North Platte River Basin
Wetland Profile and Condition Assessment

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Colorado Natural Heritage Program
Colorado State University
Fort Collins, CO 80523

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Wetland Profile and Condition Assessment

Prepared for:

Colorado Parks and Wildlife
Wetland Wildlife Conservation Program
317 West Prospect
Fort Collins, CO 80526

U.S. Environmental Protection Agency, Region 8
1595 Wynkoop Street
Denver, CO 80202

Prepared by:

Joanna Lemly and Laurie Gilligan
Colorado Natural Heritage Program
Warner College of Natural Resources
Colorado State University
Fort Collins, Colorado 80523

In collaboration with

Brian Sullivan, Grant Wilcox, and Jon Runge
Colorado Parks and Wildlife

Dr. Jennifer Hoeting and Erin Schliep
Department of Statistics, Colorado State University

Cover photographs:

All photos taken by Colorado Natural Heritage Program Staff.

EXECUTIVE SUMMARY

The North Platte River Basin covers >2,000 square miles in north central Colorado and is known for extensive wetland resources. Of particular importance to Colorado Parks and Wildlife (CPW), the basin's wetlands serve as significant waterfowl breeding areas and refuge for rare amphibians, fish, and invertebrates. Recognizing the need for better information about wetlands across the state, CPW and Colorado Natural Heritage Program (CNHP) began a collaborative effort called *Statewide Strategies for Colorado Wetlands* to catalogue the location, type, and condition of Colorado's wetlands through a series of river basin-scale wetland profile and condition assessment projects. This report summarizes finding from the second basinwide wetland condition assessment, conducted in the North Platte River Basin. The initial step in each project is to compile a "wetland profile" based on digital wetland mapping. Wetland profiles summarize the types, abundance, and distribution of wetlands among ecoregions and landownership within a given geographic area and can be used to establish baseline conditions, assess cumulative impacts, and inform conservation planning. The second step in each project is to conduct a field-based assessment of ecological condition and associated stressors that can be extrapolated to all wetland area in the basin. Assessing the ecological condition of wetlands within each basin provides a coarse filter for prioritizing on-the-ground efforts to protect and restore wetland habitat. Through this project, CPW and CNHP developed a wetland profile of the North Platte River Basin to document the spatial distribution of wetlands, conducted a field-based assessment of wetland condition, and used the data to estimate both overall condition of wetlands and the availability of wetland habitat across the basin.

At the outset of this project, digital wetland mapping from U.S. Fish and Wildlife Service (USFWS)'s National Wetland Inventory (NWI) program was available for less than 10% of the basin, though paper maps drawn between the late 1970s and early 1980s existed for the entire area. To create the wetland profile, original paper maps for all topographic quads lacking digital spatial data were scanned and converted to geo-rectified digital polygons, producing a wall-to-wall map of wetlands in the basin. The digital NWI polygons were used to summarize wetland acreage in a number of different ways. To assess the condition of wetlands in the basin, 95 randomly selected wetland sites were visited in the field and surveyed following detailed protocols that addressed: 1) Landscape Context, 2) Biotic Condition, 3) Hydrologic Condition, and 4) Physiochemical Condition. Sites on actively managed hay pastures were removed from the sample pool to focus on natural and naturalized wetlands. Scores were produced for each site visited and summarized by wetland type and by geographic region across the basin. Site scores were extrapolated to estimate wetland condition of all non-irrigated wetland acres. A predictive model of wetland condition was also developed to predict the condition of wetlands not visited in the field.

Based on digital NWI mapping, there are 138,043 acres of wetlands and water bodies within the basin, representing approximately 11% of the total land area. Lakes and rivers comprise 6,402 of the total NWI acres. The majority (73%) of the NWI mapped acres are freshwater herbaceous wetlands. When lakes and rivers are excluded, herbaceous wetlands make up 77% of wetland acres. Shrub wetlands are the second most common class, making up 19% of all NWI acres and 20% of wetland acres. Within the basin as a whole, 59% of wetland acres are irrigated and these acres are overwhelmingly (96%) freshwater herbaceous wetlands. Among all herbaceous wetlands, 75% are irrigated. In many cases, these irrigated wetlands are actively managed as hayfields and harvested during most years. When broken down by major landowner, 73% of wetland acres are privately owned. Private landowners hold a relatively greater share of wetland acres than they do of total area within the basin (33%). This is largely because the density of wetland acres is greater within the central North Park valley, where private landownership is concentrated, than in the publically owned mountain areas. Private landowners in North Park are more likely to be irrigating hay pastures, which can increase wetland acreage. Over 70% of privately owned wetland acres are irrigated, making up 91% of the total irrigated wetland acreage.

For the purpose of understanding the quantity of habitat available to dabbling ducks in the basin, nine important habitat types were identified by CPW wildlife biologists. A crosswalk between the habitat types and NWI codes was developed, allowing for all mapped wetlands to be summarized by these habitat types. The most common habitat type identified in the basin is irrigated hay meadows, making up 53% of all NWI acres. This is slightly lower than all NWI acres mapped as irrigated (57%) because it does not include irrigated shrublands along the margins of hay meadows. After irrigated hay meadows, seasonal emergent wetlands and riparian areas without beaver influence both comprise 13% of all NWI acres. Beaver ponds and other beaver influenced wetlands make up another 4% of all NWI acres, as do lakes and reservoirs. All other habitat types identified as important for dabbling ducks make up < 1% of all NWI acres.

A statewide Level 1 GIS-based Landscape Integrity Model (LIM) for wetlands was applied to the North Platte River Basin. Results from the LIM show that although only 10% of total basin area falls within the severe stress category, 27% of wetland acres fall within the severe stress category and an additional 50% fall within the high stress category. This is largely due to the distribution of wetland acres, which are more concentrated on the valley floor and therefore affected by roads and development, agriculture, and hydrologic modification. Though these results indicate high stress in the basin, the LIM is not yet fully calibrated and over predicts high stress when compared to field-based scores of wetland condition.

Among the 95 randomly selected sites, riparian shrublands were the most common wetland type encountered with 46 sites, making up 48% of all sites surveyed, and were broadly distributed across the basin. Wet meadows were the second most common type with 28 sites surveyed. In addition, the sampled wetlands included 13 fens, 5 marshes, 2 riparian woodlands, and 1 alkaline basin. Each wetland type had its own distinct suite of plant species. Within surveyed wetlands, 612 individual plant taxa were encountered, including 538 species were identified to the species level. This represents ~17% of the entire Colorado flora.

Condition of sampled sites was assessed using the Floristic Quality Assessment (FQA or Mean C), Ecological Integrity Assessment (EIA), and Vegetation Index of Biotic Integrity (VIBI) methods. Mean C values for sampled sites ranged from 2.77–7.08 and the range of Mean C scores was related to both wetland type and the geographic gradient. The lowest Mean C scores and largest variation in scores occurred below 8500 ft. Above 9000 ft., sites predictably showed high Mean C scores. Not surprisingly, wetlands characteristic of higher elevations had the highest average Mean C values, while wetlands more common at lower elevations had lower average Mean C values. For overall EIA scores, 43 of the wetlands sampled were A-ranked, 40 were B-ranked, and 12 were C-ranked. No wetland was ranked D, where wetland conditions and their associated functions are considered significantly compromised and unlikely to be restorable. Extrapolated results indicate that 34% of all wetland area in the basin would receive an overall EIA rank of A, 48% would receive a B, and 17% would receive a C.

Across all methods, trends clearly indicate that wetlands in the North Platte River Basin are in very good condition. The lack of D-ranked wetlands and low proportion of Cs indicate the basin contains many healthy, intact wetlands. The landscape of the basin is less fragmented than other parts of the state and wetlands generally have good buffers. Localized hydrologic modifications are evident, but few wetlands had signs of severe hydrologic alteration that would significantly threaten wetland health. There is little substrate disturbance and no obvious visual signs of water quality impairment. Very few noxious weeds were observed in the wetlands, though Canada thistle was found in a handful of sites. Several sites in North Park had high cover of non-native pasture grasses because they were former hay fields or were adjacent to hay fields, but many wetlands had very high Mean C and EIA biotic scores, indicative of thriving, diverse native plant communities.

Grazing by livestock and browse by native ungulates were the most common stressors observed within North Platte wetlands, which is consistent with the dominant land use in the basin. However, grazing impacts were rarely considered severe in the sampled wetlands. Continuing best management practices for cattle, such as fencing off stream channels and rotating grazing, will maintain the current balance between cattle ranching and healthy wetland systems. Oil and gas wells were not observed within this study, but drilling in the basin has increased even since 2010 and could potentially lead to significant impacts in coming years.

The field methods used in this study do not address habitat quality for specific wildlife species, but can be reflect overall condition. Through this project, eight habitat features were identified as important for dabbling ducks, but these were not developed in time to use in the assessment of wetland condition. However, though concurrent field studies conducted by CPW, two of the eight habitat value factors identified as important to dabbling ducks (vegetation type and residual cover depth) were evaluated and shown to influence duck production.

Of the 138,043 acres of wetlands and water bodies mapped in the North Platte River Basin, 90% (124,350 acres) was identified as types important to waterfowl. This justifies continued emphasis on wetland conservation in this basin by CPW and partner agencies and organizations with shared missions to conserve wetland-dependent wildlife. The prevalence of irrigated hay meadows (54% of all NWI mapped acres) in relation to other wetland types warrants new field studies to determine the importance of this habitat to wildlife. Other habitat types represent far fewer acres, and could be selectively managed for.

SIGNIFICANT FINDINGS

Wetland quantity and types

- There are 138,043 acres of wetlands and waterbodies in the North Platte River Basin (131,642 acres without lakes and rivers).
- Wetlands and waterbodies represent 10% of the basin.
- Herbaceous wetlands represent 77% of all wetlands, of which 75% are mapped as irrigated.
- 60% of all wetlands (>78,000 acres) are mapped as irrigated. These are primarily managed for hay production, though some are managed for wildlife habitat.
- 32,000 additional acres are mapped as irrigated land but not as wetland and may represent newly irrigated lands since the wetlands were mapped.
- Beaver-influenced wetlands comprise 4% of all mapped wetland acres.

Wetland distribution within basin

- 69% of wetlands and water bodies are in the North Park valley (Sagebrush Parks ecoregion).
- Higher elevations contain short stature shrublands, beaver-influenced riparian corridors, kettle ponds, fens, and alpine wet meadows.
- Lower elevations contain extensive tall stature riparian wetlands, natural wet meadows, alkaline basins, and marsh vegetation along lakeshores and ponds.
- Beaver-influenced wetlands are concentrated in mid-elevation and subalpine zones; and are scare in the alpine zone, North Park, and the Laramie Basin.

Ownership of wetland acres

- 73% of wetland acres are privately owned.
- 15% are owned by the U.S. Forest Service
- 5% are owned by the U.S. Fish and Wildlife Service
- 4% are owned by the U.S. Bureau of Land Management
- 3% are owned by the Colorado State Land Board
- 1% are owned by Colorado Parks and Wildlife

Wetland Condition

- Population level estimates indicate that 82% (44,409 acres) of non-irrigated wetlands are A- or B-ranked based on Level 2 EIA scores, meaning they are in reference condition or deviate only slightly from reference condition.
- An additional 17% (9,096 acres) are C-ranked, meaning a moderate deviation from reference condition that would warrant some type of management or restoration.
- Few wetlands had signs of severe hydrologic alteration that would significantly threaten wetland health.
- There is little substrate disturbance and no obvious visual signs of water quality impairment.
- Biotic condition is generally high. Very few noxious weeds were observed, though wetlands that were former hay fields or adjacent to active hay field contained significant cover on non-native species.

Stresses faced by wetlands

- Higher stress wetlands are located in the valleys where human activities have altered the landscape.

- Lower stress wetlands occur at higher elevations where there is less human-caused disturbance.
- Grazing by livestock and browsing by native ungulates were the most common stressors observed. However, grazing impacts observed in the field were rarely considered severe.

Waterfowl value

- 90% of wetland acres (124,350 acres) are of types important to waterfowl, and a large majority of this is irrigated hay meadows.
- Eight habitat features were identified as potentially important to waterfowl: (1) dominant vegetation type, (2) percent of emergent cover, (3) depth of residual cover, (4) interspersion (ratio of cover to water), (5) size of wetland, (6) landscape context (percent of wetlands or open water on the landscape within a defined buffer of wetland margins or habitat edge), (7) stream flow (cubic feet per second), and (8) stream order.
- Empirical data from field studies confirmed that vegetation type and residual cover did influence duck production, with higher production in sites dominated by bulrush and with increasing depth of residual cover.

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1.0 INTRODUCTION

Wetlands are an integral component of Colorado's landscape. They provide a host of beneficial services, such as flood abatement, storm water retention, groundwater recharge, and water quality improvement (Mitsch & Gooselink 2007; Millennium Ecosystem Assessment 2005). Wetlands are particularly important for wildlife because they are highly productive and diverse ecosystems, providing habitat for many of Colorado's species. Of the nearly 500 wildlife species in Colorado, more than 25% are considered "wetland-dependent," meaning wetlands are their primary habitat (Ringelman 1996). Many others use wetlands and riparian areas at some point during their life cycle.

The relative importance of wetlands is underscored by the fact that they occupy a small fraction of the landscape. Though total acreage of wetlands in Colorado is unknown, estimates place the extent at roughly 1 million acres or 1.5% of Colorado's land area (Dahl 1990). Historically, Colorado likely supported twice the wetland acreage that exists today. Up to 50% of Colorado's original wetlands have been drained and converted to farmland or urban development or lost as a result of water diversion and storage. Wetlands in Colorado continue to be impacted by multiple human uses, but the magnitude of these impacts is difficult to quantify as data on the location, type, and condition of Colorado's wetlands are limited. To ensure the benefits Coloradoans receive from wetlands continue into the future, scientifically grounded information about the status and trends of Colorado's wetland resource is essential for wetland conservation and management.

1.1 Statewide Strategies for Colorado Wetlands

Recognizing the need for better information, Colorado Parks and Wildlife (CPW) and the Colorado Natural Heritage Program (CNHP) began a collaborative effort called *Statewide Strategies for Colorado Wetlands* to catalogue the location, type, and condition of Colorado's wetlands through a series of river basin-scale wetland profile and condition assessment projects (Lemly et al. 2011). The first project was a pilot assessment of the Rio Grande Headwaters River Basin (Lemly et al. 2011). This report from the North Platte River Basin represents the second. CPW and CNHP plan to implement a rotating basin strategy for wetland assessments, beginning a new river basin study every one to two years depending on resource availability. The mission of CPW's Wetland Wildlife Conservation Program[1] is to maintain or improve the population status of priority wetland-dependent wildlife species, primarily through restoration of critical wetland habitats. Data from the wetland profile and condition assessment projects will help prioritize funding through the Wetlands Program and will feed directly into the program's strategic plan (CPW 2011). The information can also be used by numerous other partners interested in the conservation and management of Colorado's wetlands.

The initial step in each project is to compile a "wetland profile" based on digital wetland mapping. Wetland profiles summarize the types, abundance, and distribution of wetlands within a given geographic area and can be used to establish baseline conditions, assess cumulative impacts, and

[1] For more information on CPW's Wetlands Program and to read the program's strategic plan, see the website: (http://wildlife.state.co.us/LandWater/WetlandsProgram/).

inform strategic goals (Bedford 1996; Gwin et al. 1999; Johnson 2005). By connecting wetland habitat types within the profile with specific wildlife species, general statements can be made about the extent of wildlife habitat available. Depending on need or interest, other classification systems (e.g., Cowardin: Cowardin et al. 1979; Hydrogeomorphic: Brinson 1993; NatureServe's Ecological Systems: Comer et al. 2003) can be used to evaluate different functions and services provided by a basin's wetland resources.

The second step in each project is to conduct a field-based assessment of ecological condition and associated stressors that can be extrapolated to all wetland area in the basin. As human stressors negatively impact wetland condition, the ability of a wetland to provide functions and services, such as wildlife habitat, may also be negatively impacted. Assessing the ecological condition of wetlands within each basin provides a coarse filter for prioritizing on-the-ground efforts to protect and restore wetland habitat. The link between general ecological condition and specific habitat quality is based on the assumption that a wetland in its natural, minimally impacted state will provide maximum suitable habitat for the wetland-dependent wildlife that use that wetland type. To confirm this connection, however, additional research is needed. Through this and subsequent wetland assessment projects, CPW and CNHP will seek to develop methods to assess specific habitat quality as well as general ecological condition.

The North Platte River Basin (Figure 1) in north central Colorado has long been recognized for its wetland resources (USFWS 1955). Of particular importance to CPW, the basin's wetlands serve as significant waterfowl breeding areas and refuge for rare amphibians, fish, and invertebrates. A recent study of important wetlands in the basin documented the area's high biodiversity significance for both plant and animal populations (Culver et al. 2010). Wetland complexes in the basin support all three rare montane amphibians: boreal toad (*Bufo boreas boreas*), northern leopard frog (*Rana pipiens*), and wood frog (*Rana sylvatica*). The basin also contains one of three known Colorado breading sites for the American white pelican (*Pelecanus erythrorhynchos*), one of the few Colorado nesting populations of greater sandhill cranes (*Grus canadensis tabida*) and Colorado's largest nesting populations of willets (*Catoptrophorus semipalmatus*). Presently, many of the basin's large wetland complexes are still intact and contiguous, providing migration corridors and extensive wildlife habitat. However, effective management is needed to preserve this resource in the face of increasing human pressure. Demand from major urban areas for water development and storage projects, rapid growth in Colorado's oil and gas industry, and significant changes in forest health threaten the long-term viability and integrity of the basin's wetland resources. Through this project, CPW and CNHP developed a wetland profile of the North Platte River Basin to document the spatial distribution of wetlands, conducted a field-based assessment of wetland condition, and used the data to estimate both overall condition of wetlands and the availability of wetland habitat across the basin.

Figure 1. North Platte River Basin in Colorado (HUC 6: 1018000). The study area is bound by the 6-digit HUC river basin boundaries to the south, east, and west and the Colorado state line to the north. The basin encompasses all of Jackson County and a portion of western Larimer County. Blue lines show rivers, lakes, and reservoirs. Inset map shows study area in relation to Denver and all counties in the state.

1.2 Project Objectives

The four primary objectives of this project were to (1) compile existing spatial data on wetlands in the North Platte River Basin and develop a wetland profile; (2) conduct a statistically valid, field-based survey of wetland condition in the basin; (3) model the distribution of wetland condition throughout the basin using collected field data and additional spatial data on potential stressors; and (4) determine metrics for measuring key habitat features for priority waterfowl species.

The project objectives were implemented with the following tasks:

1. **Compile existing spatial data on wetlands in the North Platte River Basin and develop a wetland profile. (Implemented by CPW and CNHP.)**

    - Digital wetland mapping from the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) program was compiled for the basin.

- Based on digital NWI mapping, a detailed wetland profile was developed summarizing the extent of wetland acreage throughout the basin by NWI system/class, hydrologic regime, extent modified, extent irrigated, land ownership, and Level IV Ecoregions.

- Along with the wetland profile, a landscape level assessment of wetland condition within the basin was conducted based on a statewide Wetland Landscape Integrity Model.

2. **Conduct a statistically valid field-based assessment of wetland condition for the North Platte River Basin. (Implemented by CNHP.)**

   - Using the digital NWI mapping, a spatially balanced random sample survey design was developed for the North Platte River Basin based on principles outlined by U.S. Environmental Protection Agency (EPA)'s Environmental Monitoring and Assessment Program (Stevens and Olson 2004; Detenbeck et al. 2005).

   - The ecological condition of 95 randomly selected wetlands was measured using rapid and intensive protocols developed by CNHP. These protocols include the Floristic Quality Assessment (FQA: Rocchio 2007b), Ecological Integrity Assessment (EIA: Faber-Langendoen et al. 2008a; Lemly and Rocchio 2009a), and Vegetation Index of Biotic Integrity (VIBI: Rocchio 2007a; Lemly and Rocchio 2009b), all of which were developed for Colorado with funds provided by EPA Region 8 Wetland Program Development Grants and CPW's Wetlands Program.
   - The proportion of wetland area within major condition classes was estimated based on field collected data.

3. **Model the distribution of wetland condition throughout the basin using collected field data and additional spatial data on potential threats and stressors. (Implemented by CNHP through a partnership with the CSU Statistics Department.)**

   - A regression model of wetland condition was developed in which the response was overall EIA scores and the predictors were spatial data on potential threats and stressors.

   - Wetland condition was predicted at 7830 random locations across the basin to provide a spatially explicit map of predicted condition.

4. **Identify metrics for measuring key habitat features for priority waterfowl species. (Implemented by CPW.)**

   - Literature on the specific wetland habitat needs of dabbling ducks was reviewed to determine key habitat features that can be easily and repeatedly measured in the field (i.e., hydrological regime, water depth, plant associations, open water interspersion, proximity of upland types, food sources, etc.).

- Specific habitat requirements of waterfowl were investigated in the field to determine how hydrologic regime and vegetation structure influence waterfowl populations. Field work combined hydrologic and vegetation measures with nest searching, marking of waterfowl with leg bands and nasal markers, and re-sighting of nasal-marked hens.

1.3 Wetland Monitoring and Assessment Frameworks

To maximize the utility of the information, work conducted through this project can be viewed through two important frameworks. First is the EPA's Level 1-2-3 Framework for wetland assessment, which defines an approach to wetland assessment at multiple scales of time, cost, and accuracy. The second is NatureServe's Ecological Integrity Assessment Framework, which outlines an approach to assessing the condition of ecological resources, in this case wetlands. Both frameworks are discussed briefly below.

1.3.1 EPA's Level 1-2-3 Framework for Wetland Assessment

Acknowledging that it is impossible to visit every wetland across a landscape to determine the range of condition, EPA recommends a three tiered approach to wetland assessment. Within the Level 1-2-3 Framework[2], Level 1 assessments are broad in geographic scope and used to characterize resources across an entire landscape. They generally rely on information available digitally in a GIS format or through remote sensing. Goals of Level 1 assessments may include summarizing the extent and distribution of a resource (such as wetland mapping from air photography) or modeling the condition of wetlands based on anthropogenic stressors such as roads, land use, resource extraction, etc. The wetland profile concept is essentially a Level 1 assessment. Level 1 assessments can be applied across a large area and can summarize general patterns, but may not accurately represent the condition of a specific wetland on the ground.

Level 2 assessments are rapid, field-based assessments that evaluate the general condition of wetlands using a suite of easily collected and interpreted metrics. The metrics are often qualitative or narrative multiple choice questions that refer to the condition of various attributes (e.g., buffers, hydrology, vegetation, soil surface disruption) based on stressors present on site. Rapid assessments should be conducted within 1–2 hours of field time and are often used to assess a large number of wetlands on the ground to make an overall estimate of condition or evaluate which sites deserve more intensive monitoring.

Level 3 assessments involve the most intensive, field-based protocols and are considered the most accurate measure of wetland condition. These assessments are based on quantitative data collection and the establishment of data-driven thresholds. They require skilled practitioners to carry out sampling and can take numerous hours for every site. Level 3 protocols are generally developed separately for different wetland attributes, such as vegetation, macro-invertebrates, water chemistry, hydrology, or wildlife habitat. In some cases, repeat sampling may be necessary to fully capture a wetland's condition.

[2] For more information on EPA's Level 1-2-3 framework, see http://www.epa.gov/owow/wetlands/pdf/techfram.pdf.

Within the Level 1-2-3 Framework, data from more detailed levels can be used to calibrate and validate levels above. Level 3 surveys can inform the narrative ratings of Level 2 assessments, and both can help refine Level 1 GIS models. Over time and with sufficient data, coarser level assessments can provide a fairly accurate overview of wetland health across a broad area. However, detailed Level 3 assessments will always provide the most accurate measure of site-specific condition.

1.3.2 NatureServe's Ecological Integrity Assessment Framework

The Ecological Integrity Assessments (EIA) Framework was developed by NatureServe[3] and ecologists from several Natural Heritage Programs across the country (Faber-Langendoen et al. 2006; Faber-Langendoen et al. 2008a). The EIA Framework evaluates wetland condition based on a multi-metric index. Biotic and abiotic metrics are selected to measure the integrity of key wetland attributes within four major categories:

1) Landscape context
2) Biotic condition
3) Hydrologic condition
4) Physiochemical condition.

Using field and GIS data, each metric is rated according to deviation from its natural range of variability, which is defined based on the current understanding of how wetlands function under reference conditions absent human disturbance. The farther a metric deviates from its natural range of variability, the lower the rating it receives. Numeric and narrative criteria define rating thresholds for each metric. Once metrics are rated, scores are rolled up into the four major categories. Ratings for these four categories are then rolled up into an overall EIA score. For ease of communication, category scores and the overall EIA score are converted to ranks following the ranges shown in Table 1. The scores and ranks can be used to track change and progress toward meeting management goals and objectives. With past funding from EPA Region 8 and CPW, CNHP developed EIA protocols for seven wetland types in the Southern Rocky Mountain Ecoregion (Rocchio 2006a-g), field tested one set of these protocols (Lemly and Rocchio 2009a), and refined the protocols through the Rio Grande Headwater pilot wetland assessment (Lemly et al. 2011).

1.4 Previous Wetland Studies in North Platte River Basin

Wetlands in the North Platte River Basin have been the subject of several previous investigations, but none have looked at the entire wetland resource using a random sample survey design that allows for extrapolation. A few studies have discussed the range of wetland types, but most have focused on a particular area of the basin, a particular wetland type, or a particular management question. Selected notable North Platte wetland studies are described here for reference, though this should not be considered an exhaustive list.

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[3] NatureServe is a non-profit conservation organization whose mission is to provide the scientific basis for effective conservation action. For more information about NatureServe, see their website: www.natureserve.org.

Table 1. Definition of Ecological Integrity Assessment ratings. Modified from Faber-Langendoen et al. 2008b.

Rank Value	Description
A	**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	**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	**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	**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.

The most recent and comprehensive study of wetlands in the North Platte River Basin is the *Identification and Assessment of Important Wetlands within the North Platte River Watershed 2009–2010,* conducted by Culver et al. (2010) of CNHP and funded by the Colorado Water Conservation Board. The focus of the 2010 CNHP study was to identify and assess biologically significant wetlands within the basin, with a particular emphasis on rare, uncommon, or significant natural communities and plant and animal populations. The study was designed to assist the North Platte Basin Round Table's non-consumptives needs assessment sub-committee in identifying important non-consumptive water needs in the basin. The 2010 CNHP study included both public and private lands and resulted in the identification of 68 new occurrences of important wetland resources (plants, animals, or natural communities) and the formation of 32 Potential Conservation Areas across the basin that represent areas of the highest conservation value. Though not a wetland study per se, the *North Park Wetlands Focus Area Strategy* (North Park Wetlands Focus Area Committee 2002) is also comprehensive and contains a wealth of information about the basin's wetland resources.

Reports or publications that document wetlands within the central North Park valley include three on the Arapaho National Wildlife Refuge (ANWR). The Refuge's *Comprehensive Conservation Plan* (USFWS 2004) describes the important role ANWR plays in providing wetland and riparian habitat for many wildlife species in the basin. Lewis' (2001) floristic survey of ANWR also contains useful information on the Refuge's wetland plants and plant communities. An earlier report by Knopf and Cannon (1982) documents the effects that past grazing practices continue to exert on willow growth and regeneration on the ANWR. Outside of the Refuge, Johnson and Gerhardt (2004, 2005) conducted ecological investigations of mire and fen wetlands on U.S. Bureau of Land Management (BLM) lands within North Park. Their two reports discuss the location and ecological significance of fen wetlands within the valley, which are relatively rare. A very early article (Davis 1937) provides historical context to the practice of irrigation within North Park.

Four publications describe wetlands within the Medicine Bow-Routt National Forest (MBRNF), which includes the basin's mid and high elevations regions to the west and south. Hay (2010) documents the succession of four beaver pond complexes on the MBRNF over 50 years of observation. Sanders (1997) presents a detailed characterization of montane wetlands and their use by waterfowl. His study includes the physical and chemical composition, aquatic invertebrate community composition, waterfowl numbers and habitat use for 24 wetlands within Big Creeks Lake area of the MBRNF. Kettler and McMullen (1996) surveyed the vegetation of 195 riparian areas across the MBRNF, many of them within the North Platte basin, as part of a statewide classification of riparian plant associations. Johnson (1941) presents an early description of the vegetation surrounding two lakes within the North Platte basin, one within the MBRNF and one, Lake John, within the North Park valley.

2.0 STUDY AREA

2.1 Geography

The North Platte River Basin is located in north central Colorado (Figure 1) and is the headwaters of the North Platte River. For the purpose of this project, the basin includes only the Colorado portion of HUC6 101800: North Platte River.[4] The majority of HUC6 101800 is located in Wyoming and is not included in this Colorado-based study. By only including the Colorado portion, the North Platte is the smallest of ten major river basins in Colorado designated for wetland condition assessment projects under *Statewide Strategies for Colorado Wetlands*.[5] Within the study area there are three HUC8 river subbasins and 68 HUC12 watersheds (Figure 2).

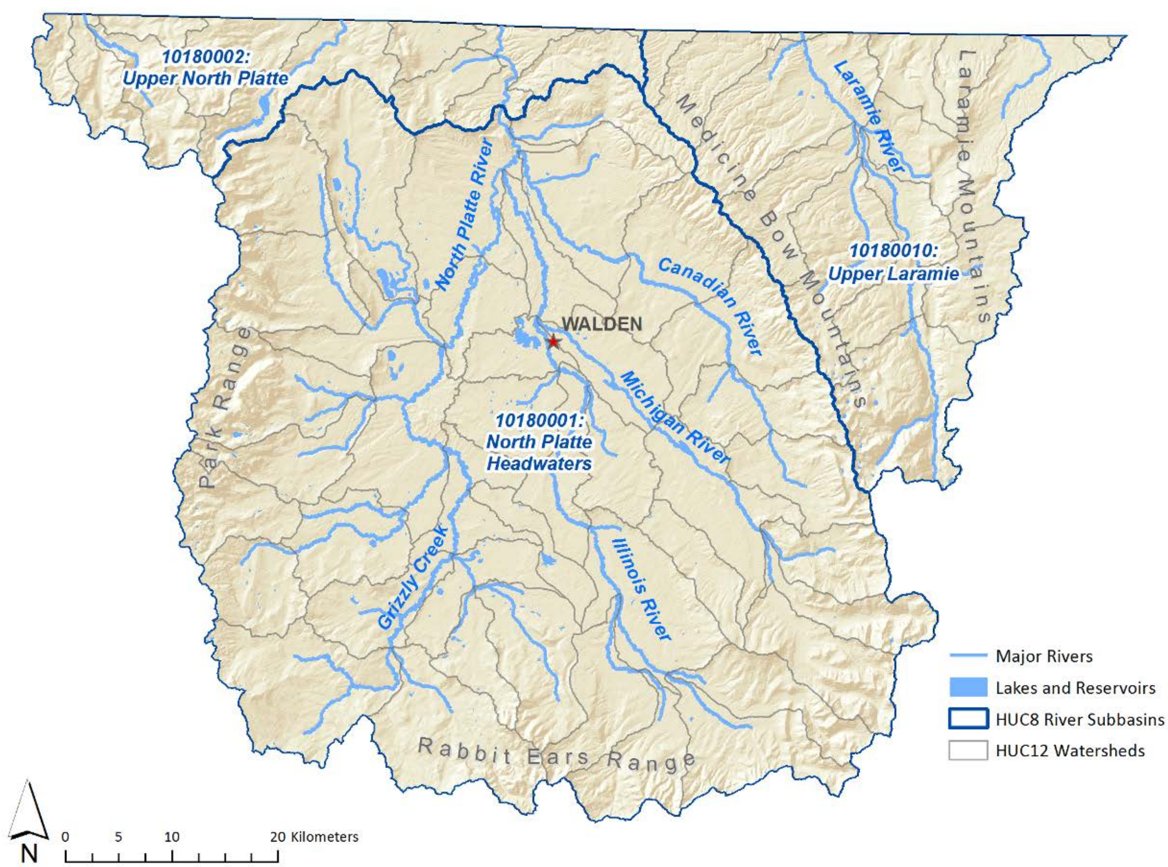


Figure 2. HUC8 river subbasins, HUC12 watersheds, and major mountain ranges within the North Platte River Basin.

[4] The U.S. Geologic Service (USGS) has divided the Unites States into a hierarchy of hydrologic units, specified by hydrologic unit codes (HUCs). Each level in the hierarchy is noted by the number of digits within the HUC (e.g., HUC6 101800 has 6 digits). The HUC6 level is referred to as the river basin scale. The HUC12 level is referred to as the watershed scale. For more information and to download GIS data, see the website: http://water.usgs.gov/GIS/huc.html.

[5] See Lemly et al. (2011) for a map of major river basins designated for wetland condition assessment projects.

The study area encompasses all of Jackson County and the county border follows the study area boundary to the north, west, and south (Figure 1). In the northeast, the river basin includes the Upper Laramie subbasin and the northwest portion of Larimer County. Walden is the largest town in the basin and the center of the basin's ranching community. Walden supports a population of 608 people and 1,394 people live in all of Jackson County, making it the fourth smallest county in Colorado by population (U.S. Census Bureau 2011). There are no established towns within the Larimer River Valley and few people live there year round.

The basin spans ~60 miles (~100 km) from east to west and ~50 miles (~80 km) from north to south, encompassing 1,289,532 acres (2,015 square miles or 521,855 ha). The center of the basin is characterized by a broad high elevation valley known as North Park, the second largest of four intermountain parks in Colorado. The North Park valley is relatively flat, although rolling hills remnant of glacial retreat are present throughout the basin. From the central North Park valley, the basin rises gradually into foothills, then inclines more steeply into the subalpine and alpine zones. Elevations in the basin range from 7,546 ft. (2,300 m) on the valley floor, to a high of 12,951 ft. (3,947 m) at Clark Peak in the Rawah Wilderness. Several other mountain peaks surrounding North Park also surpass 12,000 ft. (3,658 m).

The Park Range and Sierra Madre mountains of the Continental Divide delineate the western border of the North Platte River Basin and separate North Platte from the neighboring White-Yampa-Green River Basin to the west. The Rabbit Ears Range, also along the Continental Divide, delineates the southern border of the basin and separates North Platte from the Colorado Headwaters River Basin and Middle Park to the south. To the east, the basin is bounded by Front Range peaks of the Laramie Mountains, which separate north-flowing tributaries of the North Platte River (the Laramie River and Sand Creek) from east-flowing tributaries of the South Platte River. North Park's central valley and the main North Platte River are separated from the smaller Larimer River Valley by the Medicine Bow Mountains, which slant southeast to northwest. The Laramie River joins the North Platte outside the study area in Wyoming. The Colorado/Wyoming state line delineates the northern edge of the study area, though the North Platte River itself flows on into Wyoming, where it gently arcs east towards Nebraska to join the South Platte.

2.2 Ecoregions and Vegetation

Much of the North Platte River Basin falls within the Southern Rocky Mountains Level III Ecoregion (Figure 3: Omernik 1987[6]). The lower portion of the Laramie River Valley, however, is grouped into the Wyoming Basin Level III Ecoregion. Level IV Ecoregions further divide the Southern Rockies landscape into finer units based on geology and dominant vegetation (Table 2; Table 3). In both the Sagebrush Parks and Laramie Basin ecoregions, upland plant communities are mostly dominated by mountain sagebrush (*Seriphidium* [syn. *Artemisia*] vaseyanum). Extensive riparian floodplains fill the valleys and predominately contain mixed willow species (*Salix monticola* and *Salix geyeriana*). Irrigated hay meadows are also a major land cover, covering approximately 13% of the

[6] For more information on Omernik/EPA Ecoregions and to download GIS shapefiles, visit the following website: http://www.epa.gov/wed/pages/ecoregions.htm.

basin, and are dominated by meadow foxtail (*Alopecurus pratensis*)[7] or timothy grass (*Phleum pratense*). In the mountain foothills, vegetation transitions to forests dominated by aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*), and many of these forests are affected by mountain pine beetle (*Dendroctonus ponderosae*) mortality. In the higher subalpine zone, forests are dominated by subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*). Above treeline, vegetation consists of mixed graminoids and forbs characteristic of high elevations.

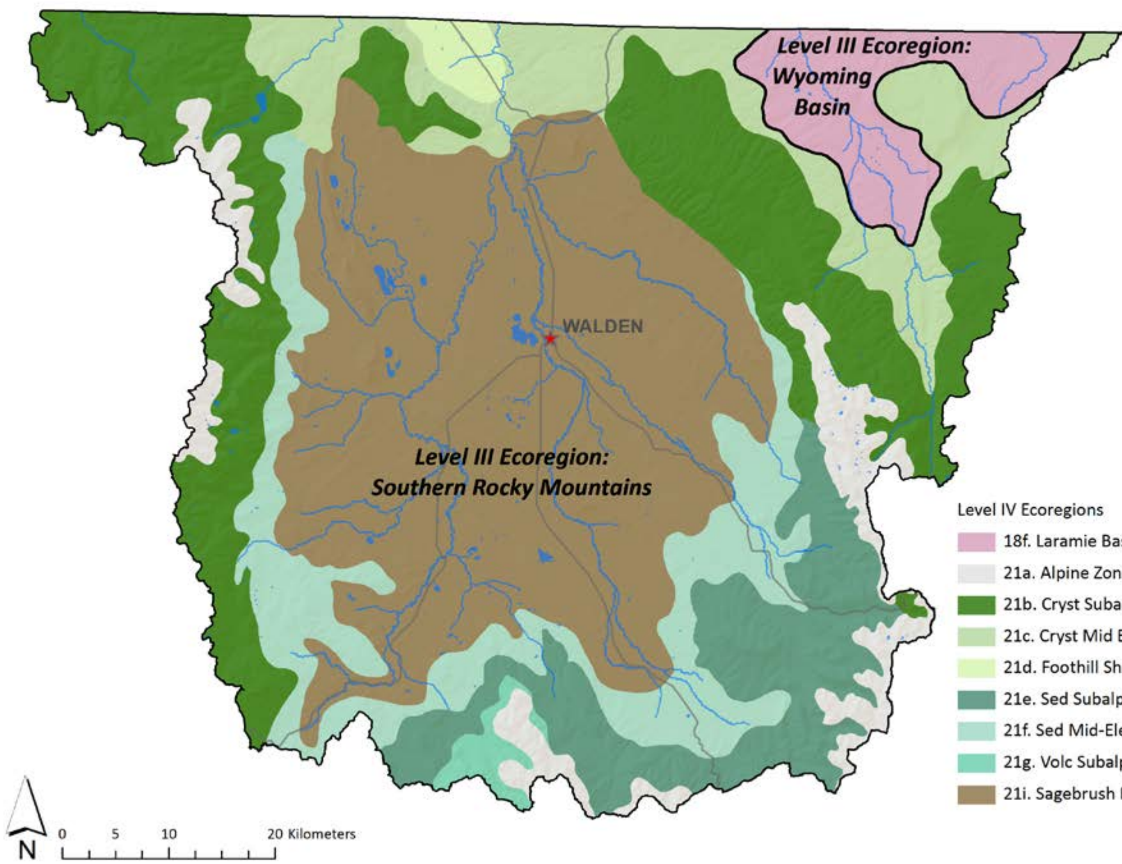


Figure 3. Level III and IV Ecoregions within the North Platte River Basin. Level III Ecoregions demarcated by the black like that separates the Wyoming Basin from the rest of the study area. See Table 3 for Level IV Ecoregion descriptions.

[7] Some floristic surveys of North Park (Lewis 2001; Culver et al. 2010) include both meadow foxtail (*Alopecurus pratensis*) and creeping foxtail (*Alopecurus arundinaceus*). Weber and Wittmann (2001), the primary flora used in this study, does not contain creeping foxtail (*A. arundinaceus*). For this reason, all observations of non-native foxtails were keyed to meadow foxtail (*A. pratensis*).

Table 2. Level III and IV Ecoregions within the North Platte River Basin.

Level III / IV Ecoregion		Acres	% of Basin
18	**Wyoming Basin**	**72,109**	**6%**
18f	Laramie Basin	72,109	6%
21	**Southern Rockies**	**1,217,422**	**94%**
21a	Alpine Zone	67,306	5%
21b	Crystalline Subalpine Forests	271,907	21%
21c	Crystalline Mid-Elevation Forests	125,329	10%
21d	Foothill Shrublands	12,483	1%
21e	Sedimentary Subalpine Forests	118,343	9%
21f	Sedimentary Mid-Elevation Forests	139,341	11%
21g	Volcanic Subalpine Forests	10,899	1%
21i	Sagebrush Parks	471,815	37%
Total		**1,289,532**	**100%**

Table 3. Descriptions of Level IV Ecoregions within the North Platte River Basin.

NAME	DESCRIPTION
18f: Laramie Basin	The **Laramie Basin** ecoregion is a wide intermontane valley of Wyoming that extends slightly into northern Colorado. Elevations in the Colorado portion are generally 7800 to 9100 feet, with annual precipitation of 15 to 20 inches. For the region as a whole, natural vegetation is mainly grassland compared to the sagebrush steppe in other regions of Ecoregion 18. Needle-and-thread, western wheatgrass, blue grama, Indian ricegrass and other mixed grass species are typical, along with rabbitbrush, fringed sage and various forb and shrub species. The rolling, high elevation valley of grass and shrubland is used primarily for seasonal livestock grazing. Some hay is produced along the Laramie River.
21a: Alpine Zone	The **Alpine Zone** occurs on mountain tops above treeline, beginning at about 10500 to 11000 feet. It includes alpine meadows as well as steep, exposed rock and glaciated peaks. Annual precipitation ranges from about 35 to greater than 70 inches, falling mostly as snow. Vegetation includes low shrubs, cushion plants and wildflowers and sedges in wet meadows. The forest-tundra interface is sparsely colonized by stunted, deformed Engelmann spruce, subalpine fir and limber pine (krummholz vegetation). Rocky Mountain bristlecone pines, some of the oldest recorded trees in North America, are also found here. Land use, limited by difficult access, is mostly wildlife habitat and recreation. Alpine is snow-free only 8 to 10 weeks annually. Snow cover is a major source of water for lower, more arid ecoregions.
21b: Crystalline Subalpine Forests	The **Crystalline Subalpine Forests** ecoregion occupies a narrow elevational band on the steep, forested slopes of the mountains, becoming more extensive on the north-facing slopes. The elevation range of the region is 8500 to 12000 feet, just below the Alpine Zone. The lower elevation limit is higher in the south, starting at 9000 to 9500 feet. The dense forests are dominated by Engelmann spruce and subalpine fir; aspen and pockets of lodgepole pine locally dominate some areas. Subalpine meadows also occur. Forest blowdown, insect outbreaks, fire and avalanches affect the vegetation mosaic. Soils are weathered from a variety of crystalline and metamorphic materials, such as gneiss, schist and granite, as well as some areas of igneous intrusive rocks. Recreation, logging, mining and wildlife habitat are the major land uses. Grazing is limited by climatic conditions, lack of forage and lingering snowpack.

NAME	DESCRIPTION
21c: Crystalline Mid-Elevation Forests	The **Crystalline Mid-Elevation Forests** are found mostly in the 7000 to 9000 feet elevation range on crystalline and metamorphic substrates. Most of the region occurs in the eastern half of the Southern Rockies. Natural vegetation includes aspen, ponderosa pine, Douglas-fir and areas of lodgepole pine and limber pine. A diverse understory of shrubs, grasses and wildflowers occurs. The variety of food sources supports a diversity of bird and mammal species. Forest stands have become denser in many areas due to decades of fire suppression. Land use includes wildlife habitat, livestock grazing, logging, mineral extraction and recreation, with increasing residential subdivisions.
21d: Foothill Shrublands	The **Foothill Shrublands** ecoregion is a transition from the higher elevation forests to the drier and lower Great Plains to the east and to the Colorado Plateaus to the west. This semiarid region has rolling to irregular terrain of hills, ridges and foot slopes, with elevations generally 6000 to 8500 feet. Sagebrush and mountain mahogany shrubland, pinyon-juniper woodland and scattered oak shrublands occur. Other common low shrubs include serviceberry and skunkbush sumac. Interspersed are some grasslands of blue grama, june grass and western wheatgrass. Land use is mainly livestock grazing and some irrigated hayland adjacent to streams.
21e: Sedimentary Subalpine Forests	The **Sedimentary Subalpine Forests** ecoregion occupies much of the western half of the Southern Rockies, on sandstone, siltstone, shale and limestone substrates. The elevation limits of this region are similar to the crystalline and volcanic subalpine forests. Stream water quality, water availability and aquatic biota are affected in places by carbonate substrates that are soluble and nutrient rich. Soils are generally finer-textured than those found on crystalline or metamorphic substrates of crystalline subalpine zone and are also more alkaline where derived from carbonate-rich substrates. Subalpine forests dominated by Engelmann spruce and subalpine fir are typical, often interspersed with aspen groves or mountain meadows. Some Douglas-fir forests are at lower elevations.
21f: Sedimentary Mid-Elevation Forests	The **Sedimentary Mid-Elevation Forests** ecoregion occurs in the western and southern portions of the Southern Rockies, at elevations generally below sedimentary subalpine forest. The elevation limits and vegetation of this region are similar to the crystalline and volcanic mid-elevation forests; however, a larger area of Gambel oak woodlands and forest is found in this region. Carbonate substrates in some areas affect water quality, hydrology and biota. Soils are generally finer-textured than those found on crystalline and metamorphic substrates such as those in the crystalline mid-elevation forest.
21g: Volcanic Subalpine Forests	The steep, mountainous **Volcanic Subalpine Forests** ecoregion is composed of volcanic and igneous rocks, predominately andesitic with areas of basalt. The region is found mainly in the San Juan Mountains, which have the most rugged terrain and the harshest winters in the Southern Rockies of Colorado. Smaller areas are found in the West Elk Mountains, Grand Mesa, Flat Tops and in the Front Range. The area is highly mineralized and gold, silver, lead and copper have been mined. Relatively young geologically, the mountains are among the highest and most rugged of North America and still contain some large areas of intact habitat. Engelmann spruce, subalpine fir and aspen forests support a variety of wildlife.
21i: Sagebrush Parks	The **Sagebrush Parks** ecoregion contains the large, semiarid, high intermontane valleys that support sagebrush shrubland and steppe vegetation. The ecoregion includes North Park, Middle Park and the Gunnison Basin and is slightly drier than the Grassland Parks. Summers tend to be hot and winters very cold, with annual precipitation of 10-16 inches. Land use is mostly rangeland and wildlife habitat, with some hay production near streams. The sagebrush provides forage and habitat to many animals and birds. Sandy loam soils are typical, formed in residuum from crystalline and sedimentary rocks, glacial outwash and colluvial or alluvial materials.

2.3 Geology

The central North Park valley is a synclinal basin. The syncline is a structural fold where the underlying strata dip toward the center of the structure, resulting in older strata being exposed at the margins of the basin and younger strata toward the center (Figure 4). In the central portion of the basin, North Park's geology is comprised of sedimentary formations with alluvial soil depositions along the riparian floodplains and foothills of the Park Range (Tweto 1979). The basin's foothills and the Larimer Valley are comprised of a mix of sedimentary shale, sandstone, siltstone, and mudstone depositions. Patches of unconsolidated sand form dunes in the western foothills of the Medicine Bow Mountains. Sedimentary formations in North Park began layering as long ago as the Permian age and are as deep as 19,000 ft. (5800 m; Voegeli 1965). The Coalmont formation that spans ~75% of the North Park valley is rich in soft coal, and the deep sedimentary layers also contain petroleum resources. In contrast, parent geology of the basin's mountains consists of older Precambrian metamorphic or igneous rock formed in the Laramide Orogeny (Dickenson 1988).

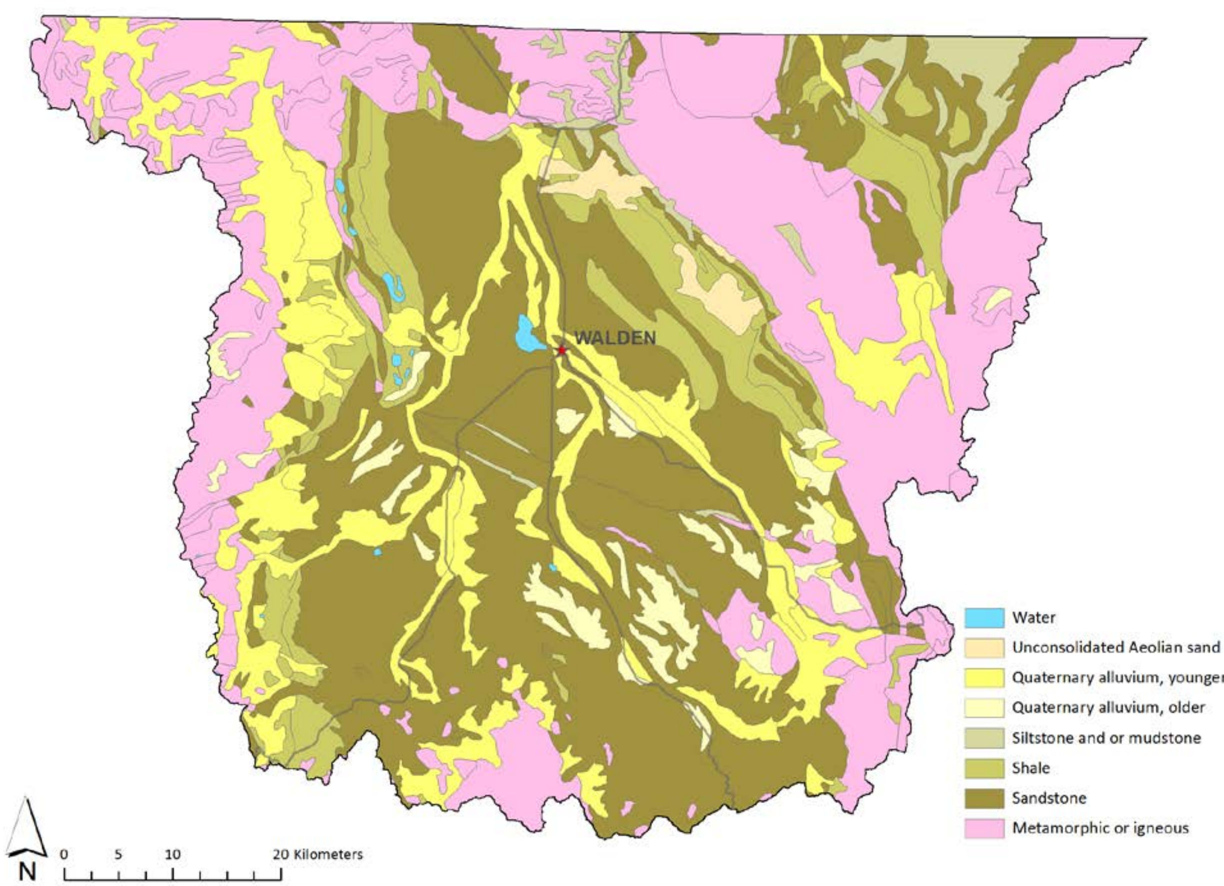


Figure 4. Dominant geology of the North Platte River Basin.

2.4 Climate and Hydrology

The semi-arid climate of the North Platte River Basin is characterized by long cold winters and short summers, and the harsh conditions limit year-round human populations. Mean annual temperatures average 37°F in Walden, and average maximum temperatures are 78° and 76°F in the warmest months of July and August (WRCC 2011). At the weather station in Walden, precipitation averages 11 in (27 cm)/year and snowfall averages 58 in (146 cm)/year. Precipitation increases to 14 in and snowfall increases to 98 in snowfall at the weather station in Rand in the mountain foothills. Temperature and precipitation peak in the summer, but on average, only the months of July and August receive no snowfall in the valleys and the mountains peaks hold snow-pack year round. Climatic conditions in the surrounding mountains (at higher elevations than the WRCC weather stations) have more extreme lows, more snowfall and more precipitation. The long winters, short growing season, and lack of developed winter resorts lend to the basin's character and have strongly affected current and historical human land use and settlement patterns.

