757 acres) of the irrigated lands are mapped as wetlands (Table 7). Over 96% of freshwater emergent wetlands do not have modifier codes indicating alteration (Table 6), but over 61% (41,757 acres) are within irrigated lands (Tables 7). In addition, 20% (1,126 acres) of the shrub wetlands receives irrigation inputs (Table

7). Freshwater emergent and shrub wetlands often occur in floodplains where hay production and cattle grazing are the dominant land uses.

Seventy-nine percent (752,391 acres) of the LPWC study area is private (Fig. 2). The majority of wetlands and water bodies are located on private lands (Table 8). Approximately 16% of private lands are irrigated and contain over 83% of the wetland area. Approximately 7% and 10% of the study area consist of lands administered by the State of Wyoming (State) and Bureau of Land management (BLM), respectively. The Wyoming Game and Fish Commission, U.S. Forest Service, U.S. Fish and Wildlife Service, and Bureau of Reclamation collectively manage less than 2% of the study area. The remaining 2.5% is mapped as open water (i.e., lakes, reservoirs, ponds, and rivers).

Three USFWS National Wildlife Refuges (NWRs), Bamforth, Mortenson Lake, and Hutton Lake, are located within the Laramie Plains Basin. These satellite holdings of the Arapahoe NWR Complex, headquartered in Walden, CO, contain the largest concentrations of wetlands on public lands. Bamforth NWR consists of 3 parcels totaling 1,116 acres and contains Bamforth Lake, a 550 acre playa surrounded by greasewood and alkali flats. This refuge was established to protect critical migratory bird habitat and is closed to public access. Mortenson Lake NWR was established in 1993 to support the last known surviving population of the Wyoming toad (*Anaxyrus baxteri*). This refuge is also closed to public access. It encompasses 1,776 acres southwest of Laramie, and contains four main lakes (U.S. Fish and Wildlife Service 2013). Hutton Lake NWR is 1,968 acres and contains 5 natural lakes that provide valuable habitat for migratory birds and wildlife viewing opportunities for local residents. Hutton Lake NWR is also involved with the Wyoming Toad Recovery Program.

Table 4. Surface areas of wetlands based on NWI classifications in the LPWC.

NWI Code	NWI Wetland and Waterbody Type	Area of Wetlands and Waterbodies Identified by the NWI (acres)	% of Study Area	Area of Wetlands in the LPWC Sample Frame (acres)	% of Study Area	% Wetlands in the LPWC Sample Frame
PFO	Forested Wetland	1,589	0.17%	1,589	0.17%	1.90%
PEM	Freshwater Emergent Wetland	65,778	6.94%	65,751	6.94%	78.62%
PAB	Freshwater Pond	1,879	0.20%	1,702	0.18%	2.03%
L1/2	Lake	11,822	1.25%	7,439	0.79%	8.89%
R2/3/4	Riverine	235	0.02%	-	-	-
PSS	Shrub Wetland	5,616	0.59%	5,616	0.59%	6.72%
PUB/US	Unconsolidated Bottom/Shore	1,559	0.16%	1,532	0.16%	1.83%
	Total	88,477	9.34%	83,629	9.07%	100.00%

Table 5. Surface areas of wetlands and waterbodies classified according to NWI water regime codes in the LPWC.

NWI Code	NWI Water Regime	Area of Wetlands and Waterbodies Identified by the NWI (acres)	% of Study Area	Area of Wetlands in the LPWC Sample Frame (acres)	% of Study Area	% Wetlands in the LPWC Sample Frame
A	Temporarily Flooded	56,834	6.00%	56,689	5.99%	67.79%
B	Saturated	1,069	0.11%	1,069	0.11%	1.28%
C	Seasonally Flooded	20,833	2.20%	20,719	2.19%	24.77%
F	Semi-permanently Flooded	9,107	0.96%	4,783	0.50%	5.72%
G	Intermittently Exposed	434	0.05%	369	0.04%	0.44%
H	Permanently Flooded	71	0.01%	-	-	-
K	Artificially Flooded	128	0.01%	-	-	-
	Total	88,477	9.60%	83,629	9.07%	100.00%

Table 6. Surface area of wetland and waterbodies classified according to NWI modifiers in the LPWC.

NWI Wetland and Waterbody Type	No Modifier		Beaver		Excavated		Impounded/diked		Drained	
	Acres	% of NWI wetland and Waterbody type	Acres	% of NWI wetland and Waterbody type	Acres	% of NWI wetland and Waterbody type	Acres	% of NWI wetland and Waterbody type	Acres	% of NWI wetland and Waterbody type
Forested Wetland	1,589	100.00%	-	-	-	-	-	-	-	-
Freshwater Emergent Wetland	63,256	96.17%	104	0.16%	27	0.04%	2,266	3.45%	123	<0.01%
Freshwater Pond	806	42.89%	336	17.89%	176	9.39%	560	29.84%	-	-
Lake	9,412	79.62%	-	-	-	-	2,409	20.38%	-	-
Shrub Wetland	5,154	91.78%	457	8.14%	-	-	5	0.09%	-	-
Riverine	235	100.00%	-	-	-	-	-	-	-	-
Unconsolidated Bottom/Shore	1,311	84.08%	-	-	27	1.71%	201	12.89%	21	1.32%
All Water bodies	81,764	92.41%	898	1.01%	230	0.26%	5,442	6.15%	144	0.16%
Wetlands	78,217	93.53%	898	1.07%	-	-	4,370	5.22%	144	0.17%

Table 7. Surface areas of irrigated wetlands and water bodies based on NWI classifications in the LPWC.

NWI Wetland and Waterbody type	Irrigated Acres	% of NWI Wetland and Waterbody type	% of irrigated lands
Forested Wetland	284	17.86%	0.21%
Freshwater Emergent Wetland	40,143	61.03%	29.51%
Freshwater Pond	130	6.89%	0.10%
Lake	24	0.21%	0.02%
Riverine	2	0.81%	<0.01%
Shrub Wetland	1,126	20.04%	0.83%
Unconsolidated Bottom/Shore	49	3.12%	0.04%
All Water Bodies	41,757	47.20%	30.70%
Wetlands	41,731	49.90%	30.68%

Table 8. Land ownership/management of irrigated lands, all wetlands, and target wetlands in the LPWC.

Landowner/ Manager	Total		Irrigated Lands			All Wetlands and waterbodies			Wetlands			
	Acres	% of Basin Area	Acres	% of Landowner Area	% of Basin Area	Acres	% of Landowner Area	% of Basin Area	Acres	% of Landowner Area	% of Basin Area	% of wetland acres
Bureau of Land Management	66,150	6.98%	269	0.41%	0.03%	1,488	2.25%	0.16%	1,418	2.14%	0.15%	1.70%
Bureau of Reclamation	880	0.09%	-	-	-	21	2.40%	< 0.01%	18	2.02%	< 0.01%	0.02%
Fish & Wildlife	4,192	0.44%	138	3.29%	0.01%	579	13.81%	0.06%	487	11.61%	0.05%	0.58%
Forest Service	1,307	0.14%	3	0.25%	< 0.01%	14	1.08%	< 0.01%	14	1.08%	< 0.01%	0.02%
Private	752,391	79.44%	124,163	16.50%	13.11%	70,952	9.43%	7.49%	69,141	9.19%	7.30%	82.68%
State	92,183	9.73%	10,349	11.23%	1.09%	4,404	4.78%	0.46%	4,366	4.74%	0.46%	5.22%
Water	23,758	2.51%	901	3.79%	0.10%	10,484	44.13%	1.11%	7,789	32.79%	0.82%	9.31%
WY Game and Fish	6,310	0.67%	193	3.05%	0.02%	536	8.49%	0.06%	395	6.26%	0.04%	0.47%
Total	**947,171**	**100.00%**	**136,016**	**-**	**14.36%**	**88,477**	**-**	**9.34%**	**83,629**	**-**	**8.83%**	**100.00%**

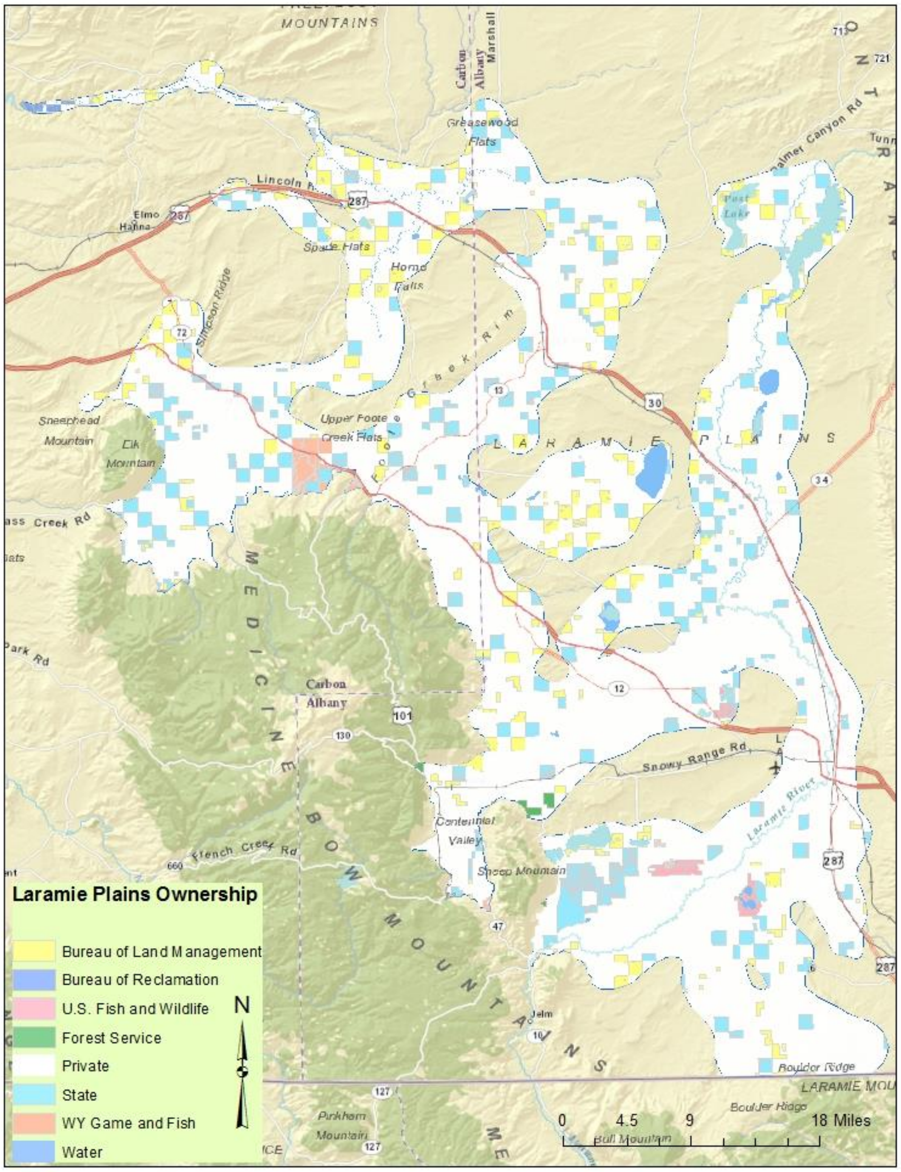

Figure 2. Spatial distribution of land ownership/management within the LPWC study area.

4.2 Description of Sampled Wetlands

4.2.1 Implementation of the Sample Design

We sampled 86 wetlands (including 8 reference wetlands) in 2013. Based on land ownership, 73% were on private lands, 13% on State lands, and 15% on lands administered by the BLM, USFWS, or Wyoming Game and Commission.

We obtained permission to sample 31% of the sites selected in the random survey design. One hundred and seventy-seven sites evaluated from the original sample design were rejected due to access denial (n = 121) or classified as not sampleable (n = 56). The percentage of the sampled points on private lands (73%) was less than the percentage of the potential, randomly selected points on private lands (83%), revealing a bias in sampling toward public-land sites.

Table 9. Composition of sampled sites based on wetland subgroups and surface ownership in the LPWC.

Wetland Subgroup	BLM	USFWS	WGFC	State	Private
Riparian Woodland and Shrubland			2	1	16
Freshwater Emergent Marsh	2	1	1	2	15
Wet Meadow		1	1	2	16
Playa and Saline Depression	2	2		6	16
Total	**4**	**4**	**4**	**11**	**63**

4.2.2 Description of Sampled Wetland Subgroups

A field key (Appendix A) was used to classify sampled wetlands and riparian sites according to ecological system. The sites were then classified into wetland subgroups based on these ecological system (Table 1). Characteristics of the four subgroups are summarized below:

Riparian Woodland and Shrubland

Riparian woodlands and shrublands are typically distributed as narrow bands along rivers and streams within the LPWC. Riparian shrublands are dominated by a shrub overstory of *Salix* sp., *Ribes* sp. and *Alnus incana* with a mesic to hydric meadow understory vegetation of *Carex utriculata*, *Mentha arvensis*, *Cirsium arvense*, and *Agrostis stolonifera.* Many are associated with historic floodplains and receive water from overbank flooding and alluvial aquifers. Some riparian shrubland complexes are associated with peat soil layers, likely relics of historic beaver activity in the basin (Knight et al. 2014).

Freshwater Marshes and Ponds

Freshwater marshes and ponds include riverine oxbows, created ponds receiving irrigation inputs, and some areas along the shorelines of major reservoirs within the basin. Marshes characteristically have central areas that are frequently flooded and surrounded by increasingly drier zones. The central area is dominated by hydrophytic species such as *Eleocharis palustris, Polygonum amphibium,* and *Hippuris vulgaris*. Dominant species in the surrounding dryer zones include *Hordeum jubatum, Distichlis spicata, Triglochin maritima. Alopecurus arundinaceus,* and *Cirsium arvense.*

Wet meadows

Wet meadows are wetlands dominated by native and non-native herbaceous vegetation, often within floodplains with a high water table and/or locations with artificial overland flow (irrigation). These sites typically lack prolonged standing water. Graminoids typically comprise the greatest canopy cover. Common native species in the LPWC include *Juncus arcticus* ssp. *Littoralis, Iris missouriensis, Triglochin maritima,* and *Deschampsia cespitosa*. Non-native hay grasses such as *Poa* spp.*, Alopecurus* sp, *Phleum pretense,* and *Bromus inermis* spp. *inermis* are often abundant within wet meadows. Standing water less than 0.1 ha can exist within wet meadows and may sustain emergent marsh vegetation, but these are not the predominant.

Playas and Saline Depressions

Playas and saline depressions are seasonally to semi-permanently flooded. These depressions occur in alkaline basins and swales and along the drawdown zones of lakes and ponds. Vegetation cover generally exceeds 10% and is typically comprised of salt-tolerant species such as *Distichlis spicata*, *Puccinellia* spp., *Schoenoplectus maritimus, Schoenoplectus pungens, Triglochin maritima,* and *Salicornia rubra*. Saline depressions generally have thick unvegetated salt crusts over clay soils surrounded by zones of vegetation. Many seasonal playas and saline depressions are associated with springs, irrigation seepage, or are located in large basins with internal drainage. Seasonal drying exposes mudflats colonized by annual wetland vegetation.

4.3 Wetland Soil Profiles and Water Chemistry

Soil pits were dug at all but four wetland sites. Two locations had very hard clay soils that were impossible to penetrate without mechanical assistance and 2 were covered with water at the time of sampling. Hydric soils were observed in 77% of sampled wetlands (Table 10). Playa and saline depressions and freshwater emergent marshes had the highest number of sites with hydric soils. Organic soil indicators such histisols, histic epipedons and mucky mineral soils were the most common hydric indicator types and were observed at approximately 40% of the sites with hydric soil characteristics. Organic soil conditions result from long-term stability in hydrologic regime and saturated soil conditions that reduce decomposition. Histisols or histic epipeons were present at 14 sites, indicating a stable hydrologic regime. Wetlands in riparian oxbows or associated with beaver complexes were the largest proportion of wetlands in which histisols and histic epipedons were documented. Interestingly, histisols were also found in an irrigated wet meadow, indicating conditions that produced a fen long before irrigation began. Forty percent of sites had mineral soils with hydric indicators. Hydric indicators in mineral soils are created by a reduction, translocation or accumulation of iron and other reducible elements, which results from fluctuating water levels or anthropogenic controls to hydrology such as irrigation. Surface water was present at 44% of wetlands at the time of sampling. Water temperature, total dissolved solids, and salinity were highest within playas and saline depressions (Table 11). Oligosaline conditions were observed for all wetland subgroups (Table 12).

Table 10. Wetland soil characteristics of sample sites in the LPWC.

Wetland Subgroup	# of Sites	# with Hydric Soil	# Hydric with Mineral Soil	# Hydric with Organic Soil	# Hydric with Mucky Mineral Soil	# Histosols and Histic Epipedons
Riparian woodland and shrubland	19	15	4	11	6	9
Emergent Marsh	19	17	8	9	8	1
Wet Meadow	20	16	6	10	7	4
Playa and Saline Depression	24	18	14	4	4	0
Total	**82**	**66**	**32**	**34**	**25**	**14**

Table 11. Mean water chemistry parameters measured at sampled wetlands with surface water present

Wetland Subgroup	n	Temperature (°C)	pH	Total Dissolved Solids (ppm)	*Salinity (ppm)
Riparian woodland and shrubland	11	19.6 ± 5.5	8.1 ± 0.9	563 ± 690	610 ± 494
Emergent Marsh	16	19.1 ± 3.7	8.5 ± 1.0	767 ± 892	620 ± 658
Wet Meadow	8	17.6 ± 5.0	7.6 ± 0.9	1608 ± 1661	1130 ± 1426
Playa and saline depression	3	21.9 ± 1.8	8.5 ± 1.2	2341 ± 1631	1389 ± 1472

*The number of sites sampled for salinity were: riparian = 11, emergent marsh = 11, wet meadow = 7, and playa and saline depression = 2.

Table 12. Salinity classifications of sampled wetlands with surface water present (Cowardin et al. 1979).

	Cowardin Salinity Class	
Wetland Subgroup	Fresh (<500 ppm)	Oligosaline (500-5000 ppm)
Riparian woodland and shrubland	5	6
Emergent Marsh	7	4
Wet Meadow	4	3
Playa and saline depression	1	1

4.4 Landscape Hydrology Metric

Based on LHM analyses, 17% of wetlands were categorized as historic (Fig. 3). Seventy-three percent of wetlands sampled were categorized as altered-hybrid, and 83% had altered hydrology of some form, indicating widespread hydrologic modification across the basin.

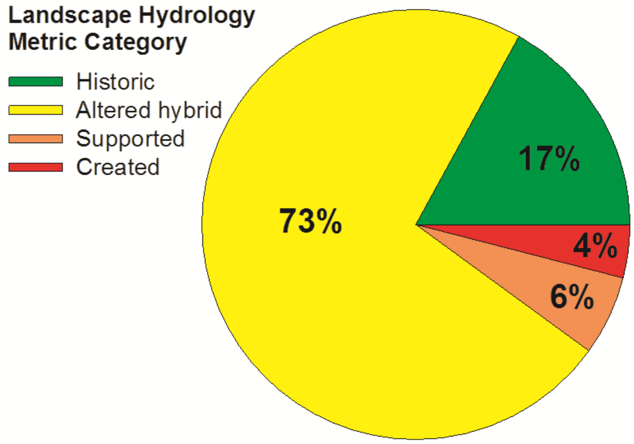

Figure 3. Proportion of wetland sites based on the Landscape Hydrology Metric.

