Jordan River Watershed
Wetland Assessment and Landscape Analysis

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Cover (clockwise from upper left): Alkaline depression in the floodplain of the Jordan River, submergent marsh in a managed impoundment at a privately owned duck hunting club near Great Salt Lake, wet meadow peatland in the Wasatch Montane Zone near the headwaters of the Little South Fork Provo River, and montane shrubland in the Wasatch Montane Zone near Lake Creek.

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Executive Summary

The Utah Geological Survey, with a grant from the U.S. Environmental Protection Agency and supplemental funding from the Uinta-Wasatch-Cache National Forest and the Utah Endangered Species Mitigation Fund, assessed wetlands in the Jordan River watershed in 2015 and 2016. The assessment project focused on wetlands and shallow waterbodies <1 m deep (e.g., playas, shallow impoundments, lake margins). The project had three main objectives, including:

1) obtaining baseline data on the types, common stressors, range of conditions, and potential functions of wetlands,
2) characterizing common Ecological Systems, including conducting an exploratory analysis to quantify reference condition for each System, and
3) creating a landscape profile by summarizing wetland spatial data.

To achieve the first two objectives, field surveys were conducted at 102 randomly selected and 7 subjectively selected wetland sites. Baseline data were analyzed for seven ecoregional strata, including three in the Central Basin ecoregion: Great Salt Lake, Jordan, and Utah Lake (from north to south), and four in the Wasatch Mountains ecoregion: Mountain Valleys, Semiarid Foothills, Wasatch Montane Zone, and Alpine Zone (from lowest to highest elevation).

Almost all wetland area in the watershed is surrounded by buffers of (semi-)natural land cover at least 50 m wide. Common stressors within 100 m of wetlands include non-native plant species (adjacent to 94% of wetland area), livestock grazing (38%), linear disturbances such as roads and power lines (37%), excessive filamentous algae (34%), and ditches (23%); these stressors are common across the watershed. Other stressors are only common in one ecoregion, including vegetation control and off-road vehicle tracks in the Central Basin and trails in the Wasatch Mountains.

Landscape-scale water quality stressors and hydrologic alteration are very common in the Jordan River watershed. Over 70% of wetlands in the Central Basin have a nearby hydrologic connection with point source dischargers or run-off from development and 50% have a nearby connection with agricultural run-off; these stressors were also present in the Wasatch Mountains ecoregion, particularly in the Mountain Valleys, but generally less prevalent. Water quality stressors often come from streams, lakes, or canals that directly provide water to wetlands instead of via overland runoff. All or almost all wetland area in the Great Salt Lake, Jordan, Utah Lake, and Mountain Valleys strata and half the wetland area in the Semiarid Foothills are estimated to have some degree of hydropattern alteration. Alteration was most pronounced in the Great Salt Lake, Jordan, and Mountain Valleys strata, due to management for wildlife habitat, urban run-off, and direct and indirect irrigation inputs, respectively. Control structures, berms, ditches, irrigation return flow, and impervious surface each affect over one-third of wetland area in the Central Basin ecoregion and in the Mountain Valleys.

Livestock grazing and excessive algae were common stressors within sites, estimated to occur in 37% and 31% of wetland area, respectively, and off-road vehicle tracks and vegetation control were found in 28% and 16% of Central Basin wetlands, respectively. However, soil disturbance from these activities was generally minor; 93% of wetland area is estimated to have good or excellent soil condition. Despite the prevalence of water quality stressors noted above, algae and turbidity conditions within

wetlands are generally good or were not evaluated due to lack of surface water; 22% of wetland area is estimated to be fair to poor for algae and 7% for turbidity.

Over one-third of wetland area has fair to poor litter accumulation, primarily in the Central Basin, and 15% has poor woody species regeneration or dominance by non-native woody species. Non-native plant species are extremely widespread in wetlands in the watershed. Almost 40% of all wetland plant cover in the Central Basin and 25% in the Wasatch Mountains is estimated to be comprised of non-native species. Eleven noxious weed species were documented during the study; most had fairly low cover in wetlands except for *Phragmites australis* (common reed) and *Tamarix* (tamarisk) in the Central Basin and *Cirsium arvense* (Canada thistle) in the Wasatch Mountains. *Phragmites australis* is the most widespread noxious weed species, with an estimated 13.6% cover across wetlands in the Central Basin.

Wetlands in the Jordan River watershed provide many functions, including wildlife habitat, recreational use, and water quality improvement. We documented over 45 species of birds, mammals, amphibians, and fishes at study sites, despite not conducting focused wildlife surveys, including three state sensitive species: American white pelican, boreal toad, and Columbia spotted frog. We collected data on habitat features for boreal toad and Columbia spotted frog; between one-third and one half of wetland area within the species' respective ranges in the Wasatch Mountains may be suitable for breeding. However, threats related to turbidity and recreational use are relatively common at potential boreal toad breeding sites and threats related to fragmentation and water quality stress from roads were common near potential Columbia spotted frog breeding sites. Wetland recreational use can be inferred from the landscape profile which shows that about 15% of wetland area in the watershed is privately or publicly managed for duck hunting and just under half the wetland area is on state or federal land, much of which is located near hiking trails. Most wetlands in the Jordan River watershed are estimated to currently provide some water quality improvement function, with both capacity and landscape need for improvement. Wetlands in the Semiarid Foothills, Wasatch Montane Zone, and Alpine Zone frequently did not show a landscape need for water quality improvement but had capacity that could be important in the face of future landscape changes such as fires or new development.

We documented nine Ecological Systems, including three Systems surveyed at one site each. We characterized the remaining Systems, including alkaline depressions, playas, and basin marshes in the Central Basin and wet meadows, foothill shrublands, and montane shrublands in the Wasatch Mountains, by summarizing hydrology, water chemistry, and plant community metrics. We screened for low disturbance reference sites in each System using data on site and surrounding stressors and plant community composition; we had to relax the screen for alkaline depressions, playas, and basin marshes to obtain at least four reference sites per System. Almost 47% of montane shrublands, about 11% of wet meadows, and between 16% and 23% of sites in other Systems had both condition scores and mean C values (a vegetation metric) above the 25th percentile of reference site scores.

Wetlands in most of the watershed were mapped using imagery from 1998, though some were mapped using imagery from the 1980s. An estimated 17% of the mapped area does not appear to be wetland based on 2015 imagery, though only 3% overlaps new development; the remaining may have been incorrectly mapped or lost to hydrologic changes. We updated spatial data in a portion of Salt Lake County; we mapped approximately one-third less wetland area than was in the original dataset. We used the wetland spatial data to profile wetlands in the watershed. Meadows, marshes, shallow lakes, and unconsolidated shores (i.e., playas, mudflats) each comprise between 20% and 28% of the wetland area in the Central Basins (where 90% of all mapped wetlands occur), whereas meadows comprise over half the wetland area in the Wasatch Mountains. Wetland polygons frequently overlapped land mapped as irrigated in two strata, with 46% overlap in the Mountain Valleys and 18% overlap in the Semiarid Foothills. According to an aquatic resource stress model, forested, scrub shrub, and pond wetlands in the Central Basin and marshes and meadows in the Wasatch Mountains face the most local stress. Local stress is highest in the Jordan and Mountain Valleys strata and lowest in the Wasatch Montane Zone and Alpine Zone.

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Introduction

Project Background

Wetlands in the Jordan River watershed include small ponds and springs in montane areas, riparian meadows and willow stands in mountain valleys, and extensive complexes of marshes, alkaline depressions, mudflats, and playas along the shores of Great Salt Lake and Utah Lake. These wetlands have the potential to provide important ecological services including wildlife habitat, water quality improvement, and flood attenuation. Wetlands in the watershed support millions of migrating and nesting birds and two state sensitive amphibian species, Columbia spotted frog and boreal toad. Wetlands can help protect in-stream water quality to support native fish species such as Bonneville cutthroat trout and bluehead sucker and to preserve recreational fishing opportunities, including on the Provo River Blue Ribbon Fishery.