The North Platte River and its tributaries collect all major runoff in the basin, directing the flow north past the Colorado/Wyoming state line through Northgate Canyon. The North Platte itself is a significant tributary of the Platte River, which is formed at the confluence of the North and South Platte Rivers in western Nebraska and flows east to the Mississippi River before emptying into the Gulf of Mexico. The collective length of the North Platte and Platte Rivers is 716 miles (1,152 km) long (USGS 2011). Within Colorado, major tributaries of the North Platte River include Arapaho Creek, Canadian River, Colorado Creek, Grizzly Creek, Illinois River, Laramie River, Michigan River, North Fork of the North Platte River, Sand Creek, and Willow Creek (Figure 2).

At the Northgate stream flow gaging station, mean annual flow of the North Platte River is ~312,000 acre-feet (USGS 2012). Mean annual flow of the Laramie River at Glendevey is ~52,000 acre-feet. There are twelve major reservoirs in the basin that store ~34,000 acre-feet (not including Chambers Lake at the headwaters of the Laramie River). Three major trans-basin diversions export water from the North Platte for use in the South Platte River Basin. In total ~23,000 acre-feet are diverted from the basin (CWCB 2012). Possibly as much as 78% of the precipitation that falls in the basin is lost to evaporation from open water, snow, and ice and by transpiration from vegetation (Robson and Graham 1996).

2.5 Land Ownership and Land Use

The first people documented to use the North Platte basin entered from Wyoming along the North Platte River to hunt large mammals during warm seasons. Ancient spear points indicate the mammoth hunting Clovis people entered the valley perhaps 11,000 years ago, during a time when intermountain canyons in the west portion of the basin were laden with glaciers (Richard 2009). Over thousands of years, various Native American tribes continued to seasonally hunt in the basin known for its abundant game, particularly bison, antelope, elk, deer, and bighorn sheep. As Euro-Americans explorers and trappers arrived in the basin in the 1830s, they used hunting methods learned from the Ute tribes and bison populations were severely reduced. Trapping for fur also decimated beaver and other wildlife populations. Over the next 100 years, increasing human presence and ranching settlements decreased ungulate, wolf, bear, and sage grouse populations.

Many populations were either significantly reduced or eradicated (Richard 2009). Major predators and bison have not returned to North Park, however, USFWS and CPW now intensively manage ungulate herds and nesting bird populations and reservoirs are stocked with trout. Once again, the basin is known for its wildlife resources and sportsmen and wildlife viewers travel to North Park for fish, elk, antelope, deer, moose, and birds. Knowledge of wetland location, type, and condition is particularly pertinent to the management of wildlife species that depend on wetlands for their habitat.

Today, the majority of land throughout the basin is owned by public entities (Figure 5). Only 33% of the basin is in private hands and these lands are concentrated in the central North Park valley. Along with private lands, North Park also contains lands managed for grazing by the Colorado State Land Board (SLB) and Bureau of Land Management (BLM) and lands managed for wildlife, including USFWS's Arapaho National Wildlife Refuge and several CPW State Wildlife Areas. The basin's mountains are mostly managed by the U.S. Forest Service (USFS). Western and southern mountains are within the Medicine Bow-Routt National Forest while eastern mountains are within the Arapaho-Roosevelt National Forest. USFS lands also contain the Mount Zirkel, Rawah, and Never Summer Wilderness Areas. A very small portion of Rocky Mountain National Park extends into the southeast corner and State Forest State Park spans the western foothills of the Laramie Mountains.

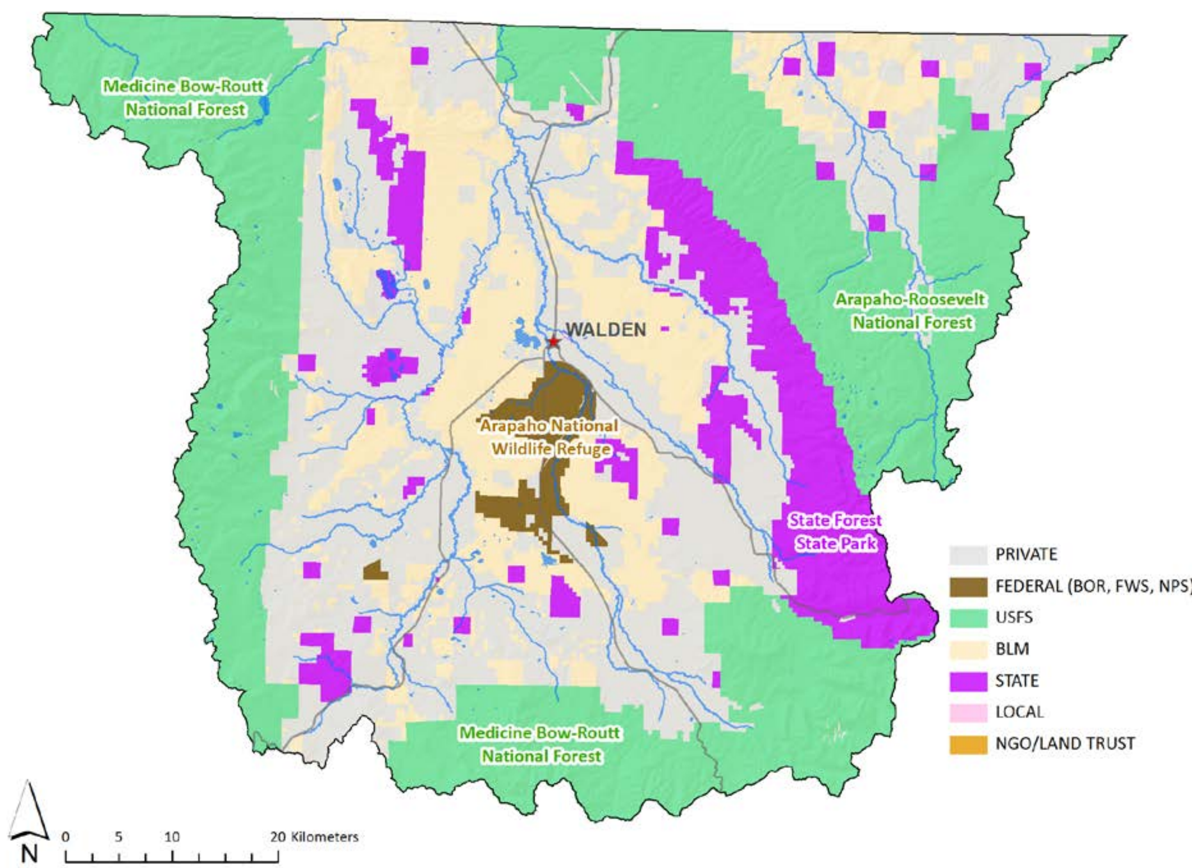


Figure 5. Land ownership within the North Platte River Basin.

Since the time of early settlement in the 1870s, the dominant land use in the basin has been cattle ranching. Hay production is a major supplement to the ranching income and provides livestock feed, however, climatic conditions only allow one hay cutting per year, unlike many other areas in Colorado that can sustain two yearly harvests. Seasonal wildlife tourism is also important, including game-viewing, hunting, and fishing in basin's lakes and streams. Dude ranches and summer vacation homes located in the North Park and Laramie River valleys add to the tourism economy based on the ranching lifestyle. The basin is relatively remote when compared with much of Colorado. Less than 0.03% of the basin is classified as low, medium, or high intensity developed land, and high intensity development makes up < 2 acres total (Landfire 2008).

Water movement and irrigation is integral to ranching in intermountain valleys. Anthropogenic hydrologic alterations in the basin began in the 1880s, shortly after settlers first overwintered. Concentrating near streams in the otherwise dry environment, they dug shallow ditches throughout much of North Park to expand the floodplain resources for their cattle, and many of these small, unlined ditches remain today. Irrigation reached its peak in North Park in 1939 with 131,810 acres (North Park Wetlands Focus Area Committee 2002). The current extent of irrigated lands is closer to 110,000 acres (CDDS 2009) and the legal limit based on inter-state water law is 145,000 acres (CWCB 2012). Existing irrigated land is still concentrated near the rivers and their broad, meandering, floodplains. Every spring, landowners flood irrigate their lands for hay and cattle, which has created additional wetland acres over many years (Peck and Lovvorn 2001). As a result, teasing out natural from created wetlands in areas where flood irrigation occurs is nearly impossible.

Fed by spring snowmelt, surface water is generally abundant and diverted in shallow ditches from streams for localized flood irrigation. Groundwater pumping is much lower than in other more intensively managed agricultural regions of Colorado, such as the Rio Grande Headwaters or the eastern plains. Only 130 active water wells are reported in North Park and many of these are under 120 feet deep (CDWR 2011).

Resource extraction has been a continuous but small share of the economy since Euro-American settlement. It began with soft coal extraction from the Coalmont Formation, was followed by gold and other metal extraction from placer mines from 1874 to the early 1900s (Athearn 1977), and later expanded to drilling the thick sedimentary layers for petroleum beginning in the 1920s. Between the 1930s–1980s, commercial logging took place in the forested mountains and foothills. In recent years, hydraulic fracturing has been used to extract natural gas from deep within the sedimentary formations throughout North Park. Oil and gas well density (COGCC 2011) is currently lower in this region than some other areas in Colorado, such as Weld County, but development of wells that use hydraulic fracturing substantially increased from 2007 to 2011, with more leases pending. Drilling for oil and gas is often contentious in pristine places popular with sportsmen, and there is concern that increasing oil and gas development in North Park may degrade important wildlife habitat (Ellenberger and Byrne 2011).

3.0 METHODS

3.1 Wetland Profile and Landscape Integrity Model

At the outset of this project, digital wetland mapping from U.S. Fish and Wildlife Service (USFWS)'s National Wetland Inventory (NWI) program was available for less than 10% of the basin, though paper maps drawn between the late 1970s and early 1980s existed for the entire area. To create the wetland profile, original paper maps for all topographic quads lacking digital spatial data were scanned and converted to geo-rectified digital polygons, producing a wall-to-wall map of wetlands in the basin. The maps were not updated in the digital conversion, but land use change in the basin has been minimal in the 30 years since the maps were drawn. The digitization process was completed concurrently with this project, but was funded through the original *Statewide Strategies for Colorado Wetlands* grant (EPA Assistance ID# CD-97874301-0; Lemly et al. 2011).

Based on completed digital NWI mapping and ancillary data sources, a detailed wetland profile for the North Platte River Basin was prepared. The profile summarizes the extent of wetland acreage throughout the basin by NWI system/class, hydrologic regime, extent modified, extent irrigated, land ownership, and Level IV Ecoregions. Along with the wetland profile, a Level 1 assessment of wetland condition within the entire river basin and each ecoregion was conducted based on a statewide Wetland Landscape Integrity Model (LIM) developed previously (Lemly et al. 2011). The model is a weighted algorithm combining several landscape level stressors derived from GIS into an overall landscape integrity score. The weighting was based on best professional judgment of each stressor's relative impact. For most stressors, a distance decay function was used to account for the fact that impacts fade with distance in a non-linear fashion.

3.2 Survey Design and Site Selection

The following paragraphs detail the survey design for the field-based component of the North Platte River Basin wetland condition assessment, including the target population, classification, sample size, sample frame, and selection criteria. The survey design follows principles outlined by the EPA's EMAP program (Stevens & Olsen 2004; Detenbeck et al. 2005).

3.2.1 Target Population

The target population for this study was all naturally occurring and naturalized vegetated wetlands within the North Platte River Basin. The target population did not include deep water lakes or stream channels, though we report out the acreage of these features in the wetland profile. During the study, the target population was modified to exclude actively managed hay pastures (see Section 3.2.5 for explanation). Minimum size criteria of 0.1 hectares in area and 10 m in width were also implemented. For safety reasons, we excluded wetland area with water > 1 m deep from field sampling.

The operational definition used in this project is the USFWS definition used for NWI mapping (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."

The USFWS definition is different than the definition of wetland used by the ACOE and the EPA for regulatory purposes under Section 404 of the Federal Clean Water Act (ACOE 1987):

"[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 that the Clean Water Act definition requires positive identification of all three wetland parameters (hydrology, vegetation, and soils) while the USFWS definition requires only one to be present. It is important to note that wetlands surveyed through this study may or may not be classified as jurisdictional wetlands under the Clean Water Act and that NWI mapped boundaries should not be interpreted as wetland delineations.

We used standard wetland identification and delineation techniques to determine inclusion in the sample population. We relied heavily on materials produced by the U.S. Army Corps of Engineers (ACOE) and the Natural Resources Conservation Service (NRCS), such as the *Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region* (ACOE 2008) and the *Indicators of Hydric Soils in the United States* (NRCS 2010). However, we only needed positive identification of one or two parameters, not all three.

NWI mapping also includes non-vegetated areas and deep water habitats, which were excluded from this study. Though the original sample frame (NWI mapping) was refined by excluding non-target attribute classes (see Section 3.2.4), the remaining sample frame still included non-target areas that were rejected through desktop review or on-site evaluation.

3.2.2 Subpopulations/Classification

The target population was classified into subpopulations based Ecological Systems (Table 4; Comer et al. 2003). Because elements within the sample frame (NWI polygons) were not attributed according to the Ecological System classification, these subpopulations were not part of the survey design *a priori.* Individual estimates of condition were calculated post hoc for subpopulations where sufficient data were collected.

The Ecological System classification is a component of the International Vegetation Classification System (Grossman et al. 1998; NatureServe 2004; Faber-Langendoen et al. 2009), developed by NatureServe and the Natural Heritage Network. It provides a finer scale of resolution than traditional wetland classification systems such as the USFWS's Cowardin classification (Cowardin et al. 1979) and the hydrogeomorphic (HGM) classification system (Brinson 1993). The Ecological System approach uses both biotic (structure and floristics) and abiotic (hydrogeomorphic template, elevation, soil chemistry, etc.) criteria to define units. These finer classes allow for greater specificity in developing conceptual models of the natural range of variation and in setting thresholds that relate to stressors. Sites were classified by Ecological Systems following the key in Appendix A. While Ecological Systems was the primary classification system used, each sampled wetland was also classified onsite by the HGM (Appendix B) and Cowardin systems in order to report on numbers of sites and scores by those systems as well.

Table 4. Wetland Ecological Systems found in the North Platte River Basin.

Ecological System
Inter-Mountain Basins Alkaline Closed Depression
Rocky Mountain Alpine-Montane Wet Meadow
Rocky Mountain Subalpine-Montane Fen
Rocky Mountain Subalpine-Montane Riparian Shrubland
Rocky Mountain Subalpine-Montane Riparian Woodland
Western North American Emergent Freshwater Marsh

3.2.3 Sample Size

The target number of sample sites was 100, stratified by Level IV Ecoregion. However, not all sites were able to be sampled given access issues and time constraints. Over the 2010 field season, 95 wetland sites were sampled.

3.2.4 Sample Frame

The sample frame was based on digital polygons converted from original NWI paper maps. From the NWI dataset, we eliminated all polygons that represented unvegetated surfaces, deep water lakes, river and stream channels, and unvegetated irrigation ditches. A list of NWI codes included in and excluded from the sample frame can be found in Appendix C. To build the final sample frame, all area within the included NWI polygons was converted into a 10-meter grid of potential sample points. A 10-meter grid was chosen as the smallest sample unit possible under the constraints of computer processing time and file size, but ensured that even small polygons would include points. Target sample points were selected from within this grid of points and not from polygon centroids because of extreme variation in the size of individual polygons. All estimates made during analysis are for wetland area, not percent or number of individual wetlands.

3.2.5 Selection Criteria

The study employed a one-stage survey design stratified by Level IV Ecoregions (see Section 2.2). The study area contains nine Level IV Ecoregions. However, to reduce the number of strata, Level IV Ecoregions that occupied < 5% of the study area were combined with similar ecoregions. Ecoregion 21g: Volcanic Subalpine Forests was combined with 21b: Crystalline Subalpine Forests and ecoregion 21d: Foothill Shrublands was combined with 21f: Sedimentary Mid-Elevation Forests and Shrublands. Target sample points were selected from each of the resulting seven ecoregional strata using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) approach in ArcGIS 9.3 (Theobald et al. 2007). The number of sample points selected per strata was proportional to the area occupied by that ecoregion (Table 5), enforcing a wider geographic distribution.

Table 5. Ecoregional strata and number of target sample points used in the North Platte River Basin survey design. Strata listed in order of descending elevation.

Ecoregional strata		Total area (acres)	Percent of study area	Target sample points	Wetland area (acres)[1]	Percent of wetland area
21a.	Alpine Zone	67,271	5%	5	1,148	1%
21b/g.	Cryst/Volc Subalpine	282,806	22%	22	10,270	8%
21e.	Sed Subalpine	118,343	9%	9	3,516	3%
21c.	Cryst Mid-Elevation	125,329	10%	10	4,974	4%
21d/f.	Sed Mid-Elevation/Foothills	151,824	12%	12	15,527	12%
21i.	Sagebrush Parks	471,815	37%	36	89,855	69%
18f.	Laramie Basin	72,109	6%	6	5,364	4%
	Total	**1,289,005**	**100%**	**100**	**130,651**	**100%**

[1] Wetland area shown only includes NWI classes included in the sample frame, not all NWI mapped area.

Through preliminary field work in the study area in August 2009, it became apparent that many acres mapped as wetland within the NWI dataset were flood irrigated hay pastures that are harvested every year in the late summer. This is particularly true within the Sagebrush Parks ecoregion. Irrigated hay pastures posed an interesting problem, as they may or may not have been naturally occurring wetlands before irrigation began. Many pasture acres are located within floodplains of the basin's rivers and streams, though they can also extend beyond the floodplain depending on the location of irrigation canals. Because of their extensive acreage, many target sample points within the Sagebrush Parks ecoregion fell within these irrigated pastures. After visiting several pasture sites, it was decided that these acres did not fit within the primary population of interest. As field time and resources were limited, it was decided that target points within irrigated pastures actively managed for hay production would be removed from the survey design and replaced by points from the over sample list. Irrigated lands were filtered from the sample frame based on a detailed GIS data layer of irrigated lands available from the Colorado Decision Support System (CDSS 2009). The final survey design is shown in Figure 6.

In order to quantify the accuracy of our sample frame, we also selected 100 sample points each in two discrete areas outside the sample frame. The first area was within the intersection of the irrigated lands data and the NWI data. This area represented lands mapped as both wetlands and irrigated, which we refer to as irrigated wetlands. The second area was outside the NWI data, representing uplands. We screened each of these 200 points in GIS using aerial photography and other supplemental data layers. For the irrigated wetlands, we noted whether or not the point appeared to be an actively managed hay pasture. If any of the irrigated wetland points fell in a wetland that was not actively managed for hay production, we attempted to sample that point in the field using the same methods as our target wetland points. For the upland points, we noted whether the point was upland or wetland.

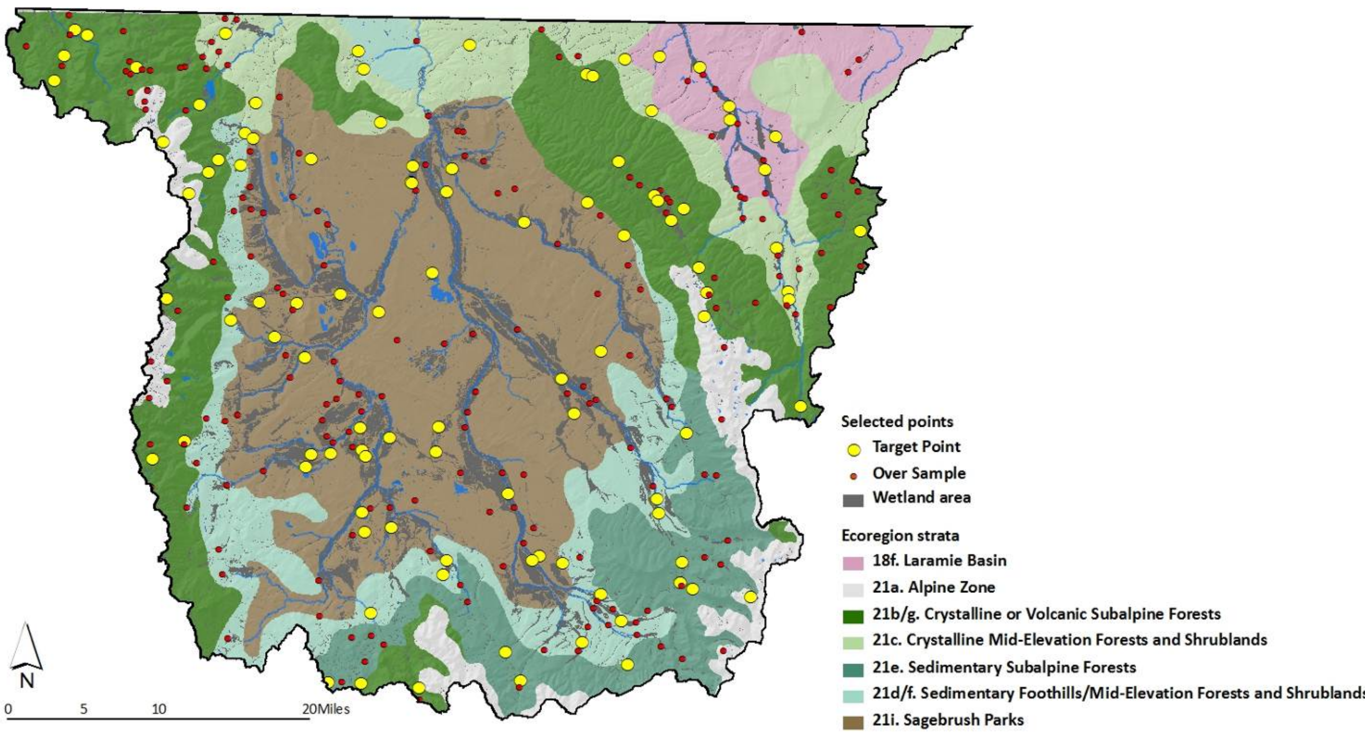


Figure 6. Target wetland sample points drawn for the North Platte River Basin. Points were stratified by Level IV Ecoregion, proportional to the ecoregion area. Points on irrigated lands were removed.

3.3 Field Methods

Field methods used in this project were based on the Ecological Integrity Assessment (EIA) framework (see Section 1.3.2). EIA protocols specific to Colorado have been developed at CNHP with previous EPA Region 8 funding and were further refined through the pilot basinwide wetland condition assessment in the Rio Grande Headwaters basin. All wetlands sampled were assessed with the Level 2 rapid EIA field form, which takes ~2–3 hours. In ~50% of sites, vegetation data were collected with intensive Level 3 protocols based on a modification of the Flexible Plot or Carolina Vegetation Survey (CVS) method (Peet et al. 1998). Intensive vegetation data allowed us to calculate Vegetation Index of Biotic Integrity (VIBI) scores (Rocchio 2007a, Lemly and Rocchio 2009b) for these wetlands. The CVS plot takes up to 8 hours to carry out and VIBI score calculations vary by Ecological System. For the remaining sites, vegetation data were collected using more rapid field methods which still allowed us to calculate metrics from the Floristic Quality Assessment for Colorado Wetlands (Rocchio 2007b). See Appendix D for a copy of the field form. More detail on each protocol follows and a copy of the field manual is available upon request.

3.3.1 Defining the Wetland Assessment Area (AA)

The basis of this study is the identification and establishment of an assessment area (AA) within the target wetland population. An AA is the boundary of the wetland (or portion of the wetland) targeted for sampling and analysis. Sample points were randomly selected from the sample frame within areas presumed to meet the target population. Before any sampling occurred, all points were screened in GIS to remove sites that were clearly non-target. Once in the field, crews verified the target status of each point and either carried out protocols according to wetland type or rejected the point. To accommodate slight inaccuracies within the sample frame and variable precision of GPS receivers, crews were able to shift up to 60 m from the original target point in order to establish an AA within a sampleable target wetland.

At each sample point determined to meet the target population, an AA was defined as all wetland area of the same Ecological System in a 0.1–0.5 ha area surrounding the target point. Where possible, the AA was delineated as a 40 m radius circle around the point. However, the size and shape of the AA could vary depending on site conditions. During data processing, the actual area of each AA was delineated in GIS based on GPS data and field notes in order to calculate estimates for total wetland area based on the area sampled. Prior to field visits, two field maps were made for each targeted sample point. The field maps outlined the potential AA boundary (40 m radius circle around the sample point) and a 100-m and 500-m radius envelope around the AA (Appendix D).

Once at the target sample point, field crew members determined the appropriate dimensions of the AA. This determination was made by first estimating the approximate boundaries of the wetland within the potential AA. Readily observable ecological criteria such as vegetation, soil, and hydrological characteristics were used to define wetland boundaries, regardless of whether they met jurisdictional criteria for wetlands regulated under the Clean Water Act. The second step was to delineate the Ecological Systems and HGM classes present within the wetland boundary based on the keys in Appendix A and Appendix B. Because field methods vary by Ecological System, it was important to focus the assessment on one Ecological System. In most instances, the potential AA included only one Ecological System; but in some instances, there were more than one within the area. For example, fens may occur along the margins of a valley and adjacent to riparian shrublands on the valley floor. Similarly, wet meadows with mineral soil are often interspersed with organic soil fens, depending on groundwater flow patterns. For such scenarios, it was necessary to delineate the boundaries of the separate Ecological Systems based on the minimum size criteria associated with each system. If an Ecological System patch was less than its minimum size, it was considered an inclusion within the type in which it was embedded. If the target sample point was at the edge of a wetland or at the edge of one Ecological System, field crews were able to adjust the center of the AA up to 60 m to be more squarely the within the target area.

3.3.2 Classification and Description of the AA

Once the AA was established, standard site variables were collected from each sample location. This included:

- UTM coordinates at four locations around the AA
- Elevation, slope, and aspect
- Place name, county, and land ownership
- Ecological System classification
- HGM classification
- Cowardin classification

- Vegetation zones within the AA
- Description of onsite and adjacent ecological processes and land use
- Description of general site characteristics and a site drawing
- At least four photos were taken at each site along the edge of the AA looking in towards the site (Figure 7).
- Additional photos were taken as need to document the wetland and surrounding landscape.

Figure 7. Example AA photos from the North Platte River Basin wetland condition assessment.

3.4.3 Ecological Integrity Assessment and the Human Disturbance Index

For every target sample point surveyed, a Level 2 rapid EIA field form was filled out according to Ecological System and HGM Class. EIA metrics used in the North Platte study are summarized in Table 6. Metric narrative ratings and scoring formulas are included as Appendix E.

Table 6. Final EIA metrics used for the North Platte River Basin.

Ecological Categories	Key Ecological Attributes	Indicators and Metrics
Landscape Context	Buffer	• Buffer Extent • Buffer Width • Buffer Condition
	Landscape Connectivity	• Landscape Fragmentation • Riparian Corridor Continuity[1]
Biotic Condition	Community Composition	• Relative Cover Native Plant Species • Absolute Cover Noxious Weeds • Absolute Cover Aggressive Native Species • Mean C
	Community structure	• Regeneration of Native Woody Species[2] • Litter Accumulation • Structural Complexity
Hydrologic Condition	Hydrology	• Water Source • Hydrologic Connectivity • Alteration to Hydroperiod[3] • Upstream Water Retention[1] • Water Diversions / Additions[1] • Bank Stability[1] • Beaver Activity[1,4]

Table continued on next page

Physiochemical Condition	Physiochemistry	• Water Quality • Algal Growth • Substrate / Soil Disturbance

[1] Metric recorded in Riverine HGM wetlands only.
[2] Only applied to sites where woody species are naturally common.
[3] Metric recorded in Non-Riverine HGM wetlands only.
[4] Only applied to sites where beaver activity is expected.

In addition to the metrics included in the EIA, information related to human disturbance was collected using the Human Disturbance Index (HDI), a semi-quantitative index that provides an independent measure of alteration (Rocchio 2007a; Rocchio 2007b). The HDI is an estimate of the degree to which each site has been impacted by human disturbance. This method assumes that the absence of historic and/or contemporary human disturbance indicates that the wetland possesses biotic and ecological integrity and that increasing human disturbance results in a predictable deviation from the ecological reference condition. The HDI uses several of the same metrics included in the EIA protocols, but does not include biotic condition metrics and adds a few additional metrics employed in other rapid wetland condition assessment methods (Ohio EPA 2001; Montana DEQ 2005; Collins et al. 2008). HDI metrics are organized into three major categories of stressors, listed in Table 7. HDI metrics that were in addition to the EIA metrics were integrated into the field form and pulled out during data analysis.

Table 7. HDI metrics and stressor categories.

Stressor Categories	Indicators and Metrics
Alterations within Buffers and Landscape Context	• Average Buffer Width • Adjacent Land Use • Landscape Fragmentation • Riparian Corridor Continuity[1]
Hydrologic Alteration	• Hydrological Alterations[2] • Upstream Surface Water Retention[1] • Water Diversions / Additions[1] • Floodplain Interaction[1]
Physical/Chemical Disturbances	• Onsite Land Use • Cattail Dominance • Algal Blooms • Sediment / Turbidity • Toxics/Heavy Metals • Substrate / Soil Disturbance • Bank Stability[1]

[1] Metric recorded in Riverine HGM wetlands only.
[2] Metric recorded in Non-Riverine HGM wetlands only.

Like the EIA, HDI metrics use descriptive criteria to inform a point rating. The two highest metric scores for each stressor category are summed, then multiplied by a weighting factor (0.33 for Buffer/Landscape Context and Physical/Chemical Disturbances; 0.34 for Hydrology) to arrive at a final score ranging from 0 (reference condition; no/minimal human-induced disturbance) to 100 (highly impacted).

3.3.4 Vegetation Data Collection

Level 3 Intensive Plots: If the target sample point was selected for intensive Level 3 sampling, a 20 m x 50 m reléve plot was used to collect vegetation data. The method has been in use by the North Carolina Vegetation Survey for over 10 years (Peet et al. 1998), has been used to successfully develop a VIBI in Ohio (Mack 2001; Mack 2004a; Mack 2004b), and was used to develop the Colorado VIBI (Rocchio 2006h; Rocchio 2007b). The structure of the plot consists of ten 10 m x 10 m (100 m^2) modules typically arranged in a 2 x 5 array (Figure 8).

The plot was subjectively placed within the AA to maximize abiotic/biotic heterogeneity. Capturing heterogeneity within the plot ensures adequate representation of local micro-variations in the floristic data produced by such things as hummocks, water tracks, side-channels, pools, wetland edge, micro-topography, etc. The following guidelines were used to determine plot locations within the AA[8]:

- The plot should be located in a representative area of the AA which incorporates as much microtopographic variation as possible.
- If the AA is homogeneous and there is no direction or orientation evident in the vegetation, the plot should be centered within the AA and laid out either N-S or E-W.
- If the AA is not homogeneous, is oddly shaped, or is directional (i.e. follows a stream), the plot should be oriented so it adequately represents the wetland features. In the case of a riparian area, this may mean along the stream bank or cutting across the stream obliquely.
- If the wetland has an irregular shape and the 20 m x 50 m plot does not "fit" within the AA, the 2 x 5 array of modules can be restructured to accommodate the shape of the AA. For example, a 1 x 5 array of 100-m^2 modules can be used for narrow, linear areas and a 2 x 2 array of 100-m^2 modules can be used for small, circular sites.
- The plot should attempt to capture the range of diversity within the AA, but should avoid crossing over into the upland. No more than 10% of the plot should be in upland areas beyond the wetland. If end modules do cross into the upland, these should not be sampled as intensive modules.
- If a small patch of another wetland type is present in the AA (but not large enough to be delineated as a separate ecological system type), the plot should be placed so that at least a portion of the patch was in the plot.
- Localized, small areas of human-induced disturbance should be included in the plot according to their relative representation of the AA.

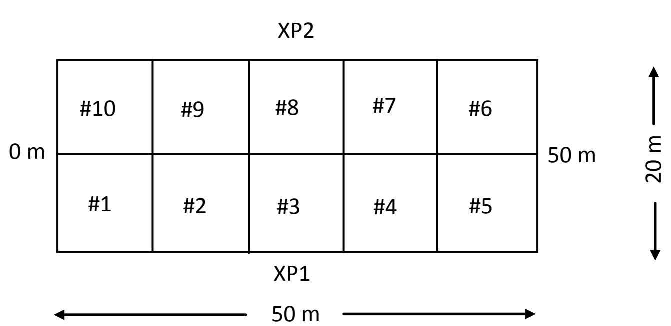


Figure 8. Schematic of the 20 m x 50 m vegetation plot with a two by five array of ten 10 m x 10 m modules. Photos and GPS waypoints taken at the 0 m and 50 m ends and at XP1 and XP2 crossplots.

[8] Many of the guidelines are based on (Mack 2004a; Mack 2004b).

Floristic measurements including presence/absence and abundance (i.e., cover) of all vascular plant species were made within four intensive modules, selected to represent the range of vegetation. Nomenclature for all plant species followed Weber and Wittman (2001) and all species were recorded on the field form using the fully spelled out scientific name. Any unknown species were entered on the field form with a descriptive name and all unknown species were collected by the field crew. The only species not collected were those identified as or suspected to be federally or state listed species.

When all species within a module had been identified, cover was visually estimated for the module using the following cover classes (Peet et al. 1998).

1 = trace (one or two individuals)
2 = 0–1%
3 = >1–2%
4 = >2–5%
5 = >5–10%
6 = >10–25%
7 = >25–50%
8 = >50–75%
9 = >75–95%
10 = >95%

After sampling each of the intensive modules, the remaining (i.e. residual) modules were walked through to document presence of any species not recorded in the intensive modules. Percent cover of these species was estimated over the entire 1000-m^2 plot.

Level 2 Rapid Plots: If the target sample point was not selected for a full VIBI plot, vegetation data were collected in a plotless sample design. All species present within the AA were identified and listed on the field form and the overall cover within the AA was visually estimated using the same cover classes as the VIBI plots. The search for species was limited to no more than one hour to minimize the amount of time spent at the site.

4.3.5 Soil Profile Descriptions and Groundwater Chemistry

At least two soil pits were dug within each AA with a 40-cm sharp shooter shovel. For Level 3 plots, the pits were placed in or near the vegetation plot and within vegetation types captured by the plot. For Level 2 plots, pits were located in area that represented the dominant vegetation type. Pits were dug to one shovel length depth (35 to 40 cm) when possible and only slightly larger than the width of the shovel on all sides to minimize disturbance to the ground surface. A bucket auger was used to examine the soil deeper in the profile if needed to find hydric soil indicators. Because of difficulty digging soil pits in areas with deep standing water, if standing water was a significant part of the AA, crews concentrated on areas near the water's edge.

Following guidance in the ACOE *Regional Supplement* (ACOE 2008) and the Natural Resources Conservation Service (NRCS) *Field Indicators of Hydric Soils in the United States* (NRCS 2010), crews identified and described each distinct layer in the soil profile. For each layer, the following information was recorded: 1) color (based on a Munsell Soil Color Chart) of the matrix and any redoximorphic concentrations (mottles and oxidized root channels) and depletions; 2) soil texture; and 3) any specifics about the concentration of roots, the presence of gravel or cobble, or any usual features to the soil. Based on the characteristics, the crew identified which, if any, hydric soil indicators occur at the pit.

3.4 Data Management

To efficiently store and analyze data collected from the wetland condition assessment, a Microsoft Access™ database was built by a database specialist at CNHP. EIA/HDI metrics and vegetation data were entered into the database at the completion of the field season. For VIBI plots, relative and mean cover values for each species were averaged across the intensive modules for use in data analysis. For those species only occurring in the residual plots, the cover value for the residual plots was used for analysis. To eliminate spelling errors, a pre-defined species list was used for species entry. During data entry, if a number in a couplet from the nested corners (presence/cover) was missing, it was assumed that the species was present in the plot and that the second value was simply overlooked. For these situations, a default cover value of 1 was entered. Unknown or ambiguous species (e.g., *Carex* sp.) were entered into the database, but not included in data analysis. Data entry was reviewed by an independent observer for quality control.

The species table from the Colorado FQA (Rocchio 2007b) was used as the pre-defined species list and to populate life history traits, wetland indicator status, and C-values in the database for each species in each plot. The FQA species table was updated and modified when converted to Microsoft Access™ in 2008 and species primary nomenclature now follows Weber and Wittmann (2001), though all names are cross-referenced to the nationally accepted names in the U.S. Department of Agriculture's PLANTS Database[9]. Life history traits and cover data were used to calculate FQA and VIBI metric values using Visual Basic queries programmed in the database. Calculations made by the queries were randomly checked to ensure that the queries were constructed correctly.

3.5 Data Analysis

3.5.1 Characterization of Wetland Vegetation

To characterize wetland vegetation across the North Platte River Basin, summary statistics on species abundance and distribution were compiled and multivariate analyses were conducted on vegetation community composition. We used Nonmetric Multidimensional Scaling (NMS) ordination (Kruskal 1964; Mather 1976) to analyze patterns in species variation across all wetland sites and to investigate relationships between species composition and a secondary matrix of sampling variables, environmental variables, and condition class.

The species matrix (95 plots x 410 species) consisted of species presence and percent cover. Species that occurred in less than two plots (202 of 612 species recorded) were dropped from the dataset to reduce noise. The species matrix was transformed with a square root transformation to reduce ordination stress and high species coefficient of variation (McCune and Grace 2002).

[9] PLANTS National Database can be accessed at the following website: http://plants.usda.gov. The National nomenclature in the Colorado FQA is based on a download from the website in January 2008.

Sampling variables were selected to assess if species composition was affected by temporal effects, size, or level (intensity) of sampling. Environmental variables were selected using available GIS and field-recorded data to assess environmental gradient that may affect species in North Platte wetlands. Condition class based on overall EIA and category scores were selected to assess the relationship between species distribution and condition. The secondary matrix (95 plots x 24 variables) was tested for covariance between plots by species and sampling effects, environmental attributes, and plot condition (Appendix F).

The ordination identified 7 of 95 plots as outliers (SD > 2.0). Deleting the two largest outliers resulted in similar plot scatter, similar strengths of relationships to the secondary matrix, and additional outliers. The outliers were not biologically anomalous. The largest outliers tended have species compositions typical of either disturbed or naturally saline wetlands with more grasses and weedy species, and presence of halophytes. These plots also tended towards a more frequent disturbance regime, either natural or not, as evidenced by dry patches with sparse vegetation and bare ground, saline deposits, and were often near artificial water controls such as reservoirs, pipes, or adjacent bermed wetlands. We did not want to eliminate plots that were outliers from analysis because they were on the lower end of the wetland integrity gradient and/or subject to more natural disturbance. Therefore, all outlier plots were retained in analyses to facilitate comparisons of wetlands across a broad range of wetland condition.

The ordination was run using the Sorensen Distance Measure and the 'slow and thorough' autopilot setting in PC-ORD 5.32 (McCune and Mefford 2006). The recommended 3-D solution had a low final stress of 13.04 and the cumulative proportion of variability in the data (R^2) explained by the solution was 84.6% (Appendix F). All randomized runs had stress < observed stress (P=0.004; Monte Carlo tests with 250 runs). The ordination solution was rotated orthogonally to maximize the correlation between overall wetland condition (from the secondary matrix) and species gradients, which also increased orthogonality of the three axes.

3.5.2 FQA and EIA Analysis

For all sites sampled, vegetation data collected with either the Level 2 or Level 3 protocols were used to calculate FQA metrics (Rocchio 2007b). One FQA metric (Mean C) is included in the Biotic Condition category of the EIA protocol and represents perhaps the single strongest measures of biotic wetland condition (Lemly and Rocchio 2009a). For all sites sampled, FQA metrics are shown both independently and as a component of the EIA scores. EIA metrics were used to calculate Level 2 scores and ranks for each site visited in the North Platte River Basin following scoring formulas presented in Appendix E. Scores and ranks were calculated for each major ecological category, as well as the overall Ecological Integrity score.

EIA scores were calculated at both the site and population level. Site level results are presented in tables and graphs that depict the range of scores observed in the field. Population level estimates were extrapolated from site level results based on survey design parameters using the software package R version 2.14.0 (R Foundation for Statistical Computing 2011) and the 'spsurvey' library. Population level estimates are presented as weighted percentages with 95% confidence intervals. The extrapolated weighted averages incorporate stratification in the sample design and adjust for survey points that could not be accessed. Cumulative distribution function (CDF) plots were created to display continuous variables, such as the overall EIA score, for the entire population. CDF plots display the cumulative proportion of the resource estimated to have at least a certain score. To facilitate interpretation, EIA rank thresholds were superimposed on the EIA CDF plot to show the cumulative acreage within each rank.

3.5.3 VIBI Analysis

For sites that were sampled with the Level 3 VIBI protocols, VIBI scores were calculated based on the three Version 2.0 VIBI models available for Colorado (wet meadows, riparian shrublands, and fens: Lemly and Rocchio 2009b). VIBI scores were compared to HDI scores to test whether Version 2.0 models performed similarly within the North Platte River Basin as with development plots.

3.5.4 Empirical Model of Wetland Ecological Integrity

A spatially explicit empirical model of wetland ecological integrity was created to predict the condition of wetlands not visited in the field. The basic multiple regression model used field-collected overall EIA scores as a response variable and numerous landscape-level GIS variables as predictors. The resulting model is similar to the conceptual Landscape Integrity Model (LIM) previously developed for the entire state of Colorado and presented as part of the wetland profile (see Section 3.1), but the empirical model was built using field collected data while the conceptual LIM used best professional judgment to weight input variables.

Twenty six potential predictors were tested for inclusion in the model (Table 8). Due to variability in the units and scales of the predictor variables, each variable set was centered and scaled. A stepwise model selection process was used to determine the best fitting model based on Akaike Information Criterion (AIC) scores (Akaike 1974). The resulting model was tested for spatial autocorrelation to see if a spatial random effect would reduce the variation. Though there was significant autocorrelation in the EIA scores, predictors included in the best fit model accounted for much of the spatial correlation, making a spatial random effect unnecessary. The chosen model was then testing by iteratively leaving each observation out of the dataset and predicting the fitted value for that data point.

To extrapolate the empirical model of ecological integrity to unsampled wetlands across the North Platte basin, nearly 20,000 new, randomly selected wetland locations were pulled from the wetlands mapping in ArcGIS. Of these new locations, 11,793 were mapped as irrigated and 7,830 were not. Because nearly all field sampled points excluded wetlands mapped as irrigated lands, predicted scores were only calculated for the analogous non-irrigated wetland points. Predictions made from the empirical model at irrigated sites would be less certain.

Table 8. Variables tested for inclusion in the empirical model of wetland condition.

Categories	Predictor Variables	Data Source
Geographic variables	Elevation	10 m Digital Elevation Model
	Latitude	ArcGIS 10.0
	Longitude	
Potential stressors	Distance to nearest oil and gas well	Colorado Oil and Gas Conservation Commission
	Distance to nearest sand / gravel mine	Colorado Division of Mine Safety (
	Distance to nearest mine (non-sand / gravel)	
	Distance to nearest groundwater well	Colorado Division of Water Resources
	Distance to nearest major road	U.S. Census Bureau TIGER/Line
	Distance to nearest primitive road	
	Distance to nearest stream	USGS National Hydrography Dataset
	Density of groundwater wells in surrounding catchment	The Nature Conservancy Freshwater Measures Database
	Density of road miles in surrounding catchment	
	Density of dams and diversion per upstream stream mile	
Percent of 500 m envelope in various land cover categories	Closed tree canopy	LandFire Current Vegetation
	Open tree canopy	
	Shrubland	
	Dwarf shrubland	
	Herbaceous vegetation	
	Snow	
	Water	
	Agriculture	
	Developed land	
Attributes of wetland complex	Size of wetland complex	NWI Data and Irrigated Lands from Colorado Decision Support System
	Percent of wetland complex mapped as irrigated	
	Percent of wetland complex mapped as non-irrigated	

3.6 Evaluation of Waterfowl Habitat

In the absence of more specific information, general wetland condition can be viewed as a proxy for habitat quality. However, to accurately evaluate habitat for specific wildlife species or guilds, separate metrics must be identified. For the North Platte River Basin project, CPW wildlife biologists conducted two analyses to identify metrics for evaluating waterfowl habitat quality.

1. Literature on the specific wetland habitat needs of dabbling ducks was reviewed to determine key habitat features that can be easily and repeatedly measured in the field (i.e.,

hydrological regime, water depth, plant associations, open water interspersion, proximity of upland types, food sources, etc.).

2. Specific habitat requirements of waterfowl were investigated in the field to determine how hydrologic regime and vegetation structure influence waterfowl populations. Field work combined hydrologic and vegetation measures with nest searching, marking of waterfowl with leg bands and nasal markers, and re-sighting of nasal-marked hens.

Both habitat analyses were carried out by CPW and fully documented as stand-alone products included in this report as Appendices. The literature review is included as Appendix G and the field-based study is included as Appendix H. Because these two studies happened concurrently with the main wetland condition assessment, metrics identified in these reports were not incorporated into the field form for the randomly sampled wetlands. In future years, the project team will conduct similar reviews of habitat requirements, but will identify habitat metrics in advance of field sampling. This will allow us to estimate habitat quantity and quality for specific wildlife species in addition to estimates of general wetland condition.

4.0 RESULTS

4.1 Wetland Profile and Landscape Integrity Model

4.1.1 Wetland Profile of the North Platte River Basin

The North Platte River Basin covers 1,289,532 acres of north central Colorado. Based on digital NWI mapping, there are 138,043 acres of wetlands and water bodies within the basin, representing approximately 11% of the total land area (Figure 9; Table 9). It is important to note that NWI mapping includes deep water bodies, such as lakes and river channels, that are important aquatic resources but are not considered true wetlands. In the North Platte, lakes and rivers comprise only 6,402 acres or 5% of the total NWI acres. The majority (73%) of the NWI mapped acres are Palustrine Emergent or freshwater herbaceous wetlands. When lakes and rivers are excluded, herbaceous wetlands make up 77% of wetland acres. Shrub wetlands are the second most common class, making up 19% of all NWI acres and 20% of wetland acres.

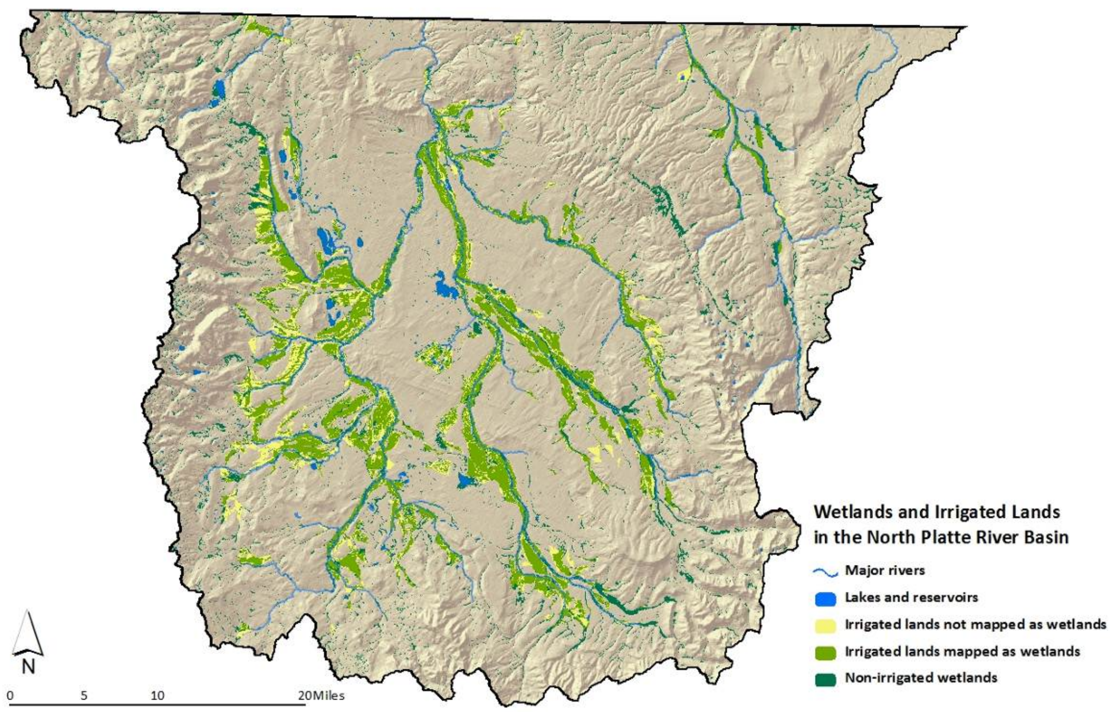


Figure 9. Digital NWI mapping in the North Platte River Basin, including extent of irrigated lands. Lighter green polygons represent lands mapped as both wetlands and irrigated. Darker green polygons represent lands mapped only as wetlands.

When broken down by hydrologic regime, temporarily and seasonally flooded wetlands are the most common, comprising 43% and 39% of wetland acres, respectively (Table 10). These hydrologic regimes represent wetlands that are wet for a few weeks to a few months each year, but are typically dry by the end of the growing season. Saturated wetlands, which maintain high groundwater tables throughout the growing season, make up 15% of wetland acreage. Wetter hydrologic regimes of semi-permanently flooded and intermittently exposed account for few acres of wetlands, comparatively (2% and 1%, respectively). The permanently flooded regime is used exclusively for lakes and rivers.

Table 9. Wetland acreage in the North Platte River Basin by NWI system / class.

NWI Code	NWI System / Class	Wetland Type (Common Name)	All NWI Acres	% Wetlands & Waterbodies	% Wetlands (excl. Lakes & Rivers)
L1/2	Lacustrine	Lakes	5,046	4%	NA
R2/3/4	Riverine	Rivers/Streams/Canals	1,355	1%	NA
PUB/US	Palustrine Unconsolidated Bottom/Shore	Unvegetated Ponds/Shores	991	1%	1%
PAB	Palustrine Aquatic Bed	Vegetated Ponds	3,321	2%	3%
PEM	Palustrine Emergent	Herbaceous Wetlands	100,880	73%	77%
PSS	Palustrine Scrub-Shrub	Shrub Wetlands	26,171	19%	20%
PFO	Palustrine Forested	Forested Wetlands	280	< 1%	< 1%
Total Wetlands & Waterbodies			138,043	100%	NA
Total Wetlands (excl. Lakes & Rivers)			131,642	NA	100%

Table 10. Wetland acreage in the North Platte River Basin by NWI hydrologic regime.

NWI Code	NWI Hydrologic Regime	All NWI Acres	% Wetlands & Waterbodies	% Wetlands (excl. Lakes & Rivers)
A	Temporarily Flooded	56,441	41%	43%
B	Saturated	19,801	14%	15%
C	Seasonally Flooded	51,653	37%	39%
F	Semipermanently Flooded	4,369	3%	2%
G	Intermittently Exposed	2,314	2%	1%
H	Permanently Flooded	3,458	3%	-
K*	Artificially Flooded	8	>1%	>1%
Total Wetlands & Waterbodies		138,043	100%	NA
Total Wetlands (excl. Lakes & Rivers)		131,642	NA	100%

* "Artificially Flooded" is more commonly treated as a modifier in the North Platte Basin. Only acres without an additional hydrologic regime code are included in this table. See Table 11 for additional acres with the Artificially Flooded modifier.

The NWI classification includes several modifiers that describe aspects of human and natural alteration. Four human-induced modifiers were mapped in the North Platte River basin (excavated, dammed/impounded, ditch/drained, and artificially flooded) and one natural modifier (beaver influenced). The vast majority of acres were not mapped with a modifier (90% of all NWI acres and 92% of wetland acres: Table 11). For certain wetland classes, however, there are exceptions. Within the basin, 65% of all lakes are mapped with a dammed/impounded modifier, indicating that many lakes are reservoirs of one kind or another. Some are entirely created while others are natural lakes

Table 11. Wetland acreage in the North Platte River Basin by NWI modifier and extent irrigated. All NWI acres shown, with totals for wetlands only in the last row. For NWI codes associated with each wetland type, see Table 9.