We observed hydrologic alterations in all wetland subgroups (Fig. 4). Wet meadows had the highest proportion of sites with hydrologic alteration with 85% categorized as altered-hybrid, 5% supported and 10% created. None of the wet meadows and only 5% of emergent marshes sampled were categorized as historic. Riparian woodland and shrublands and playas and saline depressions subgroups included the largest proportions of wetlands categorized as historic.

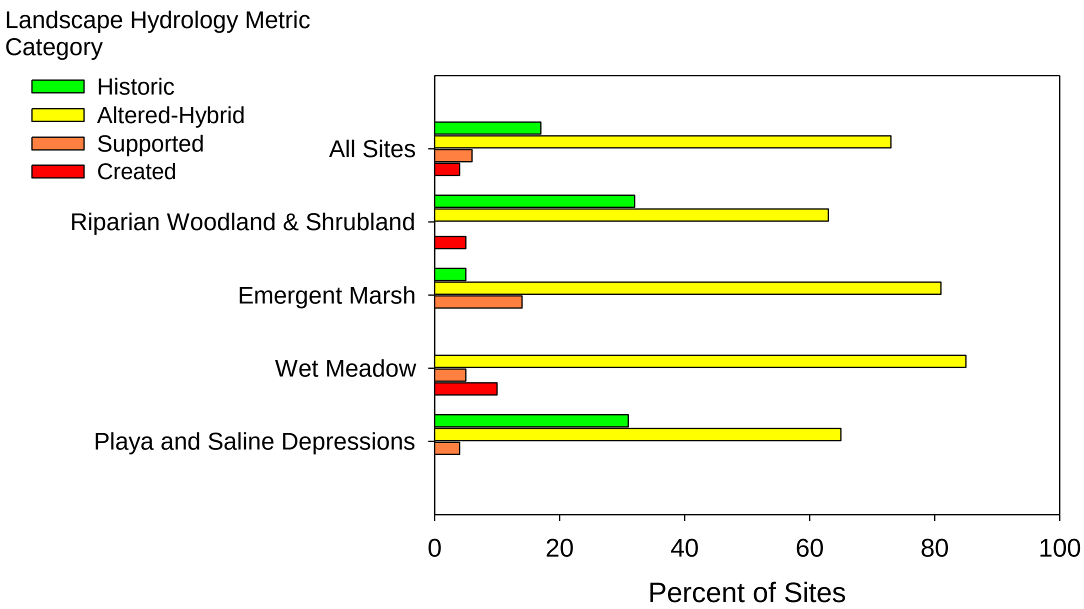

Figure 4. Landscape Hydrology Metric categories for all study sites by wetland subgroup.

4.5 Wetland Vegetation

4.5.1 Species Diversity

Plant surveys identified 258 taxa of vascular plants at the 86 wetlands sampled. Fifteen taxa were only identified to genus because diagnostic floristic parts required for species identification were absent at the time of sampling. The remaining 243 taxa were identified to the species level and represent 6% of Wyoming's flora (Dorn 2001). Given that 53% of the species were only encountered once or twice, it is probable additional survey effort would detect more species.

The three most common species were fox-tail barley (*Hordeum jubatum*) found in 44 (51% of the sampled wetland sites, arctic rush (*Juncus arcticus* ssp. *littoralis*) found in 43 (50%) of the sampled sites, and Canada thistle (*Cirsium arvense*) found in 40 (47%) of the sampled sites (Table 13). The three species were also represented in all four wetland subgroups. Fox-tail barley (*Hordeum jubatum*) and arctic rush (*Juncus arcticus* ssp. *littoralis*) are native wetland species with C-values of 2 to 4 respectively. The most common non-native species were Canada thistle (*Cirsium arvense*), creeping meadow-foxtail (*Alopecurus arundinaceus*), and common dandelion (*Taraxacum officinale*) (Table 14). These three species were found in the dry fringes of wetlands or irrigated hay fields at 40 (47%), 30 (35%) and 26 (31%) sampled wetlands respectively. Canada thistle is listed as a noxious weed in Wyoming (State of Wyoming 2015). Creeping meadow-foxtail is a common hay species planted for its palatability and high yield throughout the growing season (USDA-NRCS, 2013).

Table 13. Ten most common plant species identified at wetland sample sites in the LPWC.

Scientific Name	% of sites	Wetland Status	Nativity	WY C Value	Common Name
Hordeum jubatum	51%	FAC	Native	2	Fox-Tail Barley
Juncus arcticus ssp. littoralis	50%	FACW	Native	4	Arctic Rush
Cirsium arvense	47%	FACU	Non-native	0	Canada Thistle
Triglochin maritima	40%	OBL	Native	7	Seaside Arrow-Grass
Eleocharis palustris	36%	OBL	Native	4	Common Spike-Rush
Alopecurus arundinaceus	36%	FAC	Non-native	0	Creeping Meadow-Foxtail
Agrostis stolonifera	30%	FACW	Non-native	0	Spreading Bent
Pascopyrum smithii	30%	FAC	Native	5	Western-Wheat Grass
Taraxacum officinale	30%	FACU	Non-native	0	Common Dandelion
Argentina anserina	29%	OBL	Native	3	Common Silverweed
Phleum pratense	29%	FACU	Non-native	0	Common Timothy
Mentha arvensis	28%	FACW	Native	4	American Wild Mint
Carex nebrascensis	27%	OBL	Native	4	Nebraska Sedge

Table 14. Detection frequencies of plant species at LPWC sample sites.

Native		Non-Native	
Scientific Name	% of sites	Scientific Name	% of sites
Hordeum jubatum	51%	*Cirsium arvense*	47%
Juncus arcticus ssp. Littoralis	50%	*Alopecurus arundinaceus*	35%
Triglochin maritima	40%	*Taraxacum officinale*	30%
Eleocharis palustris	36%	*Trifolium pratense*	30%
Pascopyrum smithii	30%	*Phleum pratense*	29%
Argentina anserina	29%	*Alopecurus pratensis*	19%
Mentha arvensis	28%	*Poa pratensis*	17%
Carex nebrascensis	27%	*Melilotus officinalis*	13%
Puccinellia nuttalliana	26%	*Rumex crispus*	12%
Deschampsia cespitosa	24%	*Trifolium pratense*	10%

4.5.2 Floristic Quality Assessment

Riparian woodlands and shrublands supported the highest species richness and native species richness per site (Table 15). Wet meadows were the most influenced by the presence of non-native species. These sites supported highest mean number of non-native species and absolute cover of noxious species compared to other wetland subgroups. Many wet meadows in the LPWC are irrigated and planted with non-native and native grass species. Low species richness was observed in saline depressions, but this type supported the highest relative cover of native species. Playas and saline depressions are naturally bare areas where soil chemistry greatly restricts the number and type of plant species present.

The overall mean C ($\overline{C}_{\mathrm{all}}$) measured across sites in the LPWC was 3.62 and ranged from 2.8 - 4.5 across all sample sites in the LPWC (Table 15). Mean C based on native species ($\overline{C}_{\mathrm{n}}$) was 4.5. Riparian woodland and shrublands had the highest $\overline{C}_{\mathrm{all}}$ and $\overline{C}_{\mathrm{n}}$. Lowest $\overline{C}_{\mathrm{all}}$ values were measured in wet meadows.

Table 15. Floristic quality assessment indices calculated for sampled wetlands in the LPWC

FQA Indices	Riparian Woodland and Shrubland		Emergent Marsh		Wet Meadow		Playa and Saline Depression		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total species richness	27.05	9.83	16.33	6.23	18.55	6.89	6.88	4.46	16.47	10.01
Native species richness	21.47	9.05	13.29	4.79	12.80	5.95	5.92	3.76	12.84	8.14
Non-native species richness	4.95	2.04	2.90	2.17	5.45	2.04	0.80	1.08	3.34	2.63
Mean C of all species	3.85	0.92	3.67	0.53	3.25	0.93	3.70	0.87	3.62	0.84
Mean C of native species	4.79	0.70	4.41	0.43	4.71	0.71	4.17	0.66	4.50	0.67
FQI of all species	20.23	7.24	14.45	3.89	14.03	5.49	9.39	3.98	14.15	6.43
FQI of native species	22.23	7.11	15.84	4.16	16.65	5.37	9.90	3.96	15.71	6.77
Relative % cover of native species	86.96	13.38	87.81	14.73	66.17	23.61	91.51	22.18	83.62	21.32
Absolute % cover of noxious species	2.13	4.22	0.72	1.87	4.96	16.96	0.32	1.52	1.91	8.58

4.6 Wetland Condition Assessment

4.6.1 Ecological Integrity Assessment of Sampled Wetlands

EIA scores from the 87 sampled wetlands ranged from 2.0 – 4.5 out of a possible range of 1.0-5.0. Definition for condition categories can be found in Appendix D and are as follows:

- A = At or near reference condition
- B = Level of disturbance indicates slight departure from reference condition
- C = Level of disturbance indicates moderate departure from reference condition
- D = Level of disturbance indicates severe departure from reference condition

Two percent of the study sites were ranked "A", 67% were ranked "B", 27% were ranked "C", and 4% were ranked "D" (Fig. 5). All 4 wetland subgroupings were dominated by B-ranked wetlands, providing evidence of comparatively low disturbance and slight deviation from reference condition. A-ranked wetlands (two sites) were only present in the riparian woodland and shrubland subgroup. The wet meadow subgroup included the highest proportion of C- and D-ranked sites. Approximately 75% of emergent marshes and playas and saline depressions sampled were B-ranked and 25% C-ranked. No D-ranked sites were present in these 2 subgroups.

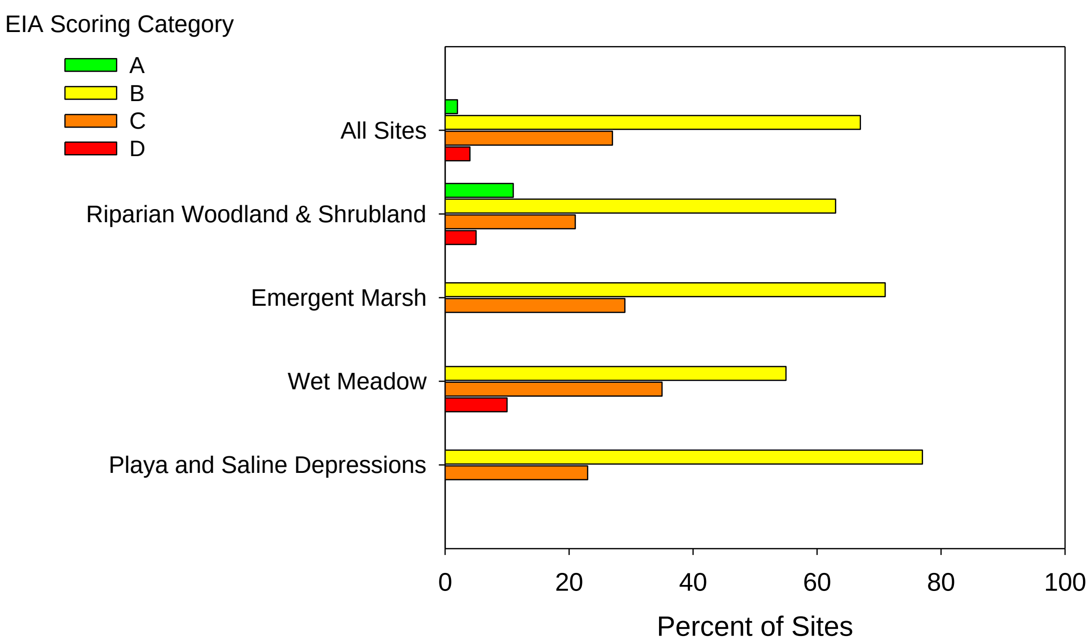

Figure 5. EIA condition categories for all wetland study sites by wetland subgroups.

EIA scores were derived from 4 attributes: landscape context, biotic condition, physicochemical condition, and the Landscape Hydrology Metric. Landscape context rankings ranged from A-C, with the exception of 1 D-ranked riparian site (Table 16). Biotic rankings were relatively lower than other attribute scores within all wetland subgroups, with 85% of wetlands receiving a rank of C or lower. No sites received a biotic condition ranking of "A." Wet meadows received the lowest biotic condition scores compared to the other wetland subgroups – 70% of sites were D-ranked. In contrast, most wetlands received relatively high physicochemical condition rankings in the A-B range. Frequencies of LHM classifications are shown at the bottom of Table 16 for comparison to the other EIA attribute ranking frequencies.

Table 16. Ranks for each EIA attribute class by wetland subgroup for the LPWC.

	EIA Landscape context rank			
Wetland Subgroup	**A**	**B**	**C**	**D**
Riparian woodland and shrubland	6	10	2	1
Emergent Marsh	11	6	4	0
Wet Meadow	11	7	2	0
Playa and Saline Depression	16	6	4	0
Total	**44**	**29**	**12**	**1**

	EIA Biotic condition rank			
Wetland Subgroup	**A**	**B**	**C**	**D**
Riparian woodland and shrubland	0	7	9	3
Emergent Marsh	0	2	15	4
Wet Meadow	0	2	4	14
Playa and Saline Depression	0	2	20	4
Total	**0**	**13**	**48**	**25**

	EIA Physicochemical condition rank			
Wetland Subgroup	**A**	**B**	**C**	**D**
Riparian woodland and shrubland	11	6	2	0
Emergent Marsh	13	5	3	0
Wet Meadow	11	9	0	0
Playa and Saline Depression	11	9	0	0
Total	**46**	**29**	**5**	**0**

	LHM Hydrology classification			
Wetland Subgroup	Historic	Hybrid	Supported	Created
Riparian woodland and shrubland	6	12	0	1
Emergent Marsh	1	17	3	0
Wet Meadow	0	17	1	2
Playa and Saline Depression	8	17	1	0
Total	**15**	**36**	**5**	**3**

4.6.2 Estimate of Wetland Condition for the Wetland Population in LPWC

The CDF plot is nonlinear, indicating that estimated EIA scores are not evenly distributed across the wetland population (Fig. 6). Confidence intervals vary along the plot and are widest at the lowest scores. Based on CDF analysis, 3% of wetlands in the LPWC would be A-ranked, 67% B-ranked, 25% C-ranked and 5% D-ranked (Table 17). An assumption of the CDF analysis is that data were obtained from a random sample representative of the wetland population in the LPWC study area. Our sample violated this assumption because 49% of wetlands in the sample design could not be sampled due to landowner denying permission and 23% due to other rejection criteria.

Table 17. Population estimate of EIA ranks for wetlands in the LPWC. Observed = percent of sampled sites within each rank; Estimate = percent of wetland number extrapolated using 2980 wetlands from the sample frame.

EIA Rank	Observed	Estimate	95% Confidence Interval
A	2%	3%	0-8%
B	67%	67%	56-77%
C	27%	25%	15-34%
D	4%	5%	0-10%

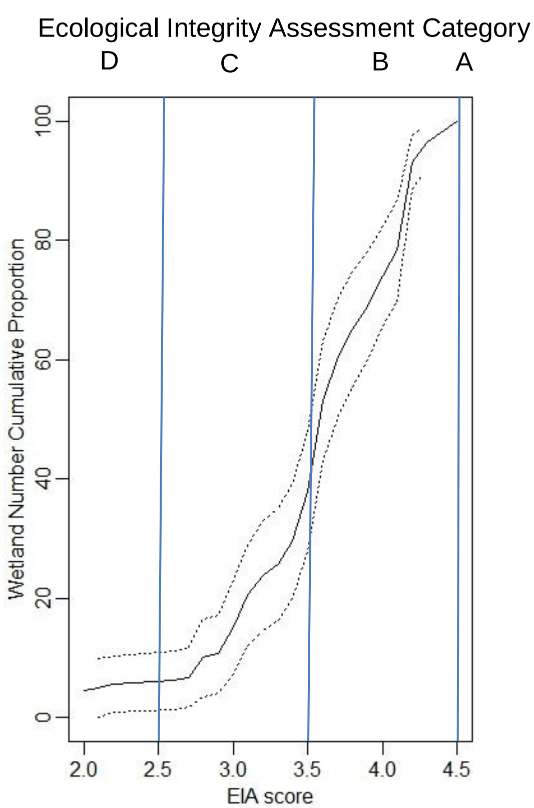

Figure 6. Cumulative distribution function of wetland EIA scores for all wetlands in the LPWC with 95% CI shown. Graph is the cumulative proportion of wetlands (y-axis) with EIA scores at or below values on the x axis.

4.6.3 Indicators of disturbance

The EIA stressor metrics provided detailed information about presence of stressors within and surrounding each wetland sample site. Unpaved roads were observed in the buffer of 48% of wetlands (Fig. 7). The next most common stressors indicated grazing by livestock and native ungulates and landscape fragmentation by paved roads, buildings, and nearby crop production. The most common stressors were soil impacts from grazing by domestic and native herbivores, and potential hydrologic stressors including pumps, diversions, and ditches (Table 18).

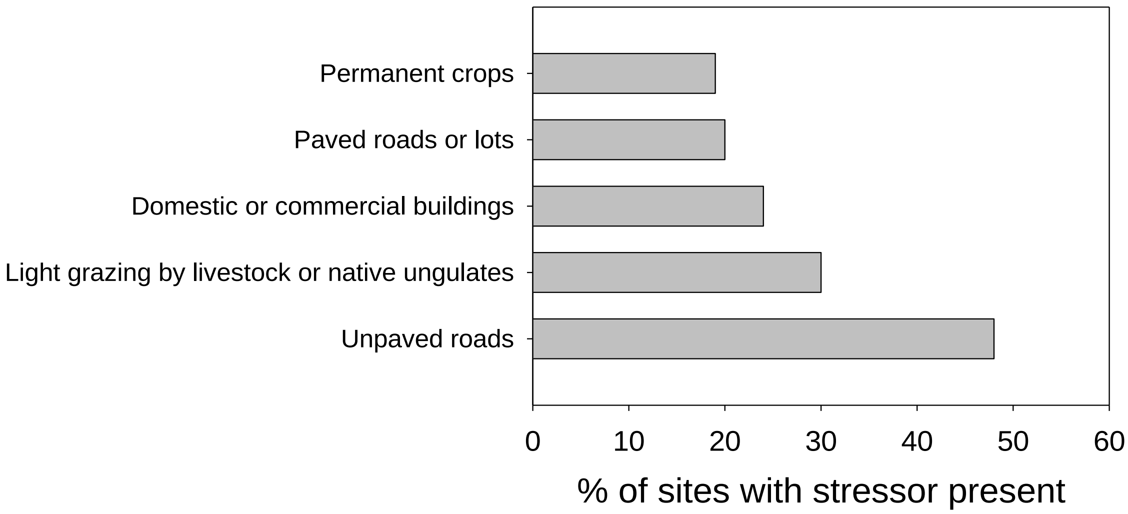

Figure 7. Five stressors observed most frequently in the 500 m buffers surrounding wetland sample site assessment areas in the LPWC.

Table 18. Prevalent stressors affecting physicochemical, vegetation, and hydrology attributes of wetlands

EIA Stressor Category	Rank of Stressor Indicator and % of sites present					
	Most Common		2nd Most Common		3rd Most Common	
Physicochemical	Compaction and soil disturbance by livestock or native ungulates	37%	Compaction and soil disturbance by human use	6.9%	Erosion/Sedimentation	6.9%
Biotic	Light grazing by livestock or native ungulates	20%	Heavy grazing by livestock or native ungulates	6.9%	Moderate grazing by livestock or native ungulates	5.8%
Hydrology	Pumps, diversions, ditches that move water into wetland	50%	Flow obstruction (road w/o culvert)	20%	Berms, dikes, levees	19%

4.6.5 Correlations between EIA Attribute Scores and Level 3 Floristic Metrics
Level 2 measures of wetland condition (EIA attributes) were compared with more intensive Level 3 floristic quality measures to assess potential relationships. The objectives of this project did not include calibration and validation of EIA methods, however the following results may provide information that can be used to improve wetland assessment methods in Wyoming.