Anthropogenic disturbances have the potential to affect wetland condition and their ability to provide ecological services. In the Jordan river watershed, about 30% of the land cover in the Central Basin and Range ecoregion and 3% of the land cover in the Wasatch and Uinta Mountains ecoregion is developed, and approximately 7% of the entire watershed is used for agriculture. Livestock grazing is common across much of the watershed, and wastewater treatment plants discharge to waterbodies that supply many of the wetlands in the watershed. Many reservoirs and streams in the watershed are not meeting water quality standards (Utah Division of Water Quality, 2016b) and hydrologic modifications such as reservoirs, groundwater withdrawal, and diversions are common. However, little work has been done to evaluate the extent to which these anthropogenic disturbances impact wetlands in the region.

The Utah Geological Survey (UGS), with a grant from the U.S. Environmental Protection Agency (EPA) and supplemental funding from the Uinta-Wasatch-Cache National Forest, conducted a field assessment of wetlands in the Jordan River watershed to provide data on the type, condition, and potential function of wetlands in the watershed. Our project had three major objectives, including obtaining baseline data on the condition and potential function of wetlands, describing common Ecological Systems, and creating a landscape profile using mapped wetland data and ancillary information to better understand the landscape setting of wetlands in the watershed.

Overview of Wetland Assessments

EPA's Three-tiered Framework

The work described in this report follows the EPA's three-tiered framework to assess wetland condition at varying spatial scales and levels of intensity (U.S. Environmental Protection Agency, 2006). Level I assessments are conducted at the broadest scale using geographic information systems (GIS) and remotely sensed data to evaluate *expected* wetland condition based on surrounding land use, potential stressors, and other inputs. These assessments are relatively inexpensive and efficient for evaluating wetlands across broad geographic areas but cannot provide data on *actual* condition and are limited to including only stressors with available spatial data. Level II assessments are field surveys designed to be relatively rapid (approximately four hours of field time per site) and are moderately detailed, often relying on qualitative rather than quantitative evaluation. These assessments maximize the amount of field sites that can be surveyed and thus the strength of inference, but methods can be difficult to develop and calibrate. Level III assessments are more detailed quantitative field evaluations that have the highest degree of reliability and can withstand the most scrutiny, but at the expense of requiring the most professional expertise and sampling time. These assessments often use invertebrate, plant community, or water quality parameters to develop indices to distinguish between low and high quality sites and can sometimes be used to evaluate or calibrate Level I and II assessments. For this project, we created a Level I landscape profile, collected primarily qualitative Level II wetland condition and function data, and collected more intensive Level III water chemistry and plant community composition data.

Condition Versus Function Assessments

The assessments conducted for this project evaluate wetland condition and some aspects of wetland function. Wetlands in good condition exhibit species composition, physical structure, and ecological processing within the bounds of states expected for systems operating under natural disturbance regimes (Lemly and others, 2016). Direct or indirect anthropogenic alteration may lead to a change in these states and a concomitant lowering of the overall condition of the wetland. For the condition assessment, wetlands are evaluated to determine the degree to which they deviate from a reference standard, or anthropogenically unaltered, wetland. In contrast, functional assessments evaluate services provided by wetlands that are deemed important to society, such as the ability to attenuate flood waters or provide wildlife habitat (Fennessy and others, 2007). Many severely altered (i.e., low condition) wetlands still provide functional services; for example, a wetland adjacent to a wastewater treatment plant can improve water quality, and an artificially impounded reservoir can provide amphibian habitat.

Reference standards are an important component of condition assessments. The reference standard condition is the condition that corresponds with the greatest ecological integrity within the continuum of possible site conditions (Sutula and others, 2006) and is usually specific to a particular class of wetland (e.g., montane meadow, playa). The reference standard condition can refer to the expected state prior to any anthropogenic disturbance or at a specified historical point in time, or it can refer to the condition found at the least disturbed sites within the survey area or wetland type (Stoddard and others, 2006). For the condition assessment, we used a reference standard adopted from Colorado Natural Heritage Program’s Ecological Integrity Assessment, which sets a standard based on “deviation from the natural range of variability expressed in wetlands over the past ~200–300 years (prior to European settlement)” (Lemly and others, 2016). While reference standard condition is ideally determined from field observations of undisturbed or minimally disturbed wetlands (i.e., reference standard sites), there can be too few undisturbed sites in some highly altered landscapes to determine the natural range of variability. Because of this, reference standards for the condition assessment were developed based on a combination of field observations from minimally disturbed wetlands, review of relevant literature, and evaluation of conditions described in rapid assessment protocols from other states. In contrast, we used the least disturbed condition as the reference standard for our exploratory analysis of wetland condition by Ecological System.

Wetland Classification

We used three wetland classification methods in this study: Cowardin, hydrogeomorphic (HGM), and Ecological System. The only currently available spatial data for wetlands in Utah is the National Wetlands Inventory (NWI). NWI classifies wetlands using the U.S. Fish and Wildlife Service’s Cowardin classification system, which separates wetlands and deep water habitat into three systems in Utah (riverine, lacustrine, and palustrine) that are further divided based on substrate material, predominant overstory life form, water regime, and other modifiers (Cowardin and others, 1979). We used the Cowardin classification system to select wetlands for our survey sample frame and to conduct the Level I landscape analysis.

We classified wetlands using both hydrogeomorphic (HGM) and Ecological Systems classifications to set the context for expected condition and function of wetlands during field assessments. The HGM system classifies wetlands as one of seven types based on water source, hydrodynamics, and geomorphology (Brinson, 1993). HGM classes are useful for determining the expected condition of hydrologic attributes, such as water retention time, nutrient cycling capacity, and hydroperiod, and for functional potential, such as water quality improvement and floodwater storage. For this study, wetlands were either classified as lacustrine fringe, riverine, slope, or depressional (four of the original HGM classes) or as one of three novel classes predominantly found around Great Salt Lake, impoundment release, depressional impoundment, and depressional impoundment fringe. These novel classes were developed by the UGS to improve description of highly managed wetlands around Great Salt Lake. *Impoundment release* wetlands receive horizontally spreading water when water is released from an upgradient impoundment, typically occur on mudflats around Great Salt Lake, and lack major channels. *Depressional impoundments* are wetlands that occur within artificial impoundments >8 ha in size and <2 m deep with primary water fluctuations that are vertical with rising and falling water levels due to steep impoundment sides. *Depressional impoundment fringe* wetlands occur on the edge of impoundments and receive water that spreads and recedes horizontally with changing water levels.

The International Terrestrial Ecological Systems Classification (Ecological Systems), developed by NatureServe, classifies terrestrial systems based on vegetation patterns, abiotic factors, and ecological processes (http://explorer.natureserve.org); 15 wetland and riparian Ecological Systems have been described for the state of Utah. Ecological Systems generally describe classes of wetlands that may be recognized by non-specialists, such as marshes and montane shrublands. Ecological Systems are useful for setting the expected condition of structural elements of wetlands, such as the relative cover of woody versus non-woody plant species and the amount and type of litter and woody debris.

Project Objectives

Objective 1: Baseline data by ecoregional strata

Our first objective was to obtain baseline data on wetlands in the Jordan River watershed, including estimates of the types, range of conditions, potential functions, and common stressors. These data can provide information for conservation and management planning and serve as a baseline for future studies. We used the Utah Rapid Assessment Procedure (URAP) to collect field data at over 100 wetlands in the Jordan River watershed. We present results for each of the two Omernik Level III ecoregions in our project area, the Central Basin and Range ("Central Basin") and the Wasatch and Uinta Mountains ("Wasatch Mountains") and for seven strata nested within the ecoregions. We also produced estimates specific to wetlands on the lower elevation portions of the Uinta-Wasatch-Cache National Forest (National Forest).