Wetland Type	No modifier		Excavated		Dammed / Impounded		Ditched / Drained		Artificially Flooded		Beaver Influenced		Irrigated Wetlands[1]		
	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	% of Irrigated Wetlands
Lakes	1,789	35%	-	-	3,258	65%	-	-	-	-	-	-	12	< 1%	< 1%
Rivers/Streams/ Canals	1,189	88%	162	12%	-	-	-	-	4	< 1%	-	-	122	9%	< 1%
Ponds/Shores	792	80%	49	5%	144	15%	7	1%	-	-	-	-	43	4%	< 1%
Vegetated Ponds	1,768	53%	8	< 1%	744	22%	-	-	-	-	801	24%	178	5%	< 1%
Herbaceous Wetlands	96,473	96%	136	< 1%	212	< 1%	1	< 1%	3,665	4%	392	< 1%	75,286	75%	96%
Shrub Wetlands	22,368	85%	11	< 1%	13	< 1%	28	< 1%	-	-	3,752	14%	2,609	10%	3%
Forested Wetlands	268	96%	1	< 1%	1	< 1%	-	-	-	-	9	3%	20	7%	< 1%
Wetlands & Waterbodies	124,646	90%	367	< 1%	4,372	3%	35	< 1%	3,669	3%	4,954	4%	78,270	57%	100%
Wetlands (excl. Lakes & Rivers)	121,669	92%	204	< 1%	1,114	1%	35	< 1%	3,665	3%	4,954	4%	78,137	59%	

[1] Irrigated lands data from the Colorado Decision Support System (CDSS 2009).

that have been modified to increase water holding capacity. Twelve percent of riverine features are mapped as excavated. These represent ditches and canal for moving water across the basin. Twenty-two percent of vegetated ponds and 15% of unvegetated ponds are mapped as impounded. These represent stock ponds, stormwater retention ponds, and other modified or created small ponds. Beavers influence only 4% of all wetland acres, but 24% of vegetated ponds are mapped as beaver ponds and 14% of shrub wetlands are mapped with beaver influence.

Another important aspect of human modification to wetlands is the degree to which they are affected by irrigation. Some wetland acres have developed on historic uplands due to long term flood irrigation practices that maintain higher water tables than the natural hydrologic regime. Other irrigation-influenced wetlands are historically natural, but are augmented by irrigation flows. It is very difficult to tease apart the differences between these two classes of irrigation influenced wetlands, but it is possible to estimate the extent of all wetlands affected by irrigation to one degree or another. By overlaying the GIS layer of irrigated acres produced by the Colorado Decision Support System (CDSS 2009) with the NWI wetland acres, it is possible to estimate the proportion of wetlands that are influenced by irrigation (Figure 9). Within the basin as a whole, 59% of wetland acres are irrigated and these acres are overwhelmingly (96%) freshwater herbaceous wetlands (Table 11). Among all herbaceous wetlands, 75% are irrigated. In many cases, these irrigated wetlands are actively managed as hayfields and harvested during most years, but they still provide important services such as groundwater recharge and wildlife habitat. The NWI modifier of artificially flooded is used in the North Platte basin for some of these irrigated wetlands (4% of herbaceous wetlands and 3% of all wetlands). However, the use of this modifier has changed over time within the NWI mapping standards, is not consistently applied to all irrigated acres, and is not as reliable as the CDSS irrigated lands data.

When broken down by major landowner, 73% of wetland acres are privately owned (Table 12). Private landowners hold a relatively greater share of wetland acres than they do of total area within the basin (33%). This is largely because the density of wetland acres is greater within the central North Park valley, where private landownership is concentrated, than in the publically owned mountain areas. Private landowners in North Park are more likely to be irrigating hay pastures, which can increase wetland acreage. Over 70% of privately owned wetland acres are irrigated, making up 91% of the total irrigated wetland acreage.

The Medicine Bow-Routt National Forest (MBRNF) owns the second highest share of wetland acres (10%), though they own 26% of the total basin land area. Less than 1% of wetland acres on the MBRNF are irrigated. The Arapaho-Roosevelt National Forest (ARNF), U.S. Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), and Colorado State Land Board (SLB) each own between 3–5% of wetland acres, while CPW owns the remaining 1%. Wetland acres owned by USFWS are located on the Arapaho National Wildlife Refuge, which is a highly productive feeding and breeding area for waterfowl. Seventy-two percent of USFWS wetland acres are irrigated, making up the only other notable share of irrigated acres (7% of all irrigated wetland acres). For the USFWS, irrigation is used to manage water levels for optimum plant growth to provide nesting cover and feeding areas for waterfowl. Thirteen percent of BLM wetlands and 17% of SLB wetlands are irrigated, likely for hay production or to improve grazing. While BLM lands within the North Platte basin are mainly located in the lower elevation valleys, SLB lands are split between lower elevation parcels leased for grazing and higher elevation land on the western flank of the Medicine Bows within State Forest State Park. Wetland acreage by agency and specific management unit is presented in Appendix I.

Table 12. Wetland acreage in the North Platte River Basin by grouped land owner and extent irrigated.

Grouped Owner[1]	Total Land Area within Basin		Total NWI Acres within Basin		Irrigated Wetlands		
	Acres	% of Basin	Acres	% of NWI Acres	Acres	% Irrigated	% of Irrigated Wetlands
Federal Lands							
Medicine Bow-Routt National Forest	331,928	26%	14,213	10%	65	< 1%	< 1%
Arapaho-Roosevelt National Forest	166,192	13%	6,515	5%	15	< 1%	< 1%
Bureau of Land Management	213,891	17%	4,873	4%	657	13%	1%
U.S. Fish and Wildlife Service	23,340	2%	7,473	5%	5,380	72%	7%
National Park Service	24	< 1%	-	-	-	-	-
State Lands							
State Land Board	128,542	10%	3,465	3%	593	17%	1%
Colorado Parks and Wildlife	3,488	< 1%	1,267	1%	66	5%	< 1%
Other							
Private	422,122	33%	100,236	73%	71,494	71%	91%
County	5	< 1%	-	-	-	-	-
Total	**1,289,532**	**100%**	**138,043**	**100%**	**78,270**	**57%**	**100%**

[1] Many properties in the basin are owned by one agency but managed by another agency through inter-agency agreements or are owned by private land owners but managed by an agency through easements. Therefore, the numbers of acres owned by a given agency is different than the number of acres managed by that agency. For the purpose of this report, acres are reported by land owner, except in Appendix I, where they are presented by management unit.

To understand the spatial distribution of wetlands across the basin, wetland area was summarized by ecoregion and wetland type (Table 13; Figure 10), NWI hydrologic regime (Table 14), and grouped land owner (Table 15). From these summaries, 69% of all NWI mapped acres occur in the Sagebrush Parks ecoregion, which is essentially the North Park valley. This is far greater than the 37% of the basin land area that ecoregion occupies. Of the Sagebrush Parks wetland acres, 86% are herbaceous (Table 13), and these herbaceous Sagebrush Parks wetlands make up 59% of all NWI mapped acres across the entire basin (data not shown). No other single ecoregion/wetland type combination comprises more than 6% of all NWI acres. In addition to herbaceous wetlands, there are extensive riparian shrublands throughout the basin, and these shrublands occupy a greater proportion of total wetland area per ecoregion as elevation increases, peaking in the subalpine zones (Table 13).

Table 13. Wetland acreage in the North Platte River Basin by ecoregion and NWI system / class. See Table 9 for explanation of NWI codes.

Level III / IV Ecoregion	Total Land Area within Basin		Total NWI Acres within Basin		Percent of Wetlands within each Ecoregion by NWI System / Class						
	Acres	%	Acres	%	L1/L2	R2/3/4	PUB/US	PAB	PEM	PSS	PFO
18: Wyoming Basin	**72,109**	**6%**	**5,538**	**4%**	**1%**	**1%**	**1%**	**< 1%**	**70%**	**26%**	**< 1%**
18f: Laramie Basin	72,109	6%	5,538	4%	1%	1%	1%	< 1%	70%	26%	< 1%
21: Southern Rockies	**1,217,423**	**94%**	**132,505**	**96%**	**4%**	**1%**	**1%**	**2%**	**73%**	**19%**	**< 1%**
21a: Alpine Zone	67,306	5%	1,544	1%	19%	2%	5%	3%	38%	34%	-
21b: Cryst Subalpine Forests	271,907	21%	11,334	8%	8%	2%	2%	6%	36%	45%	1%
21c: Cryst Mid-Elev Forests	125,329	10%	5,178	4%	-	3%	1%	4%	27%	64%	1%
21d: Foothill Shrublands	12,483	1%	398	< 1%	-	11%	4%	6%	65%	13%	< 1%
21e: Sed Subalpine Forests	118,343	9%	3,657	3%	1%	2%	1%	6%	9%	81%	1%
21f: Sedi Mid-Elev Forests	139,341	11%	15,547	11%	2%	< 1%	< 1%	5%	55%	37%	1%
21g: Volc Subalpine Forests	10,899	1%	235	< 1%%	-	2%	-	22%	22%	54%	-
21i: Sagebrush Parks	471,815	37%	94,613	69%	4%	1%	1%	1%	86%	7%	< 1%

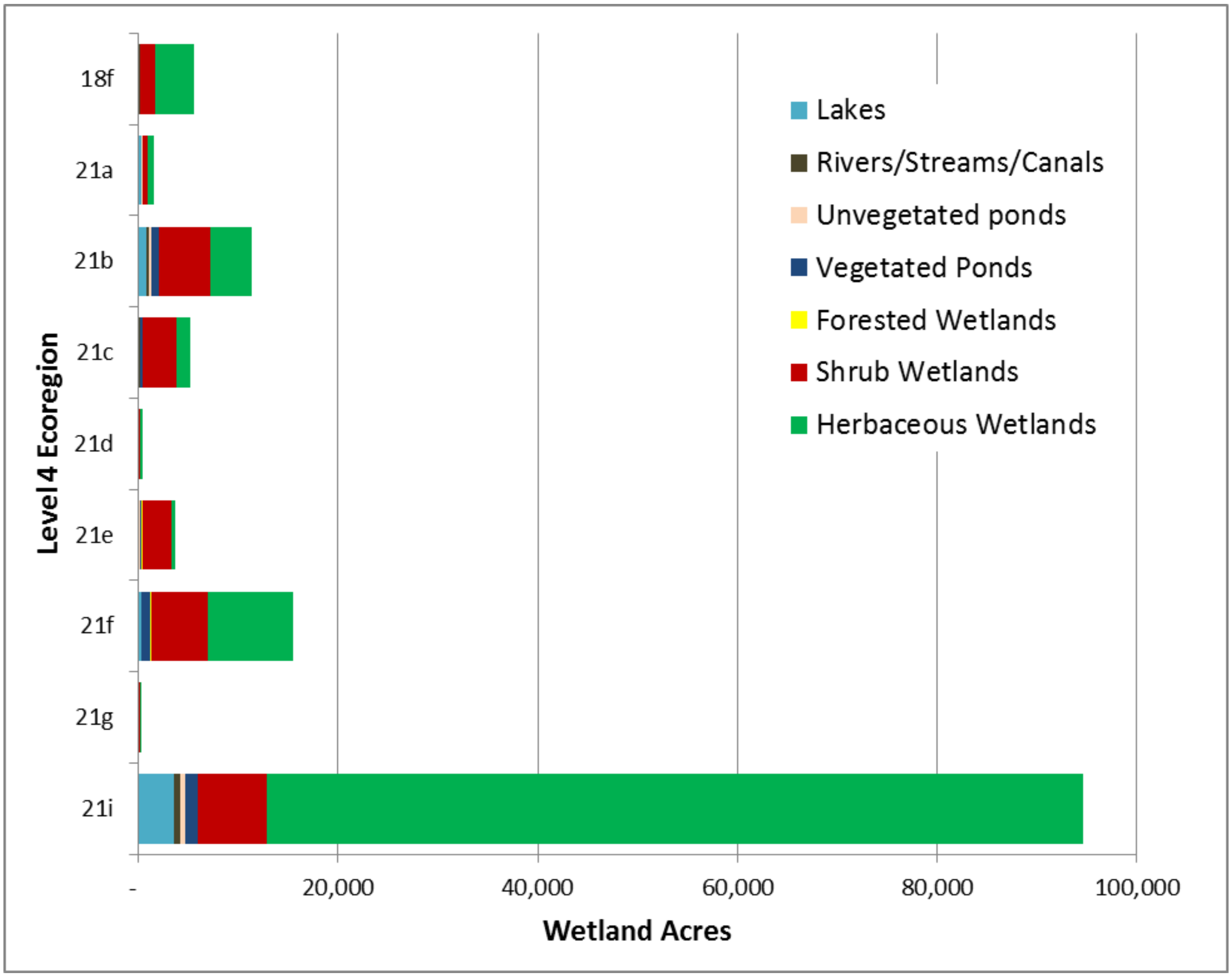


Figure 10. Wetland acreage in the North Platte River Basin by ecoregion and NWI system / class.

The majority of wetland acres at lower elevations are mapped as temporarily or seasonally flooded (Table 14). The saturated hydrologic regime becomes more common with increasing elevation, however, and represents 68% and 73% of all acres in the two subalpine zones. Irrigation is most prevalent in the Sagebrush, where 72% of all acres are irrigated. Irrigation is also common in the Laramie Basin, the Foothill Shrublands, and the two mid-elevation zones. Beaver influence is highest in the mid-elevation and subalpine zones, but represents <1% of acres in both the alpine zone and the Sagebrush Parks.

Land ownership shows distinct patterns as well (Table 15). Wetlands in the lower elevations are primarily private owned, though USFWS, BLM, SLB, and CPW own some acreage. The highest elevation wetlands are owned almost exclusively by the U.S. Forest Service, either within MBRNF or ARNF. The SLB owns wetlands in all but one ecoregion in the basin, and in particular, 19% of wetland acres in Sedimentary Subalpine Forests are located on SLB land within State Forest State Park.

Table 14. Wetland acreage in the North Platte River Basin by ecoregion and NWI hydrologic regime. "Human altered" includes all human influenced NWI modifiers. See Table 11 for more detail on human alteration.

Level III / IV Ecoregion	Wetland Acres	Percent of Wetlands within each Ecoregion by NWI Hydrologic Regime							Beaver Altered	Human Altered	Irrigated
		A: Temp Flooded	B: Saturated	C: Season-ally Flooded	F: Semi-permanent Flooded	G: Inter-mittently Exposed	H: Perm Flooded	K: Artificially Flooded			
18: Wyoming Basin	**5,538**	**3%**	**1%**	**93%**	**1%**	**1%**	**1%**	**-**	**1%**	**63%**	**47%**
18f: Laramie Basin	5,538	3%	1%	93%	1%	1%	1%	-	1%	63%	47%
21: Southern Rockies	**132,505**	**42%**	**15%**	**35%**	**3%**	**2%**	**3%**	**< 1%**	**4%**	**4%**	**57%**
21a: Alpine Zone	1,544	-	58%	14%	5%	20%	3%	-	< 1%	-	-
21b: Cryst Subalpine Forests	11,334	3%	73%	7%	5%	5%	7%	-	7%	5%	-
21c: Cryst Mid-Elev Forests	5,178	20%	26%	47%	1%	4%	2%	-	17%	5%	22%
21d: Foothill Shrublands	398	29%	6%	50%	6%	< 1%	9%	-	0%	5%	23%
21e: Sed Subalpine Forests	3,657	9%	47%	34%	4%	6%	< 1%	-	15%	1%	1%
21f: Sedi Mid-Elev Forests	15,547	21%	24%	47%	4%	2%	2%	-	14%	3%	39%
21g: Volc Subalpine Forests	235	6%	68%	1%	16%	6%	2%	-	41%	1%	-
21i: Sagebrush Parks	94,613	54%	4%	36%	3%	1%	2%	< 1%	< 1%	4%	72%

Table 15. Wetland acreage in the North Platte River Basin by ecoregion, grouped land owner and extent irrigated.

Level III / IV Ecoregion	Wetland Acres	Percent Wetlands within each Ecoregion by Grouped Land Owners						
		MBRNF	ARNF	BLM	USFWS	SLB	CPW	PRIVATE
18: Wyoming Basin	**5,538**	**-**	**< 1%**	**4%**	**-**	**2%**	**-**	**94%**
18f: Laramie Basin	5,538	-	< 1%	4%	-	2%	-	94%
21: Southern Rockies	**132,505**	**11%**	**5%**	**4%**	**6%**	**3%**	**1%**	**72%**
21a: Alpine Zone	1,544	60%	32%	-	-	9%	-	< 1%
21b: Cryst Subalpine Forests	11,334	54%	43%	1%	-	2%	-	1%
21c: Cryst Mid-Elev Forests	5,178	21%	23%	5%	-	1%	-	51%
21d: Foothill Shrublands	398	13%	-	6%	-	< 1%	-	81%
21e: Sed Subalpine Forests	3,657	71%	-	< 1%	-	19%	-	9%
21f: Sedi Mid-Elev Forests	15,547	20%	-	1%	< 1%	4%	-	76%
21g: Volc Subalpine Forests	235	100%	-	-	-	-	-	-
21i: Sagebrush Parks	94,613	< 1%	-	4%	8%	2%	1%	84%

For the purpose of understanding the quantity of habitat available to dabbling ducks in the basin, nine important habitat types were identified by CPW wildlife biologists (see Appendix G for details on the identification of habitat types). A crosswalk between the habitat types and NWI codes was developed, allowing for all mapped wetlands to be summarized by these habitat types (Table 16). The most common habitat type identified in the basin is irrigated hay meadows, making up 53% of all NWI acres. This is slightly lower than all NWI acres mapped as irrigated (57%) because it does not include irrigated shrublands along the margins of hay meadows. After irrigated hay meadows, seasonal emergent wetlands and riparian areas without beaver influence both comprise 13% of all NWI acres. Beaver ponds and other beaver influenced wetlands make up another 4% of all NWI acres, as do lakes and reservoirs. All other habitat types identified as important for dabbling ducks make up 1% or < 1% of all NWI acres.

Table 16. Wetland acreage in the North Platte River Basin by habitat types considered important and less important for dabbling ducks.

Important Habitat Types	NWI Codes	Acres	% of NWI Acres
Seasonal emergent wetlands	All acres with the following codes that are not mapped as irrigated lands: PEMA, PEMAd, PEMAh, PEMAx, PEMC, PEMCh, PEMCx, PEMKC	17,926	13%
Semi-permanent emergent wetlands	PEMF, PEMFh, PEMFx	557	< 1%
Irrigated hay meadows	All acres with the following codes that are mapped as irrigated lands: PEMA, PEMB, PEMC, and PEMKC	74,968	54%
Riparian areas (shrublands, not beaver influenced)	PSSA, PSSAh, PSSAx, PSSB (mid and low elevations), PSSBd (mid and low elevations), PSSC, PSSCh,	17,323	13%
Beaver ponds (including beaver influenced shrublands)	PABFb, PABGb, PEMBb, PFOBb, PSSBb	4,954	4%
Kettle ponds (may also include aquatic bed wetlands at lower elevations)	PABF, PABG	1,768	1%
Stock ponds	PABFh, PABGh, PABFx, PABKx	752	1%
Lakes and reservoirs (including shores)	All Lacustrine system codes	5,046	4%
Perennial rivers and streams	All R2 and R3 codes	1,056	1%
Subtotal		**124,350**	**90%**
Less Important Habitat Types	**NWI Codes**	**Acres**	**% of NWI Acres**
Intermittent streams and irrigation canals	All R4 codes	299	< 1%
Unvegetated ponds and shores	All PUB and PUS codes	991	1%
Forested riparian areas and wetlands	PFOA, PFOAh, PFOAx, PFOB (mid and low elevations)	159	< 1%
High elevation saturated wetlands (likely fens)	PEMB, PFOB, PSSB, PSSBd (all from alpine and subalpine zones)	9,790	7%
Low elevation saturated wetlands (possibly fens)	PEMB (mid and low elevations, not mapped as irrigated lands)	2,453	2%
Subtotal		**13,692**	**10%**
Grand Total		138,043	100%

4.1.2 Wetland Landscape Integrity Model

Results from the Level 1 Landscape Integrity Model (LIM) for the North Platte basin show that although only 10% of total basin area falls within the severe stress category, this number is much higher for wetlands themselves (Table 17; Figure 11). Across the basin, 27% of all wetland acres fall within the severe stress category and an additional 50% fall within the high stress category. This is largely due to the distribution of wetland acres, which are more concentrated on the valley floor and therefore affected by roads and development, agriculture, and hydrologic modification (Figure 12).

Certain wetland types are more affected by modeled stressors than others (Table 18). Herbaceous wetlands, which account for the largest share of all wetlands, fall within higher stress classes. Forested wetlands, more common at higher elevations, fall within less stressed classes. Modeled stress on wetlands also shows strong patterns related to land ownership (Table 19). Wetlands managed by USFS are the least stressed across the basin, with 54% (MBRNF) and 74% (ARNF) of acres falling within the no or low stress classes. In comparison, > 50% of private wetland acres and wetlands owned by USFWS, BLM, and SLB fall within the high or severe stress classes.

Table 17. Wetland LIM stressor class for wetlands by ecoregion. Percentages are given for NWI mapped acres in all cases except the bottom row, which shows stressor classes for all area within the basin.

Level III / IV Ecoregion	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
18: Wyoming Basin	**-**	**3%**	**6%**	**61%**	**30%**
18f: Laramie Basin	-	3%	6%	61%	30%
21: Southern Rockies	**4%**	**7%**	**12%**	**50%**	**27%**
21a: Alpine Zone	54%	41%	4%	1%	-
21b: Cryst Subalpine Forests	32%	44%	13%	9%	2%
21c: Cryst Mid-Elev Forests	2%	10%	18%	39%	32%
21d: Foothill Shrublands	-	2%	4%	41%	54%
21e: Sed Subalpine Forests	5%	40%	28%	21%	7%
21f: Sedi Mid-Elev Forests	< 1%	5%	12%	52%	31%
21g: Volc Subalpine Forests	5%	63%	23%	9%	< 1%
21i: Sagebrush Parks	< 1%	1%	11%	58%	30%
All Wetlands & Waterbodies	4%	7%	12%	50%	27%
Entire Basin	13%	35%	20%	22%	10%

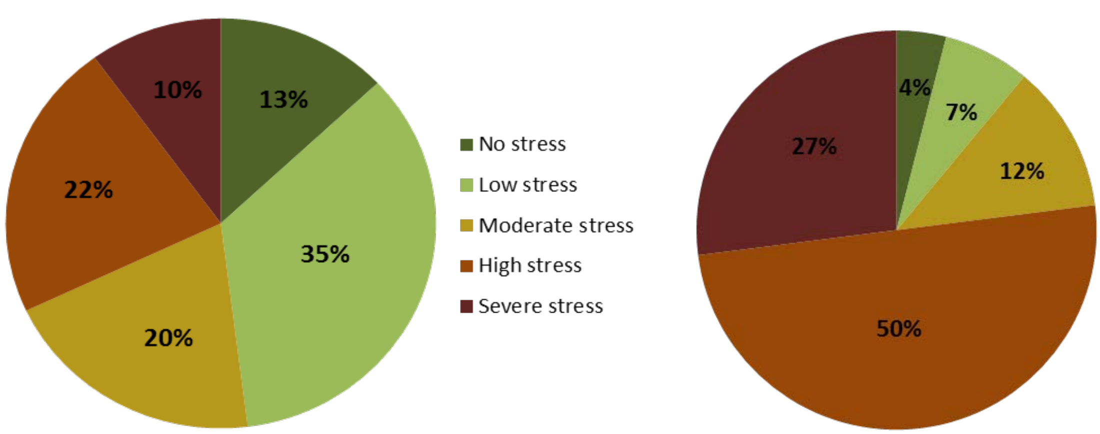


Figure 11. Comparison of Wetland LIM stressor classes for the entire North Platte River Basin (left) and all NWI acres within the basin (right).

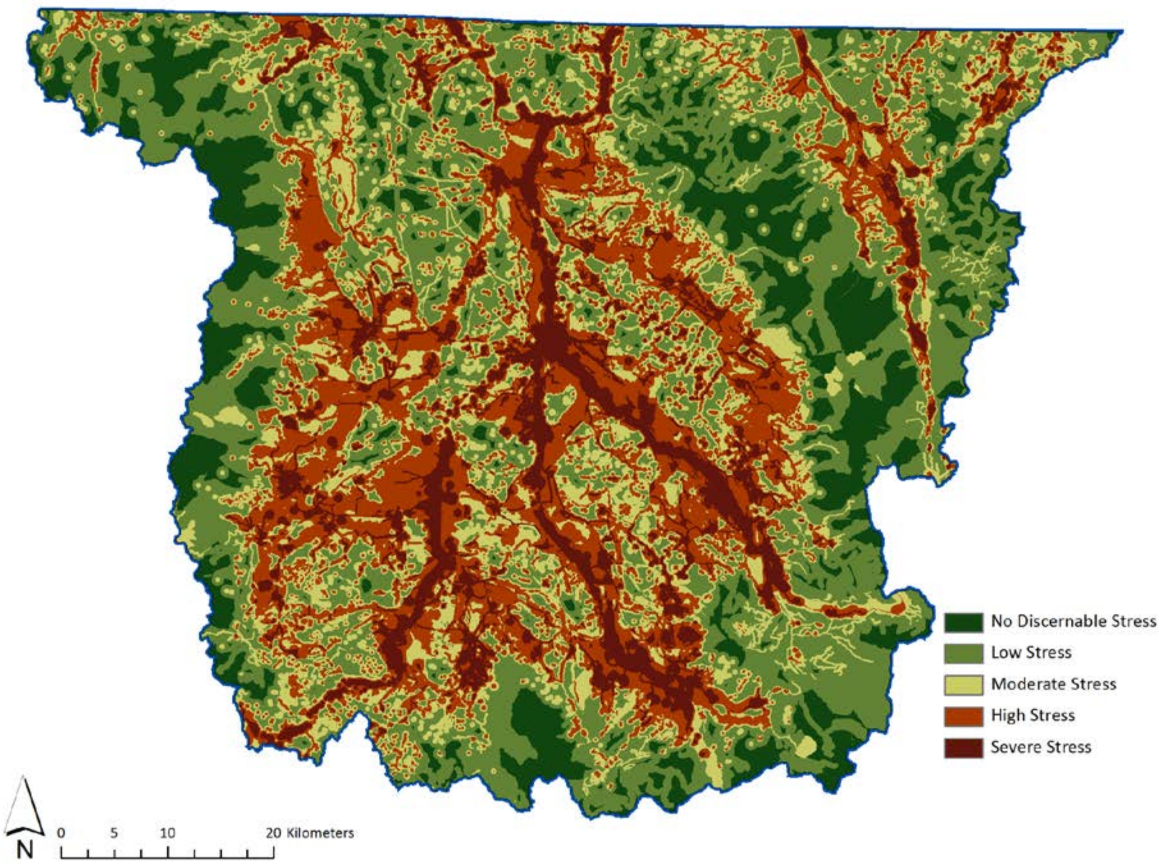


Figure 12. Map of Wetland LIM stressor classes across the North Platte River Basin.

Table 18. Wetland LIM stressor class for wetlands by major wetland type. Percentages are given for NWI mapped acres in all cases except the bottom row, which shows stressor classes for all area within the basin.

Wetland Type	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
Lakes	4%	35%	31%	21%	8%
Rivers	5%	17%	11%	44%	23%
Ponds/Shores	6%	16%	21%	33%	24%
Vegetated Ponds	6%	23%	20%	35%	16%
Herbaceous Wetlands	2%	2%	10%	57%	29%
Shrub Wetlands	9%	18%	14%	36%	23%
Forested Wetlands	14%	38%	14%	16%	19%
All Wetlands & Waterbodies	4%	7%	12%	50%	27%
All Land Area within the Basin	13%	35%	20%	22%	10%

Table 19. Wetland LIM stressor class for wetlands by major landowner. Percentages are given for NWI mapped acres in all cases except the bottom row, which shows stressor classes for all area within the basin.

Grouped Owner	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
Federal Lands					
Medicine Bow-Routt National Forest	16%	38%	19%	23%	4%
Arapaho-Roosevelt National Forest	38%	36%	14%	7%	5%
Bureau of Land Management	1%	15%	31%	39%	15%
U.S. Fish and Wildlife Service	-	< 1%	9%	65%	27%
State Lands					
State Land Board	4%	13%	21%	43%	19%
Colorado Parks and Wildlife	-	30%	29%	25%	16%
Other					
Private	< 1%	< 1%	10%	57%	32%
All Wetlands & Waterbodies	4%	7%	12%	50%	27%
Entire Basin	13%	35%	20%	22%	10%

4.2 Sampled Wetlands

4.2.1 Implementation of the Survey Design

During the summer of 2010, 95 wetland sites were surveyed for Level 2 & 3 assessments (Figure 13), nearly achieving our goal of 100 target sites. Eighty-two of these sites were sampled using the original study design (Section 3.2), and ten of the remaining sites were selected from the randomized sample pool but did not retain the sampling order due to time constraints. Instead of following the ordered sampling list and contacting all landowners, these ten sites were selected because they were located on land where access had previously been granted. This process created skipped points in the survey design and therefore the ten points could not be used when calculating overall basin estimates based on the survey design (Section 4.5). They could be used, however, in characterizing wetland vegetation (Section 4.3), summarizing Floristic Quality Assessment metrics (Section 4.4), and modeling condition across the basin (Section 4.7), as those analyses did not rely on survey design parameters. The last three additional sites sampled were on land mapped as both wetlands and irrigated, but were located on the Arapaho National Wildlife Refuge and managed for wildlife habitat, not hay production.

The success rate of accessing and sampling wetlands varied by ecoregional strata (Table 20; Table 21). We were most successful in sampling the 21b/g: Crystalline and Volcanic Subalpine stratum, where only one point evaluated was rejected due to size. In all other ecoregions, at least two wetlands were rejected from the initial sample pool either because access was not granted or because they did not meet our study design requirements. The two montane valley ecoregions (21i: Sagebrush Parks and 18f: Laramie Basin) and 21d/f: Sedimentary Mid-Elevation Forest / Foothills

Shrubland presented the most difficulty in obtaining access and finding sites within the target population. In the Sagebrush Parks, numerous potential points were not evaluated but skipped in order to maximize points sampled from this ecoregion once time was limited at the end of the season.

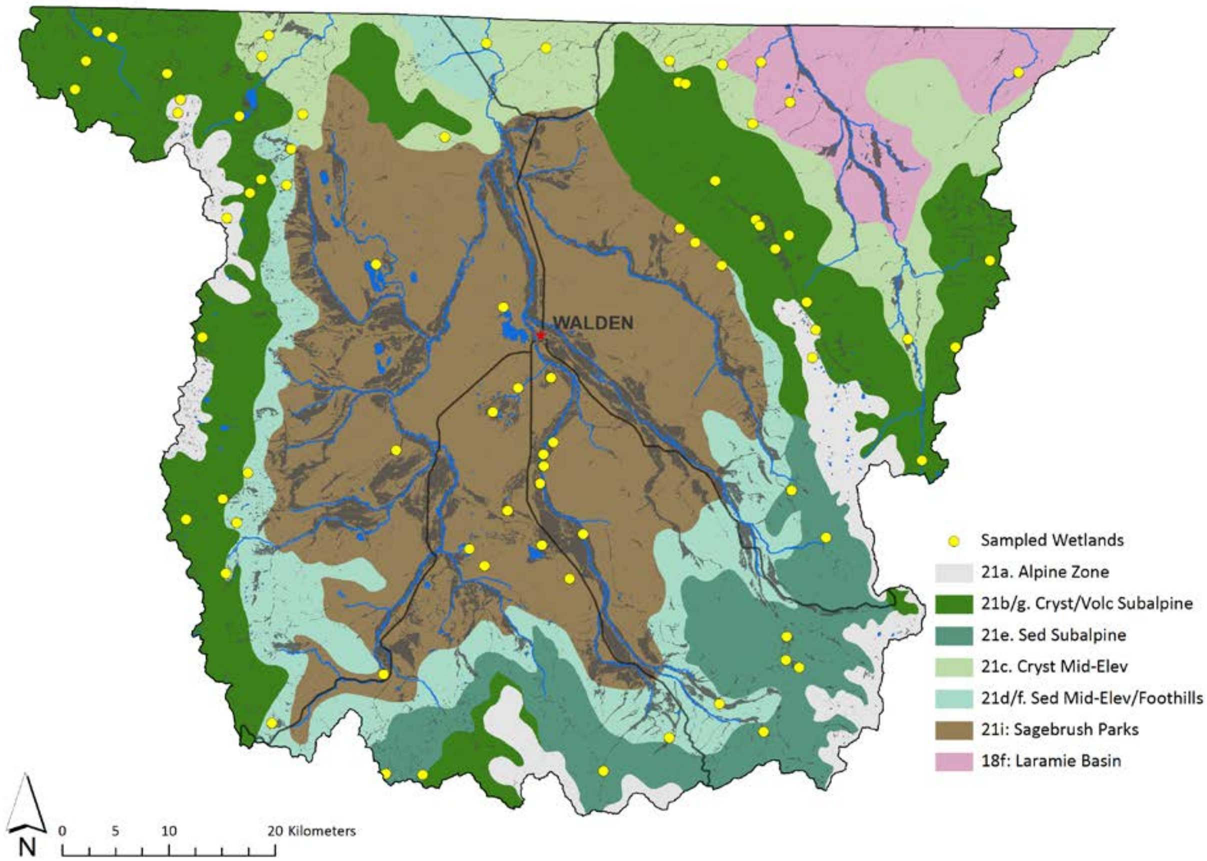


Figure 13. Randomly selected wetlands sampled in the North Platte River Basin. Seventeen points on private lands not shown.

Aside from no access, there were several reasons for dropping non-target points, as listed below:

1) Size – the wetland at the point did not meet the minimum area or width criteria.
2) Irrigated/hayed – the point was not mapped in GIS as irrigated, but evaluation of aerial photography indicated the site was likely under hay production because it showed a uniform green color signature or presence of harvesting tracks.
3) Minimum distance – the point was positioned < 500 m from another point.
4) Access distance – the point was within the target population, but would take more than one day to navigate to and sample and was not located near other target sites OR the point was not clearly within the target population and would take one complete day to navigate to for

reconnaissance. We were able to sample remotely located points if more than one could be sampled in a multi-day backcountry trip.

5) Dry – through a desktop screening, the mapped wetland did not have an aerial photo color signature characteristic of a wetland (n=8) or upon field reconnaissance, the wetland did not meet any wetland criteria (n=5). Some of these 'dry wetlands' may have dried in recent years because of a change in local hydrology after the NWI original mapping in the 1980s. All dry 'wetlands' occurred in the Sagebrush Parks and Larimer Valley ecoregions, where anthropogenic land uses have likely been the most variable since the NWI mapping.

Table 20. Number of wetland points evaluated, skipped, and surveyed by ecoregional strata. See Table 4 for detail on ecoregional strata.

Ecoregional Strata	# Target Points in Study Design	# Points Evaluated	# Points Rejected (See Table 21 for details)	# Surveyed in Order	# Points Skipped	# Surveyed out of Order	# Points Surveyed
21a	5	8	3	5	-	-	**5**
21b/21g	22	23	1	22	-	-	**22**
21e	9	11	2	9	-	-	**9**
21c	10	12	2	10	-	-	**10**
21d/21f	12	19	11	8	9	4	**12**
21i	36	87	64	23	178	6	**29**
18f	6	27	22	5	-	-	**5**
21i (irrigated)	-	n/a			n/a	3	**3**
All Ecoregions	**100**	**187**	**105**	**82**	**187**	**13**	**95**

Table 21. Rejection cause for all points evaluated but not surveyed.

Ecoregional Strata	Rejected Cause		Further Detail on Non-Target Points				
	No Access	Non-Target	Size	Irrigated/ Hayed	Minimum Distance	Access Distance	Dry (desktop/field)
21a	-	3	-	-	-	3	-
21b/g	-	1	1	-	-	-	-
21c	1	1	-	1	-	-	-
21d/f	9	2	1	-	-	1	-
21e	-	2	2	-	-	-	-
21i	41	23	2	11	-	1	4/5
18f	15	7	1	1	1	-	4/0
All Ecoregions	**66**	**39**	**7**	**13**	**1**	**5**	**13**

Land ownership of the final surveyed points was skewed more heavily towards public ownership then the initial set of target point evaluated (Figure 14). The increased skew was due both to a higher share non-target points on private lands and to difficulty obtaining access. Of the 39 non-target points evaluated (Table 21), 23 were on private lands and 16 were on public lands. Of the 66 points evaluated where access was denied, three were on SLB lands leased by private citizens who denied access, two were on BLM lands surrounded by private landowners who denied access, and the remaining 61 were privately owned. In order to obtain access to survey the 18 privately owned or leased lands, 47 landowners or lessees were contacted, of which 13 granted access and 34 denied access. This is equivalent to a 27% success rate of obtaining access.

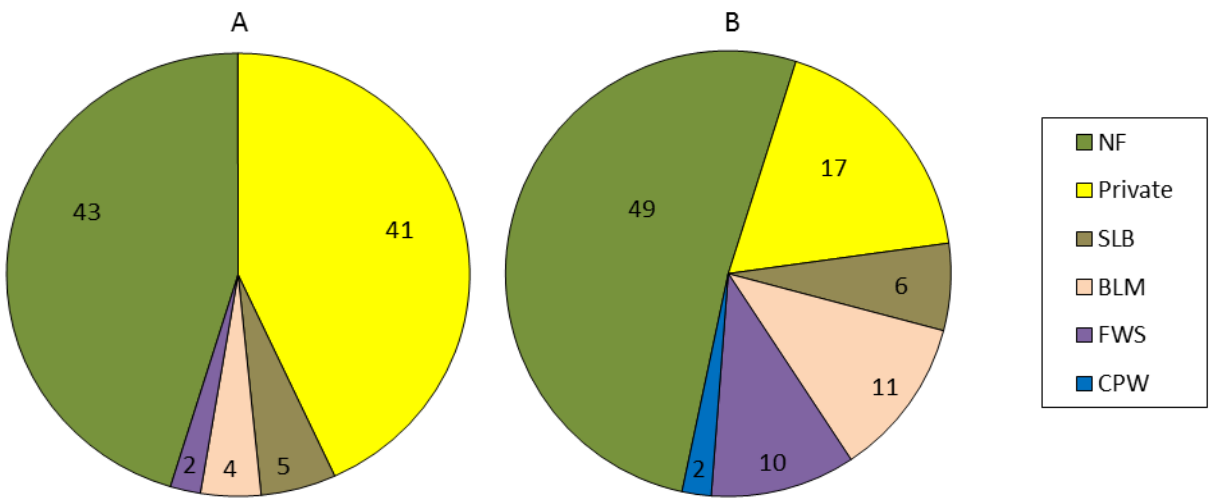


Figure 14. Comparison of land ownership distribution of the initial 95 target points evaluated (A), and the 95 wetland points actually sampled after non-target and access-denied points were dropped from design (B).

4.2.2 Evaluation of Areas Mapped as Uplands and Irrigated Wetlands

We used aerial photo interpretation in GIS to visually assess the accuracy of 1) areas mapped by both NWI and the irrigated lands layer (irrigated wetlands, our proxy for wetlands in active hay production) and 2) areas not mapped by NWI (uplands). Throughout the basin, 100 random points were assessed from each of these two regions. Of the 100 points mapped as irrigated wetlands, 76 contained indicators of hay production, such as a uniform saturated green color signatire or harvesting tracks. Out of the 24 that did not contain these indicators, five were located on Arapaho National Wildlife Refuge and were known to be managed for wildlife habitat, not hay production. The first three of these were sampled. Thirteen of the 24 showed clear evidence that the area was not hayed, such as the presence of shrubs too dense for haying equipment or very saturated soil that was likely too wet to hay. The remaining six points were managed by CPW and did appear irrigated, but it was unclear if they were actively hayed. In sum, analysis of random points from the intersection of irrigated lands and wetlands showed ~76% accuracy as a proxy for active hay crops. The remaining 24% of the area was either not hayed or it was unclear and the landowner would need to be contacted for more information. Of the 100 upland points examined, only four appeared to be wetland. This was roughly the same percentage of mapped wetland points that were determined to be too dry to sample through the desktop evaluation (8 out of 187 wetland points evaluated: Table 21).

4.2.3 Sampled Wetlands by Ecological System and HGM Class

Sampled wetlands represented a range of Ecological Systems, referred to as wetland types throughout this section. Riparian shrublands were the most common wetland type encountered with 46 sites and making up 48% of all sites surveyed (Table 22; Figure 15). Riparian shrublands were also the most broadly distributed type, occurring in all seven ecoregional strata. Riparian shrublands were generally willow *(Salix)* dominated, but species composition varied by elevation. High elevation shrublands were dominated by short plainleaf willow *(Salix planifolia)* and were often fed by snowmelt and groundwater discharge (Figure 16). In lower elevations of the Laramie Basin and Sagebrush Parks ecoregions, riparian shrublands were much taller, dominated by mountain willow *(Salix monticola)* and Geyer's willow *(Salix geyeriana),* and fed by overbank flooding and small irrigation ditches (Figure 17).

Table 22. Sampled wetlands by ecoregional strata and Ecological System.

Ecoregional Strata	Riparian Shrublands	Wet meadows	Fens	Freshwater Marshes	Riparian Woodlands	Alkaline Basin	Total
21a	2	-	3	-	-	-	5
21b/g	8	4	9	1	-	-	22
21e	6	-	-	1	2	-	9
21c	10	-	-	-	-	-	10
21d/f	8	2	1	1	-	-	12
21i	7	22	-	2	-	1	32
18f	5	-	-	-	-	-	5
Total	46	28	13	5	2	1	95
% of Sites	48%	29%	14%	5%	2%	1%	100%

Wet meadows were the second most common type with 28 sites surveyed. These wetlands occurred most commonly in the Sagebrush Parks ecoregion, though four were sampled in the subalpine zone. Wet meadows in the Sagebrush Parks ecoregion were most often dominated by meadow foxtail *(Alopecurus pratensis),* a non-native pasture grass, indicating that the meadows were either hay fields at one point in time or were seeded for grazing. Higher elevation meadows were more commonly dominated by sedge *(Carex)* species (Figure 18). Thirteen fens were surveyed, of which 12 were found in alpine or subalpine ecoregion groups and were dominated by a range of low sedge and willow species (Figure 19).

Freshwater marshes were found in several ecoregional strata; however, the plant communities and soils in marshes varied substantially with elevation. The two marshes in the Sagebrush Parks ecoregion were flooded mineral soil wetlands dominated by disturbance-tolerant species such as mountain rush (*Juncus arcticus*), tall sedge (*Carex*) and bulrush (*Scirpus / Schoenoplectus*) species, and species characteristic of saline environments. Both were adjacent to reservoirs (Figure 20). The three higher-elevation marshes had natural water sources, substantial organic soil layer, and floating vegetation (Figure 21). Two were kettle ponds that supported unique plant species indicative of high ecological integrity, and the third was a flooded sedge-dominated beaver pond.

Two riparian woodlands were sampled in the basin. These were similar to riparian shrublands, but contained a higher cover of tree species (Figure 22). In addition, one alkaline closed depression was sampled in the Sagebrush Park ecoregion (Figure 23).

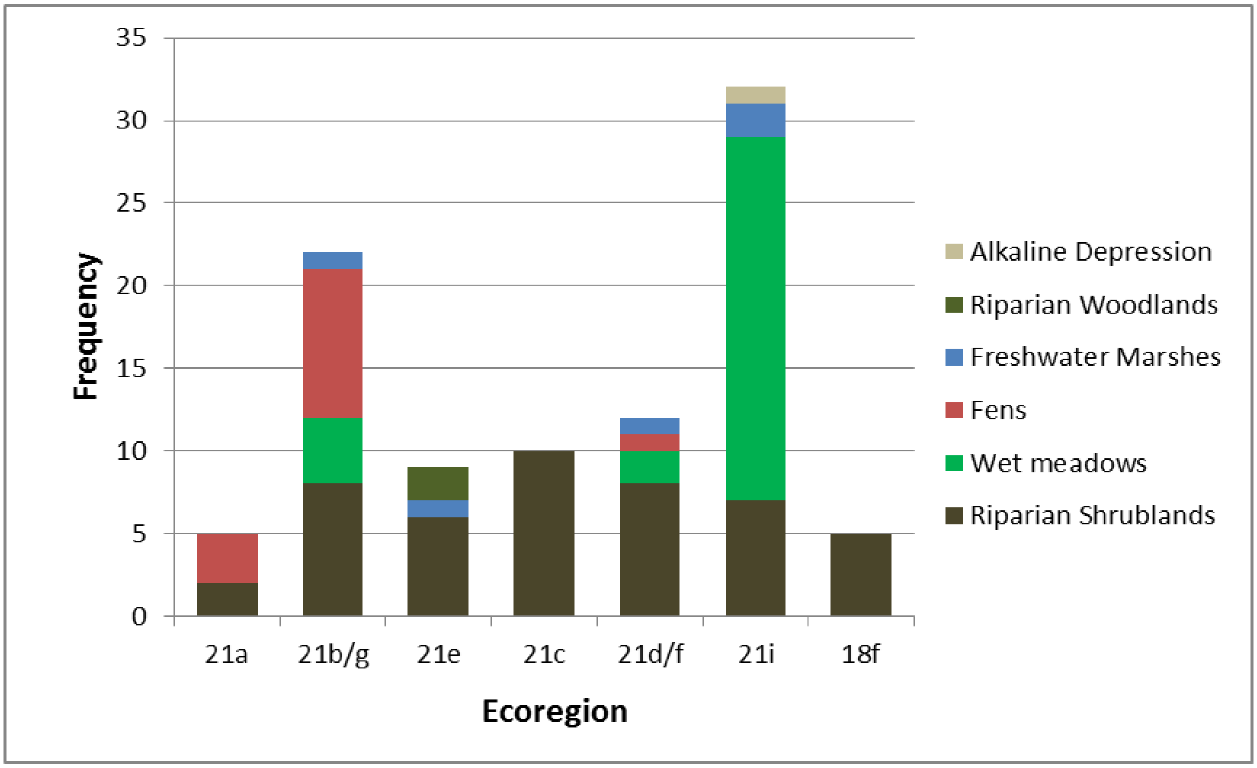


Figure 15. Sampled wetlands by ecoregional strata and Ecological System.

Figure 16. Photographs of high elevation riparian shrublands in the North Platte River Basin.

Figure 17. Photographs of low elevation riparian shrublands in the North Platte River Basin.

Figure 18. Photographs of wet meadow in the North Platte River Basin. A low elevation example (left) and a high elevation example (right).

Figure 19. Photographs of fens in the North Platte River Basin. Photograph of organic soil inset to right.

Figure 20. Photographs of low elevation marshes in the North Platte River Basin.

Figure 21. Photographs of high elevation marshes in the North Platte River Basin.

Figure 22. Photographs of riparian woodlands in the North Platte River Basin.

Figure 23. Photographs of the alkaline depression in the North Platte River Basin.

Along with the primary Ecological System classification, surveyed wetlands were also classified by the Hydrogeomorphic (HGM) system in the field. Though some terminology overlaps between the HGM and NWI classification systems (e.g. the words riverine and lacustrine are used in both systems), the meanings are different. As noted in previous tables, riverine acres mapped by NWI represent the actual rivers, streams, and canals themselves and lacustrine acres represent the actual lakes. In the HGM classification system, riverine wetlands are those wetlands influenced by rivers and streams, but not the rivers and streams themselves. The same is true for lacustrine wetlands in the HGM classification system. This HGM class represents wetlands on lake margins and influenced by the rise and fall of lake waters. In the North Platte Basin, riverine and slope HGM classes were the most common, with 49% and 43% of sites, respectively (Table 23). These wetlands were present across the range of elevation and ecoregions, but slope wetlands were more common in higher elevations where they often form the headwaters of small streams, and riverine wetlands were more common in lower elevations. Lacustrine fringe wetlands were all in the Sagebrush Parks ecoregion and their hydrology was influenced by artificial or managed water sources.

Table 23. Sampled wetlands by ecoregional strata and HGM class.

Ecoregional Strata	Riverine	Slope	Depressional	Lacustrine Fringe	Total
21a	-	5	-	-	5
21b/g	1	20	1	-	22
21e	5	4	-	-	9
21c	10	-	-	-	10
21d/f	9	1	2	-	12
21i	17	11	1	3	32
18f	5	-	-	-	5
Total	47	41	4	3	95
% of Sites	49%	43%	4%	3%	100%

4.2.4 Sampled Wetlands by Landownership

Half of all sampled wetlands were located on Forest Service land, in either the MBRNF or the ARNF (Table 24). The second largest share of sites sampled was on private lands (17 out of 95). All alpine and subalpine wetlands sampled in the North Platte River Basin occurred on Forest Service land, except for two SLB-owned sites within State Forest State Park. In contrast, wetlands sampled in mid-elevation forest and valley ecoregions occurred on a variety of land ownerships. All wetlands on land owned by CPW and USFWS occurred in the Sagebrush Parks ecoregion. All sampled fens and more than half of riparian shrublands occurred on land owned by the Forest Service (Table 25). In contrast, most of the sampled wet meadows occurred on private land or on the Arapaho National Wildlife Refuge, both areas that tend to be irrigated.

Table 24. Sampled wetlands by ecoregional strata and major land owner.

Ecoregional Strata	USFS	Private	BLM	FWS	SLB	CPW	Total
21a	5	-	-	-	-	-	5
21b/g	22	-	-	-	-	-	22
21e	7	-	-	-	2	-	9
21c	7	1	2	-	-	-	10
21d/f	8	3	1	-	-	-	12
21i	-	11	6	10	3	2	32
18f	-	2	2	-	1	-	5
Total	49	17	11	10	6	2	95
% of sites	52%	18%	12%	11%	6%	2%	100%

Table 25. Sampled wetlands by Ecological System and major land owner.

Ecological System	USFS	Private	FWS	BLM	SLB	CPW	Total
Riparian Shrublands	28	7	-	6	5	-	46
Wet Meadows	4	9	10	4	-	1	28
Fens	13	-	-	-	-	-	13
Freshwater Marshes	3	1	-	-	-	1	5
Riparian Woodlands	1	-	-	-	1	-	2
Alkaline Basin	-	-	-	1	-	-	1
Total	49	17	10	11	6	2	95
% of Sites	52%	18%	11%	12%	6%	2%	100%

4.2.5 Population Estimates of Wetland Type

Using the in-field classification of sampled wetlands and survey design parameters, we were able to estimate how frequently each of the classified wetland types occurs within the entire North Platte River Basin. Estimates were made separately for Ecological Systems (Figure 24) and HGM classes (Figure 25) and apply to all non-irrigated wetland area. The estimates are similar to the distribution of sampled sites (noted as observed in Figure 24 and Figure 25), but differ for some types. While only 29% of the wetlands sampled were classified as wet meadows, we estimate that 36% of the non-irrigated wetland area would fall into this type. Proportional to wetland area, fewer sites were sampled at lower elevations than at higher elevations. For this reason, the estimated distribution is higher than the observed distribution for wetland types that occurred more frequently in lower elevations, such as wet meadows. Riparian shrublands and wet meadows are by far the most common types in the basin. Fens are estimated to be less frequent across all wetland area than indicated by the sites sampled (9% vs. 14%), but still represent a significant portion of the wetland base. Estimates by HGM class indicate that riverine wetlands make up more than half the non-irrigated wetland area of the basin. Slope wetlands are the second most common. Depressional and lacustrine fringe wetlands both represent only 3–4% of non-irrigated wetland area.