EIA biotic condition scores were positively correlated with landscape context scores (r[s] = 0.29, *P* = 0.006). Significant relationships were found between the EIA attribute scores and Level 3 floristic quality metrics (Table 19). Non-native species richness was negatively correlated with biotic condition and EIA scores, indicating sites with lower biotic condition and EIA scores have higher prevalence of non-native species. $\overline{C}_{\text{all}}$ values were positively correlated with landscape context and LHM scores, whereas $\overline{C}_{\text{n}}$ values were positively correlated with only physicochemical condition scores. Plant species richness was not correlated with EIA attribute scores.

Table 19. Correlations between floristic quality metrics and EIA attribute scores based on Spearman's rank correlation coefficient. Significant correlations (*P* < = 0.05) are shown in bold.

	Landscape context		Biotic condition		Physicochemical condition		Landscape Hydrology Metric		EIA total score	
	[r]s	*P*	[r]s	*P*	[r]s	*P*	[r]s	*P*	[r]s	*P*
Species richness	0.02	0.8912	0.12	0.2725	0.20	0.0674	0.07	0.5096	0.16	0.1157
Non-native species richness	-0.11	0.3015	**-0.37**	**0.005**	0.13	0.2407	-0.21	0.0562	**-0.30**	**0.006**
Mean C - all species	**0.32**	**0.003**			0.19	0.0780	**0.31**	**0.0038**		
Mean C - native	0.20	0.0618			**0.33**	**0.0018**	0.09	0.4273		

4.6.6 Evaluation of Avian Habitat

Bird Surveys
Bird surveys conducted at 46 wetlands detected 3,750 birds belonging to 123 species within the LPWC (Appendix E). Highest species richness was documented on wet meadow sites and lowest on playa and saline depression sites (Table 20). Species richness on wetlands in the riparian woodland and shrubland subgroup was identical to that on wetlands in the emergent marsh subgroup (Table 20). On average, the largest numbers of birds were observed at emergent marsh sites (Table 20). Our mean abundance calculations excluded data from 2 wetland sites that would have skewed results. The 2 sites were an emergent marsh and a wet meadow where 450 and 829 birds, respectively, were detected. Twenty-one species from the "Bird Species of Concern" list for Wyoming (WYNDD 2015) were observed during surveys (Appendix E).

Table 20. Bird species richness and abundance measured within wetland subgroups in the LPWC.

		Bird richness (number of species)			Bird abundance (number of individuals)		
Wetland subgroup	**n**	**Mean**	**sd**	**Range**	**mean**	**sd**	**Range**
Riparian woodland and shrubland	11	25.7	9.56	5-45	58.2	25.7	24-125
Emergent Marsh	12	25.7	13.2	10-56	65.5*	25.2*	31-105(450*)
Wet Meadow	7	28.9	20.8	13-74	60.2*	28.9*	26-95(829*)
Playa and Saline Depression	16	13.2	8.02	4-36	46.1	30.2	15-125

*Data in parentheses were excluded from abundance statistics due to anomalous values

Analysis of EIA Attribute Scores and Bird Surveys

An objective of this study is to determine key wetland habitat features and resources that influence presence and abundance of wetland-dependent wildlife species. In light of this objective, we examined relationships between EIA scores and bird species richness and abundance. We found no significant correlations between EIA condition scores and either bird species richness or bird abundance. However, plant species richness was positively correlated with bird diversity (r[s] = 0.46, P = 0.0012), indicating wetlands with higher plant diversity support higher avian diversity.

Avian Habitat – Avian Richness Evaluation Method

AREM habitat suitability model predict that wetlands within the LPWC could provide suitable breeding habitat for 120 bird species. Riparian woodland and shrublands are predicted to provide suitable habitat for an average of 28 (range = 9-56) species per site (Fig. 8). Emergent marsh wetlands potentially provide suitable habitat for an average of 24 (range = 6-63) bird species per site. The mean number of species predicted at wet meadows is 15 (range = 4-33) and 10 (range = 4-36) at playas and saline depressions.

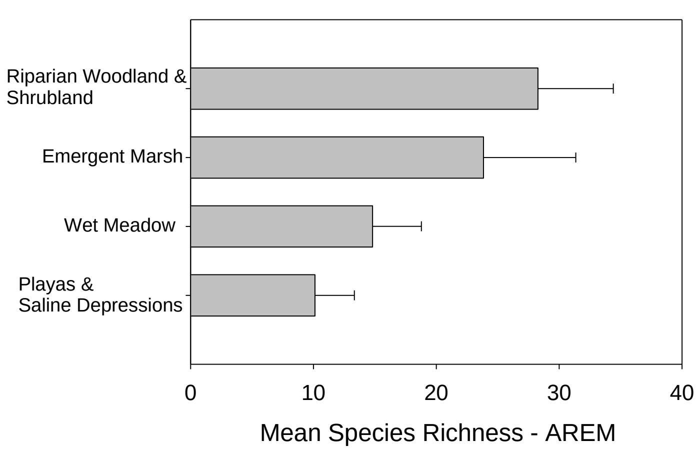

Figure 8. Mean bird richness predicted by AREM models.

Predicted bird species richness based on AREM models differed significantly from observed values (Mann-Whitney-Wilcoxon Test, $P = 0.02$). However, there was a positive correlation between the AREM predicted bird richness values and observed richness values based on a Spearman rank correlation test ($r[s] = 0.45$, $P = 0.0024$). These results indicate that although the AREM models substantially over-estimate the number of bird species per site, they do correctly predict which types of wetlands can support the most species and which types the least. Of the 120 species AREM predicted should be present based on suitable habitat, 81 were detected during bird surveys. However, 43 of the species predicted by AREM models were not detected. The overall lack of accuracy and evidence of error suggest improvements in AREM models are needed. Similarity of observed and predicted species composition were not analyzed for individual sites because data were insufficient. However, the relationship between predicted and observed species richness indicates AREM has the potential to provide information about relative bird diversity based on suitability of habitat. Further site-specific comparisons of observed and predicted species, and adjustments to scoring for birds breeding in the region, could improve the utility of AREM for predicting presence of wetland bird species.

5.0 DISCUSSION

This study provides the first basin-wide assessment of wetlands in the Laramie Plains Basin, southeast Wyoming. Results from our study provide a baseline assessment of the landscape profile, condition, and habitat potential of wetland resources in the LPWC. This information provides a reference point for wetland condition monitoring, which will help inform conservation planning and project design and implementation efforts.

The landscape profile demonstrates the importance of recognizing linkages between land use, irrigation practices and wetlands in the LPWC. Wetlands comprise a third of the irrigated landscape. Over 60% of freshwater emergent wetlands, the most common type, are mapped as irrigated. Over 80% of wetlands are privately owned. Coordination with private landowners is essential to maintain the ecological integrity of wetland resources throughout the LPWC.

Level 2 wetland condition assessments using EIA methods were developed to measure the condition of wetlands in the basin. A and B ranked wetlands indicate high potential for ecological integrity and conservation value. Management of these wetlands should focus on the prevention of further alteration. Lower-ranking wetlands have disturbance across multiple EIA metrics indicating that management would be needed to maintain or restore ecological attributes. All wetland subgroups were dominated by B-ranked wetlands. Riparian woodland and shrubland wetlands were the only subgroup with A-ranked sites, located in a beaver complex near Rock Creek. Fen-like characteristics at these sites indicate high ecological integrity that may deserve consideration for conservation. Emergent marshes and playas and saline depressions typically received B or C ranks and no A or D ranked wetlands were documented in these wetland subgroups. The highest proportion of C- and D-ranked wetland sites were classified as wet meadows (primarily irrigated hayfields).

Based on the CDF analysis, we estimate that 3% of LPWC wetlands are A-ranked, 67% B-ranked, 25% C-ranked and 5% D-ranked. These results suggest that, 30% of wetlands in the basin are moderately to highly altered from reference conditions. These inferences are based on the assumption that our data come from a random sample of study sites. Unfortunately, that assumption was weakened when we had to remove sites from our original sampling frame due to landowner denial for access and other rejection criteria. We don't know how much this affected our inferences about wetlands in the LPWC. It is impossible to know the condition of unsampled wetlands.

EIA attribute condition scores (Landscape Context, Hydrologic Condition, Physicochemical Condition, and Biotic Condition) provide key information about the distribution of factors influencing ecological integrity. EIA helps identify general patterns of disturbance in the basin, and managers can use the condition attributes to identify disturbances that might be affecting specific locations. Landscape context ranks were generally in the A-B range, indicative of wide buffers and landscape connectivity surrounding most wetlands. However, biotic condition scores were relatively low across all wetland subgroups, which is consistent with results from prior studies done in irrigated basins in Colorado (Lemly and Gilligan 2012). Lower scores are mainly due to the presence of non-native species, which influences multiple EIA biotic metrics. The positive relationship between Mean C values and LHM scores points to the potential influence of hydrologic alterations on wetland plant communities. Most wetlands received relatively high physicochemical condition rankings in the A-B range, but soil disturbance from livestock and native ungulates was observed at 1/3 of sites.

We collected data documenting potential stressors that may influence EIA attribute condition scores. Correlations between wetland condition and potential stresses can be used to direct management efforts. The most widespread sign of disturbances (stressors) identified in our study were grazing by domestic and native herbivores and modified hydrology due to the presence of pumps, ditches, and diversions. Land management policies that discourage further human disturbance and encourage sustainable grazing management in and near wetlands will help to maintain wetland function and prevent further declines in condition.

Our results point to the challenge of quantitatively assessing ecological condition of wetlands in irrigated basins because many wetlands, regardless of ecological integrity, are influenced by hydrologic alterations. Lovvern and Peck (2001) estimated only 14% of inflows to Laramie Basin wetlands were of natural water sources. Their estimate was similar to our general finding of 17% of wetland in the historic category. Our LHM analyses identified modified hydrology at 83% of sampled wetlands. Hydrology was largely characterized as altered-hybrid across all wetland subgroups. Wet meadows and emergent marshes were impacted by hydrologic alterations to a greater extent than other wetland subgroups. In several cases (4% of sampled wetlands), hydrologic alterations have created wetlands that did not historically exist. Peck and Lovvorn (2001) estimated 65% of water inflow to wetlands sampled in the Laramie Basin was from irrigation. Approximately half the irrigation inflows they identified were surface flow from ditches and half were seepage from ditches and nearby irrigation. Our results support findings that wetlands in the LPWC are intrinsically linked to irrigation and management of water resources.

Our bird surveys confirmed that *at least* 123 bird species are utilizing wetland habitat in the LPWC. Higher relative diversity of plant species was generally correlated with higher bird diversity. Although wet meadows consistently received lower EIA and LHM scores, bird diversity and abundance were generally higher. Wetlands influenced by hydrologic alterations, including inputs from flood irrigation and ditches, provide a stable water source and habitat for wetland birds during dry summer months. Wetlands supported by irrigation and urban runoff have become recognized as providing critically important avian habitat within otherwise arid regions (Trammell et al. 2011, Bateman et al. 2015) and securing these water resources will likely benefit wetland wildlife.

5.1 Wetland Priorities for Conservation and Restoration

The LPWC has been extensively modified by agriculture since being settled in the 1800s. It is likely that, as elsewhere in the US, some natural wetlands in the LPWC have been altered. Clearly, stream hydrology has been changed by impoundments, diversions, and channel modifications (Dahl 1990). However, many additional wetlands were created and/or hydrology was enhanced as a result of the irrigation infrastructure that was developed in this region in the early 20th century creating hybrid and novel systems. The ecological challenges of conserving and managing hybrid and novel ecosystems are increasingly recognized (Hobbs et al. 2014). Understanding the function of all types of wetlands along a spectrum of unaltered historic to novel wetlands, will be necessary for effective decision-making and management. To maintain or improve wetland conditions within the LPWC, conservation and restoration efforts need to focus on implications of climate change, changes to water availability, and. land use practices when prioritizing wetland management.

Climate change was identified as an extreme threat in the Laramie Plains Wetlands Complex Regional Wetlands Conservation Plan (WBHCP 2014) and wetlands were identified as highly vulnerable to climate change in a recent statewide report (Pocewicz et al. 2014). For example, recent drought conditions in southeastern Wyoming from 2002-2008 had a major impact on wetlands in the LPWC (WBHCP 2014). During that drought, irrigation inputs ceased or were substantially curtailed, leading to low or no water available to many wetlands.

Water shortages due to potential climate alteration and predicted drought (Cook et al. 2004), and increased human population (Hansen et al. 2002) may place pressure on agricultural producers to convert to center-pivot irrigation methods. According to the Laramie Plains wetlands conservation plan (Patla 2015), flood irrigation is the prevalent method currently used to irrigate.

Temporary and seasonal wetlands are especially vulnerable to loss from conversion to sprinklers or residential development (Copeland et al. 2010, Pocewicz et al. 2014). Only 30% of wetland acres are mapped as irrigated in LPWC, however, Peck and Lovvern (2001) estimated that up to 65% of wetlands depend directly or indirectly on irrigation. Therefore, conversion to center pivot irrigation could potentially affect at least 41,731 acres of wetlands in the basin, as well as the wildlife habitat they provide. Conservation strategies aimed at protecting wetlands may fall short of their intended purpose if water quantity and timing crucial to wetland function are not also maintained (Downard and Endter-Wada 2013).

Hydrology is the principal driver of ecological processes that sustain wetland ecosystem functions (Barker and Maltby 2009). Seasonal flood pulses and late summer periods of low flow are vital for maintaining structure and function of wetlands linked to streams (Junk et al. 1989). Presence of dams and diversions alter the timing and quantity of water available within the basin, and this directly or indirectly affects the quantity and types of wetlands present. Basin-level and local hydrologic alterations observed at a majority of the sampled sites within the LPWC have likely impacted the ecological integrity of most wetlands. Best management practices that focus on maintenance and improvement of the ecological integrity of wetlands, irrespective of historic versus novel status, will have the greatest conservation benefit.

There is increasing recognition of the ecosystem services provided by agriculturally influenced wetlands (Tanner et al. 2013) for pesticide de-contamination (Tournebize et al. 2013), reduction of nitrogen transport from agricultural catchments, and support of species diversity (Strand and Weisner 2013). Many studies have begun to quantify the importance of irrigation-influenced wetlands for birds and other wildlife (Chester and Robson 2013, Moulton et al. 2013, Patla 2015, Donnelly et al. In press). Many avian species have adapted to, and benefitted from these systems, and have likely altered migration patterns in response to changes in wetland habitat availability (Nichols et al. 1983, Sutherland 1998, Abraham et al. 2005). However, research is still needed to fully explore and better quantify ecosystem services and wildlife values associated with irrigation-influenced and created wetlands.

6.0 CONCLUSION

The ecological challenges of conserving and managing hybrid and novel ecosystems are increasingly being recognized. This recognition represents a shift from the traditional paradigm that pristine landscapes have the highest ecological value – all wetlands within working landscapes have intrinsic values (Hobbs et al. 2014). The wetland systems we studied constitute novel or hybrid systems resulting from anthropogenic alterations within the LPWC landscape. The same type of novel systems appear to be prevalent on other western arid landscapes (Trammell et al. 2011, Bateman et al. 2015). Understanding the functions of entire landscapes, including the spectrum of historic to created wetlands, will be necessary for effective decision-making and management of these novel systems. Traditional EIA metrics are biased in their assumption that anthropogenic disturbance is always equated with diminished condition and function. Recognizing that this broad assumption may not hold true everywhere (e.g., on arid landscapes modified by agricultural irrigation), we included LHM, floristic quality, and avian richness metrics in our analysis. These data provide a baseline for beginning to understand the complex interrelationships between anthropogenic disturbances, hydrologic modifications, and wildlife values of wetlands in the LPWC.

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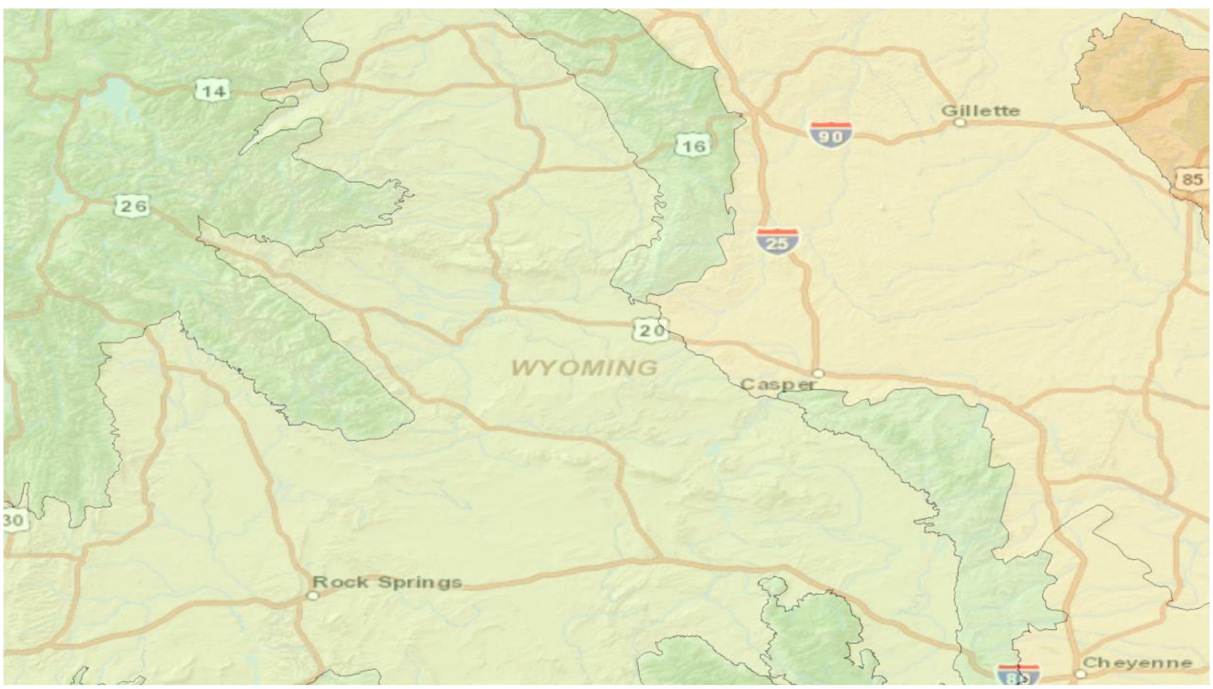
Appendix A: Field Key to Wetland and Riparian Ecological Systems of Wyoming
Last Updated April 7, 2015

1b. Wetlands and riparian areas of the Western Great Plains. *[If on the edge of the foothills, try both Key A and Key B]* .... **KEY A**: **WETLANDS AND RIPARIAN AREAS OF THE WESTERN GREAT PLAINS**

1b. Wetland and riparian areas west of the Great Plains **2**

2a. Wetlands and riparian areas with alkaline or saline soils within the inter-mountains basins of the Rocky Mountains (Upper Green River basin, Wind River basin, ect.) *[If the site does not match any of the descriptions within Key B, try Key C as well. Wetlands and riparian areas of the Rocky Mountains transition into the inter-mountain basins.]*.. ....**KEY B: WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS**

2b. Wetlands and riparian areas of the Rocky Mountains, including the Snowy Mountains, the Wind Rivers, the Absorakas and the Bighorns.. ....**KEY C: WETLANDS AND RIPARIAN AREAS OF THE ROCKY MOUNTAINS**