Objective 2: Ecological System characterization

Our second objective was to characterize common Ecological Systems in Utah. Ecological Systems are a useful classification system for determining vegetation targets (e.g., cover, richness, etc.)

for restoration or mitigation projects and may be used in the development of quantitative reference standards for Utah's wetlands. We summarized data on attributes related to elevation, depth and extent of surface flooding, water quality parameters, and richness and cover of plant species within each common Ecological System in the watershed. We also conducted an exploratory analysis to quantify reference condition by Ecological System based on a wetland condition score and on mean C, an index of plant quality. The exploratory analysis was used to determine the strengths and weaknesses of classifying wetlands by Ecological System when developing reference standards and to identify data gaps.

Objective 3: Landscape analysis

Our third objective was to create a landscape profile of wetlands in the watershed. The landscape profile combined information on wetland location, wetland type, and wetland stress to highlight uncommon, unprotected, or threatened wetland types. The landscape profile can be used to identify areas and wetland types with the most need for restoration, creation, or mitigation. However, the landscape profile depends on existing mapped wetland data, which is out-of-date. We undertook two actions to provide better context for the mapped data. First, we estimated the accuracy of the available mapped wetland data in the watershed and provided potential explanations for changes in wetland area based on examination of randomly selected points. Second, we remapped a portion of the watershed and compared the old mapping data with the new.

Study Area

Geographic and Ecoregional Setting

The study area for this project was the Jordan River watershed, as defined by the U.S. Geological Survey's (USGS) 6-digit Hydrologic Unit Code (HUC6) 160202 (http://nhd.usgs.gov/wbd.html, figure 1). The watershed is entirely in Utah and has an area of approximately 9855 km^2. The watershed is bordered by the Wasatch Range to the east, the East Tintic and Oquirrh mountains to the west, the Levan Ridge to the south, and Great Salt Lake to the northwest. Most of the watershed drains to Utah Lake from the Wasatch Range and small ranges to the south and west and then flows via the Jordan River to Great Salt Lake, though some areas drain directly to Great Salt Lake or the Jordan River.

The Central Basin and Wasatch Mountains ecoregions comprise 45.5% and 54.5% of the area of the Jordan River watershed, respectively (Omernik, 1987). Though occupying about half the watershed area, the Central Basin ecoregion contains just over 90% of the watershed's wetland acreage. Most wetlands occur along the shallow edges of Utah Lake or along the southeastern shore of Great Salt Lake. Wetland extent and type along both waterbodies fluctuate with changes in water levels, though the highly managed systems of canals, control structures, and impoundments along Great Salt Lake dampen some of this fluctuation. Plant communities vary depending on water management and the availability and duration of freshwater. Bulrush (*Schoenoplectus* spp.), cattails (*Typha* spp.), common reed (*Phragmites* spp.), and submerged aquatic vegetation (primarily *Stuckenia* spp.) are common in emergent marshes and artificial impoundments. Mountain rush (*Juncus arcticus* ssp. *littoralis),* spikerushes (*Eleocharis* spp.), and mixtures of native and non-native grasses are common in seasonally flooded areas. Barren and sparsely vegetated playas, salt flats, and mudflats also occur throughout the area and have salt-tolerant plant species including pickleweed (*Salicornia* spp.) and saltgrass (*Distichlis*

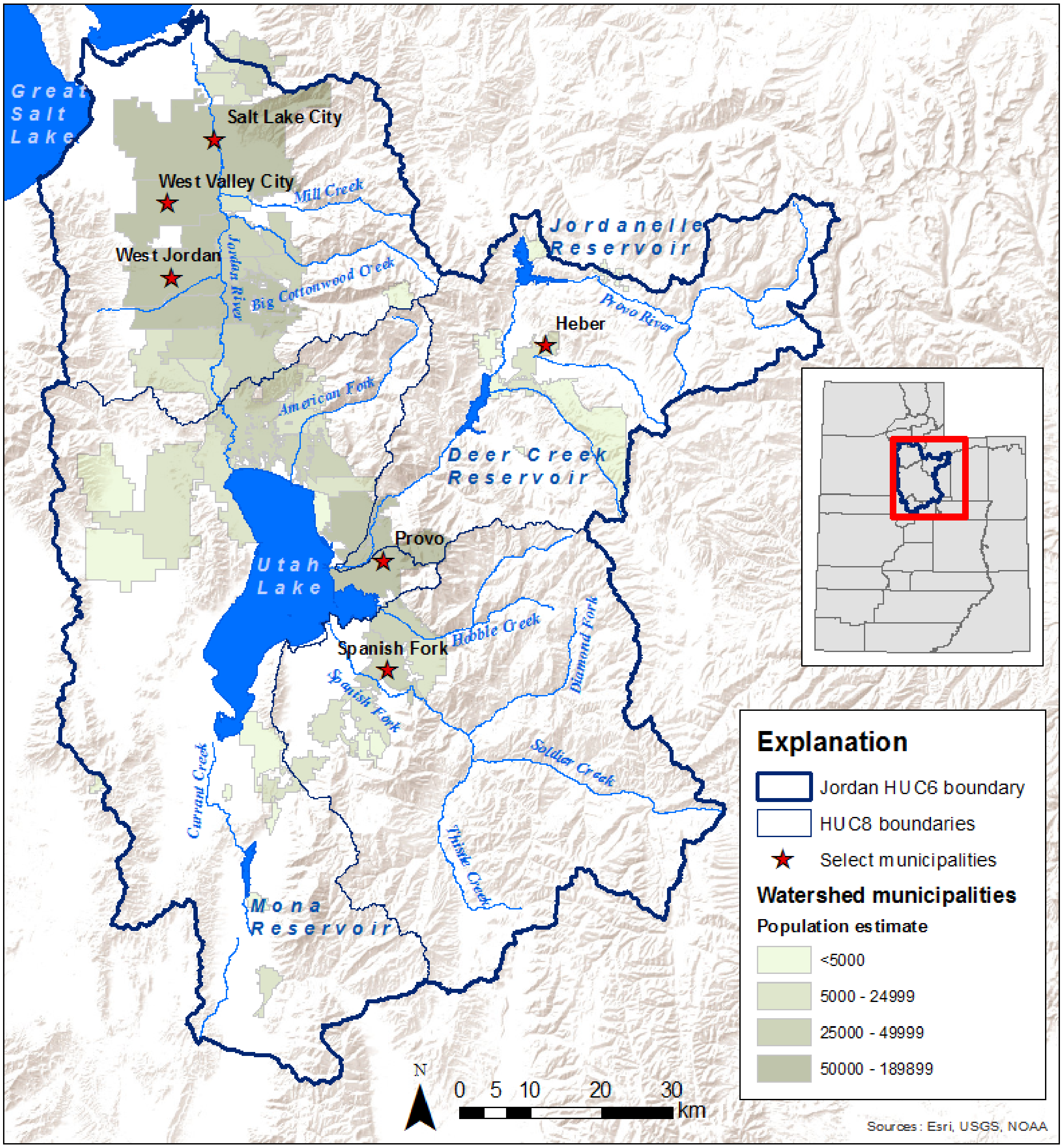

Figure 1. Overview of the Jordan River watershed, including municipalities, major streams and waterbodies, and HUC8 boundaries.

spp.). Other wetland types found in the Central Basin ecoregion include spring complexes, retention ponds, and riparian wetlands along the Jordan River.

The Wasatch Mountains ecoregion is composed of high, glaciated and partially glaciated mountains, dissected plateaus, foothills, and high elevation valleys (Woods and others, 2001). Wetlands within the ecoregion include headwater meadows and shrublands formed from groundwater and snowmelt, lower-elevation riparian areas, springs and seeps, and small and typically excavated depressions used for watering livestock. Irrigated cropland and pastureland have replaced native shrub communities in much of the mountain valleys, leading to wetlands that receive a mixture of natural and altered hydrologic inputs.