4.3 Characterization of Wetland Vegetation

4.3.1 Species Diversity in North Platte Wetlands

Within surveyed wetlands, both species and community diversity was high. In total, 612 individual plant taxa were encountered in the 95 sites. This number includes 74 taxa identified only to the genus or family level because they were found either early or late in the season and lacked the required floristic parts for identification. Discounting those taxa, 538 species were identified to the species level, which represents ~17% of the entire Colorado flora. Of the 612 total taxa, 202 were only encountered once and another 85 were only encountered twice. The high percentage of

Figure 24. Estimated distribution of Ecological Systems across non-irrigated wetland area in the North Platte River Basin.

Ecological System	Observed	Estimate	95% Confidence Interval
Riparian Shrublands	48%	48%	(39-57%)
Wet Meadows	29%	36%	(27-44%)
Fens	14%	9%	(5-13%)
Freshwater Marshes	5%	4%	(0-8%)
Alkaline Basins	2%	2%	(0-5%)
Riparian Woodland	1%	1%	(0-3%)

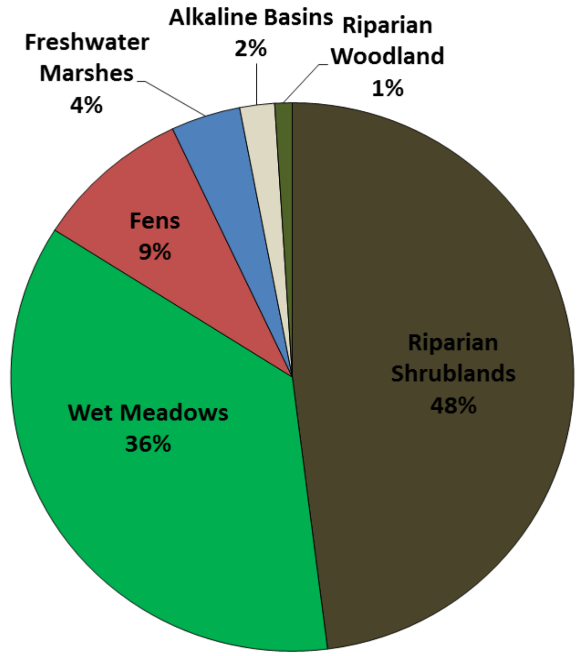
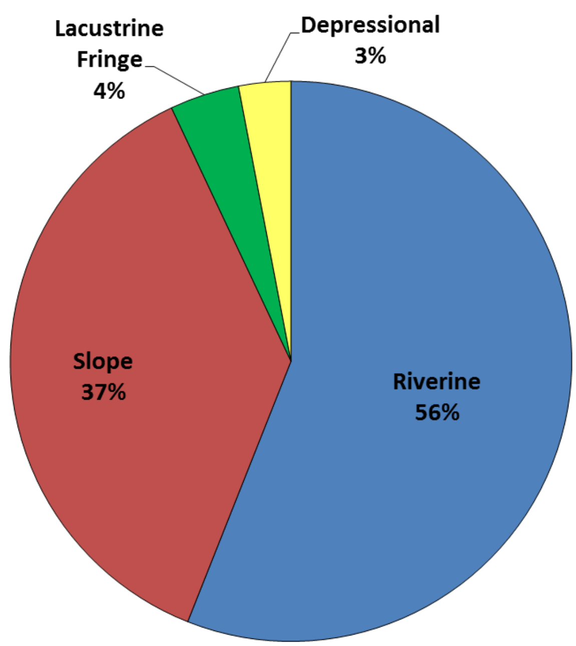


Figure 25. Estimated distribution of HGM classes across non-irrigated wetland area in the North Platte River Basin.

HGM Class	Observed	Estimate	95% Confidence Interval
Riverine	49%	56%	(47-67%)
Slope	43%	37%	(27-46%)
Lacustrine Fringe	3%	4%	(0-8%)
Depressional	4%	3%	(0-7%)



species found only once or twice indicates the high diversity found in wetlands across the basin, and it is likely that more species would be found with additional surveys. The average number of species per site was 49, but this ranged from 11 to 86 species per site. Sedges (*Carex* spp.) were the most diverse genus found in the survey, with 44 individual species. Willows (*Salix* spp.) were also diverse, with 15 individual species. Of the 538 species identified to species level, 487 (91%) were native species and 51 were non-native species. Average cover of noxious weeds was < 1% and 75 plots contained no noxious weeds. In plots that did contain noxious weeds, the most common was Canada thistle (*Breea* [syn. *Cirsium*] *arvense*). Aggressive native species (e.g. cattails: *Typha latifolia)* were not a problem in the North Platte and were dominant in only one of the 95 sites surveyed.

The most common species encountered across all sites was beaked sedge *(Carex utriculata),* a wetland obligate that can inhabit many wetland types from wet meadows to riparian shrublands to fens. This species occurred in 74 out of 95 sites (78%). Table 26 lists the ten most common species found in the survey, their wetland indicator status, nativity status, and C-value. Out of the top ten, only common dandelion *(Taraxacum officinale)* is a non-native species. This ubiquitous plant was found everywhere from disturbed lands to nearly pristine mountain meadows. It is highly adapted to spread widely, but is not considered a noxious weed. Most of the other top ten species are native with mid-range C-values, indicating they can tolerate low levels of disturbance. Three-petal bedstraw *(Galium trifidum)* and Rocky Mountain hemlock-parsley *(Conioselinum scopulorum),* ranked 8th and 10th on the list, have C-values of 7, which indicates a higher affinity for natural, undisturbed areas. The top ten most common species encountered by ecoregional strata are presented in Appendix J.

Table 26. Ten most common plant species encountered in North Platte River Basin wetlands.

Scientific Name	Common Name	Occurrences	Rank	Wetland Indicator Status[1]	Native Status	C-Value
Carex utriculata	beaked sedge	74	1	OBL	Native	5
Taraxacum officinale	common dandelion	73	2	FACU	Non-native	0
Carex aquatilis	water sedge	72	3	OBL	Native	6
Achillea lanulosa	yarrow	58	4	FACU	Native	4
Fragaria virginiana	Virginia strawberry	57	5	FACU	Native	5
Juncus arcticus	arctic rush	55	6	FACW	Native	4
Equisetum arvense	field horsetail	54	7	FAC	Native	4
Galium trifidum L. ssp. *subbiflorum*	threepetal bedstraw	51	8	OBL	Native	7
Geum macrophyllum	largeleaf avens	51	9	OBL	Native	6
Conioselinum scopulorum	Rocky Mountain hemlockparsley	49	10	FACW	Native	7

[1] Wetland Indicator Status based on the USFWS 1996 list (USFWS 1996). OBL = obligate wetland species, found in wetlands 99% of the time; FACW = facultative wetland species, found in wetlands 67–99% of the time; FAC = facultative species, found in wetlands 34–66% of the time; FACU = facultative upland species, found in uplands 67–99% of the time; UPL = obligate upland species, found in uplands 99% of the time.

4.3.2 Relationships between Wetland Vegetation and Environmental Factors

The Nonmetric Multidimensional Scaling (NMS) species ordination successfully accounted for 84.6% of the variability in the plot species community data. NMS ordinations are useful to graphically illustrate complex multivariate ecological relationships between species and their natural communities and environment. NMS ordinations can calculate relationships between hundreds of variables, such as percent cover of species by plot, to display how similar sampled plots are to each other in species space (Figure 26). NMS ordinations can also show how numerous environmental variables relate to the variation in species communities by using vectors (Figure 27; Figure 28).

The graph of the primary ordination axes 1 and 2 and the indicator species vectors ($r \geq 0.25$) illustrate similarities between plots clustered on the left side of axis 1 that had shrub and understory species characteristic of tall woody wetlands, such as mountain willow (*Salix monticola*), field horsetail (*Equisetum arvense*) and largeleaf avens (*Geum macrophyllum;* Figure 26; Table 27). Plots clustered on the right side of axis 1 and the lower half of axis 2 were predominantly low elevation herbaceous wetlands, including wet meadows, marshes, and the alkaline basin. Species characteristic of these wetlands include meadow foxtail (*Alopecurus pratensis*), clustered field sedge (*Carex praegracilis*), and arctic rush (*Juncus arcticus*). Wetlands clustered on the upper half of axis 2 and central portion of axis 1 were variably woody and herbaceous cover dominated, but had species characteristic of fens and other higher elevation wetlands such as plainleaf willow (*Salix planifolia*), water sedge (*Carex aquatilis*), marsh marigold (*Psychrophila leptosepala*), elephant-head lousewort (*Pedicularis groenlandica*), queen's crown (*Clementsia rhodantha*), and white bog orchid (*Limnorchis dilatata*).

The environmental/condition matrix overlaid on the species ordination detected strong relationships between species composition and elevation, climate, and wetland condition (Figure 27; Figure 28; Appendix F). The dominant axis clustered wetland communities typical of higher elevations with more precipitation, cooler temperatures, less disturbance, and an organic soil component on the upper portion of axis 2. Wetlands with species adapted to more disturbance were on the low side of axis 2 with less precipitation, warmer temperatures, and mineral soil composition. The climate and elevation gradients paralleled the wetland condition gradient. Higher integrity wetlands were located on the upper axis 2 and lower integrity wetlands with altered hydrologic origin were located on the low end of axis 2. This condition gradient also loosely corresponded to ecoregions (Figure 27). Interestingly, separation of woody and herbaceous wetlands along axis 1 was not related at all to the condition gradient, suggesting that presence of more vertical structural complexity is not necessarily indicative of higher wetland condition in the North Platte River Basin. Although wetlands on the highest end of the condition gradient tended to be owned by the USFS, wetlands on the mid and low end of the condition gradient had mixed ownership (Figure 28). There was no significant difference between plant communities in wetlands grouped by private ownership or SLB, USFWS, CPW, and BLM land ownership groups (MRPP, $A < 0.01$). A lack of plot groupings by sampling variables indicates that the vegetation composition survey results were not strongly influenced by date of sampling, sampling intensity (Level 2 or 3), or variations in plot size.

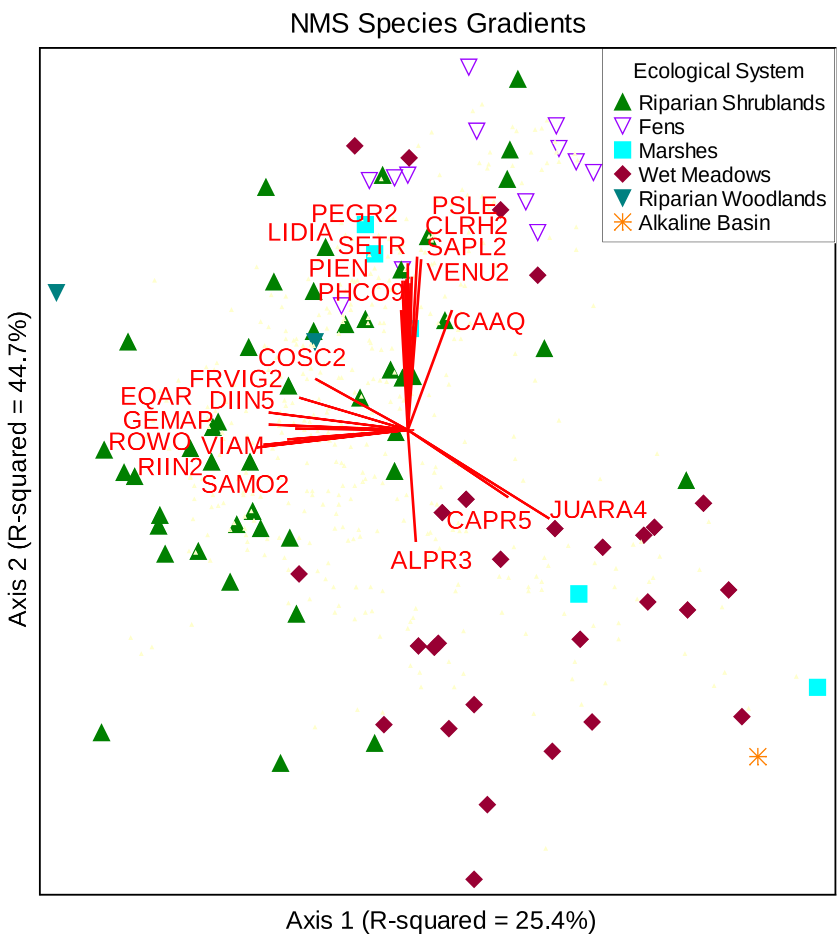


Figure 26. NMS ordination of plots (shown as symbols grouped by Ecological System) in species space. Plots more similar in species composition and diversity are closer in graphical space than plots with less similar species. Red vectors and their associated plant codes are displayed in the direction of their correlation with an axis when r ≥ 0.25.

Table 27. Reference table for species codes in Figure 26.

Species Code	Scientific Name	Species Code	Scientific Name
ALPR3	*Alopecurus pratensis*	PIEN	*Picea engelmannii*
CAPR5	*Carex praegracilis*	PHCO9	*Phleum commutatum*
JUARA4	*Juncus arcticus* ssp. *ater*	COSC2	*Conioselinum scopulorum*
CAAQ	*Carex aquatilis*	FRVIG2	*Fragaria virginiana* ssp. *glauca*
VENU2	*Veronica nutans*	EQAR	*Equisetum arvense*
SAPL2	*Salix planifolia*	DIIN5	*Distegia involucrata*
CLRH2	*Clementsia rhodantha*	GEMAP	*Geum macrophyllum*
PSLE	*Psychrophila leptosepala*	ROWO	*Rosa woodsii*
PEGR2	*Pedicularis groenlandica*	VIAM	*Viola americana*
LIDIA	*Limnorchis dilatata*	RIIN2	*Ribes inerme*
SETR	*Senecio triangularis*	SAMO2	*Salix monticola*

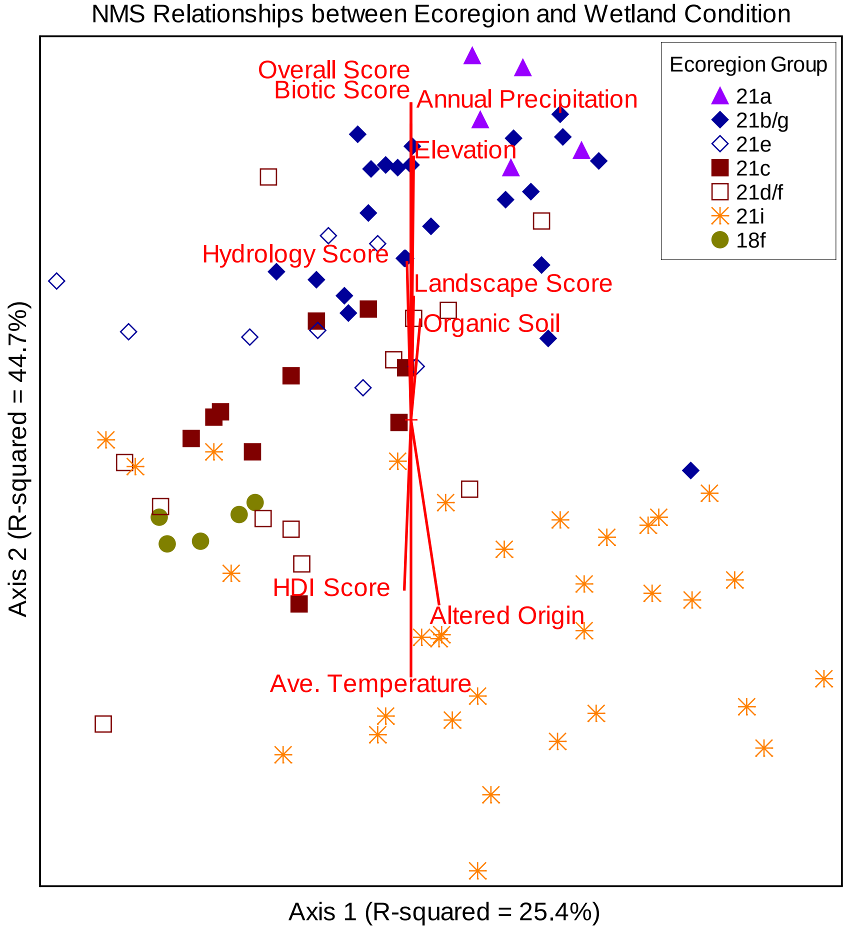


Figure 27. NMS ordination of plots (shown as symbols grouped by ecoregion) in species space. Red score and environmental vectors are oriented in the direction of their correlation with an axis when r ≥ 0.20.

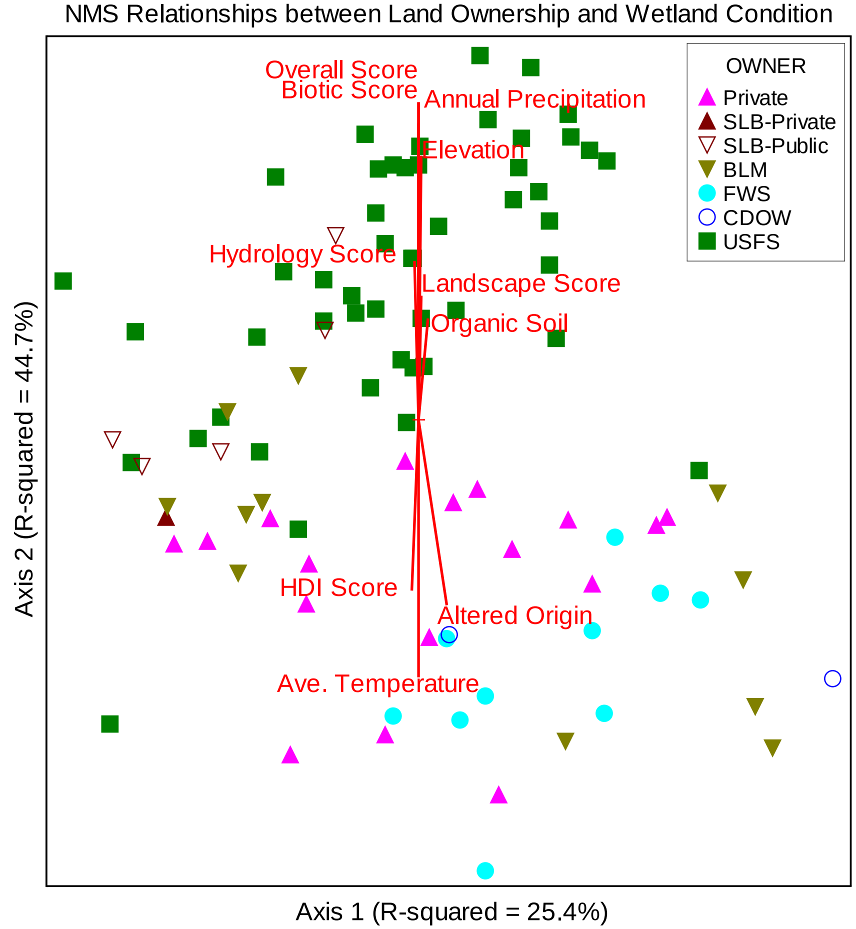


Figure 28. NMS ordination of plots (shown as symbols grouped by land owner) in species space. Red score and environmental vectors are oriented in the direction of their correlation with an axis when r ≥ 0.20.

4.4 Floristic Quality Assessment

Vegetation surveys were conducted in all sampled wetlands, though the intensity of the protocols varied between Level 2 and Level 3 sites. Regardless of data collection intensity, FQA metrics were calculated for all sites. From past experience testing differences between FQA metrics collected using Level 2 and Level 3 protocols, we know that metrics related to relative cover or abundance (percent-based metrics) are very similar between the two protocols, while absolute species richness is generally lower with the less intensive plot methods (Lemly and Rocchio 2009a). Given this experience, we felt confident that Mean C values were comparable across sites, regardless of sampling protocols.

The overall average Mean C score was 5.46. Mean C values for sampled sites ranged from 2.77–7.08, with a bimodal distribution (Figure 29). The range of Mean C scores was related to both wetland type and the geographic gradient. Average Mean C scores varied between both ecoregional strata (Figure 30) and Ecological System (Figure 31). The lowest Mean C scores and largest variation in scores occurred below 8500 ft. Above 9000 ft., sites predictably showed high Mean C scores, though scores did not continue to increase linearly with elevation. Not surprisingly, fen wetlands characteristic of higher elevations had the highest average Mean C values, while wet meadows, which were more common at lower elevations, had lower average Mean C values. Wet meadows and riparian shrublands sampled spanned various ecoregional and elevation gradients and had a wider range of Mean C values, while high elevation fens had a tighter range of values. The one alkaline basin sampled had a lower mean C than the overall average, which was consistent with Mean C's of saline wetlands sampled in the other basins (Lemly et al. 2011). Figure 32 through Figure 35 show the distribution of Mean C values by Ecological System.

In addition to Mean C, the FQA methodology includes a number of different metrics that can be evaluated to gauge biotic condition. Table 28 shows means and standard deviations for each FQA metric by Ecological System group. The same general pattern was seen across all FQA metrics. Fens scored the highest among wetland types, while wet meadows and the alkaline basin scored on the lower end. The HDI was not strongly linked to the FQA in North Platte River Basin plots. Riparian shrublands scored moderately well on the FQA, but had a lower HDI on average. Marshes had the highest HDI score on average, but scored variably across FQA metrics.

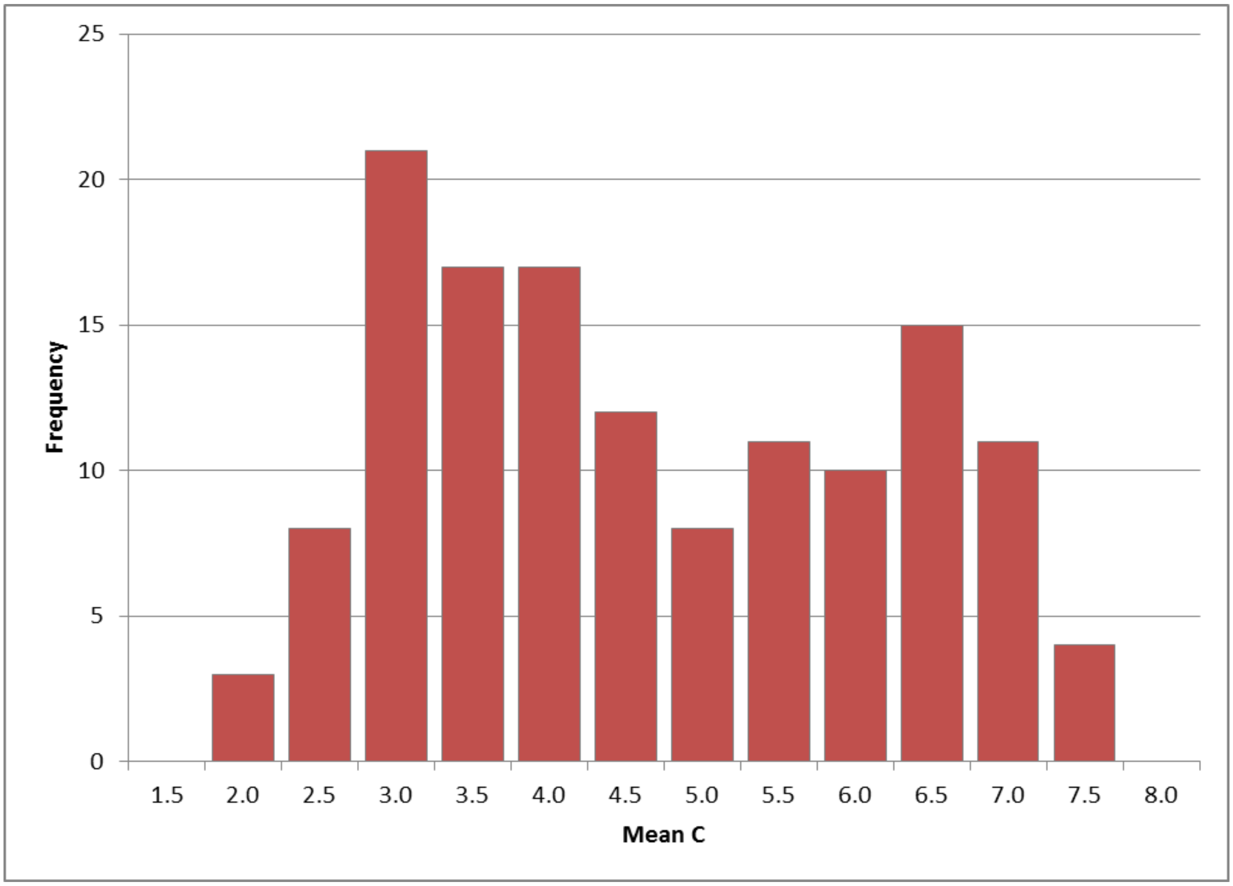


Figure 29. Frequency of Mean C values for all sampled wetlands. Number under each bar represents the upper bound of the bin.

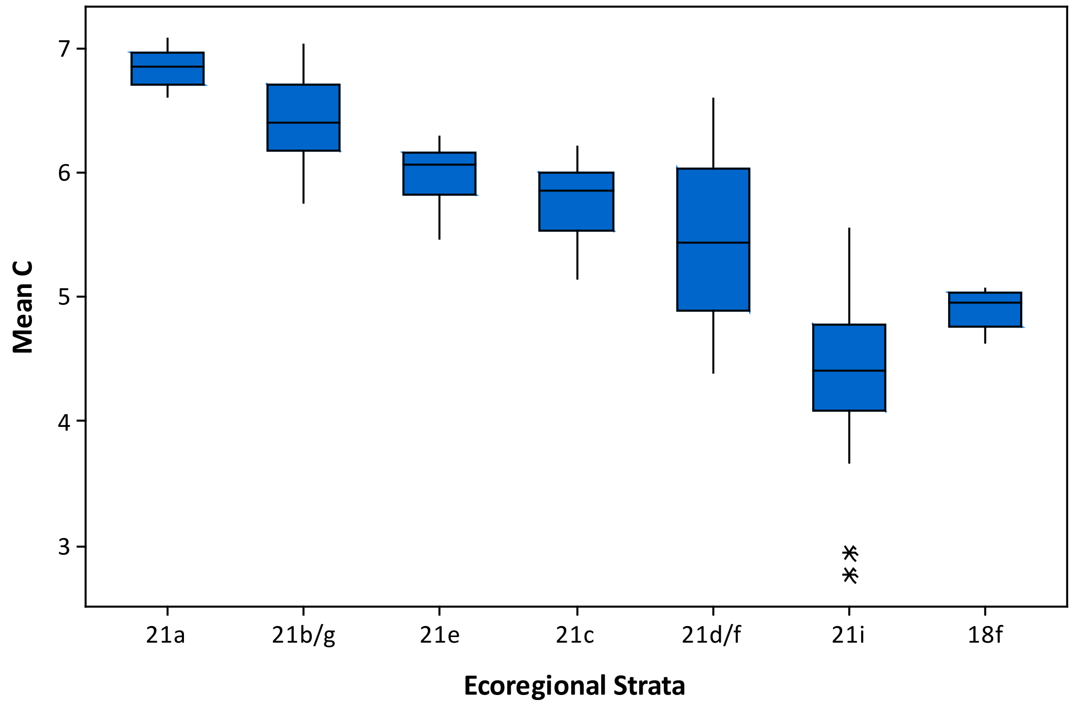


Figure 30. Range of Mean C scores by ecoregional strata. Boxes represent 75th percentile to 25th percentile. Horizontal line represents the median. Whiskers extend to 95th and 5th percentiles and stars are outliers.

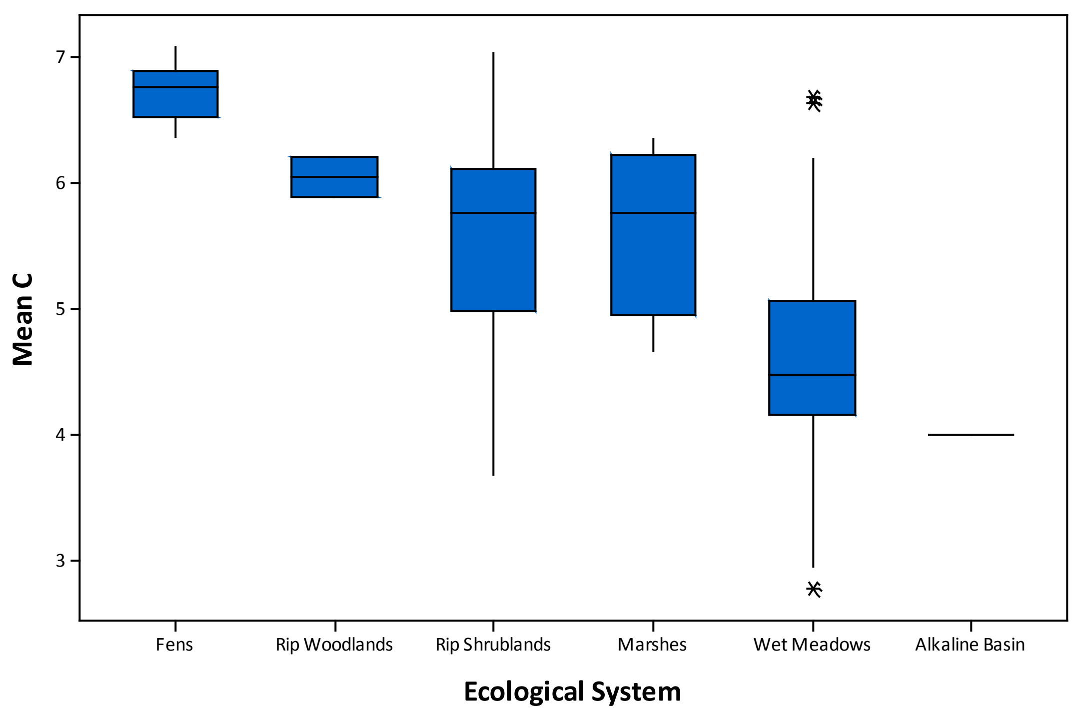


Figure 31. Range of Mean C scores by Ecological System. Boxes represent 75th percentile to 25th percentile. Horizontal line represents the median. Whiskers extend to 95th and 5th percentiles and stars are outliers.

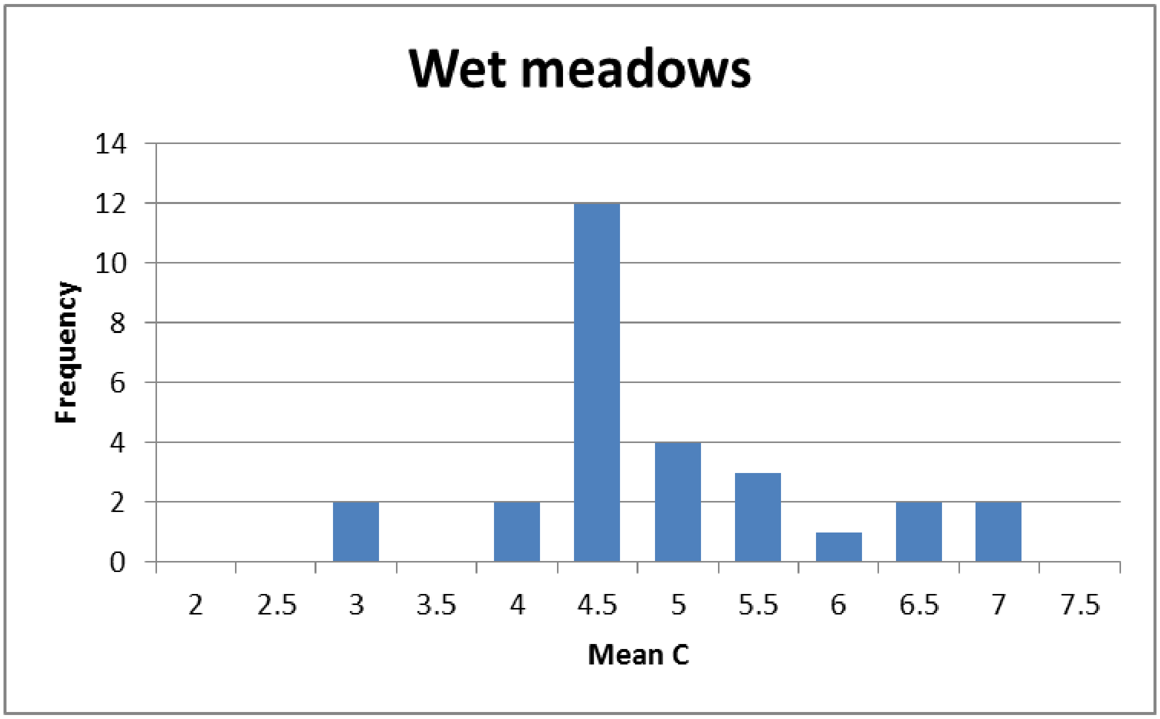


Figure 32. Frequency of Mean C values for all sampled wet meadows. Number under each bar represents the upper bound of the bin.

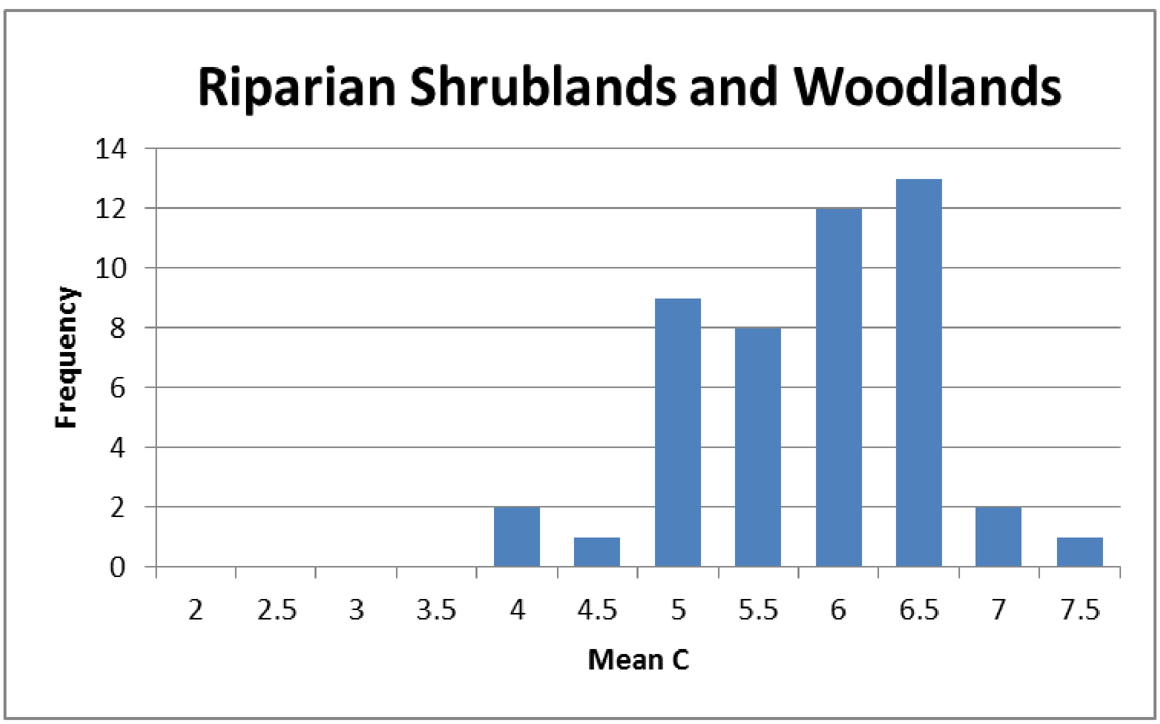


Figure 33. Frequency of Mean C values for all sampled riparian shrublands and woodlands. Number under each bar represents the upper bound of the bin.

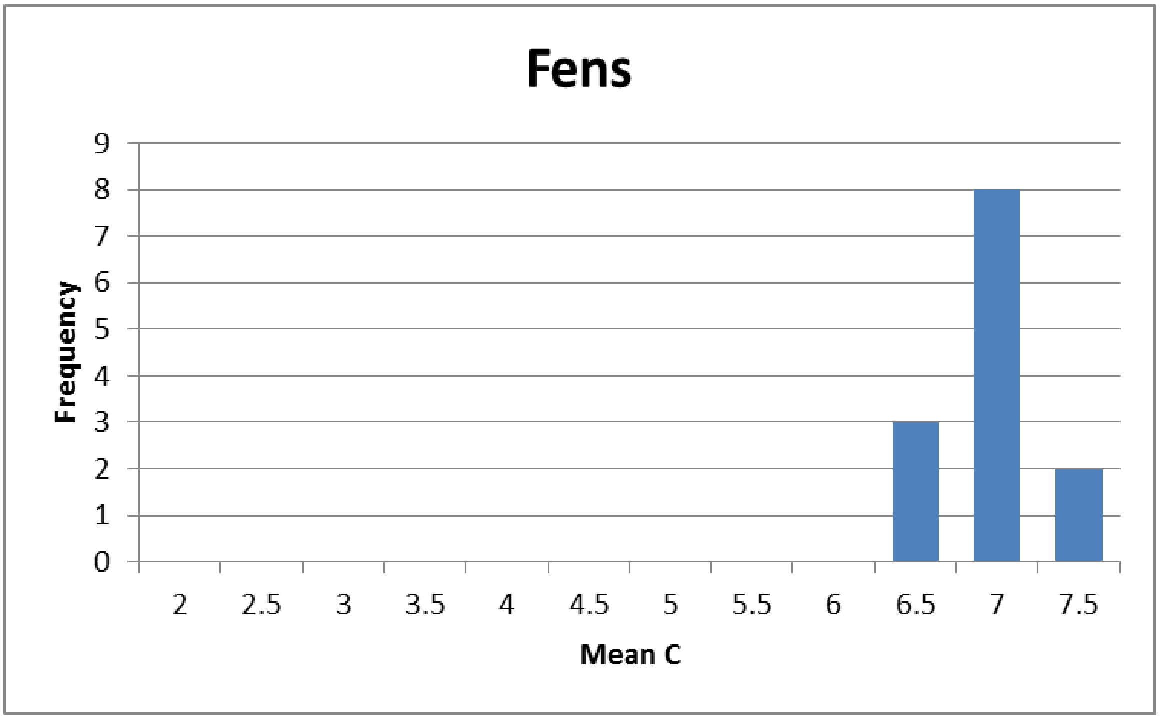


Figure 34. Frequency of Mean C values for all sampled fens. Number under each bar represents the upper bound of the bin.

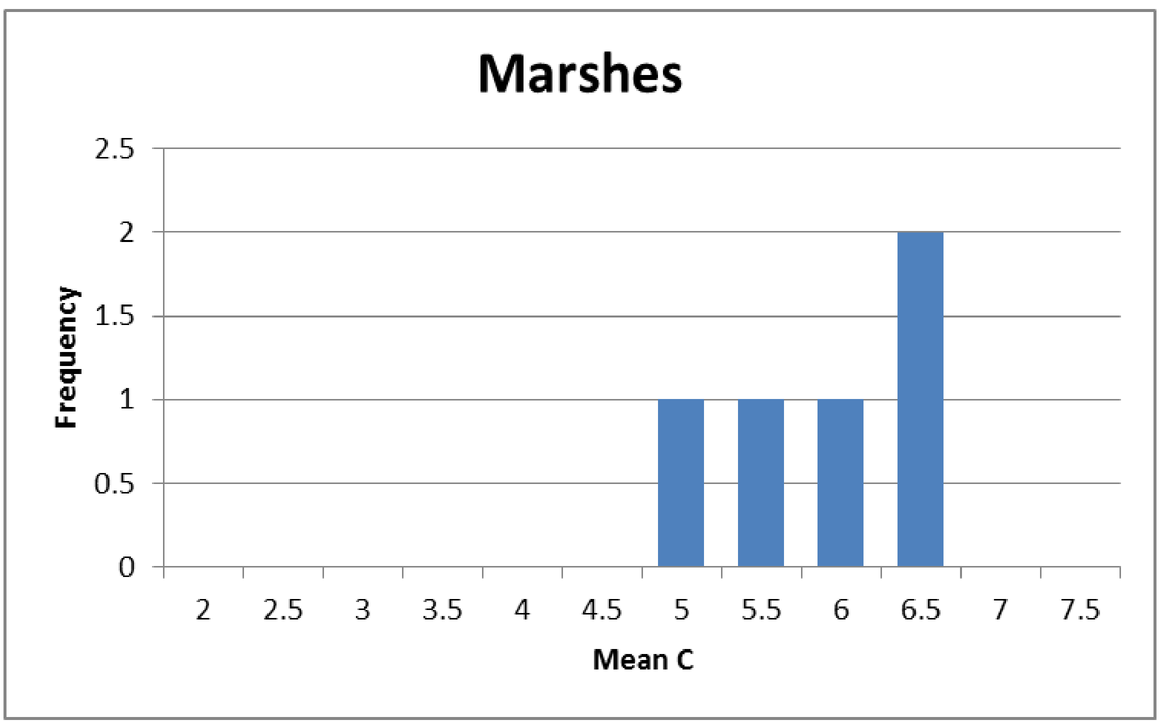


Figure 35. Frequency of Mean C values for all sampled marshes. Number under each bar represents the upper bound of the bin.

Table 28. Means and standard deviations of all FQA metrics by Ecological Systems.

FQA Indices	Riparian Shrublands *n* = 46		Wet Meadows *n* = 28		Fens *n* = 13		Freshwater Marshes *n* = 5		Riparian Woodlands *n* = 2		Alkaline Basin *n* = 1
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Value SD=n/a**
Total species richness	57.61	15.98	36.86	12.97	51.46	13.85	41.4	8.82	45	8.49	20
Native species richness	47.91	14.62	27.21	12.37	47.08	13.24	35.8	7.92	40.5	9.19	11
Non-native species richness	3.96	2.52	4.79	2.67	0.62	0.65	1.6	1.14	2	1.41	1
% Non-native	8.20%	5.90%	16.40%	9.50%	1.40%	1.60%	4.60%	3.40%	4.40%	2.20%	8.30%
Mean C of all species	5.59	1.08	4.65	0.95	6.72	0.24	5.62	0.68	6.05	0.23	4
Mean C of native species	6.09	0.94	5.58	0.59	6.82	0.2	5.89	0.52	6.35	0.08	4.4
Cover-weighted Mean C of all species	5.54	1.18	4.52	1.42	6.57	0.58	5.55	0.86	5.79	0.03	5.09
Cover-weighted Mean C of native species	5.98	0.93	5.21	0.74	6.61	0.54	5.63	0.81	5.82	0.03	5.12
FQI of all species	39.07	9.08	25.35	8.51	45.09	6.09	33.82	6.63	38.05	3.34	13.27
FQI of native species	40.7	8.79	27.61	8.14	45.41	5.97	34.58	6.33	39	3.9	13.91
Cover-weighted FQI of all species	38.84	9.75	24.8	9.94	44.18	7.46	33.45	7.62	36.51	4.73	16.89
Cover-weighted FQI of native species	39.99	8.8	25.97	8.28	44.11	7.28	33.17	7.83	35.8	4.21	16.18
Adjusted FQI	58.3	10.04	50.86	7.7	67.68	2.12	57.52	6.03	62	1.54	41.95
Adjusted cover-weighted FQI	57.24	9.66	47.59	8.83	65.6	5.38	55.01	8.87	56.85	0.41	48.78
HDI Score	23.38	17.28	26.41	16.84	12.55	15.26	8.64	8.33	13.38	18.92	19.95

4.5 Ecological Integrity Assessment

4.5.1 EIA Scores of Sampled Wetlands

Level 2 condition scores were calculated for all 95 wetlands sampled in 2010 based on the EIA methodology. Across all sites, scores ranged from 2.94–5.00 out of a possible range of 1.00–5.00. For ease of discussion, EIA scores are translated into a 4-tiered ranking system of A, B, C, and D based on the scoring thresholds outlined in Appendix E. These ranks can be interpreted as:

- A = Reference (no or minimal human impact)
- B = Slight deviation from reference
- C = Moderate deviation from reference
- D = Significant or severe deviation from reference

Within the North Platte River basin, EIA ranks never reached the worst class of D, where wetland conditions and their associated functions are considered significantly compromised and unlikely to be restorable. Of the 95 wetlands surveyed, 43 were A-ranked, 40 were B-ranked, and 12 were C-ranked. Trends among the ranks were clearly evident between both ecoregion and Ecological Systems. A-ranked sites were observed across all ecoregional strata except 21i: Sagebrush Parks, while the only C-ranked sites surveyed were located in 21i and 18f (Table 29; Figure 36). Among Ecological Systems, fens and riparian woodlands received the highest ranks, with all 15 sites surveyed as A-ranked. (Table 30; Figure 37). Riparian shrublands, wet meadows, and marshes had EIA ranks spread across the range, indicating that they face a range of disturbance depending on where they are located within the basin. There were A-ranked wetlands in all wetland types surveyed except for the alkaline basin, which had a sample size of one.

To explore the drivers of the overall EIA scores, it is important to look at the component ranks of landscape context, biotic condition, hydrologic condition, and physiochemical condition (Table 31). Landscape context ranks for most wetland types were spread between A and B, with only a few C ranks, indicating that wide buffers were generally present around wetlands and landscape connectivity was fairly intact. This is particularly true for fen wetlands, which received nearly all A ranks for landscape context. While some wetlands types showed consistently high ranks for hydrology, half of riparian shrublands received B or C hydrology ranks. The majority of wet meadows received B, C, or even D hydrology ranks. These lower hydrology ranks for riparian shrublands and wet meadows were largely related to impacts of water management through localized irrigation practices. Few sites overall showed significantly impacted hydrology. On the whole, physiochemical ranks were consistently high, indicating that, in general, negative alterations to soil integrity and water quality were not evident. In each component category, at least one site scored a D. But because these sites were buffered by higher scores in other component categories, their overall condition was never ranked poor.

Biotic ranks were generally lower than other EIA component categories, with more sites receiving B and C ranks. Lower biotic scores compared to other categories is similar to results from the field test of the Riparian Shrubland EIA protocol (Lemly and Rocchio 2009a). Metrics within the biotic category generally integrate the cumulative effects of numerous stressors on multiple different scales. The other component categories depict condition at either a large scale (landscape context) or a site-level scale (hydrologic or physiochemical condition), and therefore each category only captures a slice of the overall condition. Sites may be located within a relatively unfragmented landscape and have a relatively wide and intact buffer, but may be impacted by onsite hydrologic alteration. The biotic condition category is likely to integrate those impacts, while the landscape context score would be high and the hydrology score would be lower.

Table 29. EIA ranks by ecoregional strata.

Ecoregional Strata	A	B	C	D	Total
21a. Alpine Zone	5	-	-	-	5
21b/g. Cryst/Volc Subalpine	21	1	-	-	22
21e. Sed Subalpine	6	3	-	-	9
21c. Cryst Mid-Elevations	5	5	-	-	10
21d/f. Sed Mid-Elev/Foothills	5	7	-	-	12
21i. Sagebrush Parks	-	21	11	-	32
18f. Laramie Basin	1	3	1	-	5
Total	43	40	12	-	95
% of Sites	45%	42%	13%	-	100%

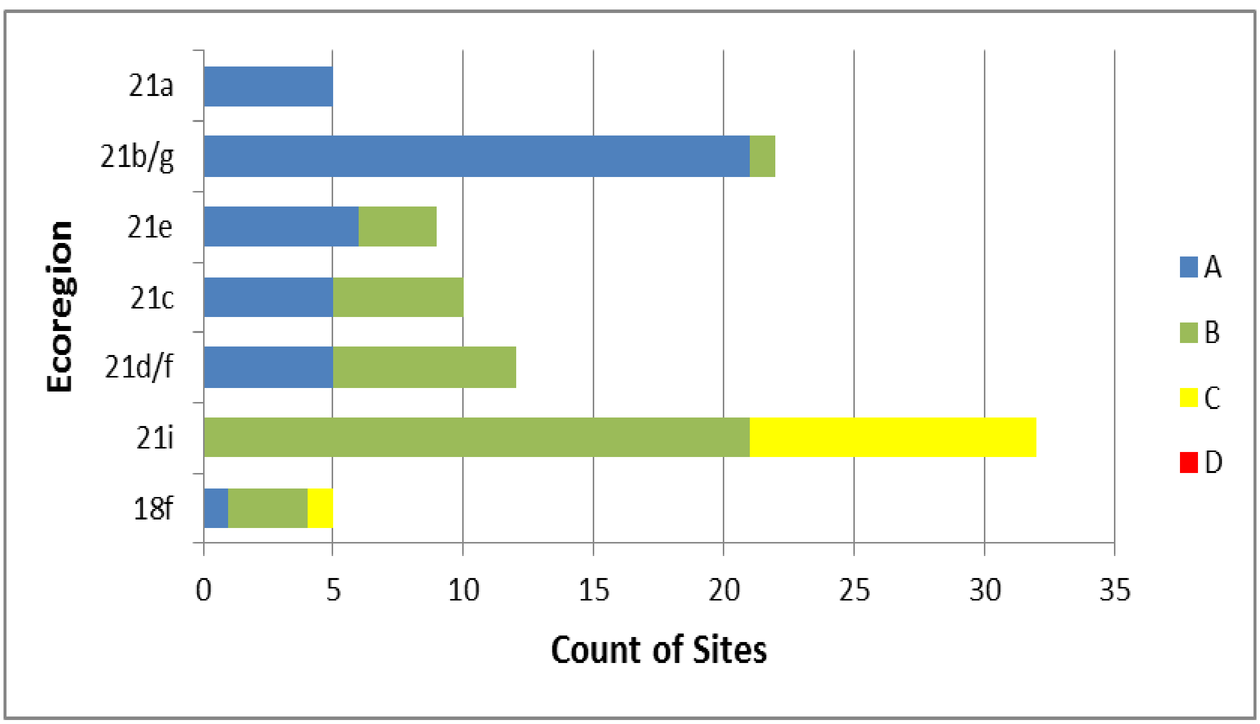


Figure 36. EIA ranks by ecoregional strata.

Table 30. EIA ranks by Ecological Systems.

Ecological System	A	B	C	D	Total
Riparian Shrublands	21	22	3	-	46
Wet Meadows	4	16	8	-	28
Fens	13	-	-	-	13
Freshwater Marshes	3	1	1	-	5
Riparian Woodlands	2	-	-	-	2
Alkaline Basin	-	1	-	-	1
Total	43	40	12	-	95
% of Sites	45%	42%	13%	-	100%

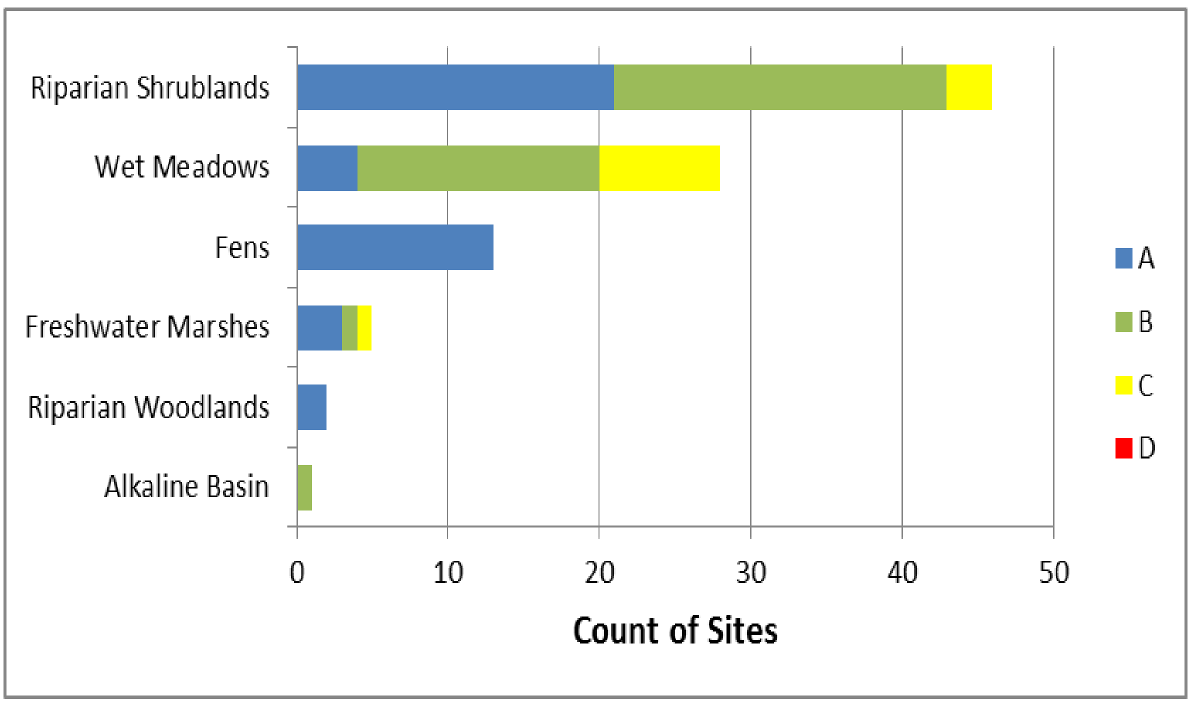


Figure 37. EIA ranks by Ecological Systems.