Ecological Systems of Wyoming

- Black Hills
- Inter-mountain Basins
- Rocky Mountains
- Western Great Plains

KEY A: WETLANDS AND RIPARIAN AREAS OF THE WESTERN GREAT PLAINS

1a. Low stature shrublands dominated by species such as *Sarcobatus vermiculatus, Atriplex* spp., *Ericameria nauseosa*, *Artemisia sp.* Vegetation may be sparse and soils may be saline. Sites may be located on the edge alkali depressions, or in flats or washes not typically associated with river and stream floodplains. *[These systems were originally described for the Inter-Mountain Basins, but may extend to the plains.]* **2**

1b. Wetland is not a low stature shrub-dominated saline wash or flat. **3**

2a. Shrublands with sparse (<20%) vegetation cover, located on flats or in temporarily or intermittently flooded drainages, or on the edge of playas and alkali depressions. They are typically dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of *Sporobolus airoides, Pascopyrum smithii, Distichlis spicata, Puccinellia nuttalliana,* and *Eleocharis palustris* herbaceous vegetation ……………………………………………………………………………………………….**Inter-Mountain Basins Greasewood Flat**

2b. Sites with > 20% total vegetation cover and restricted to temporarily or intermittently flooded drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia sp., Grayia spinosa*, *Distichlis spicata*, and *Sporobolus airoides.* ....
…….**Inter-Mountain Basins Wash**

3a. Sites located within the floodplain or immediate riparian zone of a river or stream. Vegetation may be entirely herbaceous or may contain tall stature woody species, such as *Populus* spp. or *Salix* spp. Water levels variable. Woody vegetation that occurs along reservoir edges can also be included here.... **4**

3b. Herbaceous wetlands of the Western Great Plains that are isolated or partially isolated from floodplains and riparian zones, often depressional with or without an outlet. **8**

4a. Herbaceous wetlands within the floodplain with standing water at or above the surface throughout the growing season, except in drought years. Water levels are often high at some point during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of *Typha, Scirpus, Schoenoplectus*, *Carex*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*. The hydrology may be entirely managed. Water may be brackish or not. Soils are highly variable. This system includes natural warm water sloughs and other natural floodplain marshes as well as a variety of managed wetlands on the floodplain (e.g., recharge ponds, moist soil units, shallow gravel pits, etc.)……… .... **Western North American Emergent Marsh**

4b. Not as above. Wetland and riparian vegetation that typically lacks extensive standing water. Vegetation may be herbaceous or woody. Management regimes variable.. **5**

5a. Large herbaceous wetlands within the floodplain associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water. Vegetation is dominated by native or non-native herbaceous species; graminoids have the greatest canopy cover. Species composition may be dominated by non-native hay grasses such as *Poa spp., Alopecurus sp, Phleum pretense, and* Bromus inermis spp. inermis. There can be patches of emergent marsh vegetation and standing water less than 0.1 ha in size; these are not the predominant vegetation. .... **Irrigated Wet Meadow (not an official Ecological System)**

5b. Predominantly natural vegetation (though may be weedy and altered) within the floodplain or immediate riparian zone of a river or stream, dominated by either woody or herbaceous species. Not obviously controlled by irrigation. **6**

6a. Riparian woodlands and shrublands of the Rocky Mountain foothills on the very western margins of the Great Plains. Woodlands are dominated by *Populus* spp. (mainly *Populus angustifolia*,). Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. .... **Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

6b. Riparian woodlands, shrublands and meadows of Wyoming's Western Great Plains. Common native trees are *Populus deltoides*, *Salix amygdaloides, Acer negundo, Fraxinus* pennsylvanica., and *Ulmus* americana. Common native shrubs include *Salix* spp., Rosa spp, and Symphoricarpos spp. Common non-native trees and shrubs are *Tamarix* spp. and *Elaeagnus angustifolia.* **7**

7a. Riparian woodlands, shrublands, and meadows along medium and small rivers and streams. Sites have less floodplain development and flashier hydrology than the next, and all streamflow may drawdown completely for some portion of the year. Water sources include snowmelt runoff (more common in Wyoming), groundwater (prairie streams), and summer rainfall. Dominant species include *Populus deltoides, Salix* spp., *Fraxinus pennsylvanica, Pascopyrum smithii, Panicum sp., Carex* spp., *Tamarix* spp., *Elaeagnus angustifolia,* and other non-native grasses and forbs……….W**estern Great Plains Riparian**

7b. Woodlands, shrublands, and meadows along large rivers (the North Platte and its larger tributaries) with extensive floodplain development and periodic flooding that is more associated with snowmelt and seasonal dynamics in the mountains than with local precipitation events. Hydroperiod alterations from major dams and reservoirs alter historic flooding patterns. Dominant communities within this system range from floodplain forests to wet meadow patches, to gravel/sand flats dominated by early successional herbs and annuals; however, they are <u>linked by underlying soils and the flooding regime</u>. Dominant species include *Populus deltoides* and *Salix* spp., *Panicum sp.* and *Carex* spp. *Tamarix* spp., *Elaeagnus angustifolia,* and non-native grasses..……………………….…….**Western Great Plains Floodplain**

8a. Natural shallow depressional wetlands in the Western Great Plains with an impermeable soil layer, such as dense hardpan clay that causes periodic ponding after heavy rains. Sites generally have closed contour topography and are surrounded by upland vegetation. Hydrology is typically tied to precipitation and runoff but lacks a groundwater connection; however some of these sites are receiving increased water from irrigation seepage. Ponding is often ephemeral and sites may be dry throughout the entire growing season during dry years. Species composition depends on soil salinity, may fluctuate depending on seasonal moisture availability, and many persistent species may be upland species. *[The wetlands within this group are collectively referred to* ***playas or playa lakes****. Ecological systems listed below separate playas based on the level of salinity and total cover of vegetation.]* **9**

8b. Herbaceous wetlands in the Western Great Plains not associated with hardpan clay soils. Sites may or may not be depressional and may or may not be natural. **10**

9a. Shallow depressional wetlands with less saline soils than the next. Dominant species are typically not salt-tolerant. Sites may have obvious vegetation zonation of tied to water levels, with the most hydrophytic species occurring in the wetland center where ponding lasts the longest. Common native species include *Pascopyrum smithii, Iva axillaris, , Eleocharis* spp., *Oenothera canescens, Plantago* spp., *Polygonum* spp., *Conyza canadensis* ,and *Phyla cuneifolia.* Non-native species are very common in these sites, including *Salsola australis, Bassia sieversiana, Verbena bracteata,* and Polygonum aviculare. Sites have often been affected by agriculture and heavy grazing. Many have been dug out or "pitted" to increase water retention and to tap shallow groundwater...
....**Western Great Plains Closed Depression Wetland**

9b. Shallow depressional herbaceous wetlands with saline soils. Salt encrustations can occur on the surface. Species are typically salt-tolerant, including *Distichlis spicata*, *Puccinellia nuttalliana, Salicornia rubra, Schoenoplectus maritimus, Schoenoplectus americanus, Suaeda calceoliformis, Spartina* spp., *Triglochin maritima,* and occasional shrubs such as *Sarcobatus vermiculatus .[This system resembles the Inter-Mountain Basins Alkaline Closed Depression but occur in the Great Plains ecoregion. Note: Low stature shrub-dominant wetlands key in the flats and wash systems above.]* ....**Western Great Plains Saline Depression Wetland**

10a. Herbaceous wetlands with standing water at or above the surface throughout the growing season, except in drought years. Water levels are often high at some point during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of *Typha, Scirpus, Schoenoplectus*, *Carex*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*. The isolated expression of this system can occur around ponds, as fringes around lakes, and at any impoundment of water, including irrigation run-off. The hydrology may be entirely managed or artificial. Water may be brackish or not. Soils are highly variable.. **Western North American Emergent Marsh**

10b. Herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation) or artificial groundwater seepage (including from leaky irrigation ditches). Sites typically lack prolonged standing water. Vegetation is dominated by native or non-native herbaceous species; graminoids have the greatest canopy cover. s. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation. ....**Irrigated Wet Meadow (not an official Ecological System)**

KEY B: WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS

1a. Depressional, herbaceous wetlands occurring within dune fields of the inter-mountain basins (e.g. Great Divide basin)...**Inter-Mountain Basins Interdunal Swale Wetland**

1b. Wetlands not associated with dune fields **2**

2a. Depressional wetlands. Soils are typically alkaline to saline clay with hardpans. Salt encrustation typically visible on the soil surface or along the water edge. Water levels various. Cover of vegetation variable, can be extremely sparse (<10% cover) or moderate to high (30–60% cover). Typically herbaceous dominated, but may contain salt-tolerant shrubs on the margins. **3**

2b. Non-depressional wetlands on flats or in washes, with alkaline to saline soils. Cover of vegetation variable, can be extremely sparse (<10% cover) or moderate to high (30–60% cover). Typically shrub dominated. Most common species are *Sarcobatus vermiculatus* and *Atriplex* spp.................................... **4**

3a. Depressional, alkaline wetlands that are seasonally to semi-permanently flooded, usually retaining water into the growing season and drying completely only in drought years. Many are associated with irrigation seepage, springs, or located in large basins with internal drainage. Seasonal drying exposes mudflats colonized by annual wetland vegetation. This system can occur in alkaline basins and swales and along the drawdown zones of lakes and ponds. They generally have thick unvegetated salt crusts over clay soils surrounded by zones of vegetation transitioning to the uplands. In these zones vegetation cover is generally >10% and species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Leymus* sp., *Schoenoplectus maritimus, Schoenoplectus americanus, Triglochin maritima,* and *Salicornia* spp*.*...**Inter-Mountain Basins Alkaline Closed Depression**

3b. Barren and sparsely vegetated playas (generally <10% plant cover. Could be more if annuals or upland vegetation are encroaching). Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water generally comes from precipitation and is prevented from percolating through the soil by an impermeable soil sub horizon and is left to evaporate. Soil salinity varies with soil moisture and greatly affects species composition. Characteristic species may include *Sarcobatus vermiculatus, Distichlis spicata,* and/or *Atriplex* spp. .... **Inter-Mountain Basins Playa**

4a. Shrublands with >10% total vegetation cover, located on flats. Vegetation dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of *Artemisia tridentata ssp. Tridentate, Sporobolus airoides, Pascopyrum smithii, Distichlis spicata, Puccinellia nuttalliana,* and.herbaceous vegetation. .... **Inter-Mountain Basins Greasewood Flat**

4b. Sites with < 10% total vegetation cover and restricted to temporarily or intermittently flooded drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia cana*, *Artemisia tridentata*, *Distichlis spicata*, and *Sporobolus airoides.* .... **Inter-Mountain Basins Wash**

KEY C: WETLANDS AND RIPARIAN AREAS OF THE ROCKY MOUNTAINS

1a. Wetland defined by groundwater inflows and organic soil (peat) accumulation of at least 40 cm in the upper 80 cm. Vegetation can be woody or herbaceous. If the wetland occurs within a mosaic of non-peat forming wetland or riparian systems, then the patch must be at least 0.1 hectare (0.25 acre). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criterion. .... **Rocky Mountain Subalpine-Montane Fen**

1b. Wetland does not have at least 40 cm of organic soil (peat) accumulation or occupies an area less than 0.1 hectares (0.25 acres) within a mosaic of other non-peat forming wetland or riparian systems ... 2

2a. Total woody canopy cover generally 25% or more within the overall wetland/riparian area. Any purely herbaceous patches are less than 0.5 hectare and occur within a matrix of woody vegetation. *[Note: Relictual woody vegetation such as standing dead trees and shrubs are included here.] 3*

2b. Total woody canopy cover generally less than 25% within the overall wetland/riparian area. Any woody vegetation patches are less than 0.5 hectare and occur within a matrix of herbaceous wetland vegetation 5

3a. Riparian woodlands and shrublands of the foothill and lower montane zones on the Rocky Mountains. Woodlands are dominated by *Populus* spp. (*Populus angustifolia*, or the hybrid *P. acuminate*. At higher elevations Picea engelmannii, Abies lasiocarpa, Pseudotsuga menziesii, and Pinus ponderosa can be found. Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. (this system is also found in the inter-mountain basin ecoregion).. ....
………………………………………..**Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

3b. Riparian woodlands and shrublands of the montane or subalpine zone 4

4a. Montane or subalpine riparian woodlands (canopy dominated by trees). This system occurs as a narrow streamside forest lining small, confined low- to mid-order streams. Common tree species include *Abies lasiocarpa*, *Picea engelmannii*, ,and *Populus tremuloides* (The overstory consists of Picea engelmannii, often with some Abies lasiocarpa and Populus tremuloides. These riparian areas generally occur at elevations where the uplands support upper montane and subalpine forests -- Pinus contorta, Picea engelmannii, Abies lasiocarpa. The common riparian trees in this type -- Picea engelmannii, Abies lasiocarpa, Populus tremuloides -- also grow in riparian zones in the lower montane, but there they are joined by Populus angustifolia, sometimes Populus acuminata, Populus balsamifera (mostly in NW Wyoming), Picea pungens (NW Wyoming : Snake River drainage, and the Wind River around Dubois), Pseudotsuga menziesii, Pinus ponderosa (eastern half of WY). Then, with decreasing elevation, the conifer drop out, Populus acuminata increases, and Populus deltoides becomes a major species.) ....
.... **Rocky Mountain Subalpine-Montane Riparian Woodland**

4b. Montane or subalpine shrub wetlands (canopy dominated by shrubs with sparse or no tree cover). This system is most often associated with streams (Riverine HGM Class), occurring as either a narrow band of shrubs lining streambanks of steep V-shaped canyons (straight, with boulder and cobble substrate)*or* as a wide, extensive shrub stand on alluvial terraces in low-gradient valley bottoms (more sinuous, with finer-textured substrates. Sometimes referred to as a *shrub carr*). Beaver activity is common within the wider occurrences. In addition, this system can occur around the edges of fens, lakes, seeps, and springs on slopes away from valley bottoms. This system can also occur within a mosaic of multiple shrub- and herb-dominated communities within snowmelt-fed basins. In all cases, vegetation is dominated by species of *Salix*, *Alnus*, or *Betula* but their composition varies depending on stream gradient. Alnus incana is a dominant or co-dominant along high-gradient streams; Betula occidentalis often co-dominates. Willows are present, as is Cornus sericea, but rarely dominate. In contrast, along the lower-gradient streams in wide valleys, the willows dominate; Betula and Cornus often are present but secondary to the willows; Alnus usually is a minor component. . ...
....**Rocky Mountain Subalpine-Montane Riparian Shrubland**

5a. Herbaceous wetlands with water present throughout all or most of the year. Water is at or above the surface throughout the growing season, except in drought years. This system can occur around ponds, as fringes around lakes, and along slow-moving streams and rivers. The vegetation is dominated by common emergent and floating leaved plants, including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Juncus*, *Carex*, *Potamogeton*, *Polygonum*, and *Nuphar*..
.... **Western North American Emergent Marsh**

5b. Herbaceous wetlands that typically lack extensive standing water. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation............. **7**

6a. Herbaceous wetlands associated with a high water table or overland flow, but typically lack standing water. Sites with *no channel formation* are typically associated with snowmelt or groundwater and not subjected to high disturbance events such as flooding (Slope HGM Class). Sites *associated with a stream channel* are more tightly connected to overbank flooding from the stream channel than with snowmelt and groundwater discharge. Vegetation is dominated by herbaceous species; typically graminoids have the highest canopy cover including *Carex* spp., *Calamagrostis* spp., and *Deschampsia caespitosa*.............
.... **Rocky Mountain Alpine-Montane Wet Meadow**

6b. Large herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water, but may have standing water early in the season if water levels are very high. Vegetation is dominated by native or non-native herbaceous species; graminoids have the highest canopy cover ....
. ...**Irrigated Wet Meadow (not an official Ecological System)**

Appendix B: 2013 Laramie Plains Wetland Assessment Field Form

LOCATION AND GENERAL INFORMATION

Point Code __________ Date: __________________________Surveyors:____

Directions to Point:

Access Comments (note permit requirement or difficulties accessing the site):

GPS COORDINATES OF TARGET POINT AND ASSESSMENT AREA

Elevation (m):	Slope (deg):	Aspect (deg):	Area (hectares)

Dimensions of AA:	Point info:	Target Wetland:
____40 m radius circle ____Rectangle, width______ length:______ ____Freeform, describe and take a GPS Track	____ The original point is the center of the AA ____ The original point is not the center but contained within the AA boundary _____ AA was relocated and does not contain the original point	____ Within target population ____ Not within target population, but within 200 m of a sampleable wetland

AA-Center WP #: __________ E: ___ ___ . ___ ___ ___ ___ ___ ___ N: ___ ___ . ___ ___ ___ ___ ___ ___ Error (+/-): ______________

AA-Track Track Name: ______________________________________ Comments: ____

Wildlife:

PHOTOS OF ASSESSMENT AREA(Taken at four points on edge of AA looking in.

AA-1 Photo #: _____________ Aspect: _____________

AA-2 Photo #: _____________ Aspect: _____________

AA-3 Photo #: _____________ Aspect: _____________

AA-4 Photo #: _____________ Aspect: _____________

Additional AA Photos and Comments:
(Note range of photo numbers and explain particular photos of interest)

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA

Non-target Inclusions:

% AA with > 1m standing water: ______________

% AA with upland inclusions: _________________

Wetland origin (if known):

____ Natural feature with minimal alteration

____ Natural feature, but altered or augmented by modification

____ Non-natural feature created by passive or active management

____ Unknown

Ecological System: (see manual for key and rules on inclusions and pick the *best match*) Fidelity: High Med Low

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA(CONTINUED)

Cowardin Classification (pick *one each that best represents AA*)

Fidelity: High Med Low

System and Class:		Water Regime:		Modifier (optional):	
____ PEM	____ PAB	____ A	____ F	____ b	____ h
____ PSS	____ PUB	____ B	____ G	____ x	____ f
____ PFO	____ PUS	____ C	____H	____ d	
____ L2AB	____ L2US				

HGM Class (pick *only one that best represents AA*)

Fidelity: High Med Low

____Riverine* ____Lacustrine Fringe

____Depressional ____ Slope

____ Flats ____ Irrigated (choose additional class)

**Specific classification and metrics apply to the Riverine HGM Class*

***RIVERINESPECIFIC* CLASSIFICATION OF THE ASSESSMENT AREA**

Confined vs. Unconfined Valley Setting

______ Confined Valley Setting (valley width < 2x bankfull width)

______ Unconfined Valley Setting (valley width ≥ 2x bankfull width)

Stream Flow Duration

______ Perennial

______ Intermittent

______ Ephemeral

AA Proximity to Channel

______ AA includesthe channel and both banks

______ AA is adjacent to or near the channel (< 50 m) and evaluation includes one or both banks

______ AA is > 50 m from the channel and banks were not evaluated

Stream Depth at Time of Survey (if evaluated)

______ Wadeable

______ Non-wadeable

AA REPRESENTATIVENESS

Is AA the entire wetland? ___ Yes ___ No If no, is AA representative of larger wetland? ___ Yes ___ No

Provide comments:

ASSESSMENT AREA DRAWING AND COMMENTS

Add north arrow and approx. scale bar. Document **Community types and abiotic zones** (particularly open water), inflows and outflows, and indicate direction of drainage. Include sketch of soil pit placement. If appropriate, add a **cross-sectional diagram** and indicate slope of side.