Climate and Hydrology

Most precipitation in the Jordan River watershed falls as snow in the higher elevation mountain valleys, foothills, and mountains, which receive between 51 and 88 cm of precipitation per year (Daly and others, 2008). The Central Basin ecoregion receives between 40 and 51 cm of precipitation. Mean annual temperatures in the study area range from 3.2°C in the Uinta Mountains and alpine areas to between 5.2 and 7.5°C in the mid-elevation mountains and mountain valleys and between 10 and 11.8°C in the Central Basin ecoregion.

Most of the watershed drains to Great Salt Lake via the Jordan River and canals off the river or directly to Great Salt Lake, except for a small internally draining basin to the west of Utah Lake. About three-quarters of the watershed first drains to Utah Lake via several rivers from the Wasatch and Uinta Mountains and smaller tributaries and springs to the south and west, before exiting Utah Lake to the Jordan River. The Jordan River accounts for approximately 17% of the surface flow and 12% of the overall inflow to Great Salt Lake (Utah Division of Forestry, Fire, and State Lands, 2013).

Major dams and reservoirs in the Jordan River watershed provide a total storage capacity of over 1.3 million acre-feet of water, almost all of which is in the Utah Lake portion of the watershed (Utah Division of Water Resources, 2014a). Utah Lake was dammed in 1872 to provide water to Utah and Salt Lake counties and additional reservoirs were built in the early 1900s, including Mona Reservoir and more than a dozen small reservoirs in the Uinta Mountains. More recently, the Bureau of Reclamation has invested in several large water projects in the region, including the construction of Deer Creek and Jordanelle Reservoirs along the Provo River and transbasin diversion projects bringing water from the Duchesne and Weber basins.

Wildlife

The most well-known and extensive wetland habitat in the Jordan River watershed occurs around Great Salt Lake and Utah Lake. Great Salt Lake wetlands support millions of migratory birds, including two-thirds of all Wilson's phalaropes (*Phalaropus tricolor*) and half of all eared grebes (*Podiceps nigricollis*) (Jehl Jr., 1988) as well as large populations of breeding birds, including several species of gull, heron, and egret (Paul and Manning, 2002). Two species that utilize Great Salt Lake and Utah Lake wetlands, American white pelicans (*Pelecanus erythrorhynchos*) and long-billed curlew (*Numenius americanus*), have been designated as Species of Concern by the state of Utah due to declining nesting populations caused by habitat alteration, increased disturbance, and increased predation (Utah Division of Wildlife Resources, 2011).

The rivers, streams, lakes, and reservoirs in the Jordan River watershed provide habitat for several native fish species, although non-native fish are also abundant and often dominate the larger streams and lakes. The June sucker, a federally endangered native fish, is endemic to Utah Lake (June Sucker Recovery Team, 1999). Two other native fish species known to occur in the watershed, the bluehead sucker (*Catostomus discobolu*s) and Bonneville cutthroat trout (*Oncorhynchus clarkia utah*), receive special management in Utah under a state Conservation Agreement (Utah Division of Wildlife Resources, 2017). A third Conservation Agreement species, the least chub (*Iotichthys phlegethontis*), has been extirpated from the Jordan River watershed, though is extant in other parts of the state (Bailey and others, 2005).

Wetland habitats are important for a number of amphibian and mammal species in the Jordan River watershed. Common native amphibian species include the western chorus frog (*Pseudacris maculate*), northern leopard frog (*Lithobates pipiens*), and tiger salamander (*Ambystoma tigrinum*) as well as the non-native American bullfrog (*Rana catesbeiana*). Small populations of both the Columbia spotted frog (*Rana luteiventris*), a Conservation Agreement species, and boreal toad (*Bufo boreas*), a Utah Species of Concern, also occur in the watershed (Bailey and others, 2006). The American beaver (*Castor canadensis*) and the less common northern river otter (*Lontra canadensis*) both occur along creeks, rivers, and ponds, primarily in the upper portions of the watershed.

Land Ownership and Land Use

Land ownership within the Jordan River watershed is 50% private, 39% federal, and 11% state, according to GIS calculations using data from the Automated Geographic Reference Center (http://gis.utah.gov/data/sgid-cadastre/land-ownership). Government land managers in the Central Basin ecoregion include the U.S. Bureau of Land Management and the Utah School and Institutional Trust Lands Administration south and west of Utah Lake, the Utah Division of Wildlife Resources at Farmington Bay Waterfowl Management area on the shore of Great Salt Lake, and the Utah Division of Forestry, Fire, and State Lands on the lakebeds of Utah Lake and Great Salt Lake. About 25% of land in the watershed adjacent to Great Salt Lake is privately managed for duck hunting or avian conservation. Private land ownership decreases, and U.S. Forest Service ownership increases, with increasing elevation in the Wasatch Mountains ecoregion, ranging from 78% private ownership in the mountain valleys and about 55% in the lower montane areas to <1% in the highest elevation montane areas. The State owns about 7% of the land in the Wasatch Mountains ecoregion, much of it as state parks or wildlife management areas. About 4% of the land is enlisted as Cooperative Wildlife Management Units (CWMUs). The CWMU program incentivizes landowners to preserve and manage land for wildlife and to create public hunting opportunities in exchange for the right to privately sell hunting permits. CWMU landowners must write a management plan with the assistance of a state wildlife biologist and must have a minimum of 5000 contiguous acres to enroll in the program.

The population in the Jordan River watershed is predominantly located in the Central Basin ecoregion, and over 1.5 million people can be found in the band of development extending from Bountiful to the north to Spanish Fork and smaller municipalities to the south. Populations are continuing to grow, with some of the highest rates of anticipated growth on the northwestern side of Utah Lake, southern Utah County, and Wasatch County (Utah Governor’s Office of Management and Budget, 2012). Salt Lake City, West Jordan, West Valley, and Provo all have over 100,000 people as of 2010. Heber, along the middle Provo River, has the largest population in the Wasatch Mountains ecoregion with more than 11,000 people. The adjacent town of Midway has a population of almost 4,000, and the remaining towns have populations less than 1000. Overall, development accounts for 30% of the land cover in the Central Basin ecoregion and 3% in the Wasatch Mountains ecoregion, including 19% in the mountain valleys (Landfire, 2014). Approximately 7% of the watershed is used for agriculture, of which about 61% is irrigated and the remainder is sub-irrigated, idle, or dry farmed (Utah Division of Water Resources, 2014b and c). Alfalfa and pasture are the most common agricultural uses on irrigated land, followed by corn, grain, and grass or hay. The remaining land cover in the watershed is a mixture of open water, grassland, shrubland, and forested areas in the Central Basin ecoregion and forest with a smaller component of shrubland in the Wasatch Mountains ecoregion. Much of the non-agricultural, non-developed land is used as rangeland.

Mining is an important part of the current and historical landscape of the watershed. Rio Tinto's Bingham Canyon Mine, the largest human excavation on earth, and associated mining infrastructure, including large tailings ponds, occur in the northern Oquirrh Mountains and adjacent to Great Salt Lake. Rock quarries are common, including several large operations on the eastern bench of the Central Basin ecoregion. The largest concentration of historical mineral mining operations recorded in Utah Division of Oil, Gas, and Mining's database of abandoned mines are found in the drainages for Big and Little Cottonwood Creeks, American Fork, just east of Park City, and the southern edge of the Oquirrh Mountains (R. Williams, Utah Division of Oil, Gas, and Mining, unpublished information, 2015).

Recreation is another important land use in the watershed. The Jordan River watershed supports Blue Ribbon Fisheries at Jordanelle Reservoir and the lower and middle Provo River, meaning that these waterbodies have met criteria for high quality fishing, outdoor experience, fish habitat, and economic benefits (https://wildlife.utah.gov/hotspots/blueribbon.php). Waterfowl hunting and bird watching are popular along Great Salt Lake. Other recreational opportunities include big game hunting, boating in lakes and reservoirs, skiing, and hiking.