Table 31. Component EIA ranks by Ecological Systems.

	A	B	C	D	Total
Landscape Context Rank					
Riparian Shrublands	26	18	2	-	46
Wet Meadows	12	14	1	1	28
Fens	11	2	-	-	13
Freshwater Marshes	2	2	1	-	5
Riparian Woodlands	1	1	-	-	2
Alkaline Basin	1	-	-	-	1
Total	**53**	**37**	**4**	**1**	**95**
Biotic Condition Rank					
Riparian Shrublands	15	19	10	2	46
Wet Meadows	4	4	16	4	28
Fens	12	1	-	-	13
Freshwater Marshes	2	3	-	-	5
Riparian Woodlands	2	-	-	-	2
Alkaline Basin	-	-	1	-	1
Total	**35**	**27**	**27**	**6**	**95**
Hydrologic Condition Rank					
Riparian Shrublands	23	20	3	-	46
Wet Meadows	5	17	5	1	28
Fens	13	-	-	-	13
Freshwater Marshes	3	-	1	1	5
Riparian Woodlands	1	1	-	-	2
Alkaline Basin	1	-	-	-	1
Total	**46**	**38**	**9**	**2**	**95**
Physiochemical Condition Rank					
Riparian Shrublands	34	12	-	-	46
Wet Meadows	20	7	-	1	28
Fens	13	-	-	-	13
Freshwater Marshes	4	1	-	-	5
Riparian Woodlands	1	1	-	-	2
Alkaline Basin	1	-	-	-	1
Total	**73**	**21**	**-**	**1**	**95**

4.5.2 Population Estimate of Wetland Condition

Survey design parameters were used to extrapolate EIA results from sampled wetlands to all non-irrigated wetland area in the North Platte River Basin. Extrapolated results indicate that 34% of all non-irrigated wetland area in the basin would receive an overall EIA rank of A, 48% would receive a B, and 17% would receive a C (Figure 38; Table 32). Proportional to wetland area, fewer sites were sampled per wetland acre at lower elevations than at higher elevations. This results in fewer A ranks and more B and C ranks in the population estimate than for the sampled wetlands. When applied to the acres mapped by NWI, these percentages translate to 18,459 acres of A-ranked wetlands, 25,950 acres of B-ranked wetlands, 9,096 acres of C-ranked wetlands, along with 78,137 acres of irrigated wetlands (Figure 39).

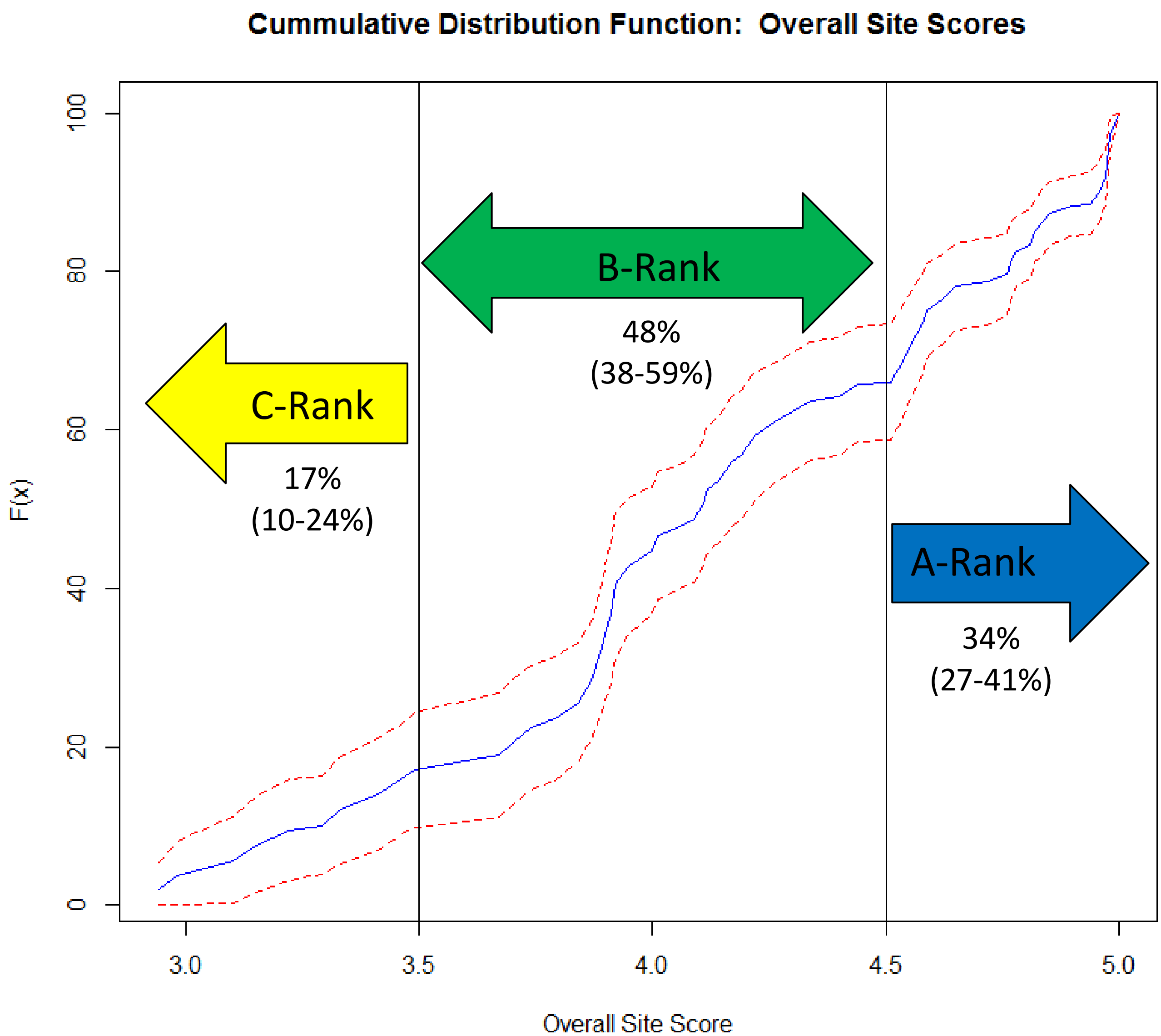


Figure 38. Cumulative distribution function of overall EIA scores and ranks for wetlands in the North Platte River Basin. Graph shows the cumulative proportion of wetland area (y axis) at or below a given EIA score (x axis). Blue solid line represents the estimate; red dashed lines represent the upper and lower 95% confidence limits.

EIA Rank	Observed	Estimate	95% Confidence Interval
A	45%	34%	27-41%
B	42%	48%	38-59%
C	13%	17%	10-24%
D	0%	0%	NA

Table 32. Population estimate of wetland EIA ranks for the North Platte River Basin. Observed = percent of sites sampled within each rank. Estimate = extrapolated the percent of non-irrigated wetland area within each rank.

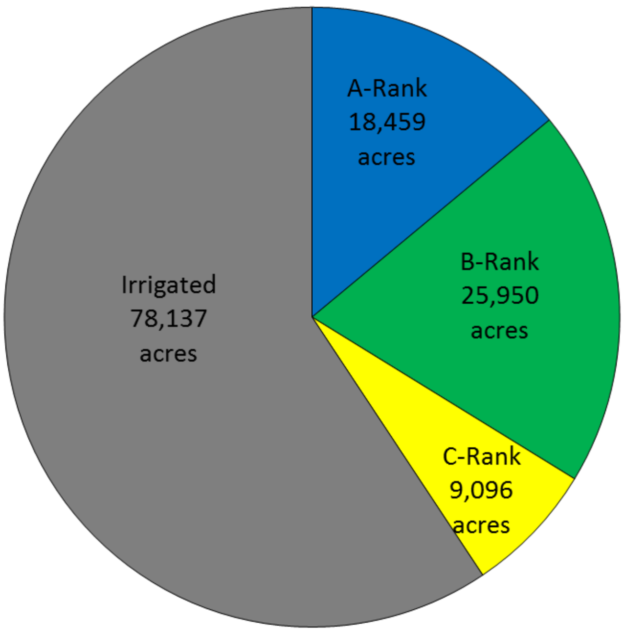


Figure 39. Estimated wetland acres in the North Platte River Basin ranked A, B, and C, along with irrigated acres.

4.5.3 Land Use Stressors

Selected land uses both within the AA and within a 500 m envelope surrounding the AA were examined to identify potential causes of wetland condition in the North Platte River Basin (Table 33; Table 34). Land uses were recorded in the field by percent cover in descending order of potential impact, following the table on page 11 of the field form (Appendix D). This method was used in order to calculate onsite and adjacent land scores used in the HDI. However, this method presents limitation when summarizing the frequency of land use stressors. For instance, if an area of the 500 m envelope was both moderately grazed and selectively logged, it would only be reported as moderately grazed. But if the land uses were mutually exclusive, both would be reported. As a result, observed land uses recorded represent a minimum number of occurrences. We chose to report this minimum number because there were not many overlapping land uses recorded in the basin, and the information gives an approximate estimate of which stressors were more common. In future years, we will record land uses individually, regardless of the severity of the stressor.

Fewer land uses were observed within the AAs than in the surrounding 500m envelopes, which could include both wetland and non-wetland land cover. Because the AA had to include ≥ 90% wetland land cover, some land uses, such as paved roads, would never be within the AA. Even more notable, > 50% of AAs had no observed land use stressors. No observed stressors were recorded in 15% of the 500 m envelopes, but all of these plots occurred in higher elevations.

The only anthropogenic land use recorded in the 21a: Alpine Zone ecoregion was light human recreation (not listed in Table 33 because in most ecoregions, light recreation was not the most severe stressor at any given area and was therefore not consistently recorded). Grazing signs were observed in all ecoregions except for the Alpine Zone, and grazing was the most common recorded stressor in both AAs and 500 m envelopes. Of three levels of grazing recorded (light / moderate / heavy), grazing in was moderate in 13% of AAs and light in the other grazed wetlands (data not shown). Grazing was only heavy in two of the 500 m envelopes and it was never heavy in the AA. Signs of native ungulate browse were more common than grazing in the wetland AAs and were nearly as common in the envelopes. However, the degree of browse was usually light, with moderate browse only occurring in two sites and heavy browse only in one. Beetle-killed conifers were also very common in 500 m envelopes. Only 13% of sites had developed land recorded in the envelope, but unpaved roads were common in the envelopes. Logging was not a commonly recorded stressor, except in the 21e: Sedimentary Subalpine ecoregion, where it occurred in most envelopes and in some AAs. At the time of survey, oil and gas wells were uncommon in the North Platte River Basin, and were not commonly noted in field notes. However, oil and gas leasing has increased since the summer of 2010 and there is potential for wells to become a stressor to wetlands in the basin in future years.

Table 33. Anthropogenic land uses and natural disturbances observed in wetland assessment areas (AA).

Anthropogenic Land Use in AA	21a n=5	21b/g n=22	21e n=9	21c n=10	21d/f n=12	21i n=32	18f n=5	Total
Unpaved roads	-	-	-	-	-	1	-	1
Logging – selective	-	-	3	-	3	-	-	6
Grazing signs	-	1	1	-	-	26	2	30
No anthropogenic stressors present	5	20	3	9	9	5	-	51
Natural disturbances in AA								
Browse by native ungulate	2	6	7	3	7	20	1	46
Trampling paths by native ungulate	2	1	3	1	4	8	-	19
Beetle-killed conifers	2	8	2	4	1	-	-	17

Table 34. Anthropogenic land uses and natural disturbances observed in 500 m envelopes surrounding the AAs.

Anthropogenic Land Use in 500m Envelope	21a n=5	21b/g n=22	21e n=9	21c n=10	21d/f n=12	21i n=32	18f n=5	**Total**
Development – paved roads, buildings, parking lots	-	-	1	2	1	7	1	12
Unpaved roads	-	6	9	8	10	19	5	57
Active or inactive mining	-	-	-	1	1	2	-	4
Logging – selective or full removal	-	3	8	3	3	-	1	18
Moderate or heavy use recreation – trails, camping, ATV's, fishing	-	1	5	-	3	2	1	12
Grazing signs	-	2	4	3	7	28	5	49
Disturbed areas - unnaturally bare or dominated by non-native species, reservoir shorelines	-	1	-	1	1	9	-	12
Hay pastures	-	-	-		2	6	2	10
No anthropogenic stressors present	2	9	-	2	-	-	-	14
Natural disturbances in 500m Envelope								
Browse by native ungulate	2	7	7	3	6	23	-	48
Trampling paths by native ungulate	3	6	4	1	5	16	-	35
Beetle-killed conifers	3	20	9	7	7	3	-	49
Evidence of recent fire	-	1	-	-	-	-	-	1

4.6 Vegetation Index of Biotic Integrity

Intensive Level 3 protocols were used to collect vegetation data in 52 out of 95 wetlands sampled, allowing us to calculate Vegetation Index of Biotic Integrity (VIBI) scores. Wetlands sampled with Level 3 protocols included 19 wet meadows, 23 riparian shrublands, and 5 fens. Other wetland types (3 marshes and 1 riparian woodland) were also sampled with Level 3 intensity but a VIBI has not been developed for these systems in the Rocky Mountains yet. Given the sample sizes, more detailed analyses were possible for wet meadows and riparian shrublands than for fens.

4.6.1 Wet Meadows

Using metrics and scoring formulas from version 2.0 of the wet meadow VIBI model (Lemly and Rocchio 2009b), sites in the North Platte River Basin had estimated scores between 2.86–9.02 out of a potential range of 1.00–10.00. Two-thirds of scores were between >6.00–8.00 (Figure 40). The mean VIBI score was 6.96 with a standard deviation of 1.63. During calibration of the version 2.0 model, a threshold was set at 5.24 to distinguish between higher and lower integrity sites. Only two condition classes could be identified during the version 2.0 calibration based on the limited sample size of the development plots. Based on this threshold, most wetlands in the North Platte basin had vegetation indicative of high biotic integrity, with only two out of 19 wet meadows in the lower integrity class.

However, the version 2.0 wet meadow VIBI model is not fully calibrated and the North Platte sites frequently had component VIBI metric values outside of the range observed of the model development dataset. Because the scores are based on deviation from a given range, each model needs to be continually updated until the range accurately represents that expected range of all wetlands within the type. As a result, scores are estimates, but are generally still indicative of higher integrity wetlands.

To further test the effectiveness of the VIBI model for the North Platte wet meadows, we plotted VIBI scores against the Human Disturbance Index, which was used to develop the original and calibrated model. Based on development and calibration plots, the wet meadow version 2.0 VIBI model had a strong correlation to the HDI (R^2 = 0.74 and correlation coefficient = -0.87: Lemly and Rocchio 2009b). For the North Platte plots, the relationship was significantly weaker (Figure 41: R^2 = 0.29 and correlation coefficient = -0.54). This indicates that the model's estimated performance was weak in the study area and needs further calibration. Since the development of the VIBI 2.0, the Colorado basin-wide assessments have created datasets with many more Level 3 wet meadow site scores, and we anticipate the capacity to develop and calibrate a more representative VIBI model for Colorado wetlands in future years.

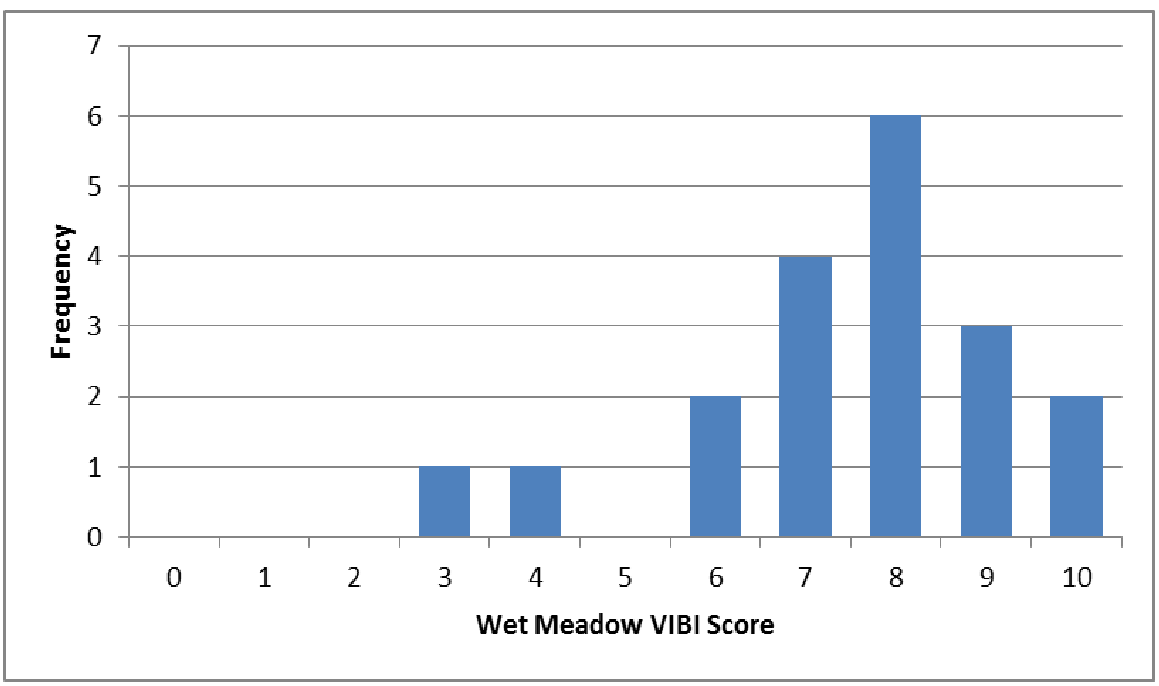


Figure 40. Frequency of estimated Wet Meadow VIBI scores for all wet meadows sampled with Level 3 protocols. Numbers under each bar represents the upper bound of the bin.

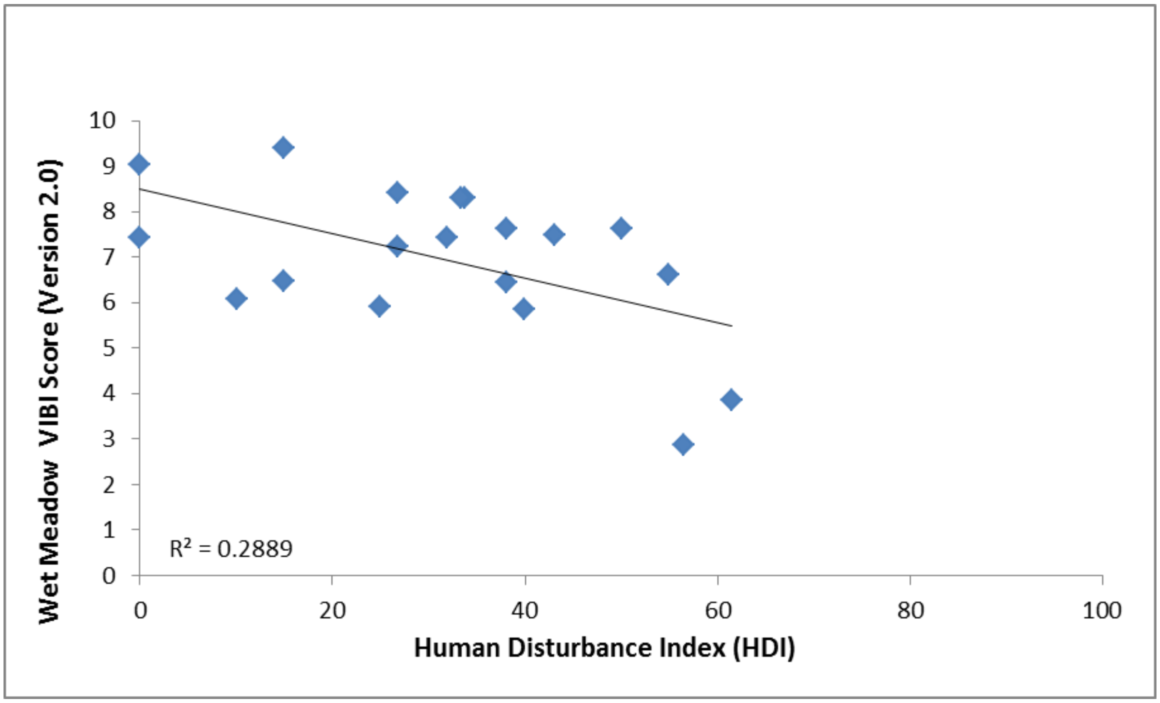


Figure 41. Correlation of estimated Wet Meadow VIBI scores to the Human Disturbance Index (HDI).

4.6.2 Riparian Shrublands

Using metrics and scoring formulas from version 2.0 of the riparian shrubland VIBI model (Lemly and Rocchio 2009b), sites in the North Platte River Basin scored between 2.98–9.42, with one-third of the sites scoring >8.00 (Figure 42). The mean VIBI score for riparian shrublands was 6.93 with a standard deviation of 1.66. During calibration of the version 2.0 model, thresholds were set at 6.56 and 8.08 to distinguish between low, moderate, and high integrity sites. Based on these thresholds, eight riparian shrublands in the North Platte River Basin fall within the low integrity class, seven fall within the moderate integrity class, and eight fall within the high integrity class.

In contrast to the wet meadow VIBI model, the riparian shrubland VIBI model was developed with a larger number of sites and more confidence in scoring thresholds, but the North Platte and Rio Grande Headwaters datasets indicate further development is still needed. Among the North Platte plots, component VIBI metric values in 2 of the 9 metrics fell outside the range of the development plots, and in the Rio Grande Headwaters survey, the other 7 of the 9 metrics contained values outside of the range of development plots. The component metric scores were not as far from the range of development scores as in wet meadows, but more calibration is still needed for riparian shrublands. The correlations between North Platte riparian shrubland VIBI scores and the HDI scores are weaker than the development plots (Figure 43: R^2 = 0.22 and correlation coefficient = -0.46).

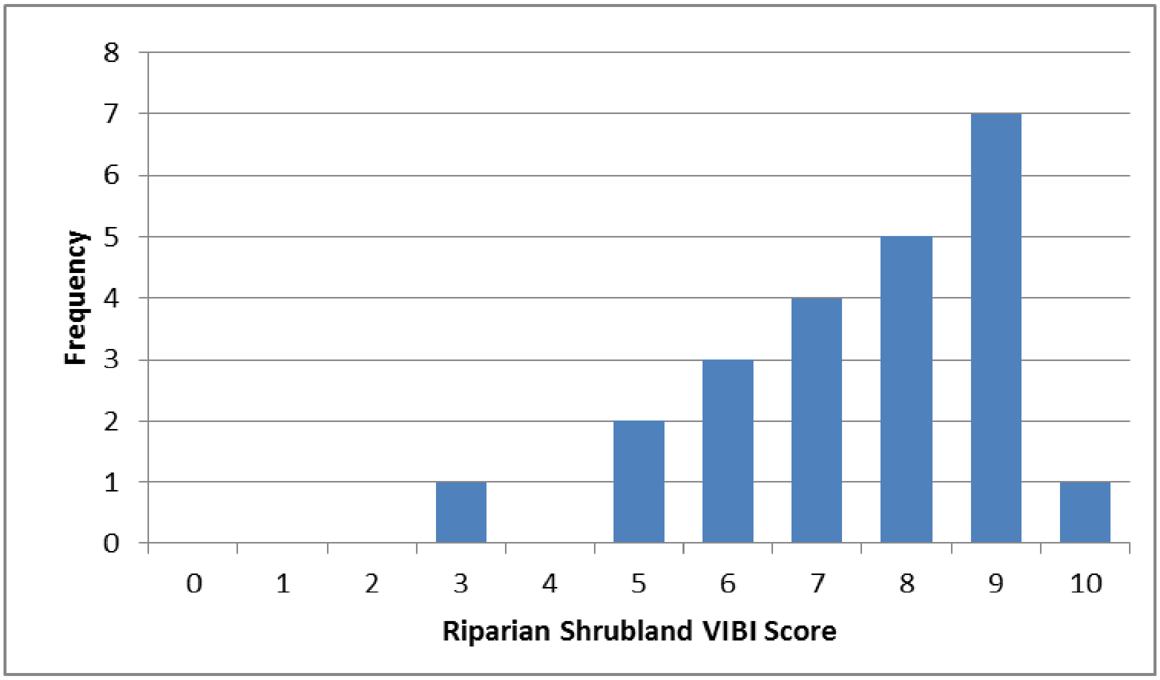


Figure 42. Frequency of estimated Riparian Shrubland VIBI scores for all riparian shrublands sampled with Level 3 protocols. Numbers under each bar represents the upper bound of the bin.

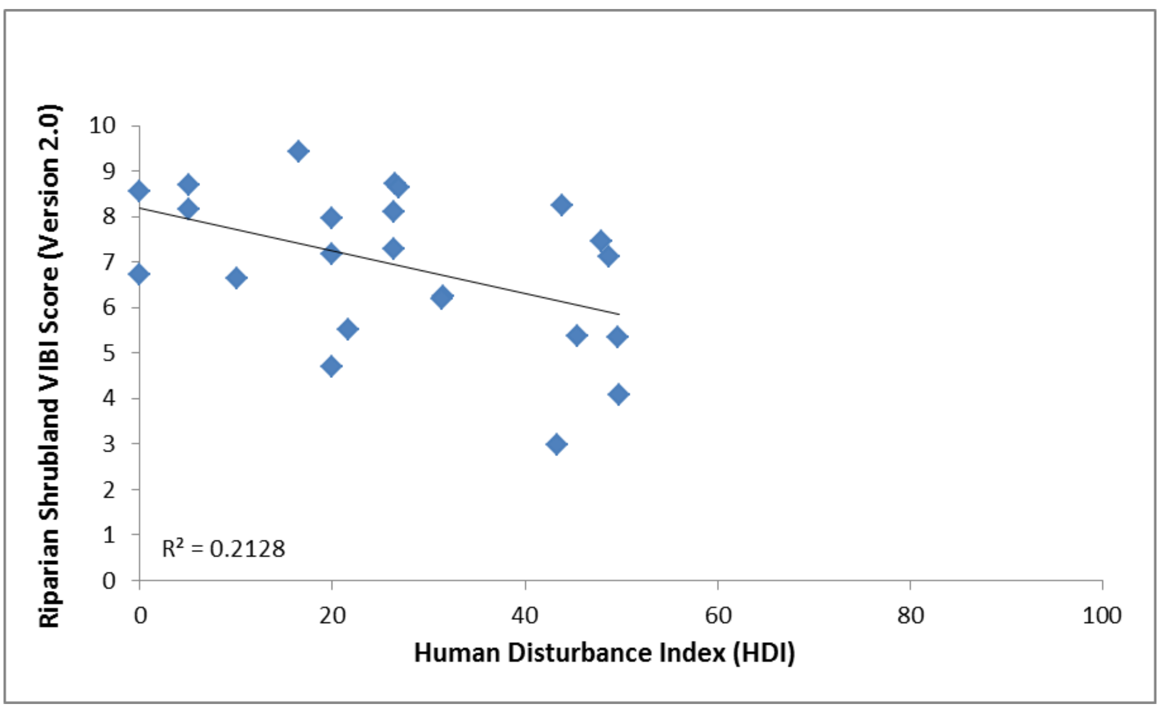


Figure 43. Correlation of estimated Riparian Shrubland VIBI scores to the Human Disturbance Index (HDI).

4.6.3 Fens

Using metrics and scoring formulas from version 2.0 of the fen VIBI model (Lemly and Rocchio 2009b), sites in the North Platte River Basin scored between 8.10–8.90, with a mean of 8.48 and standard deviation of 0.36. All five of the sites fell well in the high VIBI integrity class based on the calibration of the fen model. Most (4 of 5) of the fens surveyed had a perfect HDI of zero, so correlations of the HDI scores with the VIBI scores are not informative. It appears that the fens surveyed have very high biotic integrity.

4.7 Empirical Model of Wetland Ecological Integrity

A spatially explicit empirical model of wetland condition across the North Platte River Basin was developed through multiple regression of 26 landscape-level predictor variables. Using stepwise model selection, the best model contained eight of the 26 possible predictors (Table 35). The regression model of these eight predictors explained 83% of the variation within the observed EIA scores (adjusted $R^2 = 0.83$, $F_{(8,86)} = 59.14$, $p < 0.001$). Performance of the model was evaluated using leave-one-out cross validation. Results of this test show that the model predicted the correct EIA rank 78% of the time (Table 36). The most common types of error in prediction included under-ranking A sites and over-ranking C sites.

Table 35. Selected variables included in the predictive model of wetland condition.

Predictor variable	Effect on EIA Score (+/-)	β	p-value
Elevation	+	0.238	<0.001
Distance to nearest groundwater well	+	0.096	<0.001
Distance to nearest major road	+	0.094	<0.01
Density of dams and diversion per upstream stream mile	-	-0.037	<0.01
Closed tree canopy in 500 m envelope	+	0.239	0.14
Open tree canopy in 500 m envelope	+	0.128	<0.001
Shrubland in 500 m envelope	+	0.122	<0.001
Developed land in 500 m envelope	-	-0.059	<0.001

Table 36. Fitted vs. actual EIA ranks.

EIA Ranks	Fitted		
Actual	**A**	**B**	**C**
A	**36**	7	0
B	2	**35**	3
C	0	9	**3**

The empirical model was used to predict ecological integrity at 7,830 non-irrigated wetland points across the North Platte basin (Figure 44). Model predictions show the distinct elevation gradient, with A ranked sites occurring in the basin's high elevations and C ranked sites near the center of North Park and along the major roads. Across the basin, the model predicted that 27% of all sites would rank A, 65% would rank B, and only 7% would rank C (Table 37). The model did predict a few D ranked wetlands, but they represented < 1% of the total points. Compared to the estimates derived using survey design parameters (see Section 4.5.2), the regression model predicted more B ranked and fewer A and C ranked wetlands (Table 37).

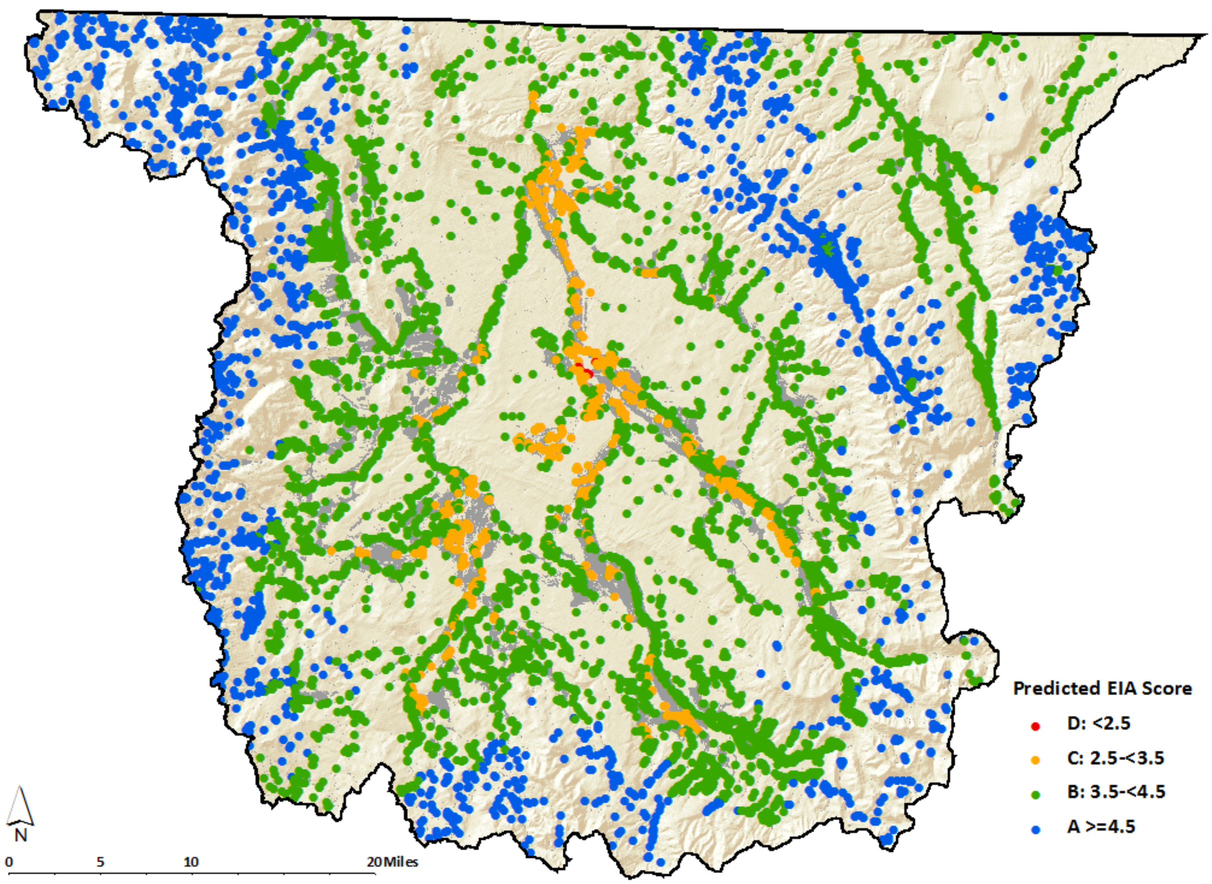


Figure 44. Predicted EIA ranks at 7,830 randomly selected wetland points.

Table 37. Model predicted EIA ranks vs. EIA ranks extrapolated from the survey design.

Estimate Method	EIA Rank			
	A	B	C	D
Model Predicted Scores	27%	65%	7%	< 1%
Survey Design Estimate	34%	48%	17%	0%

The empirical model developed for the North Platte River Basin is essentially a Level 1 assessment of wetland condition specific to this basin. We compared the accuracy of the North Platte empirical model to the existing Level 1 Landscape Integrity Model (LIM) developed for the entire state (see Section 3.1 and Section 4.1.2) by looking at the correlation of both the predicted EIA scores and the modeled LIM values with the observed EIA scores for all sampled wetlands (Figure 45). The empirical model was closely correlated to the observed EIA scores (non-adjusted $R^2 = 0.84$ and correlation coefficient = 0.92), as would be expected. The LIM was also correlated to the observed EIA scores ($R^2 = 0.56$ and correlation coefficient = -0.75), but not as strongly as the empirical model. However, the correlation between the LIM and observed EIA scores was stronger in the North Platte River Basin than in the Rio Grande Headwaters ($R^2 = 0.47$ and correlation coefficient = -0.69: Lemly et al. 2011).

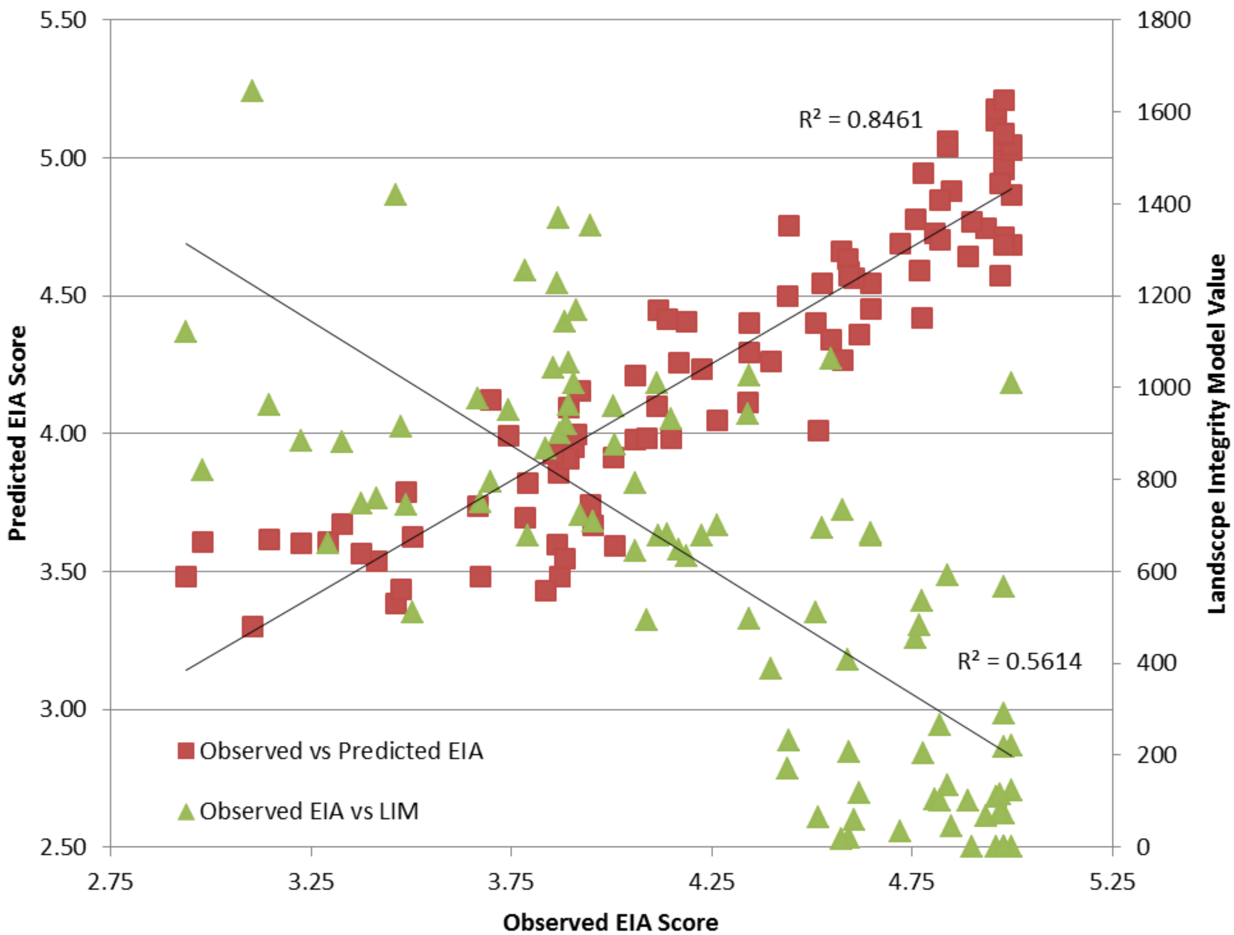


Figure 45. Observed EIA scores vs. predicted EIA scores and LIM values for all sampled wetlands.

4.8 Evaluation of Waterfowl Habitat

For each of the nine wetland habitat types identified as important to dabbling ducks in the Basin (see Table 16), habitat features influencing the value of these wetlands to dabbling ducks were identified for the spring and fall migration, nesting, and brood-rearing periods. Eight measurable habitat features were identified: (1) dominant vegetation type, (2) percent of emergent cover, (3) depth of residual cover, (4) interspersion (ratio of cover to water), (5) size of wetland, (6) landscape context (percent of wetlands or open water on the landscape within a defined buffer of wetland margins or habitat edge), (7) stream flow (cubic feet per second), and (8) stream order; and field measurement protocols were described. Qualitative values (high, medium or low) were assigned to measurable ranges of conditions representing relative value to dabbling ducks, and management practices that could be used to influence habitat value (e.g., as part of wetland restoration or enhancement projects) were described (Appendix G).

Empirical data from field studies in the Basin confirmed that vegetation type and residual cover did influence duck production, with higher production in sites dominated by bulrush and with increasing depth of residual cover (see Appendix H, Figure 1).

5.0 DISCUSSION

5.1 Wetlands of the North Platte River Basin

The North Platte River Basin contains extensive, contiguous wetland area that serves as important habitat for many wildlife species, especially breeding and migratory birds. Limited human development in the basin has preserved intact riparian corridors through the valleys and large wetland complexes on subalpine slopes. Prior to this project, estimates of wetland acreage in the North Platte Basin were based on generalized understandings or loose extrapolations, not systematic mapping or accounting. An early study by the USFWS estimated wetland acreage in the North Park valley at 32,965 acres (USFWS 1995), but this estimate likely did not include irrigated hay pastures. National Wetland Inventory mapping digitized for this project places the aerial extent of wetlands and water bodies at 138,043 acres (131,642 acres of wetlands and 6,402 acres of lakes and rivers). Of the wetland acres, 94,613 acres occur in the North Park valley (21i: Sagebrush Parks ecoregion). Based on NWI mapping, over 10% of the basin is mapped as wetlands. Though wetland mapping is not complete across the state, it is estimated that only 2% of Colorado would be mapped as wetlands (Dahl 1990), making the North Platte Basin significantly wetter than many other regions of the state.

5.1.1 Irrigated Wetlands

It is impossible to talk about wetlands in the North Platte River Basin without talking about the role irrigation plays in creating and maintaining them. Though North Park is known for extensive riparian shrublands along the basin's many streams, herbaceous wetlands account for 77% of all mapped wetlands. Herbaceous wetlands are especially concentrated in the Sagebrush Parks ecoregion and 75% of all herbaceous wetlands are mapped as irrigated lands. Across all mapped wetlands, nearly 60%, or >78,000 acres, are mapped as irrigated lands.

Most mapped irrigated wetlands are actively managed as hay fields and harvested every year. However, 3,000–5,000 acres mapped as both wetland and irrigated lands are shrublands, ponds, and stream banks on the edges of hay pastures. These areas receive irrigation flows, but are not harvested. There are also >5,000 irrigated acres mapped in NWI on lands managed by the USFWS or CPW for wildlife habitat. Many of these areas are also not harvested for hay. The *Comprehensive Conservation Plan* of the Arapaho National Wildlife Refuge (ANWR) actually places the extent of irrigated meadows on the ANWR closer to 9,500 acres (USFWS 2004).

Irrigation waters likely affect even more acreage than what is mapped as irrigated. Many riparian shrublands adjacent to hay pastures are influenced by irrigation return flows, but are not mapped as irrigated. In addition to lands mapped as both wetlands and irrigated lands, there are 32,000 acres mapped as irrigated lands that are not mapped as wetlands. The wetland mapping used for this project was originally delineated in the 1980s, while the irrigated lands layer is from 2005. Some irrigated lands that are not mapped as wetlands by NWI may be newly irrigated since the 1980s and would be mapped as wetlands if NWI was updated.

Irrigation practices in North Park have greatly influenced the landscape and expanded the wetland resource. Diversions draw water from the basin's many streams and rivers during spring runoff and release it slowly over hay fields, extending the residence time of surface water, increasing groundwater recharge, and delaying return flows to streams. Throughout the west, irrigation waters create or augment wetlands along leaky ditches or in ponded depressions, and in some instances, irrigated fields themselves develop wetland characteristics (Peck and Lovvorn 2001; Adamus 1993). In North Park, spring flooding is so extensive that wetland characteristics have developed within many hay fields.

Beaver (*Castor canadensis*) were once abundant throughout Colorado, including North Park (USFWS 2004; Hay 2010). However, by the 1850s and prior to permanent settlement of the North Park valley, fur trapping had dramatically reduced their populations. In the long distance past, beaver dams may have helped retain water within the riparian floodplains of North Park, but today their numbers are concentrated in higher elevations. While beaver influence is mapped on up to 41% of wetland acres in the mid- and subalpine elevations, < 1% of wetland acres in the Sagebrush Parks ecoregion received this designation. Within a working landscape, beaver dams can disrupt water management and canal systems, are often regarded as a nuisance, and are actively removed. In their place, irrigation plays an important role in maintaining the basin's wetlands and has likely added considerable wetland area above what would have been found in the basin prior to settlement. Quantifying the specific role that beaver once played in supporting floodplain wetlands in North Park and the current role irrigation plays is worth additional research.

Though irrigated hay meadows are a significant portion of the wetland resource, we decided early in the project to focus our condition assessment sampling effort on natural or naturalized wetlands and to avoid areas actively managed for hay production. This was a different approach than we took in the Rio Grande Headwaters assessment, where hay meadows were included in the field sample. Not including hay meadows in North Platte allowed us to diversify the types of wetlands we could sample and to draw more specific conclusions about non-hay meadow wetlands. Meadows managed for hay production are relatively consistent across the basin. Most have been seeded at one point in time with introduced (non-native) pasture grasses such as meadow foxtail (*Alopecurus pratensis*), timothy grass (*Phleum pratense*), or Kentucky bluegrass (*Poa pratensis*), but they also contain a mix of native sedges, grasses, and forbs. The dominance of non-native species would affect FQA and biotic EIA scores. Because hay meadows are specifically managed for the production of these non-native species, we felt evaluating them again the reference standard (minimal or no human influence) would be the wrong standard. Instead, we report out on the proportion of wetland acres managed as hay pastures, but not on their ecological condition. In essence, we are considering hay pasture to be a condition state. Hay fields do serve as important waterfowl habitat (Adamus 1993) and CPW, USFWS and Ducks Unlimited are currently investigating how they are used by birds. The habitat metrics contained in Appendix G would be a useful tool to measure the habitat value of hay meadows. In future studies of wetlands in the North Platte and other river basins, it would be useful to look at hay meadows through the lens of a habitat evaluation.

5.1.1 Non-Irrigated Wetlands

There is great diversity among the 40% of wetlands (53,505 acres) not mapped as irrigated lands. Lower elevations contain extensive tall stature riparian shrublands, natural wet meadows, alkaline basins, and marsh vegetation along lakeshores and ponds. Higher elevations contain short stature shrublands, beaver influenced riparian corridors, kettle ponds, fens, and alpine wet meadows. While previous studies of North Platte wetlands have focused on specific wetlands areas or types, or have targeted wetlands with the highest biodiversity significance, this study of randomly selected wetlands sought to characterize wetland types proportional to their abundance across the basin.

Targeted and random sample surveys are different, but complimentary approaches. Targeted surveys produce more detailed information on individual wetlands or specific wetland types, but random surveys set those studies in context of the entire wetland resource and can highlight their importance. For example, fens are considered highly significant wetlands because they contain many rare plant species and thick organic soil takes centuries to develop. In the current study, no fens were found in the Sagebrush Parks ecoregion, but they are known to occur there. In 2002 and 2003, seventeen fen complexes were identified on BLM lands in North Park (Johnson and Gerhardt 2004, 2005). One newly documented fen was found on the edge of the North Park valley during targeted surveys in 2009 (Culver et al. 2010). The fact that none were encountered in this survey suggested that low elevation fens likely comprise less than 1% of non-irrigated wetland area, emphasizing the need to preserve them when found. Targeted studies of high elevation fens in the North Platte Basin have also located many populations of state rare fen-specific vascular plants (Culver et al. 2010). High elevation fens encountered in this study did contain a handful of state rare species, but several others species known from the basin were not found. Riparian shrubland, wet meadow, and marsh communities documented here, however, are consistent with other studies from the basin (Johnson 1941; Kettler and McMullen 1996; Sanders 1997; Lewis 2001).

5.2 Ecological Condition of Wetlands in the North Platte River Basin

This study used four separate approaches to assess the condition of North Platte wetlands.

1. Conceptual Level 1 Landscape Integrity Model (LIM) developed for use statewide and based on best profession judgment of stressor impacts.
2. Level 2 Ecological Integrity Assessment (EIA) method, including metrics from the Floristic Quality Assessment (FQA).
3. Level 3 Vegetation Index of Biotic Integrity (VIBI) scores for selected wetlands and wetland types.
4. Empirical Level 1 model of condition based on a multiple regression of EIA scores and GIS predictors.

Each approach produced slightly different results, but the same general trends are evident from all four methods.

The Level 1 LIM placed only 11% of wetland area within no or low stress classes, 12% within the moderate stress class, 50% within the high stress class, and the remaining 27% within severe stress class. These results include irrigated wetlands, which were removed from the Level 3 and Level 3 surveys and empirical model. If irrigated lands are removed from the LIM analysis, 24% of wetland area is classified as no or low stress, 15% moderate stress, 39% high stress, and 22% severe stress. In the Rio Grande Headwaters Basin, results indicated that the LIM overestimated both ends of the spectrum (no/low stress and severe stress), at least when compared with field-based EIA scores (Lemly et al. 2011). In the North Platte, LIM scores were much lower than EIA scores across the board, though the two sets of scores were correlated.

The LIM has not been rigorously calibrated and represent the first version of a statewide Level 1 assessment tool for Colorado. While 61% of non-irrigated wetlands were modeled as high or severe stress in the LIM, there were no D-ranked and few C-ranked wetlands based on Level 2 field scores. This discrepancy indicates that threshold breaks between classes within the LIM are either set too low or that individual LIM variable thresholds and weights are set too high. The information from this study and future basinwide assessments will help calibrate future iterations of the LIM model. However, the LIM model does show overall spatial trends that make sense for the basin and are consistent with both the Level 2 scores and the empirical model of wetland ecological integrity. Higher stress wetlands are located in the valleys where human activities have altered the landscape. Lower stress wetlands occur at higher elevations where there is less human-caused disturbance.

Level 2 EIA scores showed that a majority of non-irrigated wetlands (82%) ranked either A or B, meaning they are either in reference condition or deviate only slightly from reference condition. An additional 17% were ranked C, meaning a moderate deviation from reference condition that would warrant some type of management or restoration. It is possible that the range of field scores was influenced by the suite of sites where access was granted. Many private land owners denied access and our final sample was skewed more heavily towards public land than the actual distribution of wetlands. However, vegetation analysis showed no significant differences between plant communities on public and private lands and C-ranked wetlands were sampled on both public and private lands. Level 2 scores varied by both ecoregion and wetland type. Scores were higher in the higher elevation ecoregions and lower at low elevations. Wetland types common at high elevations (fens and riparian woodlands) consistently ranked high, while wetland types that also occurred at lower elevations (riparian shrublands and wet meadows) ranked lower. However, there were A-ranked or B-ranked wetlands in all wetland types and no one wetland type was consistently ranked low.

Level 3 scores were specific to wetland type and did not produce overall estimates, but reflected similar trends as the Level 2 scores. Fens universally received high VIBI scores, while wet meadows and riparian shrublands had mostly high and a few lower scores. Level 3 methods are still in development and need further refinement before they can be used to reliable indicate condition.

The empirical Level 1 model predicted more B-ranks and fewer A and C ranks than were observed, but was highly correlated with Level 2 scores. The key role geography plays in wetland condition in the basin is evident from the empirical model. Several of the variables included within the model were related to geography, including elevation and closed tree canopy, open tree canopy, and shrublands surrounding the wetlands. While open and closed tree canopies are far more common at higher elevations than in the valleys, shrublands occur within riparian corridors across the elevation gradient. The fact that all three wooded land covers were important in predicting condition on a landscape scale may imply that wooded buffers are effective at dampening the potential impacts of stressors. The remaining variables within the model highlight some of the major stressors to wetlands: roads, groundwater wells, dams and diversions, and developed land.

The empirical Level 1 model was more closely correlated with the Level 2 EIA scores than was the conceptual Level 1 LIM. The empirical model better depicts wetland condition within North Platte River Basin because the model was fit using field data from the basin. Because condition in the North Platte is tied closely to the elevation, the model relies heavily on elevation and landcover data. It is likely that this specific model would not perform as well in other parts of the state, such as the eastern plain, where elevation is not a factor. The LIM, on the other hand, is intended to capture the potential range of wetland condition across the entire state, and is based largely on best professional judgment instead of field scores. Once we have carried out several field-based condition assessment projects, we will reevaluate the LIM to see if the model can be calibrated to more accurately reflect on-the-ground condition.