Major Zones within the AA (See field manual for rules and definitions. Mark each zone on the site sketch)	
Physiognomy________________________________ % of Area__________ Dom Species____ ____ ____ ____	Description:
Physiognomy________________________________ % of Area__________ Dom Species____ ____ ____ ____	Description:
Physiognomy________________________________ % of Area__________ Dom Species____ ____ ____ ____	Description:
Physiognomy________________________________ % of Area__________ Dom Species____ ____ ____ ____	Description:
Physiognomy________________________________ % of Area__________ Dom Species____ ____ ____ ____	Description:
Comments:	

Point Code___________________

AA GROUND COVER AND VERTICAL STRATA		
Ground Cover		**AA**
	(A) Cover of water (any depth, vegetated or not, standing or flowing)	
Set 1 B+C = A	**(B)**Cover of shallow water <20cm / average depth shallow water (cm)	/
	(C) Cover of deep water >20 cm / average depth deep water (cm)	/
Set 2 D+E+F = A	**(D)**Cover of open water with no vegetation	
	(E) Cover of water with submergent or floating aquatic vegetation	
	(F) Cover of water with emergent vegetation	
*Bare ground has no vegetation/litter/water cover. The three categories of bare ground are mutually exclusive and should total ≤100%.		
	Cover of exposed bare ground* – soil / sand / sediment	
	Cover of exposed bare ground* – gravel / cobble (~2–250 mm)	
	Cover of exposed bare ground* – bedrock / rock / boulder (>250 mm)	
Cover Classes 1: trace 2: <1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95% (Unless otherwise noted)		
	Cover of litter (all cover, including under water or vegetation)	
	Depth of litter (cm) – average of fournon-trampled locations where litter occurs	
	Predominant litter type (C = coniferous, E = broadleaf evergreen, D = deciduous, S = sod/thatch, F = forb)	
	Cover of standing dead trees (>5 cm diameter at breast height)	
	Cover of standing dead shrubs or small trees (<5 cm diameter at breast height)	
	Cover of downed coarse woody debris (fallen trees, rotting logs, >5 cm diameter)	
	Cover of downed fine woody debris (<5 cm diameter)	
	Cover bryophytes (all cover, including under water, vegetation or litter cover)	
	Cover lichens (all cover, including under water, vegetation or litter cover)	
	Cover algae(all cover, including under water, vegetation or litter cover)	

Height Classes 1:<0.5 m 2: 0.5–1m 3: 1–2 m 4: 2–5 m 5: 5–10 m 6: 10–15 m 7: 15–20 m 8: 20–35 m 9: 35–50 m 10:>50 m		
Vertical Vegetation Strata(live or very recently dead) **Cover / Height →**	**C**	**H**
(T1) Dominant canopy trees (>5 m and > 30% cover)		
(T2) Sub-canopy trees (> 5m but < dominant canopy height) or trees with sparse cover		
(S1) Tall shrubs or older tree saplings (2–5 m)		
(S2) Short shrubs or young tree saplings (0.5–2 m)		
(S3) Dwarf shrubs or tree seedlings (<0.5 m; included short *Vaccinium* spp., etc.)		
(HT) Herbaceous total		
(H1) Graminoids (grass and grass-like plants)		
(H2) Forbs (all non-graminoids)		
(H3) Ferns and fern allies		
(AQ) Submergent or floating aquatics		

Vegetation Species List

Walk through the AA and identify as many plant species as possible beginning with the most dominant species first. Spend *no more* than 1 hour compiling the species list. Once the species list is compiled, use the first module column on the form to estimate cover for the entire AA

Cover Classes 1: trace 2: <1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95%

Scientific Name or Pseudonym	% Cover	Coll #	Photos

Point Code___________________

Walk through the AA and identify as many plant species as possible beginning with the most dominant species first. Spend *no more* than 1 hour compiling the species list. Once the species list is compiled, use the first module column on the form to estimate cover for the entire AA

Cover Classes 1: trace 2: <1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95%

Scientific Name or Pseudonym	% Cover	Coll #	Photos

SOIL PROFILE DESCRIPTION – SOIL PIT ☐ Representative Pit? GPS Waypoint _______________ E: ___ ___ . ___ ___ ___ ___ ___ ___ N: ___ ___ . ___ ___ ___ ___ ___ ___ **Photo #s _____**

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so:☐Pit is filling slowly OR ☐Pit appears dry

Temp_____________ pH _____________ EC _____________ | If no surface water exists on the site but appears in the soil pit sample: Nitrate ____________

Horizon (optional)	Dept (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	%	Secondary Redox Features Color (moist)	%	Texture	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____Histic Epipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)

Comments:

SOIL PROFILE DESCRIPTION – SOIL PIT 2☐ Representative Pit? GPS Waypoint _______________ E: ___ ___ . ___ ___ ___ ___ ___ ___ N: ___ ___ . ___ ___ ___ ___ ___ ___ **Photo #s _____**

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Temp_____________ pH _____________ EC _____________ | If no surface water exists on the site but appears in the soil pit sample: Nitrate ____________

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	%	Secondary Redox Features Color (moist)	%	Texture	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____HisticEpipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)

Comments:

Point Code__________________

SOIL PROFILE DESCRIPTION – SOIL PIT 3☐ Representative Pit? GPS Waypoint ______________ E: ___ ___ . ___ ___ ___ ___ ___ ___ N: ___ ___ . ___ ___ ___ ___ ___ ___ **Photo #s _____**

Settling Time: ___________ Depth to saturated soil (cm): ___________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Temp_____________ pH _____________ EC _____________ | If no surface water exists on the site but appears in the soil pit sample: Nitrate ____________ Phosphorous ___________

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	Dominant Redox Features %	Secondary Redox Features Color (moist)	Secondary Redox Features %	Texture	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____HisticEpipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)

Comments:

WATER QUALITY

GPS Waypoint ______________ E: ___ ___ . ___ ___ ___ ___ ___ ___ N: ___ ___ . ___ ___ ___ ___ ___ ___ | **Standing OR Flowing**

Temp_____________ pH _____________ ORP __________________ EC _____________ Nitrate ____________ Turbidity _____________ Dissolved Oxygen __________________

Water quality measurement comments:

LEVEL 2 ECOLOGICAL INTEGRITY ASSESSMENT

1. *LANDSCAPE CONTEXT METRICS – Check the applicable box.*

1a. LANDSCAPE FRAGMENTATION		
Select the statement that best describes the **landscape fragmentation** with in a 500 m envelope surrounding the AA. To determine, identify the largest unfragmented block *that includes the AA* within the 500 m envelope and estimate its percent of the total envelope. Well-traveled dirt roads and major canals count as fragmentation, but hiking trails, hayfields, fences and small ditches can be included in unfragmented blocks (see definitions).	Intact: AA embedded in >90–100% unfragmented, natural landscape.	
	Variegated: AA embedded in >60–90% unfragmented, natural landscape.	
	Fragmented: AA embedded in >20–60% unfragmented, natural landscape.	
	Relictual: AA embedded in ≤20% unfragmented, natural landscape.	

1b. RIPARIAN CORRIDOR CONTINUITY*(RIVERINE WETLANDS ONLY)*		
For riverine wetlands, select the statement that best describes the **riparian corridor continuity** within 500 m upstream and downstream of the AA. To determine, identify any non-buffer patches (see definitions) within the potential riparian corridor (natural geomorphic floodplain) both upstream and downstream of the AA. Estimate the percentage of the riparian corridor they occupy. *For AAs on one side of a very large river channel (~20 m width),* only consider the riparian corridor on that side of the channel.	Intact: >95–100% natural habitat within the riparian corridor both upstream and downstream.	
	Variegated: >80–95% natural within the riparian corridor both upstream and downstream.	
	Fragmented: >50–80% natural habitat within the riparian corridor both upstream and downstream.	
	Relictual: ≤50% natural habitat within the riparian corridor both upstream and downstream.	

Landscape fragmentation and riparian corridor continuity comments:

1c. BUFFER EXTENT		
Select the statement that best describes the **extent of buffer land cover** surroundingthe AA. To determine, estimate the percent of the AA surrounded by buffer land covers (see definitions). Each segment must be ≥ 5 m wide and extend along ≥ 10of the AA perimeter.	Buffer land covers surround >100% of the AA.	
	Buffer land covers surround >75–<100% of the AA.	
	Buffer land covers surround >50–75% of the AA.	
	Buffer land covers surround >25–50% of the AA.	
	Buffer land covers surround ≤25% of the AA.	

1d. BUFFER WIDTH

Select the statement that best describes the **buffer width**. To determine, estimate width (up to 200 m from AA) along eight lines radiating out from the AA at the cardinal and ordinal directions (N, NE, E, SE, S, SW, W, NW).

1: _____________	5: _____________	Average buffer width is >200 m	
2: _____________	6: _____________	Average buffer width is >100–200 m	
3: _____________	7: _____________	Average buffer width is >50–100 m	
4: _____________	8: _____________	Average buffer width is >25–50 m	
Average width: _________________________		Average buffer width is ≤25 m OR no buffer exists	

1e. BUFFER CONDITION

Select the statement that best describes the **buffer condition**. Select one statement per column. Only consider the actual buffer measured inmetrics 1c and 1d.

Abundant (≥95%) relative cover native vegetation and little or no (<5%) cover of non-native plants.		Intact soils, little or no trash or refuse, and no evidence of human visitation. Light grazing can be present.	
Substantial (≥75–95%) relative cover of native vegetation and low (5–25%) cover of non-native plants.		Intact or moderately disrupted soils, moderate or lesser amounts of trash, light grazing to moderate grazing OR minor intensity of human visitation or recreation	
Moderate (≥50–75%) relative cover of native vegetation.		Moderate or extensive soil disruption, moderate or greater amounts of trash, moderate to heavy grazing OR moderate intensity of human use.	
Low (<50%) relative cover of native vegetation OR no buffer exists.		Barren ground and highly compacted or otherwise disrupted soils, moderate or greater amounts of trash, moderate or greater intensity of human use, very heavy grazing OR no buffer exists.	

Buffer comments:

1f. NATURAL COVER WITHIN A 100 M ENVELOPE

Using the table below, estimate the percent cover of each **natural cover type within a 200 m envelope** of the AA. Natural cover includes both *native and non-native vegetation*. This measure applies to the entire 200 m envelope and not just buffer land covers. Estimate the total combined cover and wetland and upland cover separately.

Natural Cover Type	*Total % Cover*	*Upland % Cover*	*Wetland % Cover*
Total non-natural cover (development, roads, row crops, feed lots, etc).			
Total natural cover (breakdown by type below)			
A. Deciduous forest			
B. Coniferous forest			
C. Mixed forest type (neither deciduous nor coniferous trees dominate)			
D. Shrubland			
E. Perennial herbaceous (includes hay fields and CRP lands)			
F. Annual herbaceous or disturbed bare (generally weedy)			
G. Naturally bare (open water, rock, snow/ice)			

Natural cover comments (and note the dominant species from above):

A.

B.

C.

D.

E.

F.

G.

LANDSCAPE STRESSORS

Using the table below, estimate the independent and cumulative percent of each **landscape stressor / land use within a 500 m envelope** of the AA. Stressors can overlap and do not need to total 100% (e.g., light grazing and moderate recreation can both be counted in the same portion of the envelope). ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Landscape stressor/ land use categories	*Scope*
Paved roads, parking lots, railroad tracks	
Unpaved roads (e.g., driveway, tractor trail, 4-wheel drive roads)	
Domestic or commercially developed buildings	
Gravel pit operation, open pit mining, strip mining	
Mining (other than gravel, open pit, and strip mining), abandoned mines	
Resource extraction (oil and gas wells and surrounding footprint)	
Agriculture – tilled crop production	
Agriculture – permanent crop (hay pasture, vineyard, orchard, tree plantation)	
Haying of *native* grassland (*not* dominated by non-native hay grasses)	
Recent old fields and other fallow lands dominated by *non-native* species (weeds or hay)	
CRP lands (grasslands planted with a mix of *native* and *non-native* species)	
Intensively managed golf courses, sports fields, urban parks, expansive lawns	
Vegetation conversion (chaining, cabling, rotochopping, or clear-cutting of woody veg)	
Heavy grazing by livestock or native ungulates	
Moderate grazing by livestock or native ungulates	
Light grazing by livestock or native ungulates	
Heavy browse by livestock or native ungulates	
Moderate browse by livestock or native ungulates	
Light browse by livestock or native ungulates	
Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)	
Moderate recreation or human visitation (high-use trail)	
Light recreation or human visitation (low-use trail)	
Logging or tree removal with 50-75% of trees	
Selective logging or tree removal with <50% of trees	
Evidence of recent fire (<5years old, still very apparent on vegetation, little regrowth)	
Dam sites and flood disturbed shorelines around water storage reservoirs	
Beetle-killed conifers	
Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)	
Moderate recreation or human visitation (high-use trail)	
Other:	

Landscape stressor comments:

2. VEGETATION CONDITION METRICS – *Check the applicable box.*

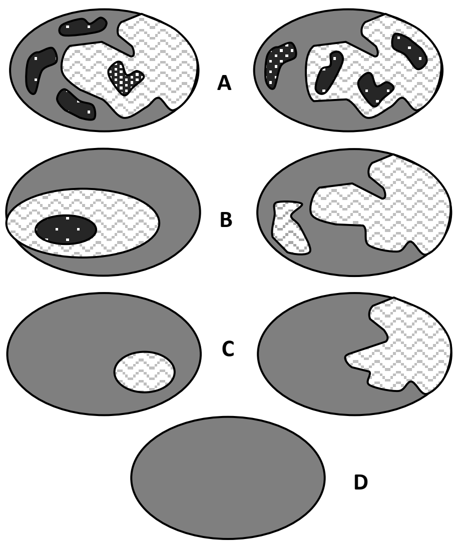
2A-D. VEGETATION COMPOSITION
Vegetation composition metrics can be calculated out of the field based on the species list and cover values. To aid data interpretation, provide comments on composition and **list noxious species identified in field.**

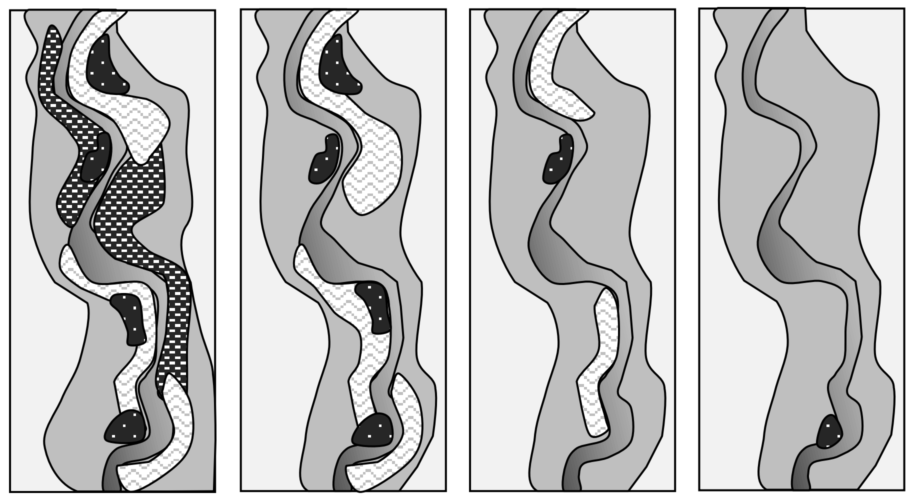
2e. REGENERATION OF NATIVE WOODY SPECIES	
Select the statement that best describes the **regeneration of native woody species**within the AA.	
Woody species are naturally uncommon or absent.	**N/A**
All age classes of desirable (native) woody riparian species present.	
Age classes restricted to mature individuals and young sprouts. Middle age groups absent.	
Stand comprised of mainly mature species OR mainly evenly aged young sprouts that choke out other vegetation.	
Woody species predominantly consist of decadent or dying individuals	
Regeneration comments and photo #'s:	

2f. COARSE AND FINE WOODY DEBRIS	
Select the statement that best describes c**oarse and fine woody debris** within the AA.	
There are no obvious inputs of woody debris.	**N/A**
AA characterized by moderate amount of coarse and fine woody debris, relative to expected conditions. For riverine wetlands, debris is sufficient to trap sediment, but does not inhibit stream flow. For non-riverine wetlands, woody debris provides structural complexity, but does not overwhelm the site.	
AA characterized by small amounts of woody debris OR debris is somewhat excessive. For riverine wetlands, lack of debris may affect stream temperatures and reduce available habitat.	
AA lacks woody debris, even though inputs are available.	
Woody debris comments and photo #'s:	

2g. HERBACEOUS / DECIDUOUS LEAF LITTER ACCUMULATION	
Select the statement that best describes **herbaceous and/or deciduous leaf litter accumulation** within the AA.	
AA characterized by moderate amount of herbaceous and/or deciduous leaflitter. New growth is more prevalent than previous years'. Litter and duff layers in pools and topographic lows are thin. Organic matter is neither lacking nor excessive.	
AA characterized by small amounts of litter with little plant recruitment OR litter is somewhat excessive.	
AA lacks litter OR litter is extensive and limiting new growth.	
Herbaceous / deciduous litter accumulation comments and photo #'s:	

2h. HORIZONTAL INTERSPERSION OF BIOTIC AND ABIOTIC ZONES		
Refer to diagrams below and select the statement that best describes the **horizontal interspersion of biotic and abiotic zones** within the AA. Rules for defining zones are in the field manual. Include zones of open water when evaluating interspersion.	High degree of horizontal interspersion: AA characterized by a very complex array of nested or interspersed zones with no single dominant zone.	
	Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed zones with no single dominant zone.	
	Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed zones. One zone may dominate others.	
	No horizontal interspersion: AA characterized by one dominant zone.	





A B C D

Horizontal interspersion comments (note if lack of interspersion is not related to wetland integrity such as in *Carex*-dominated fens):

2k. VEGETATION STRESSORS WITHN THE AA

Using the table below, estimate the independent scope of each vegetation stressor within the AA. Independent scopes can overlap (e.g., light grazing can occur along with moderate recreation). ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Vegetation stressor categories	*Scope*
Unpaved Roads (e.g., driveway, tractor trail, 4-wheel drive roads)	
Vegetation conversion (chaining, cabling, rotochopping, clearcut)	
Logging or tree removal with 50-75% of trees >50 cm dbh removed	
Selective logging or tree removal with <50% of trees >50 cm dbh removed	
Heavy grazing/browse by livestock or native ungulates	
Moderate grazing/browse by livestock or native ungulates	
Light grazing/browse by livestock or native ungulates	
Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)	
Moderate recreation or human visitation (high-use trail)	
Light recreation or human visitation (low-use trail)	
Recent old fields and other fallow lands dominated by *non-native* species (weeds or hay)	
Haying of *native* grassland (*not* dominated by non-native hay grasses)	
Beetle-killed conifers	
Evidence of recent fire (<5 years old)	
Other:	
Other:	

Vegetation stressor comments and photo #'s:

3. HYDROLOGY METRICS – Circle the applicable letter.

4a. WATER SOURCES / INPUTS		
Select the statement below that best describes the **water sources** feeding the AA during the growing season. Check off all *major* water sources in the table to the right. If the dominant water source is evident, mark it with a star (*).	_____ Overbank flooding _____ Alluvial aquifer _____ Groundwater discharge _____ Natural surface flow _____ Precipitation _____ Snowmelt	_____ Irrigation via direct application _____ Irrigation via seepage _____ Irrigation via tail water run-off _____ Urban run-off / culverts _____ Pipes (directly feeding wetland) _____ Other:

Water sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body. The system may naturally lack water at times, such as in the growing season. There is no indication of direct artificial water sources, either point sources or non-point sources. Land use in the local watershed is primarily open space or low density, passive use with little irrigation.	
Water sources are mostly natural, but also include occasional or small amounts of inflow from anthropogenic sources. Indications of anthropogenic sources include developed land or irrigated agriculture that comprises < 20% of the immediate drainage basin, the presence of a few small storm drains or scattered homes with septic system. No large point sources control the overall hydrology.	
Water sources are moderately impacted by anthropogenic sources, but are still a mix of natural and non-natural sources. Indications of moderate contribution from anthropogenic sources include developed land or irrigated agriculture that comprises 20–60% of the immediate drainage basin or the presence of a many small storm drains or a few large ones. The key factor to consider is whether the wetland is located in a landscape position supported wetland before development and whether the wetland is still connected to its natural water source (e.g., modified ponds on a floodplain that are still connected to alluvial aquifers, natural stream channels that now receive substantial irrigation return flows).	
Water sources are primarily from anthropogenic sources (e.g., urban runoff, direct irrigation, pumped water, artificially impounded water, or another artificial hydrology). Indications of substantial artificial hydrology include developed or irrigated agricultural land that comprises > 60% of the immediate drainage basin of the AA, or the presence of major drainage point source discharges that obviously control the hydrology of the AA. The key factor to consider is whether the wetland is located in a landscape position that likely never supported a wetland prior to human development. The reason the wetland exists is because of direct irrigation, irrigation seepage, irrigation return flows, urban storm water runoff, or direct pumping.	
Natural sources have been **eliminated** based on the following indicators: impoundment of all wet season inflows, diversions of all dry-season inflows, predominance of xeric vegetation, etc. The wetland is in steady decline and may not be a wetland in the near future.	