Water Quantity and Water Quality

The combined population of the three counties that make up the majority of the Jordan River watershed—Salt Lake, Utah, and Wasatch—is projected to more than double between 2010 and 2060 (Utah Governor's Office of Management and Budget, 2012) and current water supplies are not expected to be able to meet the anticipated need (Utah Division of Water Resources, 2010 and 2014a). Water demand is already too high to be met by existing supply during drought years in parts of Utah County (Utah Division of Water Resources, 2014a). The additional demand may be met through transfers of existing agricultural water rights to municipal rights, increased water conservation, and new water development projects. Diminished irrigation return flows, declining groundwater levels, and increased water demand are all likely to impact water availability in aquatic and wetland systems.

Water quality in the Jordan River watershed has been affected by factors including urban run-off, industrial dischargers, agricultural, and resource extraction (Toole, 2011). Seven of the 15 lakes assessed by the Utah Division of Water Quality in the watershed are listed as impaired (Utah Division of Water Quality, 2016b). Only 11 of the 119 water quality stream assessment units in the watershed were designated as fully meeting water quality standards, whereas 47 were designated as impaired and 2 have water quality plans designed to address impairments; the remaining units did not have enough data to evaluate all uses. The most common impairments were *E. coli* and impaired macroinvertebrate communities, followed by dissolved oxygen, total dissolved solids, and temperature. Sixteen assessment units are impaired for selenium, cadmium, arsenic, or other elements commonly associated with mining legacies.

Field Study Design and Survey Methods

Site Selection

Target Population and Sample Frame

The target population for this study was wetlands within the Jordan River watershed that were at least 0.1 ha in size. Wetlands are areas that receive periodic substrate saturation or inundation, which often results in distinctive plant communities and distinctive soils due to the physiological constraints imposed by anoxic soil conditions (Federal Geographic Data Committee, 2013). The characteristics typically required to identify wetlands are wetland hydrology indicators, hydric soil indicators, and a predominance of hydrophytic plant species (Cowardin and others, 1979; U.S. Army Corps of Engineers, 2008; U.S. Army Corps of Engineers, 2010). For this study, a site was considered part of the target population if it had an indicator of wetland hydrology and if it had hydrophytic plants and hydric soils if vegetation or soils were present. We did not include areas we termed dry mudflats as part of the target population. These were areas along the shore of Great Salt Lake and, less frequently, Utah Lake, that never appeared wet across all the years of imagery available in Google Earth, though they are likely inundated during years with high water levels.

The U.S. Fish and Wildlife Service's NWI program maps wetlands and deepwater habitat throughout the United States using the Cowardin classification system. We obtained NWI data for the state of Utah from the U.S. Fish and Wildlife Service website (http://www.fws.gov/wetlands/data/State-Downloads.html) on March 30, 2015; the file was last updated on October 6, 2014. The urban Wasatch Front portion of the study area was mapped using imagery from 1998 and the rest of the study area was mapped using imagery from between 1981 and 1985. For the Jordan River watershed project, we focused our sampling effort on areas with water <1 m deep for the safety of field crews and because different sampling methods are more appropriate for deepwater areas. We removed deepwater areas from the NWI data by removing all polygons mapped as lacustrine limnetic (L1); these are deepwater areas with water ≥2.5 m deep. We kept polygons mapped as lacustrine littoral (L2), which includes open water <2.5 m in depth, lakeshore edges, playas, and mudflats and impoundments around Great Salt Lake. In the Cowardin classification system, riverine systems include wetlands and deepwater habitat in channels, unless the wetlands are dominated by persistent vegetation or mosses and lichens (https://www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands/nvcs-2013). We wanted to include oxbows and backwaters in our sample frame, but not perennially flowing streams or stream washes that only occasionally contained water. We eliminated all riverine polygons from the sample frame that were in the unconsolidated bottom or streambed classes. Based on visual inspection in ArcGIS, features mapped as unconsolidated bottom were mainstem river channels and features mapped as streambed were channels associated with intermittent streams. We kept riverine unconsolidated shore features in the sample frame because these were often on the edges of streams in areas that received frequent overbank flooding.

Wetlands were included in the sample frame if most of the polygon was located in the Jordan HUC6. Twenty-six polygons crossed the Jordan HUC6 boundary; most of these crossings were minor, but one feature extended over 6 km into the adjacent HUC6 at Farmington Bay Wildlife Management Area. We kept this entire feature in our sample frame for the sake of consistency and to ensure that the polygon would not be excluded from future assessments.

Strata and Selection of Study Sites

We selected wetland sites using six strata. In the Central Basin ecoregion, 20 sites were allocated to the Great Salt Lake stratum (Salt Deserts, Shadscale-Dominated Saline Basins, and Wetlands Level IV Ecoregions), 10 sites to the Jordan stratum (the remaining area of the Jordan HUC8), and 20 sites to the Utah Lake stratum (the remainder of the Central basin ecoregion). In the Wasatch Mountains ecoregion, 6 sites were allocated to the Alpine zone (Alpine Zone, Uinta Subalpine Forests, and Mid-Elevation Uinta Mountains Level IV ecoregions), 24 sites to the National Forest stratum (Uinta-Wasatch-Cache National Forest land outside of the Alpine Zone), and 20 sites to the remainder of the ecoregion. For data analysis, we analyzed results for the National Forest and Alpine Zone strata and for three additional Level IV ecoregional strata, the Mountain Valleys, Semiarid Foothills, and Wasatch Montane Zone. All sites outside the Alpine Zone stratum were classified into one of these latter three strata and analyzed with weights appropriate to their selection probability in the original data selection (figure 2). A summary of characteristics of the ecoregional strata used for data analysis can be found in table 1.

We used the spsurvey package (Tom and others, 2012) in R 3.2.0 (R Core Team, 2015) to select survey sites using a Generalized Random Tessellation Stratified (GRTS) survey design. GRTS is a statistical method to select random sample locations that are spatially balanced and ordered so that any consecutive sets of sample points are themselves spatially balanced (Stevens and Olsen, 2004). We selected survey points instead of wetland polygons because URAP evaluates fixed area plots rather than whole wetlands. We used a stratified equal weight selection design, so all wetland area within each stratum had equal probability of selection, and we selected between 25 and 50 oversample points per stratum. Oversample points were used to replace the primary sample points that could not be surveyed due to lack of permission from landowners or absence of target wetland.

Selection of Reference Sites

We wanted to survey at least one low and one high quality site in each stratum to capture the full range of wetland conditions in the watershed. We used field data from the first year of surveys and the Landscape Integrity Model (Menuz, 2015) to evaluate whether each survey stratum had randomly selected low and high quality sites. We then used two methods to develop a list of potential low and high quality reference sites to survey in addition to the randomly selected sites. First, we asked land managers, watershed specialists, and Utah Geological Survey employees for site recommendations. Second, we screened sites with low and high scores in the Landscape Integrity Model. Ten subjectively selected sites were visited in 2010, though not all were surveyed due to lack of target wetland.

Site Office Evaluation and Landowner Permission

Sample sites were screened to determine whether they were located near target wetland using true color and infrared aerial imagery, digital elevation data, data on water-related land use, the USA Soil Survey layer in ArcGIS online, and NWI polygons (Menuz and others, 2015; Appendix A). Survey points were moved up to 100 m from the original point to account for inaccuracies in the NWI mapping. We attempted to contact landowners through phone calls and a mailer. We rejected all sample points where access was denied or where we were unable to obtain permission.