Across all methods, the results clearly indicate that wetlands in the North Platte River Basin are in good condition. On the ground surveys found no D-ranked wetlands. This is not because the D-rank criteria are too stringent. Surveys in the Rio Grande Headwaters Basin and in the Front Range have found many D-ranked wetlands. The lack of Ds and low proportion of Cs indicate the basin contains many healthy, intact wetlands. The landscape of the basin is less fragmented than other parts of the state and wetlands generally have good buffers. Localized hydrologic modifications are evident, but few wetlands had signs of severe hydrologic alteration that would significantly threaten wetland health. There is little substrate disturbance and no obvious visual signs of water quality impairment. Biotic condition is generally high. Very few noxious weeds were observed in the wetlands, though Canada thistle was found in a handful of sites. Several sites in the Sagebrush Parks ecoregion had high cover of non-native pasture grasses because they were former hay fields or were adjacent to hay fields. These grasses were intentionally introduced into the basin, but do bring down the Mean C and biotic EIA scores. Restoring the native species composition of old hay fields would bring up both biotic and overall EIA scores. But many wetlands had very high Mean C and biotic scores, indicative of thriving, diverse native plant communities.

Grazing by livestock and browse by native ungulates were the most common stressors observed within North Platte wetlands. The prevalence of grazing is consistent with the fact that the dominant land use in the basin is cattle ranching. However, grazing impacts were rarely considered severe. Severe grazing may exist within the basin, but was not observed in this study either because we were not allowed access to severely grazed wetlands or because they are uncommon. The effects of grazing on wetland and riparian vegetation have been well documented (Kauffman and Krueger 1984). Research within the North Platte River Basin has shown that severe grazing can have long term impacts to the structure of wetland vegetation (Knopf and Connon 1982). Continuing best management practices for cattle, such as fencing off stream channels and rotating grazing, will maintain the current balance between cattle ranching and healthy wetland systems. Grazing was also common in lands surrounding wetlands, as were dirt roads, logging, recreation, hay pastures, development, and disturbed lands. Oil and gas wells were not observed within this study, but drilling in the basin has increased even since 2010 and could potentially lead to significant impacts in coming years.

5.3 Evaluation of Waterfowl Habitat

Overall condition as measured in this study provides CPW with a general sense of wetland ecological health within the basin. The methods used do not address habitat quality for specific wildlife species, but it can be assumed that good condition wetlands provide good habitat. Through this project, specific habitat metrics were identified for dabbling ducks, but were not developed in time to use in the assessment of wetland condition. The metrics developed, however, have paved the way for similar research in subsequent projects. In future basinwide studies, we will develop wildlife habitat metrics before conducting field work so our results can describe both general wetland ecological condition and specific habitat quality. In addition to waterfowl, habitat quality metrics also should be developed for other wildlife species/guilds.

Though concurrent field studies conducted by CPW, two of the eight habitat value factors identified as important to dabbling ducks (vegetation type and residual cover depth) were evaluated and shown to influence duck production. The importance of the other factors should be addressed in future field studies.

Of the 138,043 acres of wetlands and water bodies mapped in the North Platte River Basin, 90% (124,350 acres) were identified as important to waterfowl. This justifies continued emphasis on wetland conservation in this basin by CPW and partner agencies and organizations with shared missions to conserve wetland-dependent wildlife. The prevalence of irrigated hay meadows (54% of all NWI mapped acres) in relation to other wetland types warrants new field studies to determine the importance of this habitat to wildlife. Other habitat types represent far fewer acres, and could be selectively managed for. Beaver dams in particular, were restricted to higher elevations, but could be encouraged or protected throughout the basin where compatible with current land use.

5.4 Management Implications

The result of this study can be used to inform future management decisions in the basin. Though detailed recommendations for individual properties are outside the scope of this project, the following include major recommendations that could be implemented by CPW and partners across the basin.

- Continue or expand voluntary, incentive-based programs to protect, restore, enhance, or create wetlands on private lands, including irrigated wetlands.
- Protect low elevation fens, which are rare compared to fens at higher elevations.
- Increase riparian fencing to protect riparian shrublands and stream banks.
- Fence beaver pond complexes to restrict grazing by domestic livestock.
- Restore native species composition of old hay fields and encourage the growth of new willow stands.
- Study the importance of irrigated wet meadows to wildlife.
- Study other habitat value factors for dabbling duck abundance and vital rates.

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APPENDIX A: Field Key to Wetland and Riparian Ecological Systems of Montana, Wyoming, Utah, and Colorado

1a. Wetland defined by groundwater inflows and peat (organic soil) accumulation of at least 40 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 hectares (0.25 acres). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criteria. .... **Rocky Mountain Subalpine-Montane Fen**

1b. Wetland does not have at least 40 cm of peat (organic soil) 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 hectares and occur within a matrix of woody vegetation. Note: Relictual woody vegetation such as standing dead trees and shrubs are included here........ **GO TO KEY A: Woodland and Shrubland Ecological Systems**

2b. Total woody canopy cover generally less than 25% within the overall wetland/riparian area. Any woody vegetation patches are less than 0.5 hectares and occur within a matrix of herbaceous wetland vegetation **3**

3a. Total vegetation canopy cover generally 10% or more .... **GO TO KEY B: Herbaceous Ecological Systems**

3b. Total vegetation canopy cover generally less than 10% .... **GO TO KEY C: Sparse Vegetation**

KEY A: Woodland and Shrubland Ecological Systems

1a. Woody wetland associated with any stream channel, including ephemeral, intermittent, or perennial (Riverine HGM Class) **2**

1b. Woody wetland associated with the discharge of groundwater to the surface or fed by snowmelt or precipitation. This system often occurs on slopes, lakeshores, or around ponds. Sites may experience overland flow but no channel formation. (Slope, Flat, Lacustrine, or Depressional HGM Classes) **9**

2a. Riparian woodlands and shrublands of the montane or subalpine zone (refer to lifezone table) **3**

2b. Riparian woodlands and shrublands of the plains, foothills, or lower montane zone (refer to lifezone table) **4**

3a. 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*, *Pseudotsuga menziesii*, and *Populus tremuloides*........ **Rocky Mountain Subalpine-Montane Riparian Woodland**

3b. Montane or subalpine riparian shrublands (canopy dominated by shrubs with sparse or no tree cover). Within the Riverine HGM Class, this system occurs as either a narrow band of shrubs lining streambanks of steep V-shaped canyons *or* as a wide, extensive shrub stand on alluvial terraces in low-gradient valley bottoms (sometimes referred to as a shrub carr). Beaver activity is common within the wider occurrences. Species of *Salix*, *Alnus*, or *Betula* are typically dominant........ **Rocky Mountain Subalpine-Montane Riparian Shrubland**

4a. Riparian woodlands and shrublands of the foothills or lower montane zones of the Northern, Middle, and Southern Rockies, Wyoming Basin, Wasatch and Uinta Mountains, and Great Basin **5**

4b. Riparian woodlands and shrublands of the Northwestern or Western Great Plains of eastern Montana, central Wyoming, or northeastern Colorado.. **7**

5a. Foothill or lower montane riparian woodlands and shrublands associated with mountain ranges of the Northern Rockies in northwestern Montana. This type *excludes* island mountain ranges east of the Continental Divide in Montana. *Populus balsamifera* ssp. *trichocarpa* is typically the canopy dominant in woodlands. Other common tree species include *Populus tremuloides*, *Betula papyifera*, *Betula occidentalis*, and *Picea glauca*. Shrub understory species include *Cornus sericea*, *Acer glabrum*, *Alnus incana*, *Oplopanax horridus*, and *Symphoricarpos albus*. Areas of riparian shrubland and open wet meadow are common.................. ....**Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland**

5b. Foothill or lower montane riparian woodlands and shrublands of other mountain regions............................. **6**

6a. Foothill or lower montane riparian woodlands and shrublands associated with mountain ranges of the Southern and Middle Rockies, Wyoming Basin, and Wasatch and Uinta Mountains. This type also includes island mountain ranges in central and eastern Montana. Woodlands are dominated by *Populus* spp. including *Populus angustifolia*, *Populus balsamifera* ssp. *trichocarpa*, *Populus deltoides*, and *Populus fremontii*. Common shrub species include *Salix* spp., *Alnus incana*, *Crataegus* spp., *Cornus sericea*, and *Betula occidentalis*..........**Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

6b. Foothill or lower montane riparian woodlands and shrublands associated with mountain ranges of the Great Basin in Utah. Woodlands are dominated by *Abies concolor*, *Populus angustifolia*, *Populus balsamifera* ssp. *trichocarpa*, *Populus fremontii*, and *Pseudotsuga menziesii*. Important shrub species include *Artemisia cana*, *Betula occidentalis*, *Cornus sericea*, *Salix exigua*, *Salix lutea*, *Salix lemmonii*, and *Salix lasiolepis*.................... **Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland**

7a. Woodlands and shrublands of draws and ravines associated with permanent or ephemeral streams, steep north-facing slopes, or canyon bottoms that do not experience flooding. Common tree species include *Fraxinus* spp., *Acer negundo*, *Populus tremuloides*, and *Ulmus* spp. Important shrub species include *Crataegus* spp., *Prunus virginiana*, *Rhus* spp., *Rosa woodsii*, *Symphoricarpos occidentalis*, and *Shepherdia argentea*. .... **Western Great Plains Wooded Draw and Ravine**

7b. Woodlands and shrublands of small to large streams and rivers of the Northwestern or Western Great Plains. Overall vegetation is lusher than above and includes more wetland indicator species. Dominant species include *Populus balsamifera* ssp. *trichocarpa*, *Populus deltoides*, and *Salix* spp. **8**

8a. Woodlands and shrublands of riparian areas of medium and small rivers and streams with little or no floodplain development and typically flashy hydrology.. ....**Northwestern/Western Great Plains Riparian**

8b. Woodlands and shrublands of riparian areas along medium and large rivers with extensive floodplain development and periodic flooding................. **Northwestern/Western Great Plains Floodplain**

9a. Woody wetland associated with small, shallow ponds in northwestern Montana. Ponds are ringed by trees including *Populus balsamifera* ssp. *trichocarpa*, *Populus tremuloides*, *Betula papyrifera*, *Abies grandis*, *Abies lasiocarpa*, *Picea engelmannii*, *Pinus contorta*, and *Pseudotsuga menziesii*. Typical shrub species include *Cornus sericea*, *Amelanchier alnifolia*, and *Salix* spp. .... **Northern Rocky Mountain Wooded Vernal Pool**

9b. Woody wetland associated with the discharge of groundwater to the surface, or sites with overland flow but no channel formation. **10**

10a. Coniferous woodlands associated with poorly drained soils that are saturated year round or seasonally flooded. Soils can be woody peat but tend toward mineral. Common tree species include *Thuja plicata*, *Tsuga heterophylla*, and *Picea engelmannii*. Common species of the herbaceous understory include *Mitella* spp., *Calamagrostis* spp., and *Equisetum arvense* .... **Northern Rocky Mountain Conifer Swamp**

10b. Woody wetlands dominated by shrubs.. **11**

11a. Subalpine to montane shrubby wetlands that occur around seeps, fens, lakes, and isolated 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. Vegetation dominated by species of *Salix*, *Alnus*, or *Betula.* Within Slope, Flat, Lacustrine, or Depressional HGM Classes, this system has a similar species composition as occurrences within the Riverine HGM Class, but occurs in different landscape settings .... **Rocky Mountain Subalpine-Montane Riparian Shrubland**

11b. Lower foothills to valley bottom shrublands restricted to temporarily or intermittently flooded drainages or flats and dominated by *Sarcobatus vermiculatus* .... **Inter-Mountain Basins Greasewood Flat**

KEY B: Herbaceous Wetland Ecological Systems

1a. Herbaceous wetlands of the Northwestern Glaciated Plains, Northwestern Great Plains, or Western Great Plains regions of eastern Montana, central Wyoming, or northeastern Colorado **2**

1b. Herbaceous wetlands of other regions **5**

2a. Wetland occurs as a complex of depressional wetlands within the glaciated plains of northern Montana. Typical species include *Schoenoplectus* spp. and *Typha latifolia* on wetter, semi-permanently flooded sites, and *Eleocharis* spp., *Pascopyrum smithii*, and *Hordeum jubatum* on drier, temporarily flooded sites .... **Great Plains Prairie Pothole**

2b. Wetland does not occur as a complex of depressional wetlands within the glaciated plains of Montana **3**

3a. Depressional wetlands in the Western Great Plains with saline soils. Salt encrustations can occur on the surface. Species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Salicornia* spp., and *Schoenoplectus maritimus*.................................. **Western Great Plains Saline Depression Wetland**

3b. Depressional wetlands in the Western Great Plains with obvious vegetation zonation dominated by emergent herbaceous vegetation, including *Eleocharis* spp., *Schoenoplectus* spp., *Phalaris arundinacea*, *Calamagrostis canadensis*, *Hordeum jubatum*, and *Pascopyrum smithii* **4**

4a. Depressional wetlands in the Western Great Plains associated with open basins that have an obvious connection to the groundwater table. This system can also occur along stream margins where it is linked to the basin via groundwater flow. Typical plant species include species of *Typha*, *Carex*, *Schoenoplectus*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*.. .... **Western Great Plains Open Freshwater Depression Wetland**

4b. Depressional wetlands in the Western Great Plains primarily within upland basins having an impermeable layer such as dense clay. Recharge is typically via precipitation and runoff, so this system typically lacks a groundwater connection. Wetlands in this system tend to have standing water for a shorter duration than Western Great Plains Open Freshwater Depression Wetlands. Common species include *Eleocharis* spp., *Hordeum jubatum*, and *Pascopyrum smithii* .... **Western Great Plains Closed Depression Wetland**

5a. Small (<0.1 ha) depressional, herbaceous wetlands occurring within dune fields of the Great Basin, Wyoming Basin, and other small inter-montane basins.. **Inter-Mountain Basins Interdunal Swale Wetland**

5b. Herbaceous wetlands not associated with dune fields **6**

6a. Depressional wetlands occurring in areas with alkaline to saline clay soils with hardpans. Salt encrustations can occur on the surface. Species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Leymus* sp., *Poa secunda*, *Salicornia* spp., and *Schoenoplectus maritimus*. Communities within this system often occur in alkaline basins and swales and along the drawdown zones of lakes and ponds. .... **Inter-Mountain Basins Alkaline Closed Depression**

6b. Herbaceous wetlands not associated with alkaline to saline hardpan clay soils. **7**

7a. Wetlands with a permanent water source 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 species including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Juncus*, *Carex*, *Potamogeton*, *Polygonum*, and *Nuphar*. ....**Western North American Emergent Marsh**

7b. Herbaceous wetlands associated with a high water table or overland flow, but typically lacking standing water. Sites with *no channel formation* are typically associated with snowmelt 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 and may be subjected to high disturbance events such as flooding (Riverine HGM Class). 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**

KEY C: Sparsely Vegetated Ecological Systems

1a. Sites are restricted to drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia cana*, *Artemisia tridentata*, *Grayia spinosa*, *Distichlis spicata*, and *Sporobolus airoides*. ....**Inter-Mountain Basins Wash**

1b. Sites occur on barren or sparsely vegetated playas that are intermittently flooded and may remain dry for several years. Soil is typically saline, and salt encrustrations are common. Plant species are salt-tolerant and can include *Sarcobatus vermiculatus*, *Distichlis spicata*, and *Atriplex* spp. ....**Inter-Mountain Basins Playa**

Appendix A, Table 1. General life zones found in Colorado, Montana, Wyoming, and Utah. Note that elevations at which a life zone begins and ends is dependent upon latitude, aspect, and topographic variation.

	Colorado		Montana		Wyoming		Utah	
Life Zone	Elevation range (feet)	Dominant vegetation	Elevation range (feet)	Dominant vegetation	Elevation range (feet)	Dominant vegetation	Elevation range (feet)	Dominant vegetation
Foothills - Lower Montane	<5,500-8,000	Gambel oak, pinon-juniper, sagebrush in foothills to ponderosa pine, Douglas-fir in lower montane	<4,000-6,000	bunchgrasses, ponderosa pine, juniper, sagebrush	>5,000-6,000	bunchgrasses, ponderosa pine, juniper, sagebrush	<5,500-8,000	pinyon-juniper woodlands, oak-maple shrublands.
Montane	8,000-9,500	Douglas-fir, lodgepole pine, aspen	>4,500-7,600	Douglas-fir, spruce, cedar, lodgepole pine	6,000-7,600	Douglas-fir, spruce, lodgepole pine	8,000-9,500	lodgepole pine, ponderosa pine, aspen, Douglas-fir
Subalpine	9,500-11,500	subalpine fir, Engelmann spruce	5,000-8,800	subalpine fir, Engelmann spruce	7,600-10,000	subalpine fir, Engelmann spruce	>9,500	spruce-fir
Alpine	>11,500	grassland/tundra	>6,000-8,800	grassland/tundra	>10,000	grassland/tundra	>11,200	grassland/tundra

APPENDIX B: Field Key to Hydrogeomorphic Classes in the Rocky Mountains

1a. Entire wetland unit is flat and precipitation is the primary source (>90%) of water. Groundwater and surface water runoff are not significant sources of water to the unit ....**Flats HGM Class**

1b. Wetland does not meet the above criteria; primary water sources include groundwater and/or surface water **2**

2a. Entire wetland unit meets ***all*** of the following criteria: a) the vegetated portion of the wetland is on the shores of a permanent open water body at least 8 ha (20 acres) in size; b) at least 30% of the open water area is deeper than 2 m (6.6 ft); c) vegetation in the wetland experiences bidirectional flow as the result of vertical fluctuations of water levels due to rising and falling lake levels. ....**Lacustrine Fringe HGM Class**

2b. Wetland does not meet the above criteria; wetland is not found on the shore of a water body, water body is either smaller or shallower, OR vegetation is not effected by lake water levels.. **3**

3a. Entire wetland unit meets ***all*** of the following criteria: a) wetland unit is in a valley, floodplain, or along a stream channel where it is inundated by overbank flooding from that stream or river; b) overbank flooding occurs at least once every two years; and c) wetland does not receive significant inputs from groundwater. **NOTE:** *Riverine wetlands can contain depressions that are filled with water when the river is not flooding such as oxbows and beaver ponds*.. **Riverine HGM Class**

3b. Wetland does not meet the above criteria; if the wetland is located within a valley, floodplain, or along a stream channel, it is outside of the influence of overbank flooding or receives significant hydrologic inputs from groundwater. **4**

4a. Entire wetland unit is located in a topographic depression in which water ponds or is saturated to the surface at some time during the year. **NOTE:** *Any outlet, if present, is higher than the interior of the wetland.* ....**Depressional HGM Class**

4b. Wetland does not meet all of the above criteria. Instead, wetland meets part or all if the following : a) wetland is on a slope (slope can be very gradual or nearly flat); b) groundwater is the primary hydrologic input; c) water, if present, flows through the wetland in one direction and usually comes from seeps or springs; and d) water leaves the wetland without being impounded. **NOTE:** *Small channels can form within slope wetlands, but are not subject to overbank flooding. Surface water does not pond in these types of wetlands, except occasionally in very small and shallow depressions or behind hummocks (depressions are usually < 3ft diameter and less than 1 foot deep).* .... **Slope HGM Class**

Adapted from:

- Hruby, Tom. (2004) *Washington State Wetland Rating System for Eastern Washington - Revised.* Publication #04-06-15. Washington State Department of Ecology, Olympia, Washington.
- Williams, H. M., A. J. Miller, R. S. McNamee, and C. V. Klimas. (2010) *A Regional Guidebook for Applying the Hydrogeomorphic Approach to the Functional Assessment of Forested Wetlands in Alluvial Valleys of East Texas.* ERCD/EL TR-10-17. Army Corps of Engineers, Engineer Research and Development Center, Wetlands Regulatory Assistance Program. 144 p.

APPENDIX C: NWI Codes Included in the North Platte River Basin Sample Frame

Appendix Table C1: NWI codes included in the North Platte wetland condition assessment sample frame.

Attribute	System	Class	Regime	Modifier	Area (m2)	% of Total Area Mapped by NWI
PABF	Palustrine	Aquatic Bed	Semipermanently Flooded		6,115,625	1.09%
PABFb	Palustrine	Aquatic Bed	Semipermanently Flooded	Beaver	1,322	0.00%
PABFh	Palustrine	Aquatic Bed	Semipermanently Flooded	Diked/Impounded	2,958,069	0.53%
PABFx	Palustrine	Aquatic Bed	Semipermanently Flooded	Excavated	829	0.00%
PABG	Palustrine	Aquatic Bed	Intermittently Exposed		1,131,603	0.20%
PABGb	Palustrine	Aquatic Bed	Intermittently Exposed	Beaver	3,240,811	0.58%
PABGh	Palustrine	Aquatic Bed	Intermittently Exposed	Diked/Impounded	55,725	0.01%
PABKx	Palustrine	Aquatic Bed	Artificially Flooded	Excavated	30,991	0.01%
PEMA	Palustrine	Emergent	Temporarily Flooded		199,677,991	35.63%
PEMAd	Palustrine	Emergent	Temporarily Flooded	Partially Drained/Ditched	3,401	0.00%
PEMAh	Palustrine	Emergent	Temporarily Flooded	Diked/Impounded	321,525	0.06%
PEMAx	Palustrine	Emergent	Temporarily Flooded	Excavated	8,768	0.00%
PEMB	Palustrine	Emergent	Saturated		35,196,844	6.28%
PEMBb	Palustrine	Emergent	Saturated	Beaver	1,588,340	0.28%
PEMC	Palustrine	Emergent	Seasonally Flooded		154,414,125	27.55%
PEMCh	Palustrine	Emergent	Seasonally Flooded	Diked/Impounded	425,691	0.08%
PEMCx	Palustrine	Emergent	Seasonally Flooded	Excavated	535,499	0.10%
PEMF	Palustrine	Emergent	Semipermanently Flooded		2,137,945	0.38%
PEMFh	Palustrine	Emergent	Semipermanently Flooded	Diked/Impounded	112,122	0.02%
PEMFx	Palustrine	Emergent	Semipermanently Flooded	Excavated	6,772	0.00%
PEMKC	Palustrine	Emergent	Artificially Flooded/Seasonally Flooded		15,034,652	2.68%
PFOA	Palustrine	Forested	Temporarily Flooded		514,564	0.09%
PFOAh	Palustrine	Forested	Temporarily Flooded	Diked/Impounded	3,940	0.00%
PFOAx	Palustrine	Forested	Temporarily Flooded	Excavated	5,631	0.00%
PFOB	Palustrine	Forested	Saturated		575,942	0.10%
PFOBb	Palustrine	Forested	Saturated	Beaver	38,075	0.01%
PSSA	Palustrine	Scrub-Shrub	Temporarily Flooded		26,357,828	4.70%
PSSAh	Palustrine	Scrub-Shrub	Temporarily Flooded	Diked/Impounded	11,994	0.00%
PSSAx	Palustrine	Scrub-Shrub	Temporarily Flooded	Excavated	44,974	0.01%
PSSB	Palustrine	Scrub-Shrub	Saturated		28,464,278	5.08%
PSSBb	Palustrine	Scrub-Shrub	Saturated	Beaver	15,228,671	2.72%
PSSBd	Palustrine	Scrub-Shrub	Saturated	Partially Drained/Ditched	113,798	0.02%

PSSC	Palustrine	Scrub-Shrub	Seasonally Flooded		35,935,402	6.41%
PSSCh	Palustrine	Scrub-Shrub	Seasonally Flooded	Diked/Impounded	39,654	0.01%
					Total of all included codes	**94.63%**

Appendix Table C2: Palustrine NWI codes excluded from the North Platte wetland condition assessment sample frame.

Attribute	System	Class	Regime	Modifier	Area (m2)	% of Total Area Mapped by NWI
PUBF	Palustrine	Unconsolidated Bottom	Semipermanently Flooded		1,653,694	0.30%
PUBFx	Palustrine	Unconsolidated Bottom	Semipermanently Flooded	Excavated	177,134	0.03%
PUBG	Palustrine	Unconsolidated Bottom	Intermittently Exposed		42,071	0.01%
PUSA	Palustrine	Unconsolidated Shore	Temporarily Flooded		1,041,919	0.19%
PUSAh	Palustrine	Unconsolidated Shore	Temporarily Flooded	Diked/Impounded	71,988	0.01%
PUSAx	Palustrine	Unconsolidated Shore	Temporarily Flooded	Excavated	2,336	0.00%
PUSC	Palustrine	Unconsolidated Shore	Seasonally Flooded		518,021	0.09%
PUSCd	Palustrine	Unconsolidated Shore	Seasonally Flooded	Partially Drained/Ditched	26,347	0.00%
PUSCh	Palustrine	Unconsolidated Shore	Seasonally Flooded	Diked/Impounded	510,343	0.09%
PUSCx	Palustrine	Unconsolidated Shore	Seasonally Flooded	Excavated	17,017	0.00%
				Total of all excluded Palustrine codes		**0.72%**

Appendix Table C3: Lacustrine and Riverine NWI codes excluded from the North Platte wetland condition assessment sample frame.

Attribute	System	Subsystem	Class	Regime	Modifier	Area (m2)	% of Total Area Mapped by NWI
L1UBG	Lacustrine	Limnetic	Unconsolidated Bottom	Intermittently Exposed		1,161,295	0.21%
L1UBH	Lacustrine	Limnetic	Unconsolidated Bottom	Permanently Flooded		2,487,256	0.44%
L1UBHh	Lacustrine	Limnetic	Unconsolidated Bottom	Permanently Flooded	Diked/Impounded	8,573,331	1.53%
L2ABF	Lacustrine	Littoral	Aquatic Bed	Semipermanently Flooded		304,170	0.05%
L2ABFh	Lacustrine	Littoral	Aquatic Bed	Semipermanently Flooded	Diked/Impounded	3,995,493	0.71%
L2ABG	Lacustrine	Littoral	Aquatic Bed	Intermittently Exposed		1,980,278	0.35%
L2ABGh	Lacustrine	Littoral	Aquatic Bed	Intermittently Exposed	Diked/Impounded	491,469	0.09%
L2UBF	Lacustrine	Littoral	Unconsolidated Bottom	Semipermanently Flooded		4,766	0.00%

L2UBG	Lacustrine	Littoral	Unconsolidated Bottom	Intermittently Exposed		459,921	0.08%
L2USA	Lacustrine	Littoral	Unconsolidated Shore	Temporarily Flooded		321,398	0.06%
L2USAh	Lacustrine	Littoral	Unconsolidated Shore	Temporarily Flooded	Diked/Impounded	27,060	0.00%
L2USC	Lacustrine	Littoral	Unconsolidated Shore	Seasonally Flooded		523,325	0.09%
L2USCh	Lacustrine	Littoral	Unconsolidated Shore	Seasonally Flooded	Diked/Impounded	102,903	0.02%
R2UBG	Riverine	Lower Perennial	Unconsolidated Bottom	Intermittently Exposed		51,751	0.01%
R2UBH	Riverine	Lower Perennial	Unconsolidated Bottom	Seasonally Flooded		1,077	0.00%
R2USA	Riverine	Lower Perennial	Unconsolidated Shore	Temporarily Flooded		1,764	0.00%
R3UBF	Riverine	Upper Perennial	Unconsolidated Bottom	Semipermanently Flooded		303,560	0.05%
R3UBFx	Riverine	Upper Perennial	Unconsolidated Bottom	Semipermanently Flooded	Excavated	2,963	0.00%
R3UBG	Riverine	Upper Perennial	Unconsolidated Bottom	Intermittently Exposed		898,705	0.16%
R3UBH	Riverine	Upper Perennial	Unconsolidated Bottom	Seasonally Flooded		2,949,761	0.53%
R3USA	Riverine	Upper Perennial	Unconsolidated Shore	Temporarily Flooded		67,164	0.01%
R3USC	Riverine	Upper Perennial	Unconsolidated Shore	Seasonally Flooded		102,504	0.02%
R4SBA	Riverine	Intermittent	Streambed	Temporarily Flooded		172,663	0.03%
R4SBC	Riverine	Intermittent	Streambed	Seasonally Flooded		352,185	0.06%
R4SBCx	Riverine	Intermittent	Streambed	Seasonally Flooded	Excavated	653,511	0.12%
R4SBKC	Riverine	Intermittent	Streambed	Artificially Flooded /Seasonally Flooded		16,750	0.00%
R4USA	Riverine	Intermittent	Unconsolidated Shore	Temporarily Flooded		17,200	0.00%
				Total of Lacustrine / Riverine codes			**4.64%**

APPENDIX D: North Platte River Basin Wetland Condition Assessment Field Forms and Example Field Maps

2010 NORTH PLATTE BASINWIDE WETLAND CONDITION ASSESSMENT FIELD FORM

LOCATION AND GENERAL INFORMATION

Point Code: ____________________ Site Name: ____ ☐ Level 2 OR ☐ Level 3

Date: _________________________ Surveyors: ____ ☐ Team A ☐ Team B ☐ Team C

General Location: ____ County: ____________________________________

General Ownership: _____________________ Specific Ownership: ____

USGS Quad Name: ____ USGS Quad Code: ____________________________

Directions to Point and Access Comments:

GPS COORDINATES OF TARGET POINT AND ASSESSMENT AREA (NAD 83 UTM Zone ________) Elevation (m): ______________

Point WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

Point is:	AA is:	Dimensions of AA:
____Within target population ____ Not within target population, but within 60 m of target population	____ Centered at point ____ Not centered at point, but includes point ____ Shifted, point outside	____40 m radius circle ____Rectangle, width______ length:______ ____Other, describe and take a GPS Track

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

AA-1 WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

AA-2 WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

AA-3 WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

AA-4 WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

AA-Track Track Name: _____________________________________ Comments: ____

AA Placement and Dimensions Comments:

Is AA Representative of Larger Wetland:

PHOTOS OF ASSESSMENT AREA (Taken at four points on edge of AA looking in. Record WPs of each photo in table above.)

AA-1 Photo #: _____________ Aspect: _____________

AA-2 Photo #: _____________ Aspect: _____________

AA-3 Photo #: _____________ Aspect: _____________

AA-4 Photo #: _____________ Aspect: _____________

Additional AA Photos and Comments:

Point Code__________________

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA

Slope 1 (deg): ________________ Aspect 1 (deg): ________________ Comment: ____

Slope 2 (deg): ________________ Aspect 2 (deg): ________________ Comment: ____

Non-target Inclusions

% AA with > 1m standing water: ______________

% AA with upland inclusions: _________________

Wetland origin

____ Natural feature with minimal alteration

____ Natural feature, but altered or augmented by modification

____ Non-natural feature created by management action

Ecological System (see manual for key and rules on inclusions and pick *only one*) Conf: High Med Low

____SM Riparian Shrubland ____SM Fen ____IMB Greasewood Flat

____SM Riparian Woodland ____ Alpine-Montane Wet Meadow ____IMB Alkaline Closed Depression

____LMF Rip Woodland and Shrubland ____ NA Arid West Emergent Marsh ____IMB Playa

Cowardin Classification (pick *one each*) Conf: 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

HGM Class (pick *only one*) Conf: High Med Low

____Riverine* ____Lacustrine Fringe

____Depressional ____ Slope

____ Flats ____ Unknown

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

RIVERINE SPECIFIC CLASSIFICATION OF THE ASSESSMENT AREA

Confined vs. Unconfined Valley Setting

Estimated Valley Width (m): _________________________________

Estimated Bankfull Width (m): _______________________________

____Confined Valley Setting (valley width < 2x bankfull width)

____Unconfined Valley Setting (valley width ≥ 2x bankfull width)

Hydrologic Regime Conf: High Med Low

____Perennial (streams that hold water throughout the year; water in channel ~80% of the time)

____Intermittent (stream that holds water during wet portions of the year; water in channel 10–80% of the time)

____Ephemeral (channel that holds water only during and immediately after rain events; water in channel <10% of the time)

AA Proximity to Channel and # of Banks Included:

______ Includes (2 banks) ______ Adjacent (1 bank) ______ Far from

Stream Depth at Time of Survey:

______ Wadeable ______ Non-wadeable

VEGETATION ZONES WITHIN THE ASSESSMENT AREA (See manual for rules and definitions. Mark each zone on the site sketch.)

Zone 1 Dom stratum ___________________________ Dom spp: ____ % of AA: ___________

Zone 2 Dom stratum ___________________________ Dom spp: ____ % of AA: ___________

Zone 3 Dom stratum ___________________________ Dom spp: ____ % of AA: ___________

Zone 4 Dom stratum ___________________________ Dom spp: ____ % of AA: ___________

Zone 5 Dom stratum ___________________________ Dom spp: ____ % of AA: ___________

ENVIRONMENTAL AND CLASSIFICATION COMMENTS

ASSESSMENT AREA DRAWING

Add north arrow and approx scale bar. Document vegetation zones, inflows and outflows, and indicate direction of drainage. Include sketch of vegetation plot and soil pit placement.

ASSESSMENT AREA DESCRIPTION AND COMMENTS

Note wildlife species observed:

LEVEL 2 and 3 INTENSIVE DATA COLLECTION

VEGETATION PLOT

For Level 2 Assessments, walk through the AA and identify as many plant species as possible. Skip the vegetation plot set up and spend *no more* than 1–2 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. Estimate ground cover and vertical vegetation structure for the entire AA.

For Level 3 Assessments, carry out the full vegetation plot following directions in the field manual.

GPS COORDINATES OF VEGETATION PLOT (NAD 83 UTM Zone ________)

0 m WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

XP 1 WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

50 m WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

XP 2 WP #: __________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-): ______________

PHOTOS OF VEGETATION PLOT

0 m Photo #: _____________ Aspect: _____________

XP 1 Photo #: _____________ Aspect: _____________

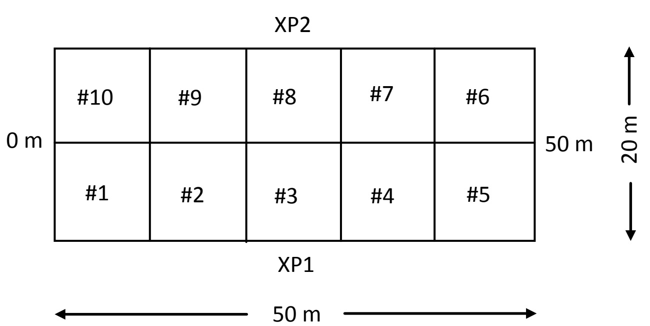
50 m Photo #: _____________ Aspect: _____________

XP 2 Photo #: _____________ Aspect: _____________

Additional AA Photos and Comments:

LAYOUT OF VEGETATION PLOT

Plot layout (circle intensive modules and note any changes to the plot layout, i.e. 1x5 or 2x2 plot)



Plot representativeness (discuss decisions for placement and/or whether the plot is representative of AA)

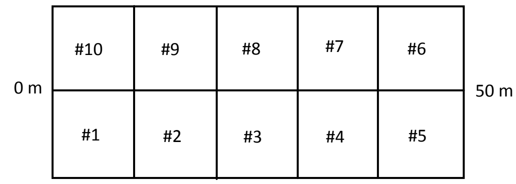
Point Code__________________

VEGETATION PLOT GROUND COVER AND VERTICAL STRATA						
	Module →					**R**
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%						
	Cover Class (unless otherwise noted) →	**C**	**C**	**C**	**C**	**C**
Ground Cover						
	Cover of water (any depth, vegetated or not, standing or flowing)					
Set 1	Cover of shallow water <20 cm / average depth shallow water (cm)	/	/	/	/	/
	Cover of deep water >20 cm / average depth deep water (cm)	/	/	/	/	/
Set 2	Cover of open water with no vegetation					
	Cover of water with submergent or floating aquatic vegetation					
	Cover of water with emergent vegetation					
	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 of litter (all cover, including under water or vegetation)					
	Depth of litter (cm) – average of 4 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 vegetation or litter cover)					
	Cover lichens (all cover, including under vegetation or litter cover)					
	Cover macroalgea (all cover, including under 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										
Cover / Height →	**C**	**H**	**C**	**H**	**C**	**H**	**C**	**H**	**C**	**H**
Vertical Vegetation Strata										
(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)										
(HT) Herbaceous total										
(H1) Graminoids										
(H2) Forbs										
(H3) Ferns and fern allies										
(AQ) Submergent or floating aquatics										

Point Code__________________

Vegetation Plot Species Table: For each intensive module, list all species within and overhanging the module and estimate percent cover for the module. List any species found in the remaining modules in the residual "R" column and estimate percent cover for the entire plot. Mark intensive modules on map for reference.



VEGETATION PLOT SPECIES TABLE												
		Module →									**R**	
		Presence / Cover →	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**
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%												
Stratum	**Species**	**Coll #**										

Point Code___________________

VEGETATION PLOT SPECIES TABLE

		Module →									**R**	
		Presence / Cover →	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**
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%												
Stratum	**Species**	**Coll #**										

SOIL PROFILE DESCRIPTION – SOIL PIT 1 **Module # or GPS Waypoint _____________ (mark on site sketch)**

Soil survey unit: ____ Soil pit matches soil survey unit? ☐ Yes ☐ No Explain in comments.

Depth to saturated soil (cm): ____________ Depth to free water (cm): _____________ ☐ Not observed* Groundwater pH: ______________ EC: ______________ Temp: ______________

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Redox Concentrations Color (moist)	Redox Concentrations %	Redox Depletions Color (moist)	Redox Depletions %	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:

*If free water is not observed in pit, note if pit appears to be filling slowly or if it appears dry.

SOIL PROFILE DESCRIPTION – SOIL PIT 2 **Module # or GPS Waypoint _____________ (mark on site sketch)**

Soil survey unit: ____ Soil pit matches soil survey unit? ☐ Yes ☐ No Explain in comments.

Depth to saturated soil (cm): ____________ Depth to free water (cm): _____________ ☐ Not observed* Groundwater pH: ______________ EC: ______________ Temp: ______________

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Redox Concentrations Color (moist)	Redox Concentrations %	Redox Depletions Color (moist)	Redox Depletions %	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:

*If free water is not observed in pit, note if pit appears to be filling slowly or if it appears dry.

SOIL PROFILE DESCRIPTION – SOIL PIT 3

Module # or GPS Waypoint _______________ (mark on site sketch)

Soil survey unit: ______________________________ Soil pit matches soil survey unit? ☐ Yes ☐ No Explain in comments.

Depth to saturated soil (cm): _____________ Depth to free water (cm): ______________ ☐ Not observed* Groundwater pH: _______________ EC: _______________ Temp: _______________

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Redox Concentrations Color (moist)	%	Redox Depletions 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:

*If free water is not observed in pit, note if pit appears to be filling slowly or if it appears dry.

SOIL PROFILE DESCRIPTION – SOIL PIT 4

Module # or GPS Waypoint _______________ (mark on site sketch)

Soil survey unit: ______________________________ Soil pit matches soil survey unit? ☐ Yes ☐ No Explain in comments.

Depth to saturated soil (cm): _____________ Depth to free water (cm): ______________ ☐ Not observed* Groundwater pH: _______________ EC: _______________ Temp: _______________

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Redox Concentrations Color (moist)	%	Redox Depletions 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:

*If free water is not observed in pit, note if pit appears to be filling slowly or if it appears dry.

Point Code__________________

LEVEL 2 ECOLOGICAL INTEGRITY ASSESSMENT FOR SOUTHERN ROCKY MOUNTAIN WETLANDS

1. *LANDSCAPE CONTEXT METRICS – Circle the applicable letter score*

1a. LANDSCAPE CONNECTIVITY: *NON-RIVERINE WETLANDS* (UNFRAGMENTED LANDSCAPE)

For non-riverine wetlands, select the statement that best describes the **landscape fragmentation** within 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 and small ditches can be included in unfragmented blocks.	Intact: AA embedded in >90–100% unfragmented, natural landscape.	**A**
	Variegated: AA embedded in >60–90% unfragmented, natural landscape.	**B**
	Fragmented: AA embedded in >20–60% unfragmented, natural landscape.	**C**
	Relictual: AA embedded in ≤20% unfragmented, natural landscape.	**D**

1a. LANDSCAPE CONNECTIVITY: *RIVERINE WETLANDS* (RIPARIAN CORRIDOR CONTINUITY)

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 field manual, Table 3) within the riparian corridor (the floodplain) both upstream and downstream of the AA. Record their length in the table below and sum all patches. Specify if the patch occurs upstream or downstream (U/D) and on the right or left bank (R/L). *For AAs that include only one stream bank,* only consider the riparian corridor on that side of the channel.

(U / D)	(R / L)	Length (m)
_______	_______	_____________
_______	_______	_____________
_______	_______	_____________
_______	_______	_____________
_______	_______	_____________
_______	_______	_____________
	Combined patch length:	_____________

Intact: >90–100% natural habitat upstream and downstream. Combined patch length <200 m for AAs with two banks and <100 m for AAs with one bank.	**A**
Variegated: >60–90% natural habitat upstream and downstream. Combined patch length <800 m for AAs with two banks and <400 m for AAs with one bank.	**B**
Fragmented: >20–60% natural habitat upstream and downstream. Combined patch length <1600 m AAs with two banks and <800 m for AAs with one bank.	**C**
Relictual: ≤20% natural habitat upstream and downstream. Combined patch length ≥1600 m for AAs with two banks and ≥800 m for AAs with one bank.	**D**

Landscape connectivity comments:

1b. BUFFER EXTENT

Select the statement that best describes the **extent of buffer land cover** surrounding the AA. To determine, estimate the percent of the AA surrounded by buffer land covers (see field manual, Table 3). Each segment must be ≥ 30 m wide and ≥ 5 long. *For AAs that include only one stream bank,* only consider the buffer on that side of the channel.	Buffer land covers surround >75–100% of the AA.	**A**
	Buffer land covers surround >50–75% of the AA.	**B**
	Buffer land covers surround >25–50% of the AA.	**C**
	Buffer land covers surround ≤25% of the AA.	**D**

1c. BUFFER WIDTH

Select the statement that best describes the **buffer width**. To determine, estimate width (up to 200 m from AA) at eight evenly spaced intervals where buffer land cover exists. *For AAs that include only one stream bank,* only consider the buffer on that side of the channel.

1: ____________ 5: ____________

2: ____________ 6: ____________

3: ____________ 7: ____________

4: ____________ 8: ____________

Average width: ______________________

Average buffer width is >200 m	**A**
Average buffer width is >100–200 m	**B**
Average buffer width is >50–100 m	**C**
Average buffer width is ≤50 m OR no buffer exists	**D**

1d. BUFFER CONDITION

Select the statement that best describes the **buffer condition**. Select one statement per columns. Only consider buffer land covers up to 200 m from the AA from 1b and 1c.

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

Buffer comments:

1e. ONSITE AND SURROUNDING LAND USE

Using the table below, estimate the percent cover of each **land use within the AA and within a 500 m envelope** of the AA. Where two or more land uses overlap, use the land use with the lowest score, but mark the other land uses with a star (*) and explain in the comments section. Multiply the percent by the land use coefficient. Based on the total land use scores, select the appropriate metric ratings from the choices below.

Land Use Categories	*Coefficient*	*Assessment Area*		*500 m Envelope*	
		% Area	*Score*	*% Area*	*Score*
Paved roads / parking lots	0.00				
Domestic or commercially developed buildings	0.00				
Gravel pit operation, open pit mining, strip mining	0.00				
Unpaved Roads (e.g., driveway, tractor trail, 4-wheel drive roads)	0.10				
Mining (other than gravel, open pit, and strip mining), abandoned mines	0.10				
Resource extraction (oil and gas)	0.10				
Agriculture - tilled crop production	0.20				
Intensively managed golf courses, sports fields	0.20				
Vegetation conversion (chaining, cabling, rotochopping, clearcut)	0.30				
Heavy grazing by livestock	0.30				
Intense recreation (ATV use / camping / popular fishing spot, etc.)	0.30				
Logging or tree removal with 50-75% of trees >50 cm dbh removed	0.40				
Agriculture – permanent crop (hay pasture, vineyard, orchard, nursery, berry field)	0.50				
Agriculture – permanent tree plantation	0.50				
Dam sites and flood disturbed shorelines around water storage reservoirs	0.50				
Recent old fields and other disturbed fallow lands dominated by non-native species	0.50				
Moderate grazing on rangeland	0.60				
Moderate recreation (high-use trail)	0.70				
Selective logging or tree removal with <50% of trees >50 cm dbh removed	0.80				
Light grazing on rangeland	0.90				
Light recreation (low-use trail)	0.90				
Haying of native grassland	0.90				
Fallow with no history of grazing or other human use in past 10 yrs	0.95				
Natural area / land managed for native vegetation	1.00				
Total Land Use Score					

RATING CRITERIA FOR ONSITE LAND USE		**RATING CRITERIA ADJACENT LAND USE**	
AA (onsite) land use score ≥95	**A**	500 m envelope (surrounding) land use score ≥95	**A**
AA (onsite) land use score = 80 to <95	**B**	500 m envelope (surrounding) land use score = 80 to <95	**B**
AA (onsite) land use score = 40 to <80	**C**	500 m envelope (surrounding) land use score = 40 to <80	**C**
AA (onsite) land use score <40	**D**	500 m envelope (surrounding) land use score <40	**D**

Land use comments:

1f. NATURAL COVER WITHIN A 100 M ENVELOPE (Supplemental Information)

Using the table below, estimate the percent cover of each **natural cover type within a 100 m envelope** of the AA. Natural cover does not need to be only native vegetation; it could contain a mix of native and non-native vegetation. This measure applies to the entire 100 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, row crops, feed lots, etc).			
Total natural cover (breakdown by type below)			
Deciduous forest			
Coniferous forest			
Mixed forest type (neither deciduous nor coniferous trees dominate)			
Shrubland			
Perennial herbaceous			
Annual herbaceous or bare (generally weedy and disturbed)			

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

1g. NATURAL DISTURBANCES / STRESSORS (Supplemental Information)

Using the tables below and the field manual, estimate the scope and severity of each natural disturbances factor within the AA or 500 m envelope. Natural disturbance factors may lead to a either a decrease or increase in wetland condition depending on wetland type. See the field manual for scope and severity (sever) ratings. If the disturbance is not noted, write a slash through the boxes.

Disturbance Factor	*AA*		*500 m*		*Comments*
	Scope	*Sever*	*Scope*	*Sever*	
Beaver presence and use					
Heavy browsing by native ungulates					
Heavy trampling, paths by native ungulates					
Beatle killed conifers					
Evidence of recent fire (< 5 yrs)					
Other:					

Natural disturbance comments:

2. *VEGETATION CONDITION METRICS – Circle the applicable letter score*

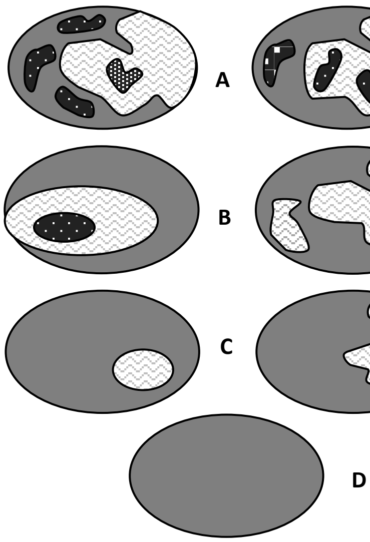
2a. RELATIVE COVER NATIVE PLANT SPECIES		
Select the statement that best describes the **relative cover of native plant species** within the AA.	>99% of vegetation cover within the AA is comprised of native species.	**A**
	95–99% of vegetation cover within the AA is comprised of native species.	**B**
	80–95% of vegetation cover within the AA is comprised of native species.	**C**
	50–80% of vegetation cover within the AA is comprised of native species.	**D**
	<50% of vegetation cover within the AA is comprised of native species.	**E**
2b. ABSOLUTE COVER OF NOXIOUS WEEDS		
Select the statement that best describes the **absolute cover of noxious weeds** within the AA. Refer to the Colorado Noxious Weed Lists A, B, and C for non-native invasive species.	Noxious weeds absent.	**A**
	Noxious weeds present, but sporadic (<3% absolute cover).	**B**
	Noxious weeds common (3–10% absolute cover).	**C**
	Noxious weeds abundant (>10% absolute cover).	**D**
2c. ABSOLUTE COVER OF AGGRESSIVE NATIVE SPECIES		
Select the statement that best describes the presence of **absolute cover of aggressive native species** within the AA. Specific examples include cattails *(Typha latifolia)* and giant reed grass *(Phragmites australis).*	Aggressive native species present, but sporadic (<5% absolute cover).	**A**
	Aggressive native species common (5–10% absolute cover).	**B**
	Aggressive native species abundant (10-25% absolute cover).	**C**
	Aggressive native species dominant (>25% absolute cover).	**D**
Species composition comments:		

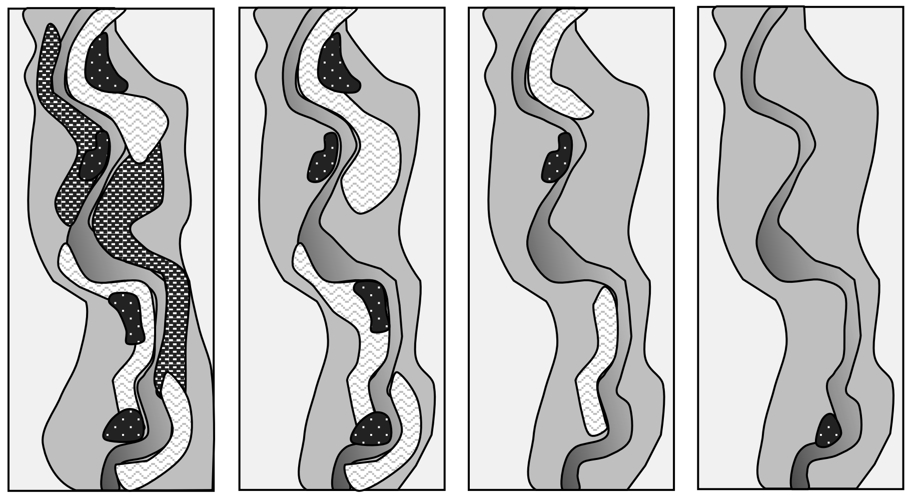
2d. REGENERATION OF NATIVE WOODY SPECIES	
Select the statement that best describes the **regeneration of native woody species** within the AA.	
All age classes of desirable (native) woody riparian species present OR woody species are naturally uncommon or absent.	**A**
Middle age group(s) absent. Other age classes well represented.	**B**
Seedlings, saplings, and middle age group(s) absent. Stand comprised of mainly mature species.	**C**
Woody species predominantly consist of decadent or dying individuals or AA has >5% canopy cover of Russian Olive and/or Salt Cedar.	**D**
Regeneration comments:	

2e. HERBACEOUS / DECIDUOUS LITTER ACCUMULATION	
Select the statement that best describes **herbaceous and/or deciduous litter accumulation** within the AA.	
AA characterized by moderate amount of fine or coarse litter. 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.	**AB**
AA characterized by small amounts of litter with little plant recruitment OR litter is somewhat excessive.	**C**
AA lacks litter OR litter is extensive and limiting new growth.	**D**
Herbaceous / deciduous litter accumulation comments:	

2f. HORIZONTAL INTERSPERSION OF VEGETATION ZONES

Refer to diagrams below and select the statement that best describes the **horizontal interspersion of vegetation zones** within the AA. Rules for defining vegetation zones are on page 14 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 vegetation zones with no single dominant zone.	**A**
	Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed vegetation zones with no single dominant zone.	**B**
	Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed vegetation zones. One zone may dominate others.	**C**
	No horizontal interspersion: AA characterized by one dominant vegetation zone.	**D**





A **B** **C** **D**

Horizontal interspersion comments:

3. NON-RIVERINE HYDROLOGY METRICS – Circle the applicable letter score

3a. WATER SOURCES

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 storage / hyporheic flow _____ Groundwater discharge _____ Precipitation _____ Snowmelt	_____ Natural surface flow _____ Irrigation run-off / ditches _____ Urban run-off / culverts _____ Pipes (directly feeding wetland) _____ Other:

Sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the growing season. There is no indication that growing season conditions are controlled by artificial water sources.	**A**
Sources are mostly natural, but also obviously include occasional or small effects of modified hydrology (e.g., developed land or irrigated agricultural land that comprises less than 20% of the immediate drainage basin within about 2 km upstream of the AA, presence of a few small stormdrains or scattered homes with septic systems). No large point sources or dams control the overall hydrology.	**B**
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 more than 20% of the immediate drainage basin within about 2 km upstream of the AA, or the presence of major drainage point source discharges that obviously control the hydrology of the AA.	**C**
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.	**D**

Water source comments:

3b. HYDROLOGIC CONNECTIVITY: *NON-RIVERINE WETLANDS EXCEPT NATURALLY ISOLATED FENS*

Select the statement below that best describes **hydrologic connectivity** within the AA. *Rating criteria is different for isolated fens.*

Rising water has unrestricted access to adjacent areas without levees or other obstructions to the lateral movement of flood waters.	**A**
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.	**B**
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 such as levees or road grades, for 50–90% of the boundary of the AA. Flood flows may exceed the obstructions, but drainage out of the AA is probably obstructed.	**C**
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 such as levees or road grades, for >90% of the boundary of the AA.	**D**

3b. HYDROLOGIC CONNECTIVITY: *NATURALLY ISOLATED FENS*

Select the statement below that best describes **hydrologic connectivity** within the AA, *if the site is a naturally isolated fen*.