4b. HYDROPERIOD	
Select the statement below that best describes the **hydroperiod** within the AA (extent and duration of inundation and/or saturation). Search the AA and 500 m envelope for hydrologic stressors (see list below). Use best professional judgment to determine the overall condition of the hydroperiod. For some wetlands, this may mean that water is being channelized or diverted away from the wetland. For others, water may be concentrated or increased.	
Hydroperiod is characterized by natural patterns of filling or inundation and drying or drawdowns. There are no major hydrologic stressors that impact the natural hydroperiod.	
Hydroperiod filling or inundation patterns deviate slightly from natural conditions due to presence of stressors such as: small ditches or diversions; berms or roads at/near grade; minor pugging by livestock; or minor flow additions. Outlets may be slightly constricted. Playas are not significantly impacted pitted or dissected. *If wetland is artificially controlled,* the management regime closely mimics a natural analogue (it is very unusual for a purely artificial wetland to be rated in this category).	
Hydroperiod filling or inundation and drying patterns deviate moderately from natural conditions due to presence of stressors such as: ditches or diversions 1–3 ft. deep; two lane roads; culverts adequate for base stream flow but not flood flow; moderate pugging by livestock that could channelize or divert water; shallow pits within playas; or moderate flow additions. Outlets may be moderately constricted, but flow is still possible. *If wetland is artificially controlled,* the management regime approaches a natural analogue. Site may be passively managed, meaning that the hydroperiod is still connected to and influenced by natural high flows timed with seasonal water levels.	
Hydroperiod filling or inundation and drawdown of the AA deviate substantially from natural conditions from high intensity alterations such as: a 4-lane highway; large dikes impounding water; diversions > 3ft. deep that withdraw a significant portion of flow, deep pits in playas; large amounts of fill; significant artificial groundwater pumping; or heavy flow additions. Outlets may be significantly constricted, blocking most flow. *If wetland is artificially controlled,* the site is actively managed and not connected to any natural season fluctuations, but the hydroperiod supports natural functioning of the wetland.	
Hydroperiod is dramatically different from natural. Upstream diversions severely stress the wetland. Riverine wetlands may run dry during critical times. *If wetland is artificially controlled,* hydroperiod does not mimic natural seasonality. Site is actively managed for filling or drawing down without regard for natural wetland functioning.	
Water source and Hydroperiod comments:	

4c. HYDROLOGIC CONNECTIVITY

Select the statement below that best describes the **hydrologic connectivity**.

Rising water has unrestricted access to adjacent areas without levees or other obstructions to the lateral movement of flood waters. Channel, if present, is not entrenched and is still connected to the floodplain (see entrenchment ratio in optional riverine metrics).	
Unnatural features such as levees or road grades limit the amount of adjacent transition zone or the lateral movement of floodwaters, relative to what is expected for the setting, but limitations exist for <50% of the AA boundary. Restrictions may be intermittent along the margins of the AA, or they may occur only along one bank or shore. Channel, if present, is somewhat entrenched. If playa, surrounding vegetation does not interrupt surface flow.	
The amount of adjacent transition zone or the lateral movement of flood waters to and from the AA is limited, relative to what is expected for the setting, by unnatural features for 50–90% of the boundary of the AA. Features may include levees or road grades. Flood flows may exceed the obstructions, but drainage out of the AA is probably obstructed. Channel, if present, may be moderately entrenched and disconnected from the floodplain except in large floods. If playa, surrounding vegetation may interrupt surface flow.	
The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features for >90% of the boundary of the AA. Channel, if present, is severely entrenched and entirely disconnected from the floodplain. If playa, surrounding vegetation may dramatically restrict surface flow.	

Hydrologic connectivity comments:

4d. HYDROLOGY STRESSORS WITHIN A 500 M ENVELOPE

Using the table below, mark the severity of each **hydrology stressor within a 500 m envelope of the AA**. Mark whether the stressor is present upstream/slope or downstream/slope of the AA. If known alteration occurs further upstream than 500 m, please explain in comments below.

Hydrology stressor categories	*Within AA*	*Upstream / Upslope*	*Downstream / Downslope*
Dam / reservoir			
Impoundment / stock pond			
Spring box diverting water from wetland			
Extensive groundwater wells in the surrounding area			
Pumps, diversions, ditches that move water *out of* the wetland			
Pumps, diversions, ditches that move water *into* the wetland			
Berms, dikes, levees that hold water in the wetland			
Deeply dug pits for holding water			
Weir or drop structure that impounds water and controls energy of flow			
Observed or potential agricultural runoff			
Observed or potential urban runoff			
Flow obstructions into or out of wetland (roads without culverts)			
Dredged inlet or outlet channel			
Engineered inlet or outlet channel (e.g., riprap)			
Other:			
Other:			

Hydrology stressor comments:

4. *PHYSIOCHEMICAL METRICS – Circle the applicable letter.*

3a. WATER QUALITY - SURFACE WATER TURBIDITY / POLLUTANTS	
Select the statement that best describes the **turbidity or evidence or pollutants** in surface water within the AA.	
No open water in AA	
No visual evidence of degraded water quality. No visual evidence of turbidity or other pollutants.	
Some negative water quality indicators are present, but limited to small and localized areas within the wetland. Water is slightly cloudy, but there is no obvious source of sedimentation or other pollutants.	
Water is cloudy or has unnatural oil sheen, but the bottom is still visible. Sources of water quality degradation are apparent (identify in comments below). *Note: If the sheen breaks apart when you run your finger through it, it is a natural bacterial process and not water pollution.*	
Water is milky and/or muddy or has unnatural oil sheen. The bottom is difficult to see. There are obvious sources of water quality degradation (identify in comments below). *Note: If the sheen breaks apart when you run your finger through it, it is a natural bacterial process and not water pollution.*	
Surface water turbidity / pollutants comments and photo #'s:	

3b. WATER QUALITY - ALGAL GROWTH	
Select the statement that best describes **algal growth** within surface water in the AA.	
No open water in AA or evidence of open water.	
Water is clear with minimal algal growth.	
Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness.	
Algal growth occurs in moderate to large patches throughout the AA. Water may have a moderate greenish tint or sheen. Sources of water quality degradation are apparent (identify in comments below).	
Algal mats are extensive, blocking light to the bottom. Water may have a strong greenish tint and the bottom is difficult to see. There are obvious sources of water quality degradation (identify in comments below).	
Algal growth comments and photo #'s: Algal growth may be natural and not necessarily indicative of poor water quality. If algal growth appears natural, describe and record % of total algae that is due to natural processes.	

3c. SUBSTRATE / SOIL DISTURBANCE	
Select the statement below that best describes disturbance to the substrate or soil within the AA. For playas, the most significant substrate disturbance is sedimentation or unnaturally filling, which prevents the system's ability to pond after heavy rains. For other wetland types, disturbances may lead to bare or exposed soil and may increase ponding or channelization where it is not normally. For any wetland type, consider the disturbance relative to what is expected for the system.	
No soil disturbance within AA. Little bare soil OR bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails OR soil is naturally bare (e.g., playas). No pugging, soil compaction, or sedimentation.	
Minimal soil disturbance within AA. Some amount of bare soil, pugging, compaction, or sedimentation present due to human causes, but the extent and impact are minimal. The depth of disturbance is limited to only a few inches and does not show evidence of altering hydrology. Any disturbance is likely to recover within a few years after the disturbance is removed.	
Moderate soil disturbance within AA. Bare soil areas due to human causes are common and will be slow to recover. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts. Sedimentation may be filling the wetland. Damage is obvious, but not excessive. The site could recover to potential with the removal of degrading human influences and moderate recovery times.	
Substantial soil disturbance within AA. Bare soil areas substantially degrade the site and have led 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. Sedimentation may have severely impacted the hydrology. The site will not recover without active restoration and/or long recovery times.	
Substrate / soil comments and photo #'s:	

3d. PHYSIOCHEMICAL STRESSORS WITHIN THE AA
Using the table below, estimate the independent scope of each physiochemical stressor within the AA. Independent scopes can overlap (e.g., soil compaction can occur with trash or refuse). ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Physiochemical stressor categories	*Scope*
Erosion	
Sedimentation	
Current plowing or disking	
Historic plowing or disking (evident by abrupt A horizon boundary at plow depth)	
Substrate removal (excavation)	
Filling or dumping of sediment	
Trash or refuse dumping	
Compaction and soil disturbance by livestock or native ungulates	
Compaction and soil disturbance by human use (trails, ORV use, camping)	
Mining activities, current or historic	
Obvious point source of water pollutants (discharge from waste water plants, factories)	
Agricultural runoff (drain tiles, excess irrigation)	
Direct application of agricultural chemicals	
Discharge or runoff from feedlots	
Obvious excess salinity (dead or stressed plants, salt encrustations)	
Other:	
Other:	
Physiochemical stressor comments:	

5. SIZE METRICS – Circle the applicable letter.

5a. RELATIVE SIZE

Estimate the potential size of the wetland containing the assessment area and compare this to the actual size. Wetland area can be lost due to human disturbance such as roads, impoundments, development, ditching, draining, mining, flooding for reservoirs, etc. Estimate using best available information (maps, air photography, etc.).	Wetland area ≈ onsite abiotic potential; <5% of wetland has been reduced.	
	Wetland area < abiotic potential; 5–25% of wetland has been reduced.	
	Wetland area < abiotic potential; 25–50% of wetland has been reduced.	
	Wetland area < abiotic potential; >50% of wetland has been reduced.	

Relative size comments:

5b. ABSOLUTE SIZE

Absolute size of the wetland will be determined in GIS. To aid data interpretation, please describe any **significant boundaries** to the targeted **Ecological System** that are not evident from aerial photography, such as break in hydrologic flow, change in soil type, or land use changes since aerial photography was flown.

6. OPTIONAL RIVERINE HYDROLOGY METRICS (use when channel is within ~50 m)

6a. RIVERINE CHANNEL AND BANK STABILITY	
Select the statement below that best describes **channel and bank stability** within or near the AA. To determine, visually survey the AA for field indicators of channel equilibrium, aggradation or degradation listed in the table below. Check "Y" for all that apply and "N" for those not observed. Use best professional judgment to determine the overall channel and bank stability.	
Condition	*Field Indicators*
	Y N
Indicators of Channel Equilibrium / Natural Dynamism	☐ ☐ The channel (or multiple channels in braided systems) has a well-defined usual high water line or bankfull stage that is clearly indicated by an obvious floodplain, topographic bench that represents an abrupt change in the cross-sectional profile of the channel throughout *most* of the site. ☐ ☐ The usual high water line or bank full stage corresponds to the lower limit of riparian vascular vegetation. ☐ ☐ Leaf litter, thatch, wrack, and/or mosses exist in most pools. ☐ ☐ The channel contains embedded woody debris of the size and amount consistent with what is available in the riparian area. ☐ ☐ Active undercutting of banks or burial of riparian vegetation is limited to localized areas and not throughout site. ☐ ☐ There is little evidence of recent deposition of cobble or very coarse gravel on the floodplain, although recent sandy deposits may be evident. ☐ ☐ There are no densely vegetated mid-channel bars and/or point bars, indicating flooding at regular intervals. ☐ ☐ The spacing between pools in the channel tends to be 5-7 channel widths, if appropriate. ☐ ☐ The larger bed material supports abundant periphyton.
Indicators of Active Aggradation / Excessive Sediment	☐ ☐ The channel through the site lacks a well-defined usual high water line. ☐ ☐ There is an active floodplain with fresh splays of sediment covering older soils or recent vegetation. ☐ ☐ There are partially buried tree trunks or shrubs. ☐ ☐ Cobbles and/or coarse gravels have recently been deposited on the floodplain. ☐ ☐ There is a lack of in-channel pools, their spacing is greater than 5-7 channel widths, or many pools seem to be filling with sediment. ☐ ☐ There are partially buried, or sediment-choked, culverts. ☐ ☐ Transitional or upland vegetation is encroaching into the channel throughout most of the site. ☐ ☐ The bed material is loose and mostly devoid of periphyton.
Indicators of Active Degradation / Excessive Erosion	☐ ☐ The channel through the site is characterized by deeply undercut banks with exposed living roots of trees or shrubs. ☐ ☐ There are abundant bank slides or slumps, or the banks are uniformly scoured and unvegetated. ☐ ☐ Riparian vegetation declining in stature or vigor, and/or riparian trees and shrubs may be falling into channel. ☐ ☐ Abundant organic debris has accumulated on what seems to be the historical floodplain, indicating that flows no longer reach the floodplain. ☐ ☐ The channel bed appears scoured to bedrock or dense clay. ☐ ☐ The channel bed lacks fine-grained sediment. ☐ ☐ Recently active flow pathways appear to have coalesced into one channel (i.e. a previously braided system is no longer braided). ☐ ☐ There are one or more nick points along the channel, indicating headward erosion of the channel bed.

RATING CRITERIA FOR ALL RIVERINE WETLANDS	
Most of the channel within or near the AA is characterized by naturally dynamic equilibrium conditions, with little evidence of excessive aggradation or degradation. Streambanks typically dominated (>90% cover) by stabilizing plant species, including trees, shrubs, herbs.	
Most of the channel within or near the AA is characterized by some aggradation or degradation, none of which is severe, and the channel seems to be approaching an equilibrium form. Streambanks may have 70–90% cover of stabilizing plant species, but some bare areas occur.	
There is evidence of severe aggradation or degradation of most of the channel within or near the AA or the channel is artificially hardened through less than half of the AA. Streambanks may have 50–70% cover of stabilizing plant species within several bare areas.	
The channel is concrete or otherwise artificially hardened through most of the AA. Streambanks have <50% cover of stabilizing plant species.	

Channel stability comments (note if channel is unstable due to beaver or natural processes):

6b. RIVERINE ENTRENCHMENT RATIO (optional guide for if stream may be entrenched)

Using the following worksheet, calculate the average **entrenchment ratio** for the channel. The steps should be conducted for each of three cross sections located in or adjacent to the AA at the approximate mid-points along straight riffles or glides, away from deep pools or meander bends. *Do not attempt to measure this for non-wadeable streams!*

Steps	*Replicate cross-sections* →	*1*	*2*	*3*
1. Estimate bankfull width.	If the stream is entrenched, the height of bankfull flow is identified as a scour line, narrow bench, or the top of active point bars well below the top of apparent channel banks. If the stream is not entrenched, bankfull stage can correspond to the elevation of a broader floodplain with indicative riparian vegetation. Estimate or measure the distance between the right and left bankfull contours.			
2. Estimate max bankfull depth.	Imagine a line between right and left bankfull contours. Estimate or measure the height of the line above the thalweg (the deepest part of the channel).			
3. Estimate flood prone height.	Double the estimate of maximum bankfull depth from Step 2.			
4. Estimate flood prone width.	Imagine a level line having a height equal to the flood prone depth from Step 3. Note the location of the new height on the channel bank. Estimate the width of the channel at the flood prone height.			
5. Calculate entrenchment.	Divide the flood prone width (Step 4) by the max bankfull width (Step 1).			
6. Calculate average entrenchment	Average the results of Step 5 for all three cross-sections and enter it here.			

RATING CRITERIA FOR CONFINED RIVERINE WETLANDS		**RATING CRITERIA FOR UNCONFINED RIVERINE WETLANDS**	
Entrenchment ratio >2.0.		Entrenchment ratio >2.2.	
Entrenchment ratio 1.6–2.0.		Entrenchment ratio 1.9–2.2.	
Entrenchment ratio 1.2–1.5.		Entrenchment ratio 1.5–1.8.	
Entrenchment ratio <1.2.		Entrenchment ratio <1.5.	

Entrenchment ratio comments:

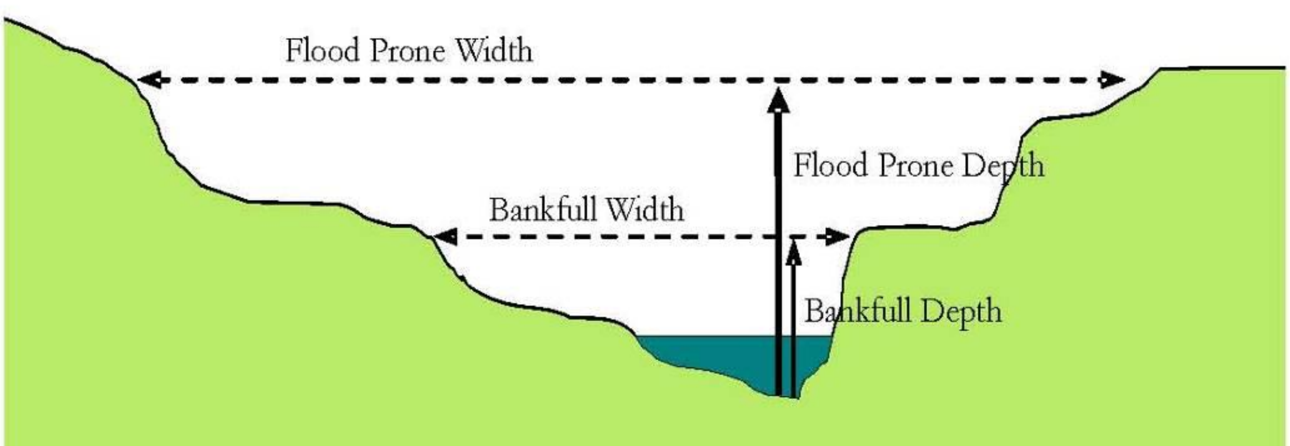


Illustration from Collins *et al.* 2008. California Rapid Assessment Method for Wetlands v 5.0.2

AREM Long Form

Type of Wetland (check one):

____ On-farm ____ Off-farm

Wetland Water Source (check one or more):

____ Subsurface seepage – Mostly Natural
____ Subsurface seepage – Mostly Irrigation-related
____ Overland runoff – Mostly Natural
____ Overland runoff – Mostly Irrigation-related
____ Channel or lake overflow – Mostly Natural
____ Channel or lake overflow – Mostly Irrigation-related

For each numbered item, check only one response unless noted otherwise. Then proceed to the next question unless noted otherwise. Parenthetical names are the names of fields in the supporting software database (WHRBASE). If a field name is lacking, the information is not used directly.