We conducted an office evaluation for each site before the field survey. We used either the Web Soil Survey (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) or the USA Soil Survey layer in

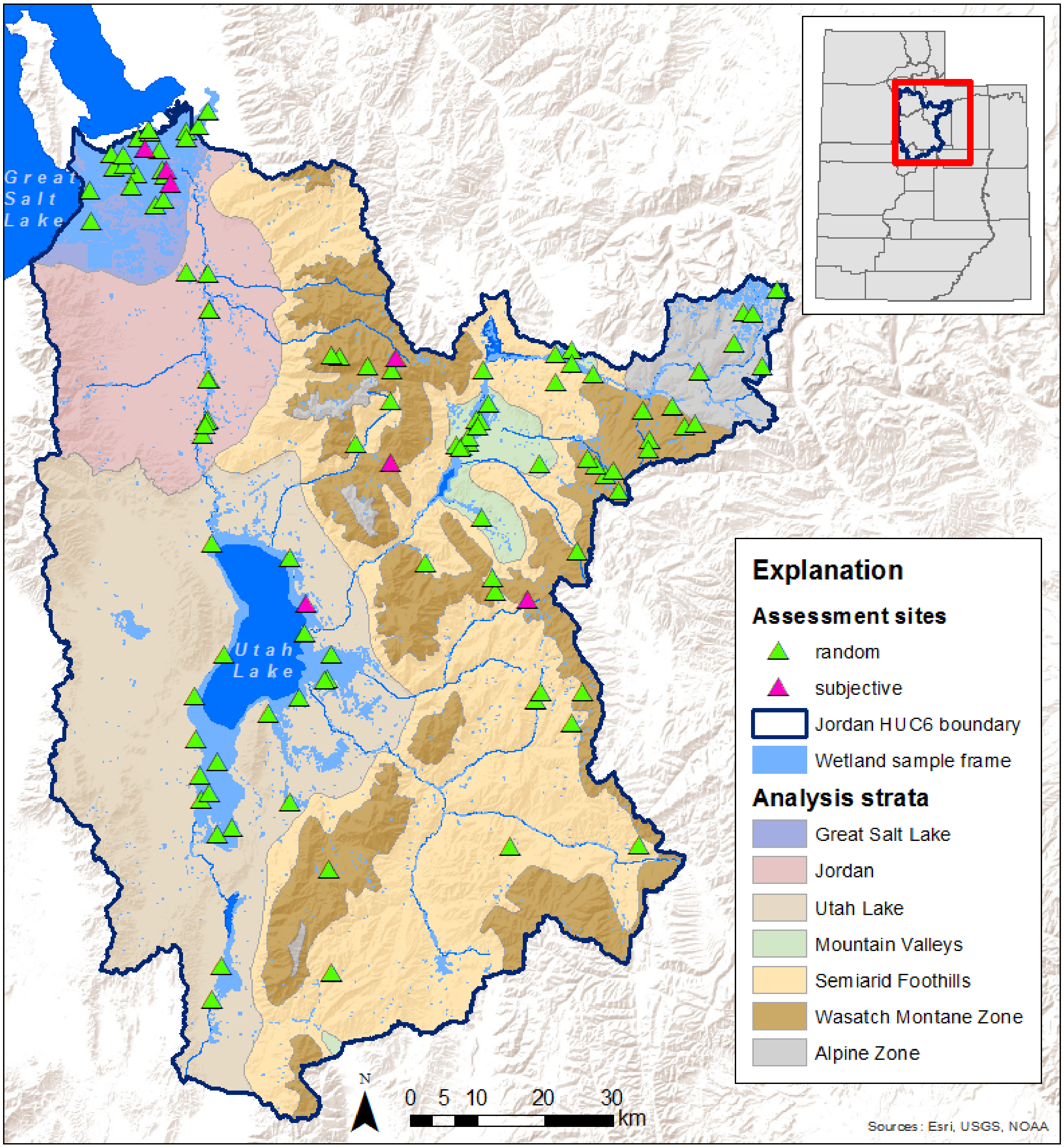

Figure 2. Strata used in data analysis and surveyed randomly and subjectively selected wetland sites. The Great Salt Lake, Jordan, and Utah Lake strata are part of the Central Basin ecoregion and the remaining strata are part of the Wasatch Mountains ecoregion

ArcGIS online to determine the soil map unit name, slope, hydric rating, and drainage class of soils at the site. We examined elevation, water-related land use, and hydrography data, including watershed boundaries and flowlines, to assess likely sources of site hydrology and visible hydrologic stressors, such as dams, water control structures, and irrigation return flows. We evaluated stressors with potential to degrade water quality including development, agriculture, rangeland, point source dischargers, oil and

Table 1. Characteristics of analysis strata including extent and abundance of wetlands in the sample frame, climatic and elevational means (Daly and others, 2008), land ownership (http://gis.utah.gov/data/sgid-cadastre/land-ownership), and land cover (Landfire, 2014).

Stratum		Great Salt Lake	Jordan	Utah Lake	Mountain Valleys	Semiarid Foothills	Wasatch Montane Zone	Alpine Zone
Area (km^2) (% of total)		384 (3.9)	1069 (10.8)	3028 (30.7)	252 (2.6)	2989 (30.3)	1741 (17.7)	392 (4.0)
# of wetlands (% of total)		1609 (14.3)	1065 (9.5)	2916 (25.9)	624 (5.5)	2108 (18.7)	1213 (10.8)	1716 (15.3)
wetland area (ha) (% of total)		17,152 (37.5)	693 (1.5)	23,572 (51.5)	1,696 (3.7)	1,262 (2.8)	457 (1.0)	946 (2.1)
30 year climate data (from mean monthly values)	Max. temperature (°C) (Standard deviation)	33.6 (0.5)	32.2 (2.1)	32.7 (1.5)	30.2 (1)	28.6 (1.9)	24.7 (1.8)	23.6 (1.8)
	Mean temperature (°C) (Standard deviation)	11.8 (0.3)	10.6 (1.5)	10.2 -1.0	7.5 (0.4)	7.4 (1.3)	5.2 (1.3)	3.2 (1.1)
	Min. Temp (°C) (Standard deviation)	-6.5 (0.2)	-7.2 (0.7)	-8.8 (1)	-11.3 (0.6)	-10.3 (1.6)	-10.8 (1.4)	-13.5 (1)
	Daily precip. (mm) (Standard deviation)	1.2 (0.1)	1.4 (0.3)	1.1 (0.2)	1.4 (0.2)	1.6 (0.4)	2.3 (0.5)	2.4 (0.4)
Mean elevation (m) (Standard deviation)		1289 (13.5)	1540 (279.6)	1561 (238.4)	1816 (130.4)	2050 (245.5)	2531 (249.5)	2833 (272)
Land ownership, by percentage	Federal	0.0%	5.5%	64.3%	20.3%	42.6%	44.3%	99.4%
	Private	55.3%	94.3%	31.6%	77.6%	55.0%	54.3%	0.6%
	State	44.7%	0.2%	4.1%	2.1%	2.4%	1.4%	0.0%
Land cover, by percentage	Developed (including mines)	29.5%	63.8%	18.8%	19.1%	3.2%	0.9%	1.3%
	Agricultural	7.7%	9.2%	22.9%	25.2%	0.9%	0.0%	0.0%
	Forested (including all	0.2%	11.1%	13.5%	9.6%	55.8%	84.8%	75.4%
	Shrubland	27.1%	11.6%	22.7%	40.5%	31.2%	9.8%	7.5%
	Grassland	1.8%	3.1%	9.3%	1.6%	7.8%	1.3%	3.9%
	Open water	26.5%	0.1%	12.5%	3.6%	0.5%	0.1%	0.8%
	Snow, barren, sparsely vegetated	7.1%	1.0%	0.4%	0.2%	0.6%	3.2%	11.1%

gas wells, and mines. We also determined whether contributing streams or lakes were listed as impaired in the draft 2014 integrated report (Utah Division of Water Quality, 2014a and 2014b). Information from the office evaluation was verified by observations in the field whenever possible. A full description of the office evaluation procedure can be found in appendix A.

Field Methods

Training

Four seasonal technicians conducted most field surveys, with a team of one botanist and one soil and water quality technician working each summer. Technicians were trained by experienced UGS employees and then conducted six surveys accompanied by an experienced UGS employee before surveying on their own. The experienced UGS employee also periodically checked in with the technicians throughout the field season, accompanying each crew on seven or eight additional surveys.