No artificial connectivity with the surrounding water bodies.	**AB**
Partial connectivity (e.g., ditching or draining to dry the fen).	**C**
Substantial to full artificial connectivity that has obvious effects of drying the peat body.	**D**

Hydrologic connectivity comments:

3c. HYDROPERIOD: *NON-RIVERINE WETLANDS*

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 indicators of altered hydroperiod. Check "Y" for all that apply and "N" for those not observed. Use best professional judgment to determine the overall condition of the hydroperiod. *Rating criteria is different for fens than for other non-riverine wetlands.*

Reduced extent and/or duration of hydroperiod	*Increased extent and/or duration of hydroperiod*
Y N	Y N
☐ ☐ Upstream spring boxes	☐ ☐ Berms
☐ ☐ Upstream impoundments and dams	☐ ☐ Dikes
☐ ☐ Pumps, diversions, ditches that move water *out* of the wetland	☐ ☐ Pumps, diversions, ditches that move water *into* the wetland
☐ ☐ Encroachment of terrestrial vegetation	☐ ☐ Late-season vitality of annual vegetation
☐ ☐ Stress or mortality of hydrophytes	☐ ☐ Recently drowned riparian vegetation
☐ ☐ Compressed or reduced plant zonation	☐ ☐ Extensive fine-grained deposits

RATING CRITERIA FOR NON-RIVERINE WETLANDS *EXCEPT FENS*		**RATING CRITERIA FOR FENS**	
Hydroperiod is characterized by natural patterns of filling or inundation and drying or drawdowns.	**A**	Hydroperiod of the site is characterized by stable, saturated hydrology or by naturally damped cycles of saturation and partial drying.	**A**
The filling or inundation patterns are of greater magnitude or duration than expected under natural conditions, but thereafter the AA is subject to natural drawdown or drying.	**B**	Hydroperiod of the site experiences minor altered inflows or drawdown/drying compared to more natural fens (e.g., minor ditching).	**B**
Hydroperiod is characterized by natural patterns of filling or inundation, but thereafter is subject to more rapid or extreme drawdown or drying compared to natural wetlands. –OR– The filling or inundation patterns are of substantially lower magnitude or duration that would be expected under natural conditions, but thereafter the AA is subject to natural drawdown or drying.	**C**	Hydroperiod of the site is somewhat altered by greater increased inflow from runoff or experiences moderate drawdown/drying compared to more natural fens (e.g., moderate ditching).	**C**
Both the inundation and drawdown of the AA deviate from natural conditions (either increased or decreased in magnitude and/or duration).	**D**	Hydroperiod of the site is greatly altered by greater increased inflow from runoff or experiences large drawdown/drying compared to more natural wetlands (e.g., severe ditching).	**D**

Non-riverine hydroperiod comments:

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

3a. WATER SOURCES

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 storage / hyporheic flow _____ Groundwater discharge _____ Precipitation _____ Snowmelt _____ Natural surface flow _____ Irrigation run-off / ditches _____ Urban run-off / culverts _____ Pipes (directly feeding wetland) _____ Other:

Sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the growing season. There is no indication that growing season conditions are controlled by artificial water sources.	**A**
Sources are mostly natural, but also obviously include occasional or small effects of modified hydrology (e.g., developed land or irrigated agricultural land that comprises less than 20% of the immediate drainage basin within about 2 km upstream of the AA, presence of a few small stormdrains or scattered homes with septic systems). No large point sources or dams control the overall hydrology.	**B**
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 more than 20% of the immediate drainage basin within about 2 km upstream of the AA, or the presence of major drainage point source discharges that obviously control the hydrology of the AA.	**C**
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.	**D**

Water source comments:

3b. HYDROLOGIC CONNECTIVITY: *RIVERINE WETLANDS* (ENTRENCHMENT RATIO)

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! Use best professional judgment to estimate entrenchment or* ***use the non-riverine criteria****.*

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.	**A**	Entrenchment ratio >2.2.	**A**
Entrenchment ratio 1.6–2.0.	**B**	Entrenchment ratio 1.9–2.2.	**B**
Entrenchment ratio 1.2–1.5.	**C**	Entrenchment ratio 1.5–1.8.	**C**
Entrenchment ratio <1.2.	**D**	Entrenchment ratio <1.5.	**D**

Hydrologic connectivity comments:

3c. HYDROPERIOD: *RIVERINE WETLANDS* (CHANNEL STABILITY)

Select the statement below that best describes **channel stability** within or adjacent to the AA, which provides a coarse understanding of the **hydroperiod**. 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 stability.

Condition	Y	N	*Field Indicators*
Indicators of Channel Equilibrium	☐	☐	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.
	☐	☐	There is little or no active undercutting or burial of riparian vegetation.
	☐	☐	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.
	☐	☐	The spacing between pools in the channel tends to be 5-7 channel widths.
	☐	☐	The larger bed material supports abundant periphyton.
Indicators of Active Aggradation	☐	☐	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	☐	☐	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 RIVERINE WETLANDS

Most of the channel through the AA is characterized by equilibrium conditions, with little evidence of aggradation or degradation. Streambanks dominated (>90% cover) by stabilizing plant species, including trees, shrubs, herbs.	**A**
Most of the channel through 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 have 70–90% cover of stabilizing plant species.	**B**
There is evidence of severe aggradation or degradation of most of the channel through the AA or the channel is artificially hardened through less than half of the AA. Streambanks have 50–70% cover of stabilizing plant species.	**C**
The channel is concrete or otherwise artificially hardened through most of the AA. Streambanks have <50% cover of stabilizing plant species.	**D**

Riverine hydroperiod (channel stability) comments:

5. *PHYSIOCHEMICAL METRICS – Circle the applicable letter score*

4a. STRUCTURAL PATCH TYPES WITHIN THE ASSESSMENT AREA

Using the following worksheet, mark all **structural patch types** that occur within or adjacent to the AA. Check "Y" for all those observed and "N" for those not observed. See the field manual for patch type definitions. For patch types present in the AA, estimate their overall cover class in the AA. Photos and comments are optional, but very helpful. *Metric rating criteria under development.*

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%

Patch type	*Present in AA? Y N*	*Cover within AA*	*Photos*	*Comments*
Open water - river / stream	☐ ☐			
Open water - tributary / secondary channel	☐ ☐			
Open water - oxbow / backwater channel	☐ ☐			
Open water - rivulets / streamlet / small channel	☐ ☐			
Open water - ditch or canal	☐ ☐			
Open water - pond or lake (>1000 m^2)	☐ ☐			
Open water - pools (<1000 m^2)	☐ ☐			
Open water - beaver pond	☐ ☐			
Active beaver dam	☐ ☐			
Beaver canal	☐ ☐			
Debris jams / woody debris in channel	☐ ☐			
Pools in stream	☐ ☐			
Riffles in stream	☐ ☐			
Point bar	☐ ☐			
Interfluve on floodplain	☐ ☐			
Bank slumps or undercut banks in channel or along shoreline	☐ ☐			
Adjacent or onsite seep / spring	☐ ☐			
Animal mounds or burrows	☐ ☐			
Mudflat	☐ ☐			
Salt flat / alkali flat	☐ ☐			
Hummock / tussock (naturally formed)	☐ ☐			
Water tracks / hollow	☐ ☐			
Floating mat	☐ ☐			
Marl / Limonite bed	☐ ☐			
Other:	☐ ☐			
Other:	☐ ☐			

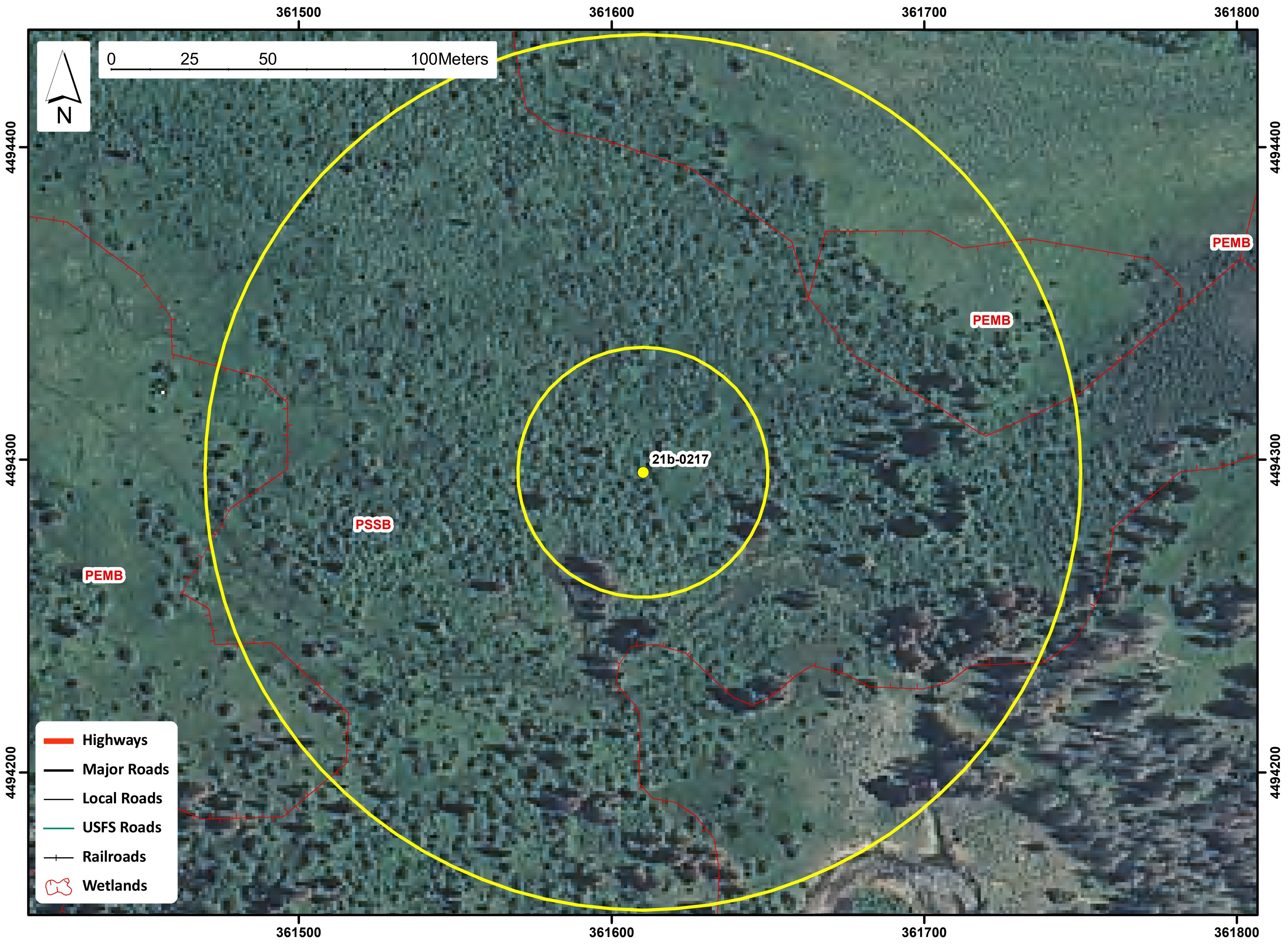
Structural patch types comments:

4b. SUBSTRATE / SOIL DISTURBANCE	
Select the statement below that best describes **disturbance to the substrate or soil** within the AA.	
No 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).	**A**
Some amount of bare soil present due to human causes, but the extent and impact is minimal. The depth of disturbance is limited to only a few inches and does not show evidence of ponding or channeling water. Any disturbance is likely to recover within a few years after the disturbance is removed.	**B**
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. Damage is not excessive and the site will recover to potential with the removal of degrading human influences and moderate recovery times.	**C**
Bare soil areas substantially degrade the site due to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water, if present, would be channeled or ponded. The site will not recover without restoration and/or long recovery times.	**D**
Substrate / soil comments:	

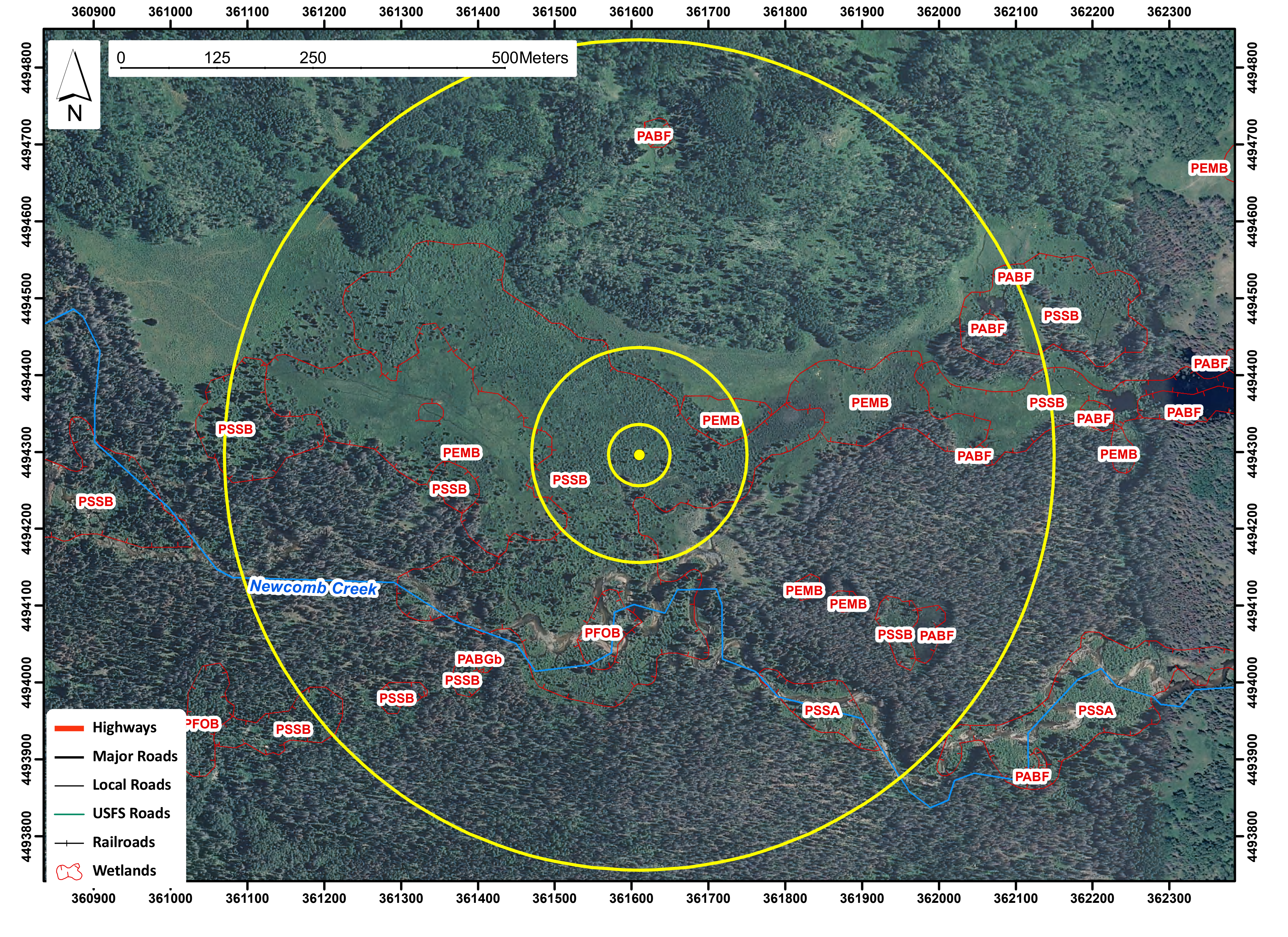
4c. WATER QUALITY - SURFACE WATER TURBIDITY / POLLUTANTS	
Select the statement that best describes the **turbidity or evidence or pollutants** in surface water within the AA.	
No visual evidence of degraded water quality. No visual evidence of turbidity or other pollutants.	**A**
Some negative water 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.	**B**
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.*	**C**
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.*	**D**
Surface water turbidity / pollutants comments:	

4d. WATER QUALITY - ALGAL GROWTH	
Select the statement that best describes **algal growth** within surface water in the AA.	
Water is clear with minimal algal growth.	**A**
Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness.	**B**
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).	**C**
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).	**D**
Algal growth comments:	

North Platte Basinwide Wetland Assessment Point 21b-0217 Assessment Area



North Platte Basinwide Wetland Assessment Point 21b-0217E 500m Envelope



APPENDIX E: Ecological Integrity Assessment (EIA) Metric Rating Criteria and Scoring Formulas for the North Platte River Basin

	Key Ecological Attribute	Indicator / Metric	Metric Rating Criteria			
		Rank / Score	**A / 5**	**B / 4**	**C / 3**	**D / 1 –OR– D / 2 and E / 1**
		Interpretation	**Reference (No or Minimal Human Impact)**	**Slight Deviation from Reference**	**Moderate Deviation from Reference**	**Significant Deviation from Reference**
LANDSCAPE CONTEXT	**Landscape Connectivity**	*1a. Landscape Fragmentation within 500 m*	Embedded in >90% unfragmented, natural landscape.	Embedded in >60–90% unfragmented, natural landscape.	Embedded in >20–60% unfragmented, natural landscape.	Embedded in ≤20% unfragmented, natural landscape.
		1b. Riparian Corridor Continuity within 500 m[1] *RIVERINE ONLY*	>90% natural habitat upstream and downstream	>60–90% natural habitat upstream and downstream	>20–60% natural habitat upstream and downstream	≤20 natural habitat upstream and down-stream
	Buffer	*1c. Buffer Extent*	Buffer at least 5 m wide surrounds 100% of AA	Buffer at least 5 m wide surrounds >75–<100% of AA	Buffer at least 5 m wide surrounds >50–75% of AA	Buffer at least 5 m wide surrounds >25–50% of AA Buffer at least 5 m wide surrounds ≤25% of AA
		1d. Buffer Width	Average buffer width is >200 m	Average buffer width is >100–200 m	Average buffer width is >50–100 m	Average buffer width is ≤50 m or no buffer exists
		1e. Buffer Condition – Vegetation	Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils.	Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants.	Moderate (25–50%) cover of non-native plants.	Dominant (>50%) cover of non-native plants.
		1f. Buffer Condition – Soils	Intact soils with little-no trash, negligible intensity of human use.	Intact or moderately disrupted soils, moderate –lesser trash, OR minor intensity of human use.	Moderate-extensive soil disruption, moderate of greater amounts of trash, OR moderate intensity of human use.	Barren ground and highly compacted or disrupted soils, moderate-greater amounts of trash, moderate-greater intensity of human use, OR no buffer.

[1] Metric used for Riverine HGM wetlands only

	Key Ecological Attribute	Indicator / Metric	Metric Rating Criteria				
		Rank / Score	A / 5	B / 4	C / 3	D / 1 –OR– D / 2 and E / 1	
		Interpretation	Reference (No or Minimal Human Impact)	Slight Deviation from Reference	Moderate Deviation from Reference	Significant or Severe Deviation from Reference	
BIOTIC CONDITION	**Community Composition**[1]	*2a. Relative Cover Native Plant Species*	Relative cover native plants > 99%	Relative cover native plants >95-99%	Relative cover native plants >80-95%	Relative cover native plants >50-80%	Relative cover native plants ≤50%
		2b. Absolute Cover Noxious Weeds	Absolute cover noxious weeds = 0%	Absolute cover noxious weeds >0-3%	Absolute cover noxious weeds >3-10%	Absolute cover noxious weeds >10% noxious	
		2c. Absolute Cover Aggressive Native Species	<10% cattail or <5% reed canary grass or giant reed grass	10-25% cattail or 5-10% reed canary grass or giant reed grass	>25-50% cattail or 10-25% reed canary grass or giant reed grass	>50% cattail or >25% reed canary grass or giant reed grass	
		2d. Mean C	Mean C > 6.0	Mean C > 5.5-6.0	Mean C >5.0-5.5	Mean C >4.0-5.0	Mean C ≤ 4.0
	Community Structure	*2e. Regeneration of Native Woody Species* [2]	All age classes present (N/A if woody sp. naturally uncommon/absent)	No middle age groups, others present	No young-middle age groups, mature present	Woody sp. mainly decadent and dying or >5% cover Tamarisk or Russian Olive	
		2f. Litter Accumulation	Moderate litter and duff and organic matter, neither lacking nor excessive.		Small amounts of litter with little plant recruitment, or excessive litter.	AA lacks litter completely, or excessive litter that limits new growth.	
		2g. Structural Complexity	Horizontal structure consists of a very complex array of nested and/or interspersed, irregular biotic and abiotic patches with no single dominant patch type.	Horizontal structure consists of a moderate array of biotic and abiotic patches with no single dominant patch type.	Horizontal structure consists of a simple array of biotic and abiotic patches.	Horizontal structure consists of one dominant patch type and thus has relatively no interspersion.	

[1] All community composition metrics calculated from the vegetation data not derived from field for rank scores. Final thresholds are different from those shown on the field form.
[2] Only applied to sites with where woody species are naturally common.

	Indicator / Metric	Metric Rating Criteria			
	Rank / Score	A / 5	B / 4	C / 3	D / 1
	Interpretation	Reference (No or Minimal Human Impact)	Slight Deviation from Reference	Moderate Deviation from Reference	Significant Deviation from Reference
HYDROLOGIC CONDITION[1]	*3a. Water Source*	Sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the growing season. There is no indication that growing season conditions are controlled by artificial water sources.	Sources are mostly natural, but also obviously include occasional or small effects of modified hydrology (e.g., developed land or irrigated agricultural land that comprises less than 20% of the immediate drainage basin within about 2 km upstream of the AA, presence of a few small storm drains or scattered homes with septic systems). No large point sources or dams control the overall hydrology.	Sources are primarily from anthropogenic sources (e.g., urban runoff, direct irrigation, pumped water, artificially impounded water, or another artificial hydrology). Indications of artificial hydrology include developed or irrigated agricultural land that comprises more than 20% of the immediate drainage basin within about 2 km upstream of the AA, or the presence of major drainage point source discharges that obviously control the hydrology.	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.
	3b. Hydrologic Connectivity	Rising water has unrestricted access to adjacent areas without levees or other obstructions to the lateral movement of flood waters, if stream present, not entrenched.	Unnatural features such as levees or road grades limit 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. If stream present, slightly entrenched.	The lateral movement of flood waters to and from the AA is limited, relative to what is expected for the setting, by unnatural features such as levees or road grades, for 50–90% of the boundary of the AA. Flood flows may exceed the obstructions, but drainage out of the AA is probably obstructed. If stream present, moderately entrenched.	The lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features such as levees or road grades, for >90% of the boundary of the AA. If stream present, very entrenched.
	3c. Alteration to Hydroperiod *NON-RIVERINE ONLY*	Hydroperiod is characterized by natural patterns of filling or inundation and drying or drawdowns with no alterations.	Filling and drying patterns deviate slightly from natural conditions due to presence of stressors such as small ditches or diversions, berms or roads at/near grade, pugging, or minor flow additions.	Filling and drying patterns deviate moderately from natural conditions due to presence of stressors such as 1-3ft deep ditches or diversions, two lane roads, roads with culverts adequate for stream flow, moderate pugging, or moderate flow additions.	Filling and drying patterns deviate substantially from natural conditions due to high intensity alterations such as a 4-lane highway, large dikes, > 3ft diversions or ditches capable of lowering water table, large amount of fill, artificial groundwater pumping, or heavy flow additions.
	3d. Upstream Water Retention *RIVERINE ONLY*	<5% of watershed drains to water storage facility.	5–20% of watershed drains to water storage facility.	20–50% of watershed drains to water storage facility.	>50% of watershed drains to water storage facility.

[1] Hydrology metrics are different for Riverine HGM and Non-Riverine HGM wetlands.

HYDROLOGIC CONDITION[1]					
	3e. Water Diversions and/or Additions *RIVERINE ONLY*	No upstream or onsite water diversions or additions present.	Few diversions/additions present or impacts minor relative to contributing watershed size. Minor impact to local hydrology.	Many diversions/additions present or impact moderate relative to contributing watershed size. Major impact to local hydrology.	Diversions/additions very numerous or impacts high relative to contributing watershed size. Local hydrology drastically altered.
	3f. Bank Stability *RIVERINE ONLY*	Most of the channel through the AA is characterized by equilibrium conditions, with little evidence of aggradation or degradation. Streambanks dominated (>90% cover) by stabilizing plant species, including trees, shrubs, herbs.	Most of the channel through 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 have 70–90% cover of stabilizing plant species.	There is evidence of severe aggradation or degradation of most of the channel through the AA or the channel is artificially hardened through less than half of the AA. Streambanks have 50–70% cover of stabilizing plant species.	The channel is concrete or otherwise artificially hardened through most of the AA. Streambanks have <50% cover of stabilizing plant species.
	3g. Beaver Activity[2] *RIVERINE ONLY*	Active or recent beaver sign present. Beaver currently active within the area.	Only old beaver sign present. No evidence of recent or new beaver activity despite available food resources and habitat. (Score = 3)		No beaver sign present.

[1] Hydrology metrics are different for Riverine HGM and Non-Riverine HGM wetlands.
[2] Only applied to sites with where beaver activity is expected.

PHYSIOCHEMICAL CONDITION					
	4a. Water Quality	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 (natural bacterial sheens break apart upon contact), but the bottom is still visible. Sources of water quality degradation are apparent.	Water is milky and/or muddy or has unnatural oil sheen (natural bacterial sheens break apart upon contact). The bottom is difficult to see and there are obvious sources of water quality degradation.
	4b. Algal Growth	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.	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.
	4c. Substrate / Soil Disturbance	No apparent modifications.	Past modifications, but recovered; OR recent but minor modifications.	Recovering OR recent and moderate modifications.	Recent and severe modifications.

EIA Scoring Formulas:

Non-Riverine HGM Wetlands

Landscape Context Score: (1a * 0.4) + ([(1c*1d)$^{1/2}$ * (1e + 1f)/2]$^{1/2}$ * 0.6)

Biotic Condition Score: (2a * 0.2) + ([2b OR 2c[1]] * 0.2) + (2d * 0.4) + (2e[2] * 0.1) + (2f[2] * [0.05 OR 0.1]) + (2g[2] * [0.05 OR 0.1])

Hydrologic Condition Score: (3a * 0.2) + (3b * 0.2) + (3c * 0.6)

Physiochemistry Condition Score: (4a * 0.25) + (4b * 0.25) + (4c * 0.5)

Riverine HGM Wetlands

Landscape Context Score: (1a * 0.1) + (1b * 0.3) + ([(1c*1d)$^{1/2}$ * (1e + 1f)/2]$^{1/2}$ * 0.6)

Biotic Condition Score: (2a * 0.2) + ([2b OR 2c[1]] * 0.2) + (2d * 0.4) + (2e[2] * 0.1) + (2f[2] * [0.05 OR 0.1]) + (2g[2] * [0.05 OR 0.1])

Hydrologic Condition Score: (3a * 0.2) + (3b * 0.2) + ([3d*3e]$^{1/2}$ * 0.4) + (3f[3] *[0.1 OR 0.2]) + (3g[3] * 0.1)

Physiochemistry Condition Score: (4a * 0.25) + (4b * 0.25) + (4c * 0.5)

Overall EIA Score

(Landscape Context Score * 0.2) + (Biotic Condition Score * 0.4) + (Hydrologic Condition Score * 0.3) + (Hydrologic Condition Score * 0.1)

[1] Lowest value from 2b or 2c is used.
[2] If 2e is NA, use 0.1 for 2f and 2g weights.
[3] If 3g is NA, use 0.2 for 3f weight.

Overall 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 F: NMS Ordination Settings and Results

Apprendix Table F1. Nonmetric Multidimensional Scaling (NMS) results and settings for ordination of wetland plots (95) in species space (410 species).

Variable	Setting/Result
Software	PC-ORD
Distance Measure	Sorenson
Starting Configuration	Random
Stability Criterion	0.000000
# Runs with Real Data	250
# Runs with Randomized Monte Carlo Data	250
Monte Carlo Test Result	p=0.004
Number of Dimensions Assessed	6
Final Number of Dimensions Selected	3
Final Stress	13.038
Final # of Iterations	146
Final Instability	0.00000
Cumulative R^2	84.6

Appendix Table F2. Correlation (Pearson's r) of condition, environmental, and sampling variables with NMS ordination axes.

Quantitative Variables	Axis 1	Axis 2	Axis 3
% variance explained by axes (R2)	**25.4%**	**44.7%**	**14.6%**
Biotic Score (1-5)	-0.01	0.88	0.15
Overall Score (1-5)	-0.04	0.88	0.14
Hydrology Score (1-5)	-0.10	0.62	0.04
Landscape Score (1-5)	0.08	0.55	0.09
Physiochemical Score (1-5)	-0.11	0.27	0.11
Human Disturbance Index (HDI; 0-100)	-0.13	-0.65	-0.13
Aspect (folded; 0-180)	-0.16	-0.19	-0.04
Slope (degrees)	-0.02	0.36	0.34
Elevation (m)	0.09	0.80	0.24
Annual Precipitation (cm)	0.04	0.85	0.17
Average Annual Temperature (°C)	-0.03	-0.79	-0.27
Organic Soil Depth (0/20/40 cm)	0.16	0.50	-0.03
Beaver Presence (presence/absence)	-0.40	0.10	-0.12
Altered Origin (presence/absence)	0.26	-0.67	-0.09
Sample Date (first day sampled = 1; last day sampled = 86)	-0.27	0.30	-0.12
Plot Area (m2)	-0.02	-0.17	0.08

Categorical Variables (and number of groups). Differences between groups assessed using MRPP; All A values <0.1.	
Ecoregion Group (7)	Land Owner (7)
HGM Class (4)	Sampling Level (2)
Ecological System (6)	Parent Geology (6)
Water Regime (4)	Woody/Herbaceous (2)

APPENDIX G: Habitat Quality for Dabbling Ducks in North Park, Colorado: Assessment, Monitoring Protocols, and Management Tools

HABITAT QUALITY FOR DABBLING DUCKS IN NORTH PARK, COLORADO: ASSESSMENT, MONITORING PROTOCOLS, AND MANAGEMENT TOOLS

FINAL REPORT

March 2012

Photograph by The Nature Conservancy

Prepared for the U. S. Environmental Protection Agency, Region 8
by Colorado Parks and Wildlife

James H. Gammonley, Mike Grooms, Catherine P. Ortega, Jonathan P. Runge, Brian D. Sullivan

PROJECT TITLE:
Basinwide Wetland Profile of the North Platte River Basin in Colorado
Assistance ID No. CD-97854101-1

INTRODUCTION

The North Platte River Basin, in north-central Colorado, lies within the Central Flyway and provides important breeding and migratory habitat for many North American wetland-dependent wildlife species, including dabbling ducks (Sanders 1997). The North Platte River Basin serves as one of the most important areas within Colorado for breeding and migrating ducks. For example, within North Park, a mean of 10.3 pairs of breeding ducks per km^2 were counted during annual surveys, and demographic studies revealed that ducks banded in North Park were recovered throughout the Central and Pacific Flyways (Szmczak 1986). It is also an important staging area for migrating ducks in both spring and fall. Therefore, the North Platte River Basin in Colorado is important for ducks throughout the region and in two major flyways.

Because of the unequivocal importance of the North Platte River Basin to ducks and other wildlife species, it is a high priority area for wetland conservation in Colorado (CDOW 1989, 2011). In partnership with the Fish and Wildlife Service, Bureau of Land Management, Ducks Unlimited, The Nature Conservancy, the Intermountain West Joint Venture, private landowners, and others, Colorado Parks and Wildlife (CPW) has regularly invested in wetland conservation here, including approximately $250,000 in 2010 alone.

This project contributes to several goals in the Strategic Plan for the Wetland Wildlife Conservation Program. Specifically, identification of best management practices and monitoring protocols for key habitat value features contributes to both Biological Planning Strategies and Conservation Design Strategies in the plan (CDOW 2011). This information directly links wetland assessments with habitat quality for wildlife, and it can be used to better inform sampling selection for wetland assessments, which will assist with prioritization of effective on-the-ground conservation actions. Decisions based on biological knowledge can lead to the most meaningful landscape conservation, which will benefit not only priority species, but also functional communities and connectivity for movement and gene flow across the landscape.

In order to provide the highest-quality habitat for dabbling ducks during all life cycles in which they are present, it is necessary to understand both proximate cues (habitat value features that attract ducks) and ultimate elements (habitat quality features necessary for reproductive success and survival, Kaminski and Prince 1981a). Proximate cues can be assessed through measurements of abundance and association with habitat features, whereas ultimate elements must be assessed by measurements of survival (banding studies) and/or reproductive success (nest studies). Using proximate cues alone can lead to false conclusions about habitat quality. For example, Johnson and Temple (1986) found in a tall-grass prairie that abundance and nest success were inversely related; if they had identified the habitat with highest abundance as being the highest quality, this would have led to counterproductive management practices. However, studies focusing on ultimate elements can determine which habitat features are most important for predicting nesting and brooding success. Measuring these key habitat value features in the field can estimate habitat quality and inform meaningful management decisions.

Understanding ultimate elements together with proximate cues is also important in identifying source and sink populations, especially for declining populations (Austin and Miller 1995, Moon and Haukos 2006, Rice et al. 2010, Pearse et al. 2011). Predation is generally the major source of nest and brood mortality for ducks (Duebbert 1966, Gammonley 1996, Drever et al. 2004, Krapu et al. 2004), and high mortality, especially in areas of high abundance of ducks, can result in sink populations. It is, therefore, also important to understand key habitat value features that influence predators, i.e., lower quality habitat. With information on the quality of key habitat value features on a continuum from high to low, management practices can sometimes be changed to improve habitat conditions, resulting in enhanced survival or recruitment.

Key habitat value features for dabbling ducks include, but are not limited to, hydrological regime (Mauser et al. 1994, Krapu et al. 2004, Heitmeyer 2006, Raven et al. 2007), dominant vegetation type (Kaiser et al. 1979, Gammonley 1996, also see Kantrud, 1986 for review), nest cover type (Burgess et al. 1965, Euliss and Harris 1987, Mowbray 1999, Raven et al. 2007), interspersion (ratio of cover to water, see Fig. 1, Kaminski and Prince 1981b, Murkin et al. 1982, Euliss and Harris 1987), residual cover (Hines and Mitchell 1983, Leschack et al. 1997, Drilling et al. 2002), size of habitat patch (Crabtree et al. 1989, Paquette and Ankney 1996, Fleskes et al. 2007), water depth (Johnson 1995, Gammonley 1996, Johnson and Rohwer 2000, Austin 2002), distance to water during nesting (Crabtree et al. 1989, Mauser et al. 1994, Mowbray 1999), amount of water in the nearby landscape (Arnold et al. 2007), and food availability (Kaminski and Prince 1981b, Ashley et al. 2000, de Szalay et al. 2003, Elmberg et al. 2003, Ballard 2004). Numerous management techniques can maintain these habitat value features at desirable levels or conditions (Table 2). Further details on management practices, identified in Table 2, are provided in Appendix A.

The goals of this project were to (1) review literature on wetland habitat requirements of dabbling ducks, (2) identify key habitat value features that can easily and repeatedly be measured in the field, (3) rank the values of habitat value features from high to low, and (4) identify protocols to measure habitat value features.

METHODS

At several work sessions, September through November, 2009, we (Gammonley, Grooms, Runge, and Sullivan) integrated information on dabbling ducks from our collective expertise and knowledge from field experience in the basin, with information available from literature (Kantrud 1986, USFWS 2009, RMBO 2011, Lorentzson date unknown, WPIF date unknown). The guild of dabbling ducks in North Park included seven species: gadwall (*Anas strepera*), American wigeon (*A. americana*), mallard (*A. platyrhynchos*), blue-winged teal (*A. discors*), cinnamon teal (*A. cyanoptera*), northern pintail (*A. acuta*), and green-winged teal (*A. crecca*). The habitat types that dabbling ducks use in North Park include the following: (1) seasonal emergent wetlands, (2) semi-permanent emergent wetlands, (3) riparian areas, (4) beaver ponds, (5) irrigated hay meadows, (6) kettle ponds, (7) lakes and reservoirs, (8) rivers and streams, (9) stock ponds, and (10) uplands.

The life cycles of dabbling ducks differ slightly among species (Austin and Miller 1995, Johnson 1995, Gammonley 1996, Leschack et al. 1997, Mowbray 1999, Drilling et al. 2002, Rohwer et al. 2002); therefore, we defined time frames that would encompass all species during nesting (15 May through 30 June), brood rearing (1 July through 31 August), and migration (spring: ice thaw through 15 May; fall: August 1 through ice formation).

We identified eight measurable key habitat value features important to habitat quality for dabbling ducks: (1) dominant vegetation type, (2) percent of emergent cover, (3) depth of residual cover, (4) interspersion (ratio of cover to water), (5) size of wetland, (6) landscape context (percent of wetlands or open water on the landscape within a defined buffer of wetland margins or habitat edge), (7) stream flow (cubic feet per second), and (8) stream order. For each key habitat value feature, during each season, within each wetland type, we assigned qualitative values (high, medium or low) to measurable ranges of conditions representing relative value to dabbling ducks. One habitat value feature (dominant vegetation type) was categorical, and we, therefore, assigned qualitative values according to known preference of vegetation type.

RESULTS

Ten habitat types in North Park supported dabbling ducks during different phases of their life cycles (Table 1). Descriptions of each habitat as well as management practices for habitat value features are identified in Table 2. Seasonal emergent wetlands, semi-permanent emergent wetlands, riparian areas, and beaver ponds supported dabbling ducks during spring migration, nesting, brood rearing, and fall migration (Tables 3-6, respectively). Irrigated hay meadows provided habitat during spring migration, nesting, and brood rearing (Table 7). Kettle ponds, lakes and reservoirs, rivers and streams, and stock ponds provided important habitat during spring migration, brood rearing, and fall migration (Tables 8- 11, respectively). Uplands provided important habitat to ducks during the nesting season (Table 12). Protocols for measurements of each habitat quality feature are provided in Table 13.

For nesting habitat, a 50:50 interspersion of cover to water, residual cover depth of > 10 cm, size (> 20 acres), and water within the landscape context contributed to high quality for dabbling ducks. Dominant vegetation types identified as high quality included Baltic rushes (*Juncus balticus*) and bulrushes (*Scirpus* spp.) for seasonal and semi-permanent wetlands, and for riparian areas, beaver ponds, and uplands, grasses were identified as the preferred dominant vegetation.

High quality brood-rearing habitat for dabbling ducks included dense emergent cover (> 80%), size (> 20 acres for most wetland types and 2-5 acres for beaver ponds and stock ponds), other water on the landscape, and vegetation dominated by grasses, sedges, rushes, pondweeds, and submergent vegetation.

During migration, high quality habitat for dabbling ducks was generally defined by dominant vegetation consisting of grasses, sedges, rushes, pondweeds, and submergent vegetation, size (> 20 acres for most wetland types and 2-5 acres for beaver ponds and stock ponds), and other water on the landscape.

DISCUSSION

Many studies have suggested an interspersion of 50:50 (cover:water) as the highest quality for dabbling ducks. For example, in a study with experimental interspersion manipulations in Texas, Smith et al. (2004) found the highest densities of waterfowl, particularly mallard, green-winged teal, and northern pintail, with a 50:50 interspersion. Similarly, Kaminski and Prince (1981c) and Murkin et al. (1982, 1997) in Manitoba, and Webb et al. (2010) in Nebraska, found the highest density and diversity of dabbling ducks in wetlands with 50:50 interspersion of cover to water. Rehm and Baldassarre (2007) further suggested that a complex pattern (see Fig. 1) increases both diversity and density of other marsh birds, such as rails and bitterns.

Dense cover for nesting improves nesting success in uplands (Beauchamp et al. 1996, Emery et al. 2005). Newbold and Eadie (2004) found in the Central Valley of California, wetlands spread throughout a landscape (high edge to area ratio) supported the highest density of mallards. Dense emergent cover for ducklings is important, not only as a substrate for invertebrates (Murkin et al. 1997) and visual protection from predators (Mauser et al. 1994), but also for thermoregulation and protection from weather, including precipitation (Stafford and Pearse 2007).

Although some variation occurs with habitat preferences both geographically and among species of dabbling ducks, these particular trends appear to be fairly consistent among duck species in many locations throughout their ranges. The information from this study can be used in numerous ways, including development of geographic priority maps, landscape-scale modeling, and incorporation of protocols that link future wetland assessments with habitat quality. The knowledge gained from this project will contribute to a better understanding of key habitat value features that benefit priority wetland-dependent wildlife species and will result in informed management decisions regarding protection and maintenance of wetland ecosystems of the North Platte River Basin.

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Table 1. Seasonal importance to dabbling ducks of wetland types in the North Platte River Basin, Colorado.

	Spring Migration Ice thaw-15 May	**Nesting** 15 May – 30 June	**Brood Rearing** 1 July-31 August	**Fall Migration** 1 August-ice formation
Seasonal emergent wetlands	√	√	√	√
Semi-permanent emergent wetlands	√	√	√	√
Riparian areas	√	√	√	√
Beaver ponds	√	√	√	√
Irrigated hay meadows	√	√	√	
Kettle ponds	√		√	√
Lakes and reservoirs	√		√	√
Rivers and streams	√		√	√
Stock ponds	√		√	√
Uplands		√		

Table 2. North Park habitat descriptions and management practices for habitat features.

Habitat	Description	Habitat value features	Management Practices
Seasonal emergent wetlands	Dominated by plants that fall to the surface of the substrate or below the surface of the water at the end of the growing season, so during certain seasons, there are no obvious signs of emergent vegetation.	Dominant Vegetation	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, seeding, planting, excavation.
		Emergent Cover	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, excavation.
		Residual Cover	Hydrologic manipulation, disking, prescribed burning, spray/chemical treatment, grazing.
		Interspersion (cover:water)	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, excavation.
		Size	Hydrologic manipulation, wetland creation.
		Landscape context	Wetland restoration, creation.
Semi-permanent emergent wetlands	Wetlands dominated by plant species that normally remain at least until the beginning of the next growing season.	Dominant Vegetation	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, seeding, planting, excavation.
		Emergent Cover	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, excavation.
		Residual Cover	Hydrologic manipulation, disking, prescribed burning, spray/chemical treatment, grazing.
		Interspersion (cover:water)	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, excavation.
		Size	Hydrologic manipulation, wetland creation.
		Landscape context	Wetland restoration, creation.
Riparian areas	Areas with characteristic vegetation restricted to areas along, adjacent to or contiguous with rivers and streams. Vegetation types may consist of willows, shrubs, sedges, and grasses.	Dominant Vegetation	Hydrologic manipulation, mowing, disking, spray/chemical treatment, grazing, seeding, planting, mechanical control of woody vegetation, excavation.
		Emergent Cover	Hydrologic manipulation, mowing, disking, spray/chemical treatment, grazing, seeding, planting, mechanical control of woody vegetation, excavation.
		Residual Cover	Hydrologic manipulation, mowing, disking, spray/chemical treatment, grazing.
		Interspersion (cover:water)	Hydrologic manipulation, mowing, disking, spray/chemical treatment, grazing, seeding, planting, mechanical control of woody vegetation, excavation.
		Landscape context	Wetland restoration, creation.
		Stream order	N.A.

Table 2, continued. North Park habitat descriptions and management practices for habitat features.

Habitat	Description	Habitat value features	Management Practices
Beaver ponds	Still water habitats constructed by beaver along rivers, streams and channels. Woody plants and vegetation types may include willow, river birch, grasses, sedges, watermilfoil, bur-reeds, pondweeds, and stonewort. Usually less than five surface acres of water.	Dominant Vegetation	Hydrologic manipulation, spray/chemical treatment, grazing, mechanical control of woody vegetation, prescribed burning.
		Emergent Cover	Hydrologic manipulation, spray/chemical treatment, grazing, mechanical control of woody vegetation, prescribed burning.
		Residual Cover	Hydrologic manipulation, spray/chemical treatment, grazing, mechanical control of woody vegetation, prescribed burning.
		Interspersion (cover:water)	Hydrologic manipulation, spray/chemical treatment, grazing, mechanical control of woody vegetation, prescribed burning.
		Size	N.A
		Landscape context	Wetland restoration, creation.
Irrigated hay meadows	Permanent pastures grazed at a low intensity or used for haying. Vegetation types within these meadows may include blue grass, common timothy, sedges, and rushes.	Dominant Vegetation	Hydrologic manipulation, spray/chemical treatment, grazing, seeding, planting, wetland creation, spray/chemical treatment.
		Emergent Cover	Hydrologic manipulation, grazing, seeding, planting.
		Interspersion (cover:water)	Hydrologic manipulation, creation.
		Size	Hydrologic manipulation, creation.
		Landscape context	Wetland restoration, creation.
Kettle ponds	Shallow, sediment-filled bodies of water formed by retreating glaciers or draining floodwaters. Size varies: usually less than 180 m diameter, but up to 20 acres or more. Water depths usually less than 2 meters. Vegetation may include grasses, sedges, watermilfoil, pondweeds and Yellow pond lily.	Dominant Vegetation	N.A.
		Emergent Cover	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, excavation.
		Size	Hydrologic manipulation, wetland creation.
		Landscape context	Wetland restoration, creation.
Lakes and reservoirs	Natural and artificial impoundments where water is stored and regulated. Yield average of five or more surface acres of water.	Dominant Vegetation	Hydrologic manipulation, mowing, disking, spray/chemical treatment, grazing, seeding, planting, excavation.
Rivers and streams	All perennial rivers and streams within the boundaries of Jackson County.	Dominant Vegetation	In-stream structural manipulation (e.g. boulder clusters).
		Emergent Cover	In-stream structural manipulation (e.g. boulder clusters).
		Landscape context	Wetland restoration, creation.
		Stream Flow (cfs)	In-stream structural manipulation (e.g. boulder clusters).

Table 2, continued. North Park habitat descriptions and management practices for habitat features.

Habitat	Description	Habitat value features	Management Practices
Stock ponds	Artificially constructed, still water ponds used as a means of supplying domestic livestock with drinking water. Yield average of less than five surface acres of water.	Dominant Vegetation	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, seeding, planting, excavation.
High elevation (10,500'-8,700') uplands within 50 m of wetland	Dominated by lodgepole pine, Engelmann spruce, subalpine fir, and Aspen. willow, river birch, and mountain alder dominant along streams, beaver wetlands and scattered locations along edges of most glacial wetlands. Sedges and grasses dominate margins of most beaver wetlands and seasonally flooded glacial wetlands. Submergent plant species include watermilfoil, bur-reeds, pondweeds, and stonewort. Yellow pond lily prevalent in deeper, permanent water zones	Dominant Vegetation	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, seeding, planting, mechanical control of woody vegetation.
		Residual Cover	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, seeding, planting, mechanical control of woody vegetation.
Low elevation (< 8,700') uplands within 50 m of wetland	Primarily consist of rabbitbrush, sagebrush, and black greasewood.	Dominant Vegetation	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, seeding, planting, mechanical control of woody vegetation.
		Residual Cover	Hydrologic manipulation, mowing, disking, prescribed burning, spray/chemical treatment, grazing, seeding, planting, mechanical control of woody vegetation.

Table 3 Dabbling duck habitat value by season for seasonal emergent wetlands in North Park, Colorado.

Season	Habitat Value Features	Qualitative/ Quantitative Habitat Value		
		HIGH	**MEDIUM**	**LOW**
Nesting 15 May – 30 June	Dominant Vegetation	Baltic rush	Sedge	Spikerush
	Interspersion (cover:water)	50:50	75:25	90:10
	Residual Cover Depth	> 10 cm	5 -10 cm	< 5 cm
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Brood-rearing 1 July – 31 August	Dominant Vegetation	Grass, sedges, rushes, submergents	Bulrush, water sedge	Cattail, yellow pond lily
	% Emergent Cover	> 80%	40-80%	< 40%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Grass, sedges, rushes, submergents	Bulrush, water sedge	Cattail, yellow pond lily
	% Emergent Cover	> 20%	5-20%	< 5%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 Mile buffer)

Table 4. Dabbling duck habitat value by season for semi-permanent emergent wetlands in North Park.

Season	**Habitat Value Features**	**Qualitative/ Quantitative Habitat Value**		
		HIGH	**MEDIUM**	**LOW**
Nesting 15 May – 30 June	Dominant Vegetation	Bulrush	Sedge	Cattail
	Interspersion (cover:water)	50:50	75:25	90:10
	Residual Cover Depth	> 10 cm	5-10 cm	< 5 cm
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Brood-rearing 1 July – 31 August	Dominant Vegetation	Grass, sedges, rushes, submergents	Bullrush, water sedge	Cattail, yellow pond lily
	% Emergent Cover	> 80%	40-80%	< 40%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Grass, sedges, rushes, submergents	Bulrush, water sedge	Cattail, yellow pond lily
	% Emergent Cover	> 80%	40-80%	< 40%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 5. Dabbling duck habitat value by season for riparian areas in North Park, Colorado.

Season	**Habitat Value Features**	**Qualitative/ Quantitative Habitat Value**		
		HIGH	**MEDIUM**	**LOW**
Nesting 15 May – 30 June	Dominant Vegetation	Grasses	Willow/Grass	Willow
	Residual Cover Depth	> 10 cm	5-10 cm	< 5 cm
	Stream order	5th or 6th order	3rd or 4th order	1st or 2nd order
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Brood-rearing 1 July – 31 August	Dominant Vegetation	Grass, sedges, pondweed	All others	Willow
	% Emergent Cover	> 80%	40-80%	< 40%
	Stream order	5th or 6th order	3rd or 4th order	1st or 2nd order
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Grass, sedges, pondweed	All others	Willow
	% Emergent Cover	> 80%	40-80%	< 40%
	Stream order	5th or 6th order	3rd or 4th order	1st or 2nd order
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 6. Dabbling duck habitat value by season for beaver ponds in North Park, Colorado.