1. LOCATION. Is the area part of, or is it within 0.5 mile of, a major* river or lake?
   ** river channel wider than 100 ft, or lake larger than 40 acres*
   ____ Yes (field BigWater) ____ No
2. SURFACE WATER. During this season, does the area contain at least 0.1 acre* of surface water, either obscured by vegetation or not?
   ** See Figure B-1 for guidance in estimating acreage categories.*
   ____ Yes (field AnyWater). Go to next question.
   ____ No. **Skip to question #5.**
3. OPEN WATER. During this season, how much open* water is present in the area?
   ** water deeper than 2 inches and mostly lacking vegetation (except submerged plants).*
   ____ > 20 acres and it is mostly wider than 500 ft (field OpenBig)
   ____ < 1 acre, or, >1 acre but mostly narrower than 3 ft (field OpenSmall)
   ____ Other conditions (field OpenOther)
4. SPECIFIC AQUATIC CONDITIONS
   Check all that apply during this season:
   ____ > 0.1 acre of the surface water is still, i.e., usually flows at less than 1 ft/s (field StillWater)
   ____ The evaluated area can be assumed to contain fish (field Fish)
   ____ The evaluated area can be assumed to contain frogs, salamanders, and/or crayfish (field Amphibs)
   ____ Water transparency in the deepest part of the area is (or would be, if depth is shallow) sufficient to see an object 10 inches below the surface, and the area is not known to have problems with metal contamination (field Clear)
   ____ The evaluated area is highly enriched by direct fertilizer applications, water from nearby feedlots, or other sources (field Enriched)
   ____ Most of the normally-flooded part of the area goes dry at least one year in five, or, is subject to flooding from a river at least as often (field Drawdown)

5. BARE SOIL. Is there at least 0.1 acre of mud*, alkali flat, gravel/sand bar, recently tilled soil, and/or heavily grazed open (grassy, non-shrubby) areas during this season?
** includes soil that is continually saturated up to the surface, or which was previously covered by water but has become exposed to the air during this period*
____ Yes (field Bare). Go to next question.
____ No. **Skip to question #7.**
6. LARGE MUDFLAT. Does the area at this season contain mud that has all these features?:
   - At least 1 acre in size
   - Maximum dimension is greater than 100 ft
   - Salt crust or salt stains are not apparent
   - Not recessed within a wash or canal whose depth (relative to surrounding landscape) is greater than half its width.

   ____ Yes (field MudBig) ____ No

7. TREES. Are there at least 3 trees*:
** woody plants taller than 20 ft.*
____ in the evaluation area? (field TreeIn).
____ within 1000 ft of the evaluation area? (field TreeNear). **Go to #8.**
____ neither of the above. **Skip to #11.**
8. TREE COVER. Check one or more responses below that describe the maximum cumulative acreage of various conditions of tree cover in the evaluation area. Also include areas within 300 ft:
____ >1 acre, dense*, and wide** (field ForestDens)
____ >1 acre and open; or, dense but narrow (field ForestOpen)
____ 0.1-1 acre, dense* (field WoodDens)
____ 0.1-1 acre, open (field WoodOpen)
____ <0.1 acre
** Dense= the tree canopy, viewed from the ground during midsummer, appears at least 50% closed, as averaged across an area that is at least as large as the acreage specified.*
*** Wide= the wooded area is wider than 300 ft (average).*
9. BIG TREES. Are there at least three trees whose trunk diameter 20 ft above the ground is >12 inches?
____ Yes (field TreesBig) ____ No
10. SNAGS. Are there at least three snags, or trees with dead limbs with diameter >5 inches?
____ Yes (field Snags) ____ No
11. SHRUBS. Is there at least 0.1 acre of shrubs*:
** woody plants 2-20 ft in height.*
____ in the evaluation area? (field ShrubIn).
____ within 1000 ft of the wetland (including the wetland itself)? (field ShrubNear). **Go to #12.**
____ Neither of the above. **Skip to #13.**
12. SHRUB SPECIES AND DENSITY. Check one or more responses below that describe the maximum cumulative extent of various types and conditions of shrub cover in the evaluation area. Also include areas within 300 ft.
Willow:
____ >1 acre, dense*, and wide** (field WwMuchDens)
____ >1 acre and open; or, dense but narrow (field WwMuchOpen)
____ 0.1-1 acre, dense* (field WwSomeDens)
____ 0.1-1 acre, open (field WwSomeOpen)
____ <0.1 acre; or larger area but height mostly <4 ft and openly spaced

13. Greasewood or other tall desert shrubs:
____ >1 acre, dense*, and wide** (field GrMuchDens)
____ >1 acre and open; or, dense but narrow (field GrMuchOpen)
____ 0.1–1 acre, dense* (field GrSomeDens)
____ 0.1–1 acre, open (field GrSomeOpen)
____ <0.1 acre

Russian olive, sumac, buffaloberry, wild rose, or others with fleshy fruit:
____ >1 acre, dense*, and wide** (field FrMuchDens)
____ >1 acre, open; or, dense but narrow (field FrMuchOpen)
____ 0.1–1 acre, dense (field FrSomeDens)
____ 0.1–1 acre, open (field FrSomeOpen)
____ <0.1 acre; or larger area but height mostly <4 ft

Tamarisk (salt cedar):
____ >1 acre, dense*, and wide** (field TmMuchDens)
____ >1 acre, open; or, dense but narrow (field TmMuchOpen)
____ 0.1–1 acre, dense (field TmSomeDens)
____ 0.1–1 acre, open (field TmSomeOpen)
____ <0.1 acre; or larger area but height mostly <4 ft

** Dense= the shrub canopy, as viewed from a height of 100 ft during midsummer, appears to be >50% closed, as averaged across an area that is at least as large as the acreage specified.*
*** Wide= the shrub area is wider than 300 ft (average).*

14. HERBACEOUS VEGETATION. Is there at least 0.1 acre of herbaceous vegetation*:
** Nonwoody plants such as cattail, bulrush, sedges, grasses, and forbs.*
____ in the evaluation area? (field HerbIn).
____ within 1000 ft? (field HerbNear). **Go to #14.**
____ Neither of the above. **Skip to #15.**

15. HERBACEOUS SPECIES. Check one or more responses below that describe the maximum cumulative extent of various types and conditions of shrub cover in the evaluation area. Also include areas within 300 ft.

Robust emergents (e.g., cattail, phragmites)
____ >1 acre, dense*, and wide** (field RbMuchDens)
____ >1 acre, open; or dense but narrow (field RbMuchOpen)
____ 0.1–1 acre, dense (field RbSomeDens)
____ 0.1–1 acre, open (field RbSomeOpen)

Other wet** emergents (e.g., bulrush, sedge)
____ >1 acre, dense*, wide**, and tall*** (field WEMuchDens)
____ >1 acre, tall, open; or dense but narrow (field WEMuchOpen)
____ >1 acre, dense or open, and short (field WEMuchShrt)
____ 0.1–1 acre, tall, dense (field WESomeDens)
____ 0.1–1 acre, tall, open; or dense but narrow (field WESomeOpen)
____ 0.1–1 acre, dense or open, and short (field WESomeShrt)

Drier emergents (e.g., saltgrass, other grasses)
____ >1 acre, dense*, wide**, and tall*** (field DEMuchDens)
____ >1 acre, tall, open; or dense but narrow (field DEMuchOpen)
____ >1 acre, dense or open, and short (field DEMuchShrt)
____ 0.1-1 acre, tall, dense (field DESomeDens)
____ 0.1-1 acre, tall, open; or dense but narrow (field DESomeOpen)
____ 0.1-1 acre, dense or open, and short (field DESomeShrt)

Broad-leaved Forbs (e.g., milkweed, thistle, alfalfa)
____ >1 acre (field ForbMuch)
____ 0.1-1 acre (field ForbSome)

Aquatic plants (e.g., watercress, sago pondweed, duckweed)
____ >10 acres (field AqMuch)
____ 0.1-10 acres (field AqSome)

** Dense= plants are so close together that the duff layer or soil beneath the plants is mostly obscured by foliage, when looking down from just above the plant tops.*
*** Wet= water is visible at or above the soil surface during most of the growing season.*
**** Wide= the shrub area is wider than 300 ft (average).*
***** Tall= taller than 1 ft.*

16. SURROUNDING LAND COVER. Check one:
Within 0.5 mi of the wetland, >60% of the land cover is:
____ Pasture, alfalfa, grain crops, row crops, other wetlands, grass lawns, and/or weed fields (field SurAgwet)
____ Desert shrubs (e.g., sagebrush, shadscale, rabbitbrush)(field SurDesrt)
____ Pinyon-juniper (field SurPJ)
____ Oak scrub (e.g., Gambel oak, serviceberry, skunkbrush)(field SurOak)
____ Other, or none of the above comprise >60%
17. LOCAL LAND COVER. Check one:
Within 3 mi of the wetland, > 60% of the land cover is:
____ Pasture, alfalfa, grain crops, row crops, other wetlands, grass lawns, and/or weed fields (field LocAgWet)
____ Desert shrubs (e.g., sagebrush, shadscale, rabbitbrush)(field LocDesrt)
____ Pinyon-juniper (field LocPJ)
____ Oak scrub (e.g., Gambel oak, serviceberry, skunkbrush)(field LocOak)
____ Other, or none of the above comprise >60%
18. VISUAL SECLUSION
Check only one:
____ Both of the following:
(a) wetland is seldom visited by people on foot or boat (less than once weekly), (b) there are no paved roads within 600 ft, or if there are, wetland is not visible from the roads (field SeclusionH).
____ Either (a) or (b) above (field SeclusionM).
____ Other condition.

19. PREDATION POTENTIAL
    Check only one. The evaluation area:
    ____ is linear*, adjoins a heavily-traveled road (usual maximum of >1 car/minute), and/or is in a high-density housing area (>1 house/5 acres) (field PredHPot)
    ____ adjoins a less-traveled road, and/or is in an area with sparser housing density but is closer than 1000 ft to a normally-occupied building (field PredMPot)
    ____ Other condition.
    ** at least 90% of the area being evaluated is within 25 ft of a canal, road, railroad tracks, or other artificially linear feature.*
20. GRAZED, BURNED, MOWED. Is the area mowed, burned, or grazed intensively (i.e., with clearly visible effects on vegetation) during this season?
    ____ Yes (field GrazBurnMo)
    ____ No
21. NESTING LOCATIONS
    Check all that apply:
    ____ Semi-open structures (bridges, barns) suitable for nesting swallows are present within 300 ft (field SwallNest)
    ____ Platforms suitable for nesting geese are present in the wetland or along its perimeter (field GooseNest)
    ____ Vertical, mostly bare dirt banks at least 5 ft high are present within 0.5 mi., of potential use to nesting kingfishers, barn owls, and swallows (field Banks)

This concludes the initial evaluation. If you intend to infer the value of this wetland at seasons or years other than the present one, you should go back over all your responses and, on a new form, change the responses that would be different at that season/year. Then, proceed to the analysis described by the User's Manual.

Appendix C. Wetland Plants found in the Laramie Plains Basin with surrogate C-values.

Scientific Name	# of Occurrences	Lifeform	Nativity	Arid West Wetland Status	WY Surrogate C_Values	Common Name
Achillea millefolium	13	Native	FACU	4		Common Yarrow
Aconitum columbianum	1	Native	FACW	5	Forb	Columbian Monkshood
Agoseris glauca	2	Native	FACU	5	Forb	Pale Goat-Chicory
Agrostis stolonifera	26	Non-native	FACW	0	Graminoid	Spreading Bent
Alisma gramineum	4	Native	OBL	3	Forb	Narrow-Leaf Water-Plantain
Allium geyeri	1	Native	FACU	5	Forb	Geyer's Onion
Allium textile	1	Native		6	Forb	
Almutaster pauciflorus	1	Native	FACW	4	Forb	Marsh-Aster
Alnus incana	10	Native	FACW	6		Speckled Alder
Alopecurus aequalis	6	Native	OBL	4	Graminoid	Short-Awn Meadow-Foxtail
Alopecurus arundinaceus	30	Non-native	FAC	0	Graminoid	Creeping Meadow-Foxtail
Alopecurus pratensis	16	Non-native	FACW	0	Graminoid	Field Meadow-Foxtail
Alyssum desertorum	1	Non-native		0	Forb	
Ambrosia acanthicarpa	1	Native		4	Forb	
Ambrosia artemisiifolia	3	Non-native	FACU	0		Annual Ragweed
Amelanchier utahensis	4	Native	FACU	6	Shrub	Utah Service-Berry
Anaphalis margaritacea	1	Native		4	Forb	
Anemone cylindrica	1	Native		5	Forb	
Argentina anserina	25	Native	OBL	3	Forb	Common Silverweed
Arnica chamissonis	2	Native	FACW	8	Forb	Leafy Leopardbane
Artemesia frigida	1		Unknown			

Artemisia cana	1	Native	FACU	6		Coaltown Sagebrush
Astragalus sp.	1	Native	Unknown			
Atriplex canescens	1	Native		6.5	Shrub	
Atriplex gardneri	2	Native		6	Shrub	
Beckmannia syzigachne	7	Native	OBL	4	Graminoid	American Slough Grass
Betula occidentalis	5	Native	FACW	6	Shrub	Water Birch
Bromus carinatus	1	Native		0	Graminoid	
Bromus ciliatus	5	Native	FAC	5		Fringed Brome
Bromus inermis	5	Non-native	FACU	0		Smooth Brome
Bromus tectorum	1	Non-native		0	Graminoid	
Calamagrostis canadensis	9	Native	FACW	6	Graminoid	Bluejoint
Calamagrostis stricta	13	Native	FACW	7	Graminoid	Slim-Stem Reed Grass
Callitriche palustris	4	Native	OBL	5	Forb	Vernal Water-Starwort
Camelina microcarpa	2	Non-native	FACU	0	Forb	Little-Pod False Flax
Campanula rotundifolia	1	Native	FACU	4	Forb	Bluebell-of-Scotland
Cardamine breweri	1	Native	FACW	7	Forb	Sierran Bittercress
Cardamine oligosperma	1	Native	FAC	3		Little Western Bittercress
Carex aquatilis	8	Native	OBL	6	Graminoid	Leafy Tussock Sedge
Carex atherodes	1	Native	OBL	6	Graminoid	Wheat Sedge
Carex canescens	1	Native	OBL	8	Graminoid	Hoary Sedge
Carex diandra	1	Native	OBL	9	Graminoid	Lesser Tussock Sedge
Carex disperma	2	Native	OBL	8	Graminoid	Soft-Leaf Sedge
Carex douglasii	1	Native	FAC	5	Graminoid	Douglas' Sedge
Carex lenticularis	1	Native	OBL	9		Lakeshore Sedge
Carex microptera	1	Native	FAC	4	Graminoid	Small-Wing Sedge
Carex nebrascensis	23	Native	OBL	4	Graminoid	Nebraska Sedge
Carex pellita	5	Native	OBL	5	Graminoid	Woolly Sedge
Carex praegracilis	16	Native	FACW	5	Graminoid	Clustered Field Sedge
Carex sartwellii	1	Native	OBL	9	Graminoid	Sartwell's Sedge
Carex simulata	1	Native	OBL	7	Graminoid	Analogue Sedge

Carex sp.	3		Unknown			
Carex utriculata	17	Native	OBL	4	Graminoid	Northwest Territory Sedge
Castilleja miniata	4	Native	FACW	5	Forb	Great Red Indian-Paintbrush
Castilleja sulphurea	1	Native	FACW	7	Forb	
Catabrosa aquatica	1	Native	OBL	4	Graminoid	Water Whorl Grass
Ceratophyllum demersum	1	Native	OBL	1	Forb	Coon's-Tail
Chenopodium album	1	Non-native	FACU	0	Forb	Lamb's-Quarters
Chenopodium capitatum	2	Non-native		0	Forb	
Chenopodium fremontii	1	Native	FACU	6	Forb	Fremont's Goosefoot
Chenopodium glaucum	3	Non-native	FAC	0	Forb	Oak-Leaf Goosefoot
Chenopodium rubrum	2	Native	FACW	2.5	Forb	Red Goosefoot
Chenopodium sp.	2		Unknown			
Chrysothamnus vaseyi	2	Native			Shrub	
Cicuta maculata var. anustifolia	3	Native	OBL	3		Spotted Water-Hemlock
Cirsium arvense	40	Non-native	FACU	0	Forb	Canadian Thistle
Cirsium ochrocentrum	1	Native		4	Forb	
Cirsium scariosum	1	Native	FAC	6	Forb	Meadow Thistle
Cirsium vulgare	1	Non-native	FACU	0	Forb	Bull Thistle
Conioselinum scopulorum	4	Native	FACW	1	Forb	Rocky Mountain Hemlock-Parsley
Conium maculatum	2	Non-native	FACW	0	Forb	Poison-Hemlock
Conyza canadensis	2	Non-native	FACU	0	Forb	Canadian Horseweed
Corispermum villosum	1	Native		3	Forb	
Cornus sericea ssp. Sericea	8	Native	FACW	6	Shrub	Red Osier
Dasiphora fruticosa ssp. Floribunda	4	Native	FAC	4	Shrub	Golden-Hardhack
Deschampsia cespitosa	21	Native	FACW	6	Graminoid	Tufted Hair Grass
Descurainia incana	4	Native	FACU	2	Forb	Mountain Tansy-Mustard

Descurainia sophia	1	Non-native		0	Forb	
Distichlis spicata	17	Native	FAC	4	Graminoid	Coastal Salt Grass
Dodecatheon pulchellum	1	Native	FACW	6	Forb	Dark-Throat Shootingstar
Dysphania botrys	1	Non-native	FACU	0		Jerusalem-Oak
Elaeagnus angustifolia	1	Non-native	FAC	0	Shrub	Russian-Olive
Eleocharis acicularis	2	Native	OBL	5	Graminoid	Needle Spike-Rush
Eleocharis palustris	31	Native	OBL	4	Gaminoid	Common Spike-Rush
Eleocharis quinqueflora	1	Native	OBL	8	Graminoid	Few-Flower Spike-Rush
Elodea bifoliata	1	Native	OBL	7	Forb	Two-Leaf Waterweed
Elodea canadensis	5	Native	OBL	3	Forb	Canadian Waterweed
Elymus repens	2	Non-native	FAC	0	Graminoid	Creeping Wild Rye
Epilobium clavatum	1	Native	FACU	10	Forb	Talus Willowherb
Epilobium hornemannii	2	Native	FACW	6	Forb	Hornemann's Willowherb
Epilobium lactiflorum	1	Native	FACW	7	Forb	White-Flower Willowherb
Epilobium oregonense	1	Native	OBL			Oregon Willowherb
Epilobium palustre	1	Native	OBL	7	Forb	Marsh Willowherb
Epilobium sp.	3		Unknown			
Equisetum arvense	12	Native	FAC	3	Forb	Field Horsetail
Equisetum hyemale	2	Native	FACW	4		Tall Scouring-Rush
Equisetum laevigatum	11	Native	FACW	4	Forb	Smooth Scouring-Rush
Erigeron lonchophyllus	1	Native	FACW	5	Forb	Short-Ray Fleabane
Erigeron sp.	1		Unknown			
Erigeron ursinus	1	Native		7	Forb	
Fragaria virginiana	6	Native	FACU	5		Virginia Strawberry
Galium bifolium	1	Native		7	Forb	
Galium boreale	3	Native	FACU	5	Forb	Northern Bedstraw
Galium triflorum	4	Native	FACU	7	Forb	Fragrant Bedstraw
Gentiana parryi	2	Native	FAC	9	Forb	Parry's Gentia
Geranium richardsonii	10	Native	FACU	6	Forb	White Crane's-Bill