Establishment of Assessment Area

We used a combination of best professional judgement and easily observable hydrologic, soil, and vegetation indicators to determine whether sites were within the target population, loosely following standards from the U.S. Army Corps of Engineers (USACE) wetland delineation guides (U.S. Army Corps of Engineers, 2008; U.S. Army Corps of Engineers, 2010). Wetland determination was conducted rapidly using traits such as redoximorphic features or gleying in augured soil samples rather than full soil profiles, as well as readily apparent hydrology indicators. We assessed sites for the presence of hydrophytic vegetation if plant species were known and otherwise only keyed out dominant plant species when site status was uncertain. Wetland determinations done for this project should not be considered USACE delineations due to the limited time spent on each determination and the broader definition of wetland used in this study.

If a site contained target wetland, we next set up an assessment area (AA). AAs were 40-m radius circular survey plots centered on the randomly selected sample point where possible, though to avoid inclusion of non-target areas, AAs can also be 40-m radius plots with shifted centers or rectangular or free form plots between 0.1 and 0.5 ha and at least 10 m wide. For this project, we shifted or reshaped AAs to ensure that they contained at least 90% target wetland and no more than 10% water >1 m in depth. AAs were also shifted to avoid features that would divide the hydrology of the wetland, such as dikes and bermed ditches. AAs were generally placed in a single Ecological System.

Wetland Soils and Water Quality Samples

Surveyors used a handheld auger to dig at least one soil pit at a representative location within the dominant vegetation type at each site. An additional pit was sometimes dug if more than one dominant vegetation type was encountered or if no hydric soil indicators were found in the first pit. Soil pits were dug to ≥50 cm depth whenever possible. For each soil layer, surveyors recorded the layer depth, color of the matrix and any dominant and secondary redox features (based on a Munsell Soil Color Chart), soil texture, and percent coarse (>2mm) material. Hydric soil indicators were recorded based on the USACE regional wetland delineation guides (U.S. Army Corps of Engineers, 2008; U.S. Army Corps of Engineers, 2010). Settling time for soil pits varied depending on total AA survey time but was generally between 50 and 120 minutes. If water was evident after the settling period, we recorded the depths to saturated soil and free water.

Groundwater and surface water chemistry data were collected with a handheld Hanna Instruments Combo meter (HI98129 and HI98130); meters were tested at least weekly and calibrated as needed. We measured pH, EC, and temperature of water samples from channels and pools, at points of groundwater discharge, and at the surface of flooded wetlands. We collected surface water samples for laboratory analysis from one location at sites when surface water was available and likely to reflect the dominant water source at the site. Samples were generally not taken when water depth was very low (<10 cm) due to the high probability of contamination from soil sediments. Water sample containers for general chemistry, total metals, and total non-filtered nutrients were prepped with the necessary preservatives by the Utah Public Health Laboratory Chemical and Environmental Services Laboratory (Utah Public Health Laboratory). After containers were filled, they were stored on ice until transferred to a refrigerator and then transferred to the Utah Public Health Laboratory within five days of collection. Samples were analyzed at the Utah Public Health Laboratory following the procedures outlined in the Client Services Manual (Utah Public Health Laboratory, 2013).

Rapid Assessment Metrics and Stressor Data

We collected wetland condition data using the metrics on the 2016 field forms and associated user's manual (appendices B and C). Each metric is composed of a series of potential states, ranked from A through D, to denote wetland condition ranging from pristine or reference condition to severely altered wetlands that may have little conservation value and be extremely difficult to restore. Metrics are divided into five categories: landscape context, hydrologic condition, physical structure, vegetation structure, and plant species composition (table 2). Plant species composition metrics were calculated in the office using plant community data collected in the field. Observers used office evaluation data, maps, and information obtained from walking around AAs and the surrounding area to score the remaining metrics. Photos and notes were frequently taken to better capture condition, especially when sites were difficult to evaluate.

Surveyors also recorded data on stressors observed in the field. Stressor data included information about features within 100 m of each AA (buffer) as well as features within the AA. For each stressor present, we recorded the extent of the evaluated area where the stressor was present and the degree of severity as one of three qualitative categories (low, moderate, high). We evaluated buffer stressor severity in specific categories: general severity, hydroperiod, water contaminants, sedimentation, and vegetation stress. For example, a downstream stressor may be less likely to affect the water quality of a wetland than an upstream stressor but may still impact the hydroperiod.

Plant Community and Ground Cover Data

We recorded a list of all plant species found within the AA after thoroughly searching the area for up to one hour. For each species found, we recorded predominant height, percent cover within the AA, and phenology. We also collected data on the percent cover of ground cover features within the AA including bare ground, litter, water, bryophytes, lichens, algae, and various classes of woody debris. Plant species not identified in the field were pressed in newspaper, brought to the office, and dried in a drying oven at approximately 38°C for at least 24 hours. We used a dissecting microscope, standard set of plant dissection tools, and several plant treatments to aid with identification, including A Utah Flora (Welsh and others, 2003), all volumes of the Intermountain Flora series (see introductory volume, Cronquist and others, 1972), Grasses of the Intermountain West (Anderton and Barkworth, 2000), Field Guide to Intermountain Sedges (Hurd and others, 1998), and Flora of North America (http://floranorthamerica.org). We used species scientific names as listed in U.S. Natural Resources Conservation Service's Plants Database (http://plants.usda.gov).

Functional Data

Data on boreal toad habitat were collected using metrics derived from the Ecological Integrity Table for the species (Oliver, 2006a) and adjusted based on a brief literature review. Final habitat metrics included types of breeding waterbodies present, presence of north shore, waterbody slope and depth, daytime summer temperature, abundance of hibernation features, and shrub cover. In 2016, the shrub metric was modified to account for the potential positive role of shading by understory-forming tall forbs and for the potential negative role of overabundance of shrubs. Water temperature data collected in the field were used to assign ranks to sites for the temperature metric.

Data on Columbia spotted frog habitat were collected using metrics derived from the Ecological Integrity Table for the species (Oliver, 2006b) and adjusted based on a brief literature review. Final habitat metrics included types of breeding waterbodies present, waterbody substrate, vegetation growing in waterbody, and overwintering waterbodies. Two boreal toad metrics, waterbody slope and

Table 2. Condition metrics evaluated by the Utah Rapid Assessment Procedure, listed under metric categories. Some metrics are evaluated directly within the assessment area (AA), some in areas surrounding the AA, and some take into consideration both local and landscape factors.

Metric	Description
Landscape Context	
Percent Intact Landscape	Percentage of 500 m buffer surrounding AA that is directly connected to AA and composed of natural or semi-natural (buffer) land cover
Percent Buffer[1]	Percentage of AA edge composed of buffer land cover
Buffer Width[1]	Mean width of buffer land cover (evaluated up to 100 m in width)
Buffer Condition- Soil and Substrate[1]	Soil and substrate condition within buffer (e.g., presence of unnatural bare patches, ruts, etc.)
Buffer Condition-Vegetation[1]	Vegetation condition within buffer (e.g., nativity of species in buffer)
Connectivity- Whole Wetland Edge	Hydrologic connection between wetland edge and surrounding landscape
Hydrologic Condition	
Hydroperiod[2]	Naturalness of wetland inundation frequency and duration
Timing of Inundation[2]	Naturalness of timing of inundation to wetlands
Turbidity and Pollutants[3]	Visual evidence of degraded water quality, based on evidence of turbidity or pollutants
Algae Growth[3]	Evidence of potentially problematic algal blooms within AA (evaluated both in water and in areas with large patches of dried algae)
Water Quality	Evidence of water quality stressors reaching AA or within AA
Connectivity- AA Edge	Hydrologic connection between AA edge and surrounding landscape
Physical Structure	
Substrate and Soil Disturbance	Soil disturbance within AA
Vegetation Structure	
Horizontal Interspersion[4]	Number and degree of interspersion of distinctive vegetation patches within AA
Litter Accumulation[5]	Naturalness of herbaceous litter accumulation within AA
Woody Debris[5, 6]	Naturalness of woody debris within AA
Woody Species Regeneration[5, 6]	Naturalness of woody species regeneration within AA
Plant Species Composition	
Relative Cover Native Species	Relative cover of native species (native species cover / total cover)
Absolute Cover Noxious Species	Absolute cover of noxious weeds

[1]Buffer metrics are combined into one overall buffer score
[2]Evaluated with respect to similar wetlands within hydrogeomorphic class
[3]Only evaluated when water is present at sites or when large patches dry algae were present at sites
[4]Excluded from scoring for emergent marsh, alkaline depression, and playa Ecological Systems
[5]Evaluted with respect to similar wetlands within Ecological System
[6]Only evaluated when woody debris and woody species are expected at sites

depth and presence of north shore, were also included as habitat metrics for Columbia spotted frog, though were only collected at sites in the Wasatch Mountains ecoregion. We also collected two stress-related metrics for the Columbia spotted frog, livestock grazing and distance to impervious surface.

Metrics were developed and collected in the field in 2016; values for 2015 sites were estimated using site data, except for the waterbody substrate metric, which was left null for the 2015 sites.

We collected data on wetland potential for water quality improvement using a presence/absence checklist of site indicators adapted from the Washington State's wetland rating system (Hruby, 2014a and b). Indicators were grouped into three categories, site potential to improve water quality, landscape potential to need improvement, and societal value. Most indicators were evaluated in the field, though some were evaluated in the office using ArcGIS. The water quality checklist was developed for the 2016 field season and applied retrospectively to 2015 field sites using site data and best professional judgement.

Data Summarization and Analysis

Weight Adjustment, Population Estimation, and Data Summaries

Sites were assigned a weight when they were originally selected by the R package spsurvey to represent the amount of area represented by the site relative to the total wetland area in the watershed. For example, Great Salt Lake wetlands were assigned higher weights than sites in the Alpine Zone because the Great Salt Lake stratum has much more total wetland area. Weights allow for accurate estimation within a stratum, where all weights may be the same, and across the whole watershed, where weights differ. We adjusted the assigned weights based on the total number of sites evaluated in each selection stratum by dividing the total stratum area by the number of sites evaluated in the stratum, including surveyed sites, non-target sites, and sites where access was denied. Site evaluation did not deviate from the original sample order so additional adjustments to weights were not necessary. We used cat.analysis and cont.analysis in the spsurvey package in R to estimate parameters for categorical and continuous variables. We used spsurvey to create cumulative density functions for some metrics. We compared cumulative density functions between strata using the cont.cdftest function in spsurvey with the default test statistic, an F-distribution version of the Wald statistic (Kincaid, 2015).

We estimated parameters using spsurvey for most wetland assessment data, including wetland stressors, condition, and function. However, in some cases we present raw, unweighted data. Data used for ordination analysis and for Ecological Systems descriptions are presented as raw data, which limits our ability to make inference to the whole watershed from these results. For example, if the raw mean native plant cover for wet meadows in our study is 70%, we cannot expect that the average cover of all wet meadows in the Jordan River watershed is also 70%. Usually, results obtained from weighted data are referred to as estimates of the percent of wetland area or total wetland area and include a measure of uncertainty. Results obtained from raw data are typically presented as a number or percent of sites. All statistical analysis was conducted in R 3.2.1 statistical software (R Core Development Team, 2013).

Wetland Condition

Stressors Data

We calculated stressor indices for buffer stress, AA stress by stress category, and water quality and hydroperiod stress recorded during the office evaluation. To calculate stressor indices, we first converted low, medium, and high severity stressors to values of 1, 2, and 4, respectively. For AA and buffer stressors, we converted extent estimates into weights based on the mid-point of the extent category, adjusting the overall weights so that the highest extent category received a weight of 1. Extent categories were converted as follows: <1%—0.001, 1-10%—0.06, 10 to 25%—0.20, 25 to 50%—0.43, 50 to 75%—0.72, 75 to 100%—1.0. We multiplied each stressor severity value by the extent weight and then summed all values within each category to obtain an estimate of stress, obtaining separate values for the buffer and each of the three categories of AA stress—vegetation, physical, and hydroperiod. Only severity, not extent, was recorded for stressors identified in the office evaluation. For these stressors, we summed the total stress by category—water quality and hydroperiod. We only evaluated water quality stressors within 2 km of the site rather than all water quality stressors. We excluded livestock grazing from the office evaluation stressors because we could not consistently evaluate the presence or severity of livestock grazing in GIS.

We calculated overall office, AA, and site stress indices as follows. Overall office stress was calculated as the sum of office hydroperiod and office water quality stress. Overall AA stress was calculated as the sum of the three categories of AA stress. Overall site stress was calculated as the sum of the overall office stress divided by 3, then added to buffer stress and overall AA stress. The weight of office stress was reduced when combining the three indices of stress together because the office evaluation method did not take into account the area affected by each stressor.

Rapid Assessment Condition Results

Wetland condition results are primarily presented at the level of the individual metric rather than for categories or as an overall site score. We used the following standard to refer to metric rankings: A—excellent, B—good, C—fair, D—poor. Rankings for the relative cover of native species and absolute cover of noxious species metrics were obtained by calculating cover estimates using plant composition data and then converting estimates to ranks using the thresholds shown in appendix B. We considered all recorded *Phragmites australis* to be the non-native, noxious subspecies of *Phragmites australis* when subspecies was not recorded.

We calculated categorical and overall condition scores for ordination analysis and overall scores for use in a cumulative density function plot and for evaluating reference sites by Ecological Systems. We converted metric ranks to point values based on the following: A or AB—5, A—4.5, B—4, C—3, C-—2, D—1. We combined metric scores for the percent buffer, buffer width, buffer soil condition, and buffer vegetation condition into an overall buffer score using the following equation:

$$overallBuffer=(percentBuffer*bufferWidth)^{0.5}*([bufferConditionSoil+bufferConditionVeg]/2)^{0.5}$$

We then calculated the mean metric score within each category (only using the overall buffer score and not the derivative components for the landscape context category), based on the categories shown in table 2. Means were taken across a variable number of metrics per site since not all metrics were evaluated at every site. Overall condition scores were obtained by taking the mean value across all categorical scores.

Plant Coefficient of Conservatism Values

We report on two vegetation metrics that rely on coefficient of conservatism values (C-values), mean C and covered-weighted mean C. C-values between 1 and 10 are assigned to species based on their association with disturbance through a combination of best professional judgment, literature review, and/or field observations. Low values indicate that species are usually found at disturbed sites, high values indicate that species are associated with pristine sites, and values in the middle indicate that species may be found equally at either type of site. All non-native species are assigned a C-value of 0.

C-values are often developed for individual states or regions to capture regional variability in how species respond to disturbance, but C-values have not been developed for the state of Utah. We instead contacted botanists and wetland scientists in surrounding states to determine which states had assigned C-values to species. We received C-value lists from Colorado (Rocchio, 2007), Montana (Jones, 2005), Wyoming (Washkoviak and others, 2015), and Idaho, which uses C-values from eastern Washington's Columbia Basin region (Rocchio and Crawford, 2013). We assigned Utah species the mean C-value of the four states' lists. We then made sure that every non-native species, and no native species, had a C-value of 0. Twenty-six species were recorded during field surveys that were not assigned C-values.

We calculated mean C by taking the average C-value for all species at a site and cover-weighted mean C by multiplying the C-value for each species by its cover at the site, summing up the result for all species, and dividing by the cover of all species at the site. Both mean C and cover-weighted mean C range from 0 to 10.

Functional Assessment Data

Boreal Toad

Boreal toad habitat estimates were made for two habitat strata in the Wasatch Mountains, prime and non-prime habitat. Wetlands in the Wasatch Montane, Mid-Elevation Uinta, and Uinta Subalpine Level IV ecoregions were considered prime habitat and wetlands in the Mountain Valleys and Semiarid Foothills were considered non-prime habitat based on the known range of climatic conditions at sites occupied by the species in Utah, outside of the lower-elevation boreal toad population in northwestern