Season	**Habitat Value Features**	**Qualitative/ Quantitative Habitat Value**		
		HIGH	**MEDIUM**	**LOW**
Nesting 15 May – 30 June	Dominant Vegetation	Grasses	Sedges	Willow
	Interspersion (cover:water)	50:50	75:25	90:10
	Residual Cover Depth	> 10 cm	5-10 cm	< 5 cm
	Size	>2acres	½-2acres	< ½ acre
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Brood-rearing 1 July – 31 August	Dominant Vegetation	Grass, sedges, pondweed	All others	Willow
	% Emergent Cover	> 80%	40-80%	< 40%
	Size	> 2 acres	½-2acres	< ½ acre
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Grass, sedges, pondweed	All others	Willow
	% Emergent Cover	> 20%	5-20%	< 5%
	Size	> 2 acres	½-2acres	< ½ acre
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 7. Dabbling duck habitat value by season for irrigated hay meadows in North Park, Colorado.

Season	Habitat Value Features	Qualitative/ Quantitative Habitat Value		
		HIGH	**MEDIUM**	**LOW**
Nesting 15 May – 30 June	Dominant Vegetation	Anything other than alfalfa	N.A.	Alfalfa
	Interspersion (hummock:water)	50:50	75:25	90:10
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Brood-rearing 1 July – 31 August	Dominant Vegetation	Sedges, rushes,	Bullrush, sedge	Grasses
	Cover	> 80%	40-80%	< 40%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May)	Dominant Vegetation	Sedges, rushes,	Bulrush, sedge	Grasses
	Cover	> 80%	40-80%	< 40%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 8. Dabbling duck habitat value by season for kettle ponds in North Park, Colorado.

Season	Habitat Value Features	Qualitative/ Quantitative Habitat Value		
		HIGH	**MEDIUM**	**LOW**
Brood-rearing 1 July – 31 August	Dominant Vegetation	Grass, sedges, pondweed	Watermilfoil, other pondweeds	Willow
	% Emergent Cover	> 80%	40-80%	< 40%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Grass, sedges, pondweed	Watermilfoil, other pondweeds	Willow
	% Emergent Cover	> 80%	40-80%	< 40%
	Size	> 20 acres	5-20 acres	< 5 acres
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 9. Dabbling duck habitat value by season for lakes and reservoirs in North Park, Colorado.

Season	Habitat Value Features	Qualitative/ Quantitative Habitat Value		
		HIGH	MEDIUM	LOW
Brood-rearing 1 July – 31 August	Dominant Vegetation	Submergent, grass, sedges, rushes,	Bulrush, water sedge	Cattail
	% Emergent Cover	> 5%	0-5%	0%
	Size	> 30 acres	10-30 acres	5-10 acres
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Submergent, grass, sedges, rushes,	Bulrush, water sedge	Cattail
	% Emergent Cover	> 5%	0-5%	0%
	Size	> 30 acres	10-30 acres	5-10 acres
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 10. Dabbling duck habitat value by season for rivers, streams and in North Park, Colorado.

Season	Habitat Value Features	Qualitative/ Quantitative Habitat Value		
		HIGH	MEDIUM	LOW
Brood-rearing 1 July – 31 August	Dominant Vegetation	Grass, sedges, rushes, submergents	Bullrush, water sedge	Cattail
	% Emergent Cover	> 80%	40-80%	< 40%
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Grass, sedges, rushes, submergents	Bulrush, water sedge	Cattail
	% Emergent Cover	> 20%	5-20%	< 5%
	Stream Flow (cfs)	1-100 cfs	100-150 cfs	> 150 cfs
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 11. Dabbling duck habitat value by season for stock ponds in North Park, Colorado.

Season	Habitat Value Features	Qualitative/ Quantitative Habitat Value		
		HIGH	**MEDIUM**	**LOW**
Brood-rearing 1 July – 31 August	Dominant Vegetation	Grass, sedges, rushes, submergents	Bullrush, water sedge	Cattail
	% Emergent Cover	> 80%	40-80%	< 40%
	Size	2-5 acres	½-2acres	< ½ acre
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)
Spring Migration (ice thaw - 15 May) Fall Migration (1 August - ice formation)	Dominant Vegetation	Grass, sedges, rushes, submergents	Bulrush, water sedge	Cattail
	% Emergent Cover	> 20%	5-20%	< 5%
	Size	2-5 acres	½-2acres	< ½ acre
	Landscape context	> 50% water (5 mile buffer)	10-50% water (5 mile buffer)	< 10% water (5 mile buffer)

Table 12. Dabbling duck habitat value by season for uplands within 50 m of a wetland or other water in North Park, Colorado.

Season	Habitat Value Features	Qualitative/ Quantitative Habitat Value		
		HIGH	**MEDIUM**	**LOW**
Nesting 15 May – 30 June	Dominant Vegetation	Grass	Greasewood/ rabbitbrush mix	Sage
	Residual Cover Depth	> 10 cm	5-10 cm	< 5 cm
	Landscape context	> 50% water (1 mile buffer)	10-50% water (1 mile buffer)	< 10% water (1 mile buffer)

Table 13. Field measurement protocols for habitat value features.

Habitat Value Features	Field Measurement Protocols
Dominant Vegetation	Visual estimates and/ or line transects and/or random plots
Interspersion (cover:water)	Ocular estimation of 50 random points while taking Robel measurements[a]
Residual Cover Depth	Use a 2-m stick and Robel pole with a minimum of 50 random points
Size	GIS
% Emergent Cover	Line transects and remote sensing
Landscape context	Aerial IR photos, NWI maps, GIS mapping using the buffer tool[b, c]
Stream order	Topographic map
Stream Flow (cfs)	Jackson County gauging stations (online)

[a]Robel et al. 1970.

[b]Colwell et al. 1978.

[c]Patience and Klemas 1993.

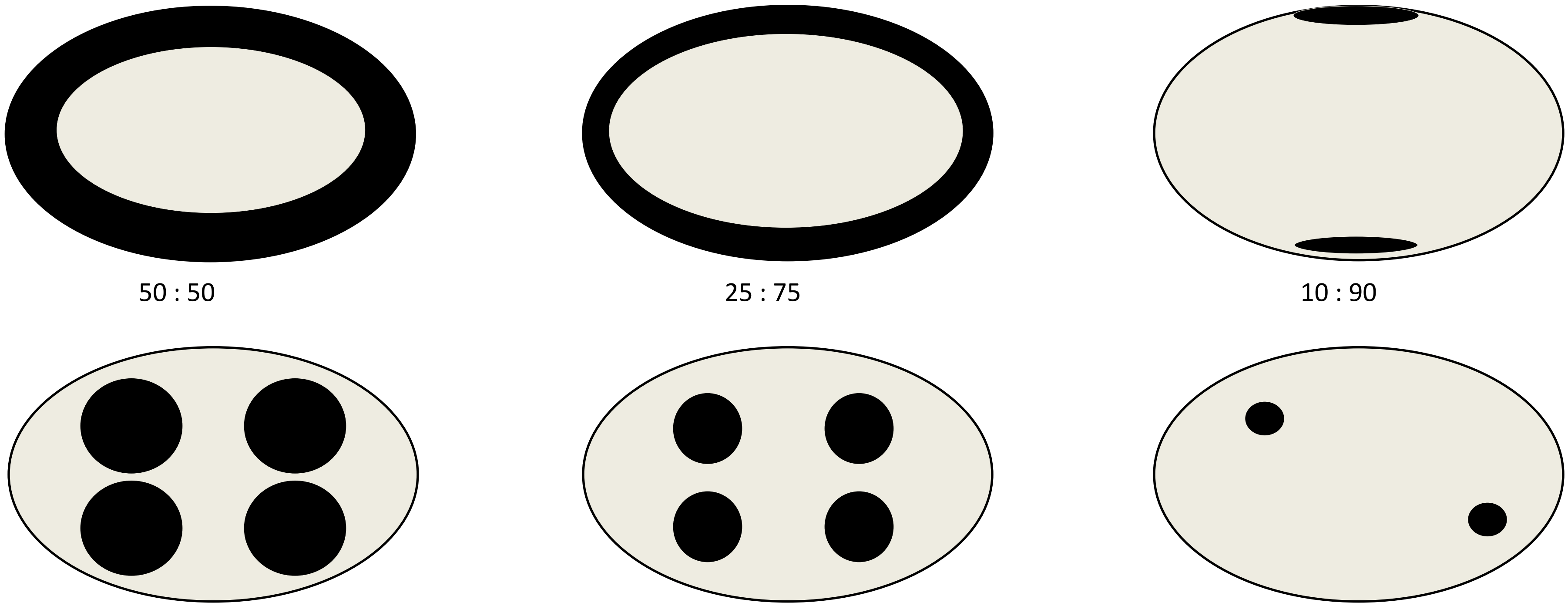

Fig. 1. Examples of possible configurations (fringe on top row; complex on bottom row) of interspersion (cover:water ratios). Black = vegetative cover and gray = water.

Appendix A - Management Practices

Disking: It is the most intense disturbance of wetland vegetation used in managing wetlands. Disking destroys both the erect stems as well as breakup the extensive rhizome system that keeps plants alive during dry conditions. The USFWS observations show that mallards, northern pintails, white fronted geese, and Canada geese choose "managed wetlands where significant amounts of vegetation remain. Snow geese select wetlands (including disked areas) where the majority of the site is open water. http://www.fws.gov/rainwater

Excavation: The processes of removing and altering the landscape for the purpose of creating or restoring a site for wetland use. Excavation usually includes three processes. Excavation of soil and vegetation, removal and transport of unwanted materials, and deposition of these materials. When excavating in a wetland, care should be taken to minimize use of heavy machinery. Whenever possible, place heavy equipment on stabilization mats to reduce unwanted damage to the surrounding landscape. If at all possible, work when the ground is frozen and during low flow and low wind periods.

Haying: This management practice is used to manage vegetation types where ungulates refuse to graze (e.g. weed patches), or where prescribed burning is not practical (e.g. in close proximity to domestic structures). Results of haying may include, killing invasive tree seedlings, and creating firebreaks for future prescribed burns. Haying is generally delayed until after mid-July to reduce depredation of nests and nesting birds.
http://www.fws.gov/rainwater

High Diversity seeding/planting: The term "high diversity seeding" includes harvesting, processing and sowing large numbers of native species in an attempt to return the plant community as close as possible to its pre-cultivation condition. Their objective is to manage uplands for warm season, grass-dominated plant communities with a diverse mix of other cool- and warm-season grasses, sedges, rushes, and broadleaf forbs. This process can be used where wet meadow plant communities are lacking in wetlands that would benefit from seeding of sedges, rushes, and wetland grasses. http://www.fws.gov/rainwater/management/reseeding.htm

Hydrologic Manipulation: Hydrologic processes that are artificially implemented to improve wetland functions. Water level manipulation may be used to increase or decrease salinity; stimulate germination and growth of moist-soil plants; decrease turbidity; increase production of invertebrates; recycle nutrients; alter the density of vegetation; control disease; and increase viable resources for target species (e.g. migratory birds). Hydrologic control can be achieved by the use of weirs (solid structures that maintain a minimum water level), dikes (impoundments), control gates, and pumps. The USFWS recommends using a cover: water ratio of about 50:50 across the entire wetland. (WPIF, date unknown).

Mechanical Control of Woody Vegetation: The means of cutting, sawing, clipping, mowing and uprooting of woody vegetation. The hand tools most commonly used for this technique are the mattock, heavy hoe and grubber. Mulching machines or tractor-mounted mowers and brush-hogs may also be used for spot cutting on larger vegetation such as willow and tamarisk.

Mowing: This management technique can be useful on small scale wetlands or artificially created wetlands (e.g. reservoirs surrounded by extensive marshes) during the winter months. At this time, water levels are typically at their lowest levels, yielding thick layers of ice. Robust emergent vegetation (e.g. cattails) can be clipped just above the ice so that spring flooding restricts the oxygen supply to the root zone. As a result, many of the plants do not resprout, allowing other emergent species to thrive (WPIF, date unknown).

Prescribed Burning: Prescribed burning in wetlands can be used to remove old vegetation; create open water areas; expose the soil profile for new germination; release nutrients that are bound in dead vegetation; remove exotic plant species; and create a mosaic of vegetation types. http://www.fws.gov/rainwater

Spraying/Chemical Treatment: The purpose is to remove undesirable plants, e.g., cattails monocultures, and invasive weeds.

Tree Removal: This management technique is primarily use on prairie wetlands (e.g. Rainwater Basin of Nebraska). In doing so, the USFWS uses tree removal around wetlands to increase the amount of upland grasslands. The North American Breeding Bird Survey reports that 70% of the 29 species characteristic of North American prairies has experienced a decline in population. A portion of that decline is attributed to the small acreage of remaining grassland parcels and the increasing number of trees found within the grasslands. http://www.fws.gov/rainwater

Ungulate Grazing: The purpose for grazing wetlands for [wildlife is]…to economically manage the type and abundance of plants. The USFWS strives for habitat which has abundant wetland plant seed, aquatic invertebrate substrate, and at least 50% open water when flooded one foot deep.
http://fws.gov/rainwater/management/grazing.htm

APPENDIX H: Intermountain Duck Habitat Management Pilot Study, North Park

INTERMOUNTAIN DUCK HABITAT MANAGEMENT PILOT STUDY, NORTH PARK

Final Report for the U. S. Environmental Protection Agency, Region 8
by Colorado Parks and Wildlife (CPW)

AUTHOR: Jonathan Runge
PROJECT PERSONNEL: Jim Gammonley, Jim Haskins, Jeff Yost, Brian Sullivan

PROJECT TITLE:
Basinwide Wetland Profile of the North Platte River Basin in Colorado
Assistance ID No. CD-97854101-1

OBJECTIVES

The two main objectives of this project were to improve duck production in Colorado and investigate techniques for improving wetland management while incorporating uncertainty surrounding ecological processes such as density-dependence and nest site fidelity in several species of ducks that commonly breed in Colorado.

INTRODUCTION

Duck production can serve as an index of wetland value, thus monitoring the effect of habitat management for ducks is important. Intermountain valleys such as North Park and the San Luis Valley account for the majority of ducks produced in Colorado. These areas therefore provide ample opportunity to investigate methods for increasing duck production, and correspondingly, wetland value.

Many management options exist for modifying wetlands for waterfowl production, and they are generally related to setting back the successional stage of the wetland. The operational theory behind such work is that waterfowl production in wetlands increases along with vegetation structure following a disturbance. However, at a certain point during the successional process, vegetation becomes thick enough to preclude nesting. Thus, according to theory, management tools such as grazing, burning, and disking can remove vegetation and maintain high duck production over the long term. The downside to such management tools is that they can remove enough cover that it takes several years for ducks to begin nesting again in substantial numbers. The challenge to managers then is to find an optimal disturbance schedule that maximizes duck production over a number of years, while minimizing management costs.

This research focuses on the investigation of determining optimal disturbance schedules for different wetland habitats in North Park. Two ecological processes may influence duck production and optimal disturbance schedules: density dependence and nest site fidelity. Theoretically, as nest density increases, per capita production may decrease due to depleted food resources. Also, dense conglomeration of nesting birds may attract predators, which could result in decreases in nest success. Thus it may be prudent to manage for an optimal nest production rates rather than maximizing nest density.

High nest success may result in greater return rates for nesting females (i.e., high nest site fidelity). This would result in a positive feedback loop in which greater return rates would cause a population to reach optimal nest density faster than if no nest site fidelity occurred. With high nest site fidelity and high nest success, nesting populations may become too dense thus invoking the negative feedback of density dependence. This study attempted to estimate nest site fidelity and the form of density dependence in breeding intermountain ducks.

Because this study uses optimal decision making policies while incorporating ecological processes, it is a form of adaptive resource management (ARM; Williams et al. 2007). It is important to note, however, that unlike much adaptive management work, this study requires several years to quantify answers to management questions due to successional dynamics. Even with this delay in feedback, ARM can improve effectiveness of habitat conservation programs by integrating research and management in a decision making framework.

STUDY AREA AND METHODS

Pilot Study.—During 2008-2010, we conducted a pilot study investigating methods for estimating duck production. To obtain an estimate of production, we measured information on nest success and density. Nest searching was conducted in the North Park wetland complexes Lake John Annex (CPW), Hebron Slough (BLM), and the Arapaho National Wildlife Refuge (USFWS) (Table 1). Targeted wetlands for study in North Park included Hebron Slough (BLM), Case Flats (USFWS), Illinois River oxbows and sloughs (USFWS), and Lake John Annex (CPW). Details pertaining to each study area are described in Table 1. Nest searching was conducted by 2-9 observers dragging a rope through vegetation to flush hens from nests (Earl 1950). The observers either walked through nesting areas or, in several of the North Park units, drove ATVs. Nest locations were marked with surveyors' pin flags and revisited weekly to determine nest success. Eggs were candled to determine incubation stage (Weller 1956). Nest searches took place 1-3 times per summer on each study unit.

In July and August of 2008-2010, we initiated and continued banding efforts in an ongoing attempt to estimate survival and recovery rates. Ducks were caught in bait traps, rocket-netted, or caught in dip nets from airboats. Captured ducks were fitted with standard aluminum USGS legbands. In 2008 and 2009, two out of every three female mallard, gadwall, and blue-winged/cinnamon teal were fit with nasal tags (Lee 1960) to aid in estimation of site fidelity (i.e., resightings of nasal-marked females on study sites in subsequent years). One out of every three females of these species received a leg band only. This will allow estimation of hunter recovery rates of nasal marked vs. non-nasal marked waterfowl. Females were not nasal-tagged in 2010 due to low resighting rates from previous years. All males of the above 4 species, and all captured ducks of other species were also legbanded. Following marking, ducks were released immediately at the capture site.

In May-June of 2009 and 2010, we collected information regarding vegetation cover (vegetation height-density as measured with Robel poles [Robel et al. 1970]), depth of dead vegetation, primary and secondary dominant vegetation types, and hydrological characteristics (water depth, % area covered by water) in focal wetlands and nesting areas. We established 50 random points in a given wetland unit via GIS sampling. At each random point we outlined a circular plot 4m in radius ($50.27m^2$ plot). At each cardinal point of the resulting circle, we recorded depth (in cm) of dead vegetation and water depth (if any). Dead vegetation included any vegetation that was lying over, but may still have had an unbroken stalk, the goal being to estimate an index for cover available to ducks initiating nests in May-July.

Analysis.— Nest success data from North Park collected in 2008 and 2009 were analyzed in program MARK (White and Burnham 1999), but data 2010 has not yet been analyzed for estimation of daily nest survival rate or overall nest success. Analysis was conducted relating vegetation type and litter depth to production in management units, including linear mixed models with hatchlings per ha. as a response variable, year as a random effect, and primary vegetation type, and litter depth as fixed effects.

RESULTS AND DISCUSSION

***Nesting*.**—During summer 2008, we located 53 active nests at the Lake John Annex. Twenty-five were mallard, 12 were blue-winged/cinnamon teal, 8 were lesser scaup, 3 were northern shoveler, 3 were canvasback, 1 was American wigeon, and 1 was gadwall. Forty-three of these nests were located in bulrush and Baltic rush, 7 were in grasses, 1 was in saltgrass, 1 was in greasewood, and 1 was located on the edge of bulrush and grass habitat. Of the two models run to investigate nest success, the model with vegetation differences fit best, and daily nest survival was estimated at 0.977 (95% CI: 0.961-0.986) for Baltic rush and bulrush-associated nests and 0.916 (95% CI: 0.832-0.960) for nests associated with grass and greasewood. For 35 day nesting periods these estimates correspond to 44.3 and 4.6% nest success, respectively. Two hundred and twenty-one eggs were known to have hatched in the Lake John Annex area during the summer of 2008. Of these, 205 hatched from nests with bulrush and Baltic rush as the proximate dominant vegetation and 16 in grass habitats. In terms of species, 99 eggs hatched were mallards, 51 were blue-winged/cinnamon teal, 40 were lesser scaup, 16 were canvasback, and 15 were northern shoveler. Conducting pilot work for future years, we found 4 nests on unit A6 of ANWR, 1 on unit C11, 0 on unit C5, C6, and C8/10. We did not follow these nests as these were pilot efforts meant to identify areas that could be included in future work on the Refuge.

During summer 2009, we found 129 active nests in North Park (Table 2). None of the explanatory variables investigated (e.g., dominant vegetation, litter depth, nest density, etc) explained daily nest survival rates better than a model expressing nest survival as constant across all area and habitat factors. The daily nest survival estimate from this model was 0.955 (95% CI: 0.943-0.964), which corresponds to 19.8% nest success for a 35 day nesting period.

Three hundred and sixty-seven eggs were known to hatch in the study area during 2009 (Table 3). One hundred and thirty-seven eggs hatched with Baltic rush as the proximate dominant vegetation (52 active nests found), 93 from nests associated with wetland grasses and sedges (31 nests), 51 from upland grasses (8 nests), 44 from bulrush (23 nests), 18 from greasewood (2 nests), 16 from rye (4 nests), and 8 from spike rush (3 nests). No eggs hatched from nests found that were associated with sage (1 nest), willow (1 nest), or no vegetation at all (1 nest). On units 12 and 13 of ANWR, and the D Meadow (west) unit of Hebron Sloughs, 0 nests were found.

During summer 2010, we found 104 active nests in North Park, including 5 nests in a privately owned hay meadow south of Hebron Slough (Table 2). Four hundred and seventy nine eggs were known to successfully hatch, including 469 eggs from nests found active (Table 3). One hundred and ninety eight hatched from nests with Baltic rush as the proximate dominant vegetation (36 active nests found), 126 from nests associated with wetland grasses and sedges (38 nests), 35 from bulrush (6 nests), 56 from greasewood (10 nests), 15 from rye (3 nests), 15 from forb associations (4 nests), 20 from sagebrush (2 nests) and 4 from spike rush (1 nest). No eggs hatched from nests found that were associated with upland grasses (1 nest) or willow (1 nest).

Using a linear mixed modeling routine, fifteen models were fit to investigate the relationship between productivity (ducklings produced per ha), vegetation type at the patch scale (bulrush, Baltic rush, grass&sedge), region (Russell Lakes, North Park), and litter depth scaled by average percent litter cover. Litter depth^2 was also included to investigate potential decreases in productivity as litter depth increased, but most models with this term produced nonsensical results. The best fitting model included an interaction between vegetation type and region with depth as an additive effect and was >7 AICc units lower than its closest competitor. Model-based estimates for productivity indicated a strong effect of vegetation type, with bulrush dominated wetlands producing the most ducklings (Figure 1).

It should be noted that productivity in bulrush dominated wetlands in North Park was much less in 2010 than in 2009 or 2008 (Table 3). This was likely due to cold temperatures in late spring that caused large blocks of ice to be present in bulrush stands in late May and early June, when many hens are usually initiating nests in bulrush. Nevertheless, wetlands dominated by bulrush remained the top producer of ducklings even in a 'down' year. Interestingly, in North Park, vegetation associations at the nest scale differed from those at the patch scale. In North Park in both 2009 and 2010, more nests occurred and more eggs hatched in proximate Baltic rush dominated microhabitat than in proximate bulrush dominated microhabitat. This pattern occurred at Lake John as well, which contains a majority of bulrush habitat. At Lake John, nests in Baltic rush are generally found close to bulrush stands. Whether this is due to increased cover in bulrush, availability of standing water, both, or some other factor is unknown. What is certain is that the Lake John complex, which contains both bulrush and Baltic rush, consistently produces more ducklings per hectare than any other area measured in North Park. The value of bulrush habitat is supported by data from Russell Lakes SWA in the San Luis Valley, where a unit dominated by bulrush produced the most ducklings in 2009, and nests associated with proximate bulrush microhabitat also produced the most ducklings in 2009.

Banding.—In 2008, we banded 741 ducks in North Park. Sex, age, and species-specific details are given in Table 4. Nasal tags were placed on 57 gadwall females (32 in ANWR, 11 in Hebron Sloughs, 1 in Lake John, 13 in Walden Reservoir), and 77 mallard females (31 in ANWR, 30 in Hebron Sloughs, 15 in Lake John, 1 in Walden Reservoir) for a total of 134 nasal tags

In 2009, we banded 1068 ducks in North Park (Table 5). Nasal tags were placed on 22 blue-winged/cinnamon teal females (15 in ANWR, 7 in Lake John), 49 gadwall females (33 in ANWR, 16 in Lake John), and 131 mallard females (48 in ANWR, 28 in Hebron Sloughs, 55 in Lake John) for a total of 202 nasal tags.

In 2010, we banded 890 ducks in North Park, with the majority being mallard and gadwall (Table 6). No nasal tags were placed on birds.

Banding summaries for all years are detailed, by species, in Table 7.

Future analyses will include nest success and overall production analysis using data from North Park and Russell Lakes SWA in the San Luis Valley that was collected in 2009 and 2010.

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Table 1. Description of sampled wetland units. ANWR = Arapaho National Wildlife Refuge.

			Dominant vegetation		Vegetation plots containing water in May & June	
Unit	Area	Ha.	2009	2010	2009	2010
25a	ANWR	27.07	Grasses & sedges	Baltic rush	39%	58%
25b	ANWR	26.64	Grasses & sedges	Grasses & sedges	10%	35%
26	ANWR	55.97	Baltic rush	Grasses & sedges	34%	41%
27a	ANWR	20.60	Grasses & sedges	Grasses & sedges	9%	52%
27b	ANWR	29.33	Grasses & sedges	Grasses & sedges	26%	39%
12	ANWR	25.32	Grasses & sedges	Baltic rush	5%	24%
13	ANWR	39.38	Baltic rush	Baltic rush	16%	24%
A5	ANWR	214.24	Baltic rush	Baltic rush	44%	49%
A6	ANWR	38.43	Baltic rush	Baltic rush	46%	34%
C12w	ANWR	184.64	Grasses & sedges	Baltic rush	10%	38%
D2	Hebron	25.99	Grasses & sedges	Grasses & sedges	28%	52%
D1	Hebron	22.83	Grasses & sedges	Grasses & sedges	10%	20%
LJ East	Lake John	8.38	Baltic rush/bulrush	Bulrush	50%	64%
LJ West	Lake John	1.26	Bulrush	Bulrush	51%	67%

Table 2. Number of active nests found in North Park 2009 and 2010 by species and management unit.

Mgmt. Unit	Area	Amwi	Bcte	Canv	Gadw	Lesc	Mall	Nopi	Nsho	Unsp	**Total**
2009											
12	ANWR										**0**
13	ANWR										**0**
25a	ANWR		2		1						**3**
25b	ANWR		1		1						**2**
26	ANWR				2		4		1	1	**8**
27a	ANWR		1								**1**
27b	ANWR		1		3						**4**
A5	ANWR		12		6	1	2		5	1	**27**
A6	ANWR		9		11	3	3		4	1	**31**
C12w	ANWR		2						4	1	**7**
D1	Hebron										**0**
D2	Hebron		1		5						**6**
LJ East	Lake John		5		2	9	9		1	8	**34**
LJ West	Lake John		6	1	1	1	7		1	2	**19**
2009 Total		**0**	**40**	**1**	**32**	**14**	**25**	**0**	**16**	**14**	**142**
2010											
12	ANWR										**0**
13	ANWR						1				**1**
25a	ANWR				3						**3**
25b	ANWR	1					1		1		**3**
26	ANWR	3	3		4	3	2				**15**
27a	ANWR		1		1						**2**
27b	ANWR				1		1				**2**
A5	ANWR		8		13	1	4	1	5	1	**33**
A6	ANWR		6		7		1		1	1	**16**
C12w	ANWR		1								**1**
D1	Hebron				1				2		**3**
D2	Hebron		2		3		1				**6**
Mehring	Private		1		1		3				**5**
LJ East	Lake John		6			3	9			2	**20**
LJ West	Lake John				2	1	3				**6**
2010 Total		**4**	**28**	**0**	**36**	**8**	**26**	**1**	**9**	**4**	**116**

ANWR = Arapaho National Wildlife Refuge, Amwi = American wigeon, Bcte = blue-winged or cinnamon teal, Canv = canvasback, Gadw = gadwall, Lesc = lesser scaup, Mall = mallard, Nopi = northern pintail, Nsho = northern shoveler, Unsp = unknown species.

Table 3. Number of eggs confirmed to hatch in North Park in 2009 and 2010 by species and management unit.

Mgmt. Unit	Area	Amwi	Bcte	Gadw	Lesc	Mall	Nopi	Nsho	Unsp	**Total**
2009										
12	ANWR									**0**
13	ANWR									**0**
25a	ANWR		9							**9**
25b	ANWR		9	6						**15**
26	ANWR			10		9				**19**
27a	ANWR		9							**9**
27b	ANWR									**0**
A5	ANWR		19	8		12		10		**49**
A6	ANWR		43	34				15		**92**
C12w	ANWR		9					9		**18**
D1	Hebron									**0**
D2	Hebron		10	18						**28**
LJ East	Lake John		10	6	32	7			25	**80**
LJ West	Lake John		9	7	9	23				**48**
2009 Total		**0**	**127**	**89**	**41**	**51**	**0**	**34**	**25**	**367**
2010										
12	ANWR									**0**
13	ANWR									**0**
25a	ANWR			9						**9**
25b	ANWR	6						9		**15**
26	ANWR		19	18	9					**46**
27a	ANWR									**0**
27b	ANWR			10						**10**
A5	ANWR		52	91		19	7	44	7	**220**
A6	ANWR		28	33		7				**68**
C12w	ANWR									**0**
D1	Hebron		8	12						**20**
D2	Hebron			9				14		**23**
LJ East	Lake John		9		10	24				**43**
LJ West	Lake John			7		18				**25**
2010 Total		**6**	**116**	**189**	**19**	**68**	**7**	**67**	**7**	**479**

ANWR = Arapaho National Wildlife Refuge, Amwi = American wigeon, Bcte = blue-winged or cinnamon teal, Canv = canvasback, Gadw = gadwall, Lesc = lesser scaup, Mall = mallard, Nopi = northern pintail, Nsho = northern shoveler, Unsp = unknown species.

Table 4. Number of ducks banded in North Park, July-September, 2008.

		Sex Age														
		F				F Tot	M				M Tot	U			U Tot	Grand Total
Region	Species	AHY	HY	L	U		AHY	HY	L	U		AHY	HY	U		
ANWR	AMWI	1				1		2			2					3
	BCTE	1				1										1
	BWTE						1		1		2					2
	CANV							1			1					1
	CITE						1				1					1
	GADW	21	16	26	1	64	11	24	14		49					113
	LESC	1	2			3		1	3		4					7
	MALL	23	14	10	1	48	106	32	5	45	188		1	3	4	240
	NOPI	2				2	2				2	2			2	6
	NSHO	1	4	3		8	1	3			4					12
	REDH							1			1					1
ANWR Total		50	36	39	2	128	122	64	23	45	254	2	1	3	6	387
Hebron	AGWT	1				1										1
	AMWI		3			3	3				3					6
	BWTE						1				1					1
	CANV		1			1		1			1					2
	GADW	6	12	2		20	5	11	4		20		1		1	41
	MALL	24	14	2	2	42	74	15	9		98					140
	NOPI							1			1					1
	NSHO	1	1			2										2
	REDH	1				1	2				2					3
	RUDU						1				1					1
Hebron Total		33	31	4	2	70	86	28	13		127		1		1	198
Lake John	AMWI							1			1					1
	BCTE		2			2		1			1					3
	CANV							1			1					1
	GADW	1	1			2	1				1					3
	LESC							1			1					1
	MALL	8	1	12	1	22	10	4	10	7	31					53
	NSHO		8			8		10			10					18
	REDH		1			1		1			1					2
Lake John Total		9	13	12	1	35	11	19	10	7	47					82
Walden Res.	AMWI				1	1										1
	BWTE							1			1					1
	CANV		3			3		1			1					4
	GADW	5	15		1	21	13	3			16					37
	MALL		3			3	2				2					5
	NOPI							1			1					1
	NSHO	4				4	10	8			18					22
Walden Res. Total		9	21		2	32	25	14			39					71
Grand Total		101	102	55	7	265	244	125	46	52	467	2	2	5	9	741

Table 5. Number of ducks banded in North Park, July-August, 2009.

		Sex Age										
		F				F Tot	M				M Tot	Grand Total
Region	Species	AHY	HY	L	U		AHY	HY	L	U		
ANWR	AGWT		8	1		9	46	11			57	66
	AMWI	19				19	20	1			21	40
	BCTE	5	14	1		20	8	16	2		26	46
	CITE						1				1	1
	GADW	36	4	7		47	73	2	5	1	81	128
	LESC			1		1						1
	MALL	33	34	6	1	74	59	30	5		94	168
	NOPI		2			2		1			1	3
	RNDU						2				2	2
ANWR Total		93	62	16	1	172	209	61	12	1	283	455
Hebron	AGWT	3	16	2		21	35	20	4		59	80
	AMWI								1		1	1
	BCTE		1	3		4		2	3		5	9
	BWTE							1			1	1
	MALL	12	20	13		45	11	36	3		50	95
Hebron Total		15	37	18		70	46	59	11		116	187
Lake John	AGWT		1			1	1				1	2
	AMWI		6	1		7		7			7	14
	BCTE	2	6			8	4	2	3		9	17
	CANV		5	2		7			1		1	8
	CITE						1				1	1
	GADW	13	6	6		25	63	5	2		70	95
	LESC		1			1	1		1		2	3
	MALL	39	42	2		83	154	36	5		195	278
	NOPI		3			3						3
	NSHO		1			1		1			1	2
	REDH		1	1		2		1			1	3
Lake John Total		54	72	12		138	224	52	12		288	426
Grand Total		162	171	46	1	380	479	172	35	1	687	1068

Table 6. Number of ducks banded in North Park, July-August, 2010.

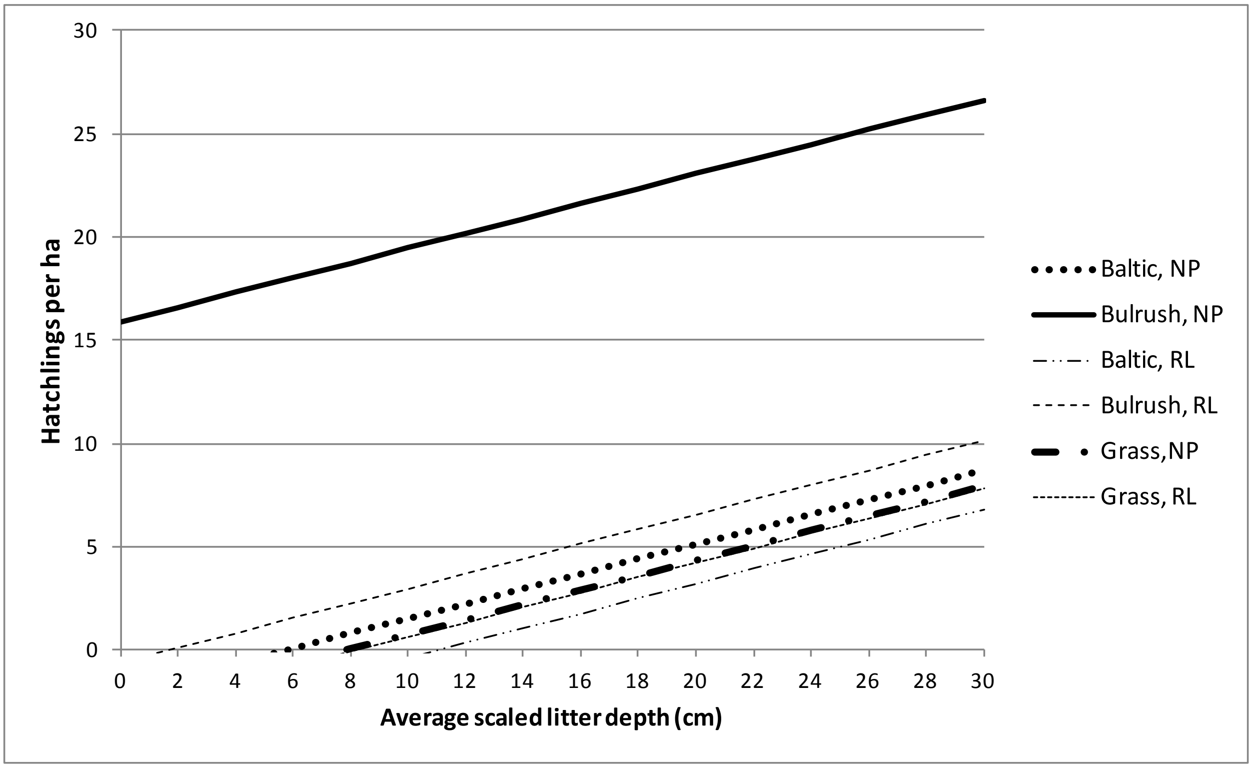
		Sex Age										
		F				F Tot	M				M Tot	Grand Total
Region	Species	AHY	HY	L	U		AHY	HY	L	U		
ANWR	AGWT	3	1	1		5	11	1			12	17
	AMWI	2		4		6	6	1	5		12	18
	BCTE	1	6	6		13		5	7		12	25
	CANV		1			1						1
	GADW	9	5	11		25	41	16	13		70	95
	LESC	1		10		11			9		9	20
	MALL	28	11	7		46	50	10	14		74	120
	NOPI	1	1			2		4			4	6
	NSHO	2	2	5		9		1	3		4	13
ANWR Total		47	27	44		118	108	38	51		197	315
Hebron	AGWT		3			3	1	2	1		4	7
	AMWI	1				1			5		5	6
	BCTE	1	2			3						3
	CANV			2		2			2		2	4
	GADW	1		23		24	2		28		30	54
	LESC	1		3		4						4
	MALL	32	18	11	1	62	9	21	14		44	106
	NOPI	3		3		6		2	5		7	13
	NSHO			2		2			1		1	3
Hebron Total		39	23	44	1	107	12	25	56		93	200
Lake John	AGWT						2				2	2
	AMWI						3				3	3
	BCTE	4	3			7	2	1			3	10
	GADW	2				2	7	2			9	11
	LESC	1		2		3			1		1	4
	MALL	34	13	1		48	185	16	1	1	203	251
	REDH						2				2	2
Lake John Total		41	16	3		60	201	19	2	1	223	283
Walden Res	BCTE	2	2	1		5		2	2		4	9
	CANV							1			1	1
	CITE						1				1	1
	GADW	21	1	14		36	21	1	17		39	75
	MALL	1				1		2			2	3
	NSHO			2		2		1			1	3
Walden Res Total		24	3	17		44	22	7	19		48	92
Grand Total		151	69	108	1	329	343	89	128	1	561	890

Table 7. Summary of ducks banded by area, species and year.

	North Park			
Species	2008	2009	2010	NP Total
AGWT	1	148	26	**175**
AMWI	11	55	27	**93**
BCTE	4	72	47	**123**
BWTE	4	1	0	**5**
CANV	8	8	6	**22**
CITE	1	2	1	**4**
GADW	194	223	235	**652**
LESC	8	4	28	**40**
MALL	438	541	480	**1459**
NOPI	8	6	19	**33**
NSHO	54	2	19	**75**
REDH	6	3	2	**11**
RNDU	0	2	0	**2**
RUDU	1	0	0	**1**
Total	**738**	**1067**	**890**	**2695**

For Tables 1-7, the following abbreviations are defined as: ANWR = Arapaho National Wildlife Refuge, NP = North Park, AGWT = American green-winged teal, AMWI = American wigeon, BCTE = blue-winged or cinnamon teal, BWTE = blue-winged teal, CANV = canvasback, CITE = cinnamon teal, GADW = gadwall, LESC = lesser scaup, MALL = mallard, NOPI = northern pintail, NSHO = northern shoveler, REDH = redhead, RNDU = ring-necked duck, RUDU = ruddy duck

Figure 1. Estimated relationship between depth of dead vegetation and ducklings produced per ha, based upon results from North Park (NP) and Russell Lakes SWA (RL), 2009 & 2010 for patches dominated by bulrush, Baltic rush, and grasses & sedges.



APPENDIX I: Wetland Acres by Land Manager and Specific Management Unit within the North Platte River Basin

Land Manager and Specific Management Unit[1]	Basin Area by Manager		Wetland Area by Manager		Wetland Area in Acres by NWI System/Class						
	Acres	% of Basin	Acres	% of Total	L1/2	R2/3/4	PUB/US	PAB	PEM	PSS	PFO
BLM	**213,053**	**16.52%**	**4,718**	**3.42%**	**1,540**	**54**	**181**	**176**	**2,010**	**753**	**4**
BLM Other	213,053	16.52%	4,718	3.42%	1,540	54	181	176	2,010	753	4
CPW	**11,837**	**0.92%**	**5,076**	**3.68%**	**1,314**	**31**	**12**	**35**	**3,399**	**284**	**-**
Brocker SHA	66	0.01%	4	0.00%	-	-	-	-	1	3	-
Brownlee SWA	35	0.00%	22	0.02%	-	14	-	2	5	1	-
Cowdrey Lake SWA	285	0.02%	66	0.05%	54	-	-	1	10	1	-
Delaney Butte Lakes SWA	2,457	0.19%	492	0.36%	427	1	2	-	61	1	-
Diamond J SWA	3,306	0.26%	2,034	1.47%	-	3	1	11	1,962	58	-
Hohnholz Lakes SWA	234	0.02%	88	0.06%	70	< 1	-	< 1	14	4	-
Hohnholz Lakes SWA-Laramie River	3	0.00%	2	0.00%	-	-	-	-	< 1	2	-
Lake John SWA	1,238	0.10%	753	0.55%	702	-	3	16	32	-	-
Manville SWA	67	0.01%	54	0.04%	-	-	-	-	14	40	-
Murphy SWA	823	0.06%	630	0.46%	-	-	-	-	518	112	-
Odd Fellows SWA	49	0.00%	20	0.01%	-	-	-	-	2	18	-
Owl Mountain SWA	843	0.07%	13	0.01%	-	-	-	-	12	< 1	-
Richard SWA	2,323	0.18%	856	0.62%	41	2	6	5	760	42	-
Seymour Lake SWA	81	0.01%	23	0.02%	20	-	-	-	3	-	-
Verner SWA	24	0.00%	19	0.01%	-	11	-	-	5	3	-
Verner SWA - Access	4	0.00%	-	-	-	-	-	-	-	-	-
COUNTY	**5**	**0.00%**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
FWS	**23,340**	**1.81%**	**7,473**	**5.41%**	**27**	**-**	**84**	**324**	**6,808**	**230**	**-**
Alamosa National Wildlife Refuge	23,340	1.81%	7,473	5.41%	27	-	84	324	6,808	230	-
NPS	**24**	**0.00%**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Rocky Mountain National Park	24	0.00%	-	-	-	-	-	-	-	-	-

[1] Many properties in the basin are owned by private land owners but managed by an agency through easements or are owned by one agency but managed by another agency through inter-agency agreements. Therefore, the numbers of acres owned by a given agency is different than the number of acres managed by that agency. In the text of this report, acres are generally reported by land owner. However, within Appendix I, acres are presented by the primary land manager and by management unit.

PRIVATE	**414,664**	**32.16%**	**96,624**	**70.00%**	**923**	**804**	**330**	**1,001**	**81,404**	**12,079**	**84**
Connor Creek Ranch I	546	0.04%	264	0.19%	-	< 1	-	-	260	3	-
Coyte	1,221	0.09%	195	0.14%	-	-	20	2	173	-	-
Deline 2010	698	0.05%	27	0.02%	-	< 1	< 1	-	27	-	-
Deline VIII 2008	1,044	0.08%	23	0.02%	-	-	< 1	-	23	-	-
Lucky Penny	924	0.07%	513	0.37%	-	-	-	5	507	1	-
Owl Mountain Ranch 2010	323	0.03%	6	0.00%	-	-	-	< 1	2	4	-
Owl Mountain Ranch I	350	0.03%	142	0.10%	-	-	-	-	139	3	-
Owl Mountain Ranch II	361	0.03%	13	0.01%	-	< 1	-	-	3	10	1
Private Other	409,197	31.73%	95,442	69.14%	923	803	309	994	80,271	12,059	82
SLB (Public Access Program unless noted)	**58,933**	**4.57%**	**1,929**	1.40%	**11**	**33**	**18**	**60**	**1,329**	**478**	**-**
Adams	3,633	0.28%	136	0.10%	-	2	-	7	66	61	-
Bull Mountain	631	0.05%	6	0.00%	-	-	-	-	-	6	-
Cohagan	2,561	0.20%	41	0.03%	-	-	-	< 1	41	-	-
Dry Creek North	652	0.05%	0	0.00%	-	-	-	-	-	< 1	-
East Delaney Butte Lake	599	0.05%	140	0.10%	1	< 1	-	-	136	3	-
Elk Mountain	2,927	0.23%	69	0.05%	-	< 1	-	6	14	48	-
Independence Mountain	11,519	0.89%	158	0.11%	-	3	8	4	138	5	-
Indian Creek	616	0.05%	26	0.02%	-	-	-	< 1	18	8	-
Jimmy Creek)	647	0.05%	30	0.02%	-	-	-	-	23	7	-
Johnny Moore Mountain	7,563	0.59%	330	0.24%	10	1	1	12	191	114	-
Kemp Draw	519	0.04%	4	0.00%	-	-	3	1	< 1	-	-
LaGarrde Creek	706	0.05%	6	0.00%	-	6	-	-	< 1	-	-
MacFarlane Reservoir	2,881	0.22%	9	0.01%	-	-	-	1	8	-	-
North Platte	150	0.01%	22	0.02%	-	5	-	-	15	2	-
Owl Creek	660	0.05%	75	0.05%	-	1	-	-	71	3	-
Owl Mountain	588	0.05%	11	0.01%	-	-	-	-	4	8	-
Pass Creek (not Public Access Program)	629	0.05%	17	0.01%	-	-	-	-	2	15	-
Pfister Draw	1,911	0.15%	27	0.02%	-	-	-	-	27	-	-
Pinkham Mountain	528	0.04%	8	0.01%	-	-	-	-	7	1	-
Rabbit Ears	5,348	0.41%	128	0.09%	-	1	-	6	49	72	-
Red Canyon	636	0.05%	5	0.00%	-	-	-	1	4	-	-
Ridge Road	320	0.02%	9	0.01%	-	3	-	-	6	< 1	-
Sand Creek (not Public Access Program)	645	0.05%	20	0.01%	-	-	-	-	-	20	-
Sand Creek	4,934	0.38%	169	0.12%	-	6	4	4	136	19	-
Spring Creek	312	0.02%	12	0.01%	-	-	-	< 1	11	1	-
Taylor Draw	315	0.02%	40	0.03%	-	< 1	-	-	34	6	-

Three Sisters	1,534	0.12%	55	0.04%	-	< 1	-	4	18	33	-
SLB Other	4,969	0.39%	376	0.27%	-	5	2	13	310	46	-
State Parks	**69,556**	**5.39%**	**1,494**	**1.08%**	**120**	**63**	**27**	**42**	**122**	**1,116**	**3**
State Forest State Park	69,556	5.39%	1,494	1.08%	120	63	27	42	122	1,116	3
USFS – Arapahoe-Roosevelt NF	**166,192**	**12.89%**	**6,515**	**4.72%**	**261**	**60**	**258**	**151**	**743**	**5,026**	**15**
Arapaho National Forest	36	0.00%	-	-	-	-	-	-	-	-	-
Boston Peak Fen RNA	321	0.02%	7	0.01%	-	< 1	-	-	-	7	-
Neota Wilderness Area	291	0.02%	6	0.00%	-	< 1	-	-	-	6	-
Never Summer Wilderness Area	12	0.00%	-	-	-	-	-	-	-	-	-
Never Summer Wilderness Area/Bowen Gulch RNA	2	0.00%	-	-	-	-	-	-	-	-	-
Rawah Wilderness Area	67,609	5.24%	2,953	2.14%	230	24	52	16	454	2,177	-
Roosevelt National Forest	97,921	7.59%	3,549	2.57%	31	36	206	136	289	2,835	15
USFS – Routt NF	**331,928**	**25.74%**	**14,213**	**10.30%**	**849**	**309**	**81**	**1,531**	**5,064**	**6,205**	**174**
Kettle Lakes RNA	1,952	0.15%	307	0.22%	-	< 1	-	120	35	146	6
Mount Zirkel Wilderness Area	85,217	6.61%	3,492	2.53%	335	97	45	262	2,292	443	18
Mount Zirkel Wilderness Area/ Kettle Lakes RNA	4,398	0.34%	297	0.22%	-	4	-	114	91	88	-
Mount Zirkel Wilderness Area/ Mad Creek RNA	8	0.00%	0	0.00%	-	-	-	-	< 1	-	-
Never Summer Wilderness Area	6,691	0.52%	168	0.12%	5	3	13	-	< 1	148	-
Platte River Wilderness Area	766	0.06%	34	0.02%	-	25	-	2	< 1	7	-
Routt National Forest	232,897	18.06%	9,915	7.18%	510	180	23	1,034	2,645	5,374	149
Grand Total	**1,289,532**	**100.00%**	**138,043**	**100.00%**	**5,046**	**1,355**	**991**	**3,321**	**100,880**	**26,171**	**280**

APPENDIX J: Most Common Plant Species Encountered In the North Platte River Basin by Ecoregional Strata

Rank	Ecoregional Strata						
	21a: Alpine Zone	**21b/g: Cryst/Volc Subalpine**	**21e: Sed Subalpine**	**21c: Cryst Mid-Elev**	**21d/f: Sed Mid-Elev/Foothills**	**21i: Sagebrush Parks**	**18f: Laramie Basin**
	**** 5 occurrences each***		**** 7 occurrences each***	**** 9 occurrences each***			**** 5 occurrences each***
1	**Epilobium sp.*	*Carex aquatilis*	*Fragaria virginiana* ssp. *glauca*	*Epilobium sp.*	*Carex utriculata*	*Taraxacum officinale*	**Achillea lanulosa*
2	**Carex aquatilis*	*Phleum commutatum*	*Taraxacum officinale*	*Carex utriculata*	*Geum macrophyllum*	*Carex praegracilis*	**Alnus incana* ssp. *tenuifolia*
3	**Clementsia rhodantha*	*Epilobium sp.*	*Equisetum arvense*	*Fragaria virginiana* ssp. *glauca*	*Fragaria virginiana* ssp. *glauca*	*Juncus arcticus* ssp. *ater*	**Carex utriculata*
4	**Pedicularis groenlandica*	*Pedicularis groenlandica*	*Geranium richardsonii*	*Geum macrophyllum*	*Poa pratensis*	*Carex utriculata*	**Conioselinum scopulorum*
5	**Phleum commutatum*	*Psychrophila leptosepala*	*Geum macrophyllum*	**Achillea lanulosa*	*Carex aquatilis*	*Alopecurus pratensis*	**Equisetum arvense*
6	**Psychrophila leptosepala*	*Clementsia rhodantha*	*Vicia americana*	**Carex aquatilis*	*Equisetum arvense*	*Argentina anserina*	**Fragaria virginiana* ssp. *glauca*
7	**Salix planifolia*	*Salix planifolia*	**Achillea lanulosa*	**Distegia involucrata*	*Salix geyeriana*	*Carex aquatilis*	**Geum macrophyllum*
8	**Senecio triangularis*	*Carex utriculata*	**Calamagrostis canadensis*	**Equisetum arvense*	*Galium trifidum* ssp. *subbiflorum*	*Iris missouriensis*	**Poa palustris*
9	**Veronica nutans*	*Deschampsia cespitosa*	**Carex aquatilis*	**Juncus arcticus* ssp . *ater*	*Ribes inerme*	*Achillea lanulosa*	**Ribes inerme*
10	*10 spp with 4 occurrences*	*Galium trifidum* ssp. *subbiflorum*	**Castilleja sulphurea*	**Juniperus communis* ssp. *alpina*	*Taraxacum officinale*	*Epilobium sp.*	**Rosa woodsii*
Ties			**Luzula parviflora*	**Ribes inerme*			**Salix geyeriana*
Ties			**Mertensia ciliata*	**Salix geyeriana*			**Salix monticola*
Ties			**Pedicularis groenlandica*	**Taraxacum officinale*			**Taraxacum officinale*
Ties			**Phleum commutatum*				**Trifolium repens*
Ties							**Urtica gracilis*
Ties							**Vicia americana*