Geum macrophyllum	8	Native	FACW	6		Large-Leaf Avens
Glaux maritima	14	Native	FACW	7	Forb	Sea-Milkwort
Glyceria grandis	8	Native	OBL	7	Graminoid	American Manna Grass
Glyceria striata	7	Native	OBL	6	Graminoid	Fowl Manna Grass
Glycyrrhiza lepidota	10	Native	FAC	3	Forb	American Licorice
Grass sp.	1		Unknown			
Grindelia sp.	1					
Grindelia squarrosa	2	Native	FACU	1.5	Forb	Curly-Cup Gumweed
Grindelia subalpina	3	Native		4	Forb	
Halogeton glomeratus	1	Non-native		0	Forb	
Heracleum maximum	2	Native	FACW	6	Forb	American Cow-Parsnip
Hieracium gracile var. gracile	1	Native		6	Forb	Slender Hawkweed
Hippuris vulgaris	15	Native	OBL	6	Forb	Common Mare's-Tail
Hordeum jubatum	44	Native	FAC	2		Fox-Tail Barley
Iris missouriensis	11	Native	FACW	3	Forb	Rocky Mountain Iris
Isoetes bolanderi	2	Native	OBL	8	Graminoid	Bolander's Quillwort
Iva axillaris	6	Native	FAC	3	Forb	Deer-Root
Juncus alpinoarticulatus	1	Native	OBL	8	Graminoid	Northern Green Rush
Juncus arcticus ssp. Littoralis	43	Native	FACW	4	Graminoid	Arctic Rush
Juncus bufonius	2	Native	FACW	2	Graminoid	Toad Rush
Juncus compressus	1	Non-native	OBL	0	Graminoid	Round-Fruit Rush
Juncus confusus	1	Native	FAC	5	Graminoid	Colorado Rush
Juncus drummondii	1	Native	FACW	7	Graminoid	Drummond's Rush
Juncus ensifolius	3	Native	FACW	5	Graminoid	Dagger-Leaf Rush
Juncus gerardii	8	Native	FACW	0	Graminoid	Saltmarsh Rush
Juncus interior	1	Native	FAC	4.5	Graminoid	Inland Rush
Juncus longistylis	5	Native	FACW	6	Graminoid	Long-Style Rush
Juncus mertensianus	3	Native	OBL	7	Graminoid	Mertens' Rush
Juncus nevadensis	4	Native	FACW	7	Graminoid	Sierran Rush
Juniperus communis	1	Native	FACU	6		Common Juniper
Koeleria macrantha	1	Native		6	Graminoid	

Krascheninnikovia lanata	1	Native		8	Shrub	
Lemna turionifera	3	Native	OBL		Forb	Turion Duckweed
Lepidium latifolium	5	Non-native	FAC	0	Forb	Broad-Leaf Pepperwort
Lomatium bicolor	1	Native	FACU			Wasatch Desert-Parsley
Lomatogonium rotatum	1	Native	OBL	9	Forb	Marsh-Felwort
Lycopus asper	1	Native	OBL	5.2	Forb	Rough Water-Horehound
Maianthemum stellatum	6	Native	FACU	7	Forb	Starry False Solomon's-Seal
Melilotus officinalis	11	Non-native	FACU	0	Forb	Yellow Sweet-Clover
Mentha arvensis	24	Native	FACW	4	Forb	American Wild Mint
Mertensia ciliata	2	Native	FACW	7	Forb	Tall Fringe Bluebells
Mimulus sp.	1		Unknown			
Muhlenbergia asperifolia	2	Native	FACW	4	Graminoid	Alkali Muhly
Myosotis sp.	2					
Myriophyllum sibiricum	10	Native	OBL	3	Forb	Siberian Water-Milfoil
Nasturtium officinale	3	Non-native	OBL	0	Forb	Watercress
Osmorhiza berteroi	2	Native	FACU	4.33	Forb	Mountain Sweet-Cicely
Parnassia palustris	1	Native	OBL	8		Marsh Grass-of-Parnassus
Pascopyrum smithii	26	Native	FAC	5	Graminoid	Western-Wheat Grass
Pedicularis crenulata	5	Native	FACW	7	Forb	Purple-Flower Lousewort
Pedicularis groenlandica	3	Native	OBL	8	Forb	Bull Elephant's-Head
Petasites frigidus	1	Native	FACW	8		Arctic Sweet-Colt's-Foot
Phalaris arundinacea	9	Non-native	FACW	0	Graminoid	Reed Canary Grass
Phleum pratense	25	Non-native	FACU	0	Graminoid	Common Timothy
Pinus contorta	1	Native	FAC	5		Lodgepole Pine
Plantago eriopoda	10	Native	FACW	5	Forb	Red-Woolly Plantain
Plantago major	8	Non-native	FAC	0	Forb	Great Plantain
Platanthera huronensis	1	Native	OBL	7		Lake Huron Green Orchid

Poa compressa	3	Non-native	FACU	0	Graminoid	Flat-Stem Blue Grass
Poa palustris	11	Native	FAC	3	Graminoid	Fowl Blue Grass
Poa pratensis	15	Non-native	FAC	0	Graminoid	Kentucky Blue Grass
Poa secunda	12	Native	FACU	3	Graminoid	Curly Blue Grass
Polygonum amphibium	14	Native	OBL	5		Water Smartweed
Polygonum aviculare	4	Non-native	FACW	0	Forb	Yard Knotweed
Polygonum douglasii	2	Native	FACU	3	Forb	Douglas' Knotweed
Polypogon monspeliensis	1	Non-native	FACW	0	Graminoid	Annual Rabbit's-Foot Grass
Populus angustifolia	8	Native	FACW	5	Tree	Narrow-Leaf Cottonwood
Populus tremuloides	6	Native	FACU	5	Tree	Quaking Aspen
Potamogeton illinoensis	1	Native	OBL	5	Forb	Illinois Pondweed
Potamogeton praelongus	1	Native	OBL	5	Forb	White-Stem Pondweed
Potentilla ambigens	1	Native		5	Forb	
Potentilla paradoxa	2	Native	FACW	5	Forb	Bushy Cinquefoil
Potentilla sp.	1		Unknown			
Prunus virginiana	3	Native	FAC	4		Choke Cherry
Psathyrostachys juncea	1	Non-native	UPL	0	Graminoid	Russian-Wild Rye
Puccinellia nuttalliana	22	Native	FACW	6	Graminoid	Nuttall's Alkali Grass
Pyrola asarifolia	1	Native	FAC	8		Pink Wintergreen
Pyrrocoma lanceolata	2	Native	FAC	4	Forb	Lance-Leaf Goldenweed
Ranunculus abortivus	2	Native	FACW	2.25	Forb	Kidney-Leaf Buttercup
Ranunculus aquatilis	9	Native	OBL			White Water-Crowfoot
Ranunculus cymbalaria	21	Native	OBL	4	Forb	Alkali Buttercup
Ranunculus flammula	2	Native	OBL	4.5		Greater Creeping Spearwort
Ranunculus gmelinii	7	Native	FACW	5	Forb	Lesser Yellow Water Buttercup
Ranunculus macounii	1	Native	OBL	6	Forb	Macoun's Buttercup
Ranunculus sp.	1		Unknown			

Ribes aureum	1	Native	FAC	5.5	Shrub	Golden Currant
Ribes hudsonianum	1	Native	FACW			Northern Black Currant
Ribes inerme	8	Native	FAC	5	Shrub	White-Stem Gooseberry
Ribes lacustre	1	Native	FACW	7	Shrub	Bristly Black Gooseberry
Ribes sp.	1		Unknown			
Rosa arkansana	1	Native	FACU	4	Shrub	Prairie Rose
Rosa nutkana	2	Native	FACU	5	Shrub	Nootka Rose
Rosa woodsii	3	Native	FACU	5	Shrub	Woods' Rose
Rubus idaeus	1	Native	FACU	5		Common Red Raspberry
Rudbeckia laciniata var. ampla	4	Native	FAC	5.33	Forb	Green-Head Coneflower
Rumex crispus	10	Non-native	FAC	0	Forb	Curly Dock
Rumex paucifolius	3	Native	FAC		Forb	Alpine Sheep Sorrel
Rumex salicifolius var. denticulatus	2	Native	FACW	4.5	Forb	
Ruppia cirrhosa	1	Native	OBL	6	Forb	Spiral Ditch-Grass
Sagittaria cuneata	4	Native	OBL	7	Forb	Arum-Leaf Arrowhead
Salicornia rubra	17	Native	OBL	4	Forb	Red Saltwort
Salix bebbiana	13	Native	FACW	5	Shrub	Gray Willow
Salix brachycarpa	1	Native	FACW	7	Shrub	Short-Fruit Willow
Salix drummondiana	2	Native	FACW	6	Shrub	Drummond's Willow
Salix eriocephala	1	Native		5.5	Shrub	
Salix exigua	17	Native	FACW	3	Shrub	Narrow-Leaf Willow
Salix geyeriana	3	Native	OBL	6	Shrub	Geyer's Willow
Salix planifolia	3	Native	OBL	7	Shrub	Tea-Leaf Willow
Salix tweedyi	2	Native	FACW			Tweedy's Willow
Sarcobatus vermiculatus	4	Native	FAC	4	Shrub	Greasewood
Schoenoplectus acutus	3	Native	OBL	3		Hard-Stem Club-Rush
Schoenoplectus maritimus	8	Native	OBL	5.66	Graminoid	Saltmarsh Club-Rush
Schoenoplectus pungens	11	Native	OBL	5	Graminoid	Three-Square
Schoenoplectus tabernaemontani	6	Native	OBL	3	Graminoid	Soft-Stem Club-Rush
Scirpus microcarpus	7	Native	OBL	5	Graminoid	Red-Tinge Bulrush
Scutellaria galericulata	1	Native	OBL	7	Forb	Hooded Skullcap

Senecio triangularis	2	Native	FACW	6	Forb	Arrow-Leaf Ragwort
Sisyrinchium sp.	1		Unknown			
Sium suave	17	Native	OBL	7	Forb	Hemlock Water-Parsnip
Solidago canadensis	2	Native		4	Forb	
Solidago gigantea	7	Native	FACW	6	Forb	Late Goldenrod
Sonchus arvensis	3	Non-native	FACU	0	Forb	Field Sow-Thistle
Sparganium emersum	6	Native	OBL	7	Forb	European Burr-Reed
Spartina gracilis	1	Native	FACW	6	Graminoid	Alkali Cord Grass
Spergularia maritima	1	Non-native	FACW	0	Forb	Satin-Flower
Spergularia rubra	4	Non-native	FAC	0	Forb	Ruby Sandspurry
Sporobolus airoides	8	Native	FAC	5	Graminoid	Alkali-Sacaton
Stachys pilosa	2	Native	FACW			Hairy Hedge-Nettle
Stuckenia filiformis var. occidentalis	2	Native				
Stuckenia pectinata	6	Native	OBL	4	Forb	Sago False Pondweed
Stuckenia vaginata	1	Native	OBL	10	Forb	Sheathed False Pondweed
Suaeda calceoliformis	14	Native	FACW	3	Forb	Paiuteweed
Suckleya suckleyana	4	Native	FACW	4	Forb	Poison Suckleya
Symphorocarpus sp.	4					
Taraxacum officinale	26	Non-native	FACU	0	Forb	Common Dandelion
Taraxacum officinale ssp. ceratophorum	1	Native	UPL			Common dandelion
Thalictrum dasycarpum	1	Native	FACW	7	Forb	Purple Meadow-Rue
Thalictrum sp.	2		Unknown			
Thermopsis divaricarpa	5	Native	FAC	6	Forb	Spread-Fruit Golden-Banner
Thinopyrum ponticum	1	Non-native		0	Graminoid	
Thlaspi arvense	5	Non-native	UPL	0	Forb	Field Pennycress
Tragopogon dubius	2	Non-native		0	Forb	
Trifolium pratense	9	Non-	FACU	0	Forb	Red Clover

		native				
Trifolium repens	2	Non-native	FACU	0	Forb	White Clover
Triglochin maritima	34	Native	OBL	7	Graminoid	Seaside Arrow-Grass
Typha angustifolia	3	Non-native	OBL	0	Forb	Narrow-Leaf Cat-Tail
Typha latifolia	10	Native	OBL	3	Forb	Broad-Leaf Cat-Tail
Typha sp.	1		Unknown			
Urtica dioica	3	Native	FAC	3		Stinging Nettle
Utricularia macrorhiza	4	Native	OBL	7	Forb	Greater Bladderwort
Veronica serpyllifolia	1	Native	FAC	6	Forb	Thyme-Leaf Speedwell
Viola macloskeyi	1	Native	OBL	8		Smooth White Violet
Zigadenus elegans ssp. Elegans	1	Native	FACU	6	Forb	

APPENDIX D. Scoring formulas for Ecological Integrity Assessment wetland condition scores.

Table D.1. EIA ranks and definitions adapted from (Lemly and Gilligan 2013).

Rank	*Condition Category*	*Interpretation*
A	**Excellent / Reference Condition (No or Minimal Human Impact)**	Wetland functions within the bounds of natural disturbance regimes. The surrounding landscape contains natural habitats that are essentially unfragmented with little to no stressors; vegetation structure and composition are within the natural range of variation, nonnative species are essentially absent, and a comprehensive set of key species are present; soil properties and hydrological functions are intact. Management should focus on preservation and protection.
B	**Good / Slight Deviation from Reference**	Wetland predominantly functions within the bounds of natural disturbance regimes. The surrounding landscape contains largely natural habitats that are minimally fragmented with few stressors; vegetation structure and composition deviate slightly from the natural range of variation, nonnative species and noxious weeds are present in minor amounts, and most key species are present; soils properties and hydrology are only slightly altered. Management should focus on the prevention of further alteration.
C	**Fair / Moderate Deviation from Reference**	Wetland has a number of unfavorable characteristics. The surrounding landscape is moderately fragmented with several stressors; the vegetation structure and composition is somewhat outside the natural range of variation, nonnative species and noxious weeds may have a sizeable presence or moderately negative impacts, and many key species are absent; soil properties and hydrology are altered. Management would be needed to maintain or restore certain ecological attributes.
D	**Poor / Significant Deviation from Reference**	Wetland has severely altered characteristics. The surrounding landscape contains little natural habitat and is very fragmented; the vegetation structure and composition are well beyond their natural range of variation, nonnative species and noxious weeds exert a strong negative impact, and most key species are absent; soil properties and hydrology are severely altered. There may be little long term conservation value without restoration, and such restoration may be difficult or uncertain.

Table D.2. EIA methods for scoring.

1. The score for each EIA submetric was calculated using the equations below.

   Landscape Context Score:
   (Landscape Fragmentation * 0.4) + ([(Buffer Width * Buffer Extent)$^{1/2}$ * ((Buffer Condition + Buffer Natural Cover)/2)]$^{1/2}$ * 0.6)

   Biotic Condition Score:
   (Relative Cover Native Plant Sp. * 0.2) + (Absolute Cover Noxious Weeds * 0.2) + (Mean C * 0.4) + (Horizontal Interspersion * 0.2)

   Hydrologic Condition Score:
   Landscape Hydrology Metric score

   Physicochemical Condition Score:
   (Surface Water Quality * 0.25) + (Algal Growth * 0.25) + (Substrate/Soil Disturbance * 0.5)
   If no standing water was present, score = Substrate/Soil Disturbance.

2. EIA score was calculated using submetric scores:
   EIA Score:
   (Landscape Context * 0.2) + (Biotic Condition * 0.4) + (Hydrologic Condition * 0.3) + (Physicochemical Condition * 0.1)

3. Score to rank conversion:

   A = 4.5 – 5.0
   B = 3.5 – <4.5
   C = 2.5 - <3.5
   D = 1.0 - <2.5

Appendix E: Species detected across all wetlands during bird surveys within the Laramie Plains Wetland Complex.

Table E.1. List of species detected, species of concern or potential concern, and number of occurrence records across all sampled wetlands in the Laramie Plains Wetland Complex. If a species was on the "Bird Species of Concern" list (WYNND 2015), Heritage Ranking codes were included.

Bird Species Observed	Species of Concern	Species of Potential Concern	# of Occurrences
American Avocet		G5/S3B	10
American Bittern	G4/S3B		1
American Coot			5
American Crow			6
American Goldfinch			10
American kestrel			3
American Pipit			1
American Robin			8
American White Pelican	G4/S1B		2
American Wigeon			1
Bald Eagle	G5/S2B, S5N		2
Bank Swallow			1
Barn Swallow			17
Belted Kingfisher			2
Black Tern	G4/S1		1
Black-capped Chickadee			4
Black-crowned Night-Heron		G5/S3B	2
Black-headed Grosbeak			1
Blue-winged Teal			7
Brewers Blackbird			18
Brewers Sparrow			5
Broad-tailed Hummingbird			7
Brown-headed Cowbird			26
Bufflehead		G5/S2B	2
Bullocks Oriole			1
Canada Goose			21
Canvasback			2
Chestnut-collared Longspur			3
Cinnamon Teal			14
Cliff Swallow			14
Common Goldeneye		G5/S3B	1
Common Grackle			3

Bird Species Observed	Species of Concern	Species of Potential Concern	# of Occurrences
Common Merganser			8
Common Nighthawk			1
Common Raven			5
Common Yellowthroat			5
Coot			2
Cormorant			2
Dark-eyed Junco	G5/S5B,S5N		1
Eared Grebe			4
Eastern Kingbird			1
European Starling			1
Evening Grosbeak			1
Ferruginous Hawk	G4/S4B,S5N		2
Forster's Tern	G5/S1		8
Franklins Gull			1
Gadwall			20
Golden Eagle		G5/S4B,S4N	3
Gray Catbird			6
Great Blue Heron			5
Great-horned Owl			2
Green-winged Teal			15
Hermit Thrush			1
Horned Grebe			1
Horned Lark			18
House Wren			4
Killdeer			23
Lark Bunting			10
Lesser Scaup			3
Lincolns Sparrow			1
Loggerhead Shrike	G4/S3		1
MacGillivaries Warbler			1
Magpie			8
Mallard			30
Marsh Wren			4
McCowns Longspur			10
Meadowlark			2
Mountain Bluebird			1
Mountain Plover	G3/S2B,S3B		1
Mourning Dove			6
Northern Flicker			5
Northern Harrier			8

Bird Species Observed	Species of Concern	Species of Potential Concern	# of Occurrences
Northern Pintail			8
Northern Rough-winged Swallow			3
Northern Shoveler			10
Northern Waterthrush			7
Orange-crowned Warbler			1
Peregrine Falcon	G4/S2		1
Pied-billed Grebe			3
Pine Siskin			1
Pintail			1
Prairie Falcon			1
Redhead			3
Red-naped Sapsucker			1
Red-necked Phalarope			1
Red-tailed Hawk			1
Red-winged Blackbird			31
Ring-billed Gull		G5/S2	3
Ring-necked Duck		G5/S4B	2
Rock Wren			1
Rough-legged Hawk			1
Ruby-crowned Kinglet			2
Ruddy Duck			2
Sage Thrasher		G5/S5	7
Sandhill Crane		G5/S3B,S5N	2
Savannah Sparrow			25
Says Phoebe			1
Semi-palmated Sandpiper			1
Song Sparrow			10
Sora			2
Spotted Sandpiper			6
Swainsons Hawk			4
Tree Swallow			20
Unknown gull			2
Veery			6
Vesper Sparrow			15
Violet-green Swallow			6
Virginia Rail		G5/S3B	1
Warbling Vireo			3
Western Grebe			1
Western Meadowlark			29
Western Tanager			1

Bird Species Observed	Species of Concern	Species of Potential Concern	# of Occurrences
Western Wood Peewee			3
White-crowned Sparrow			1
White-faced Ibis	G5/S1B		2
Wigeon			8
Willet			19
Wilson's Phalarope			19
Wilson's Snipe			18
Wood Duck			1
Yellow Warbler			12
Yellow-headed Blackbird			10
Yellow-rumped Warbler			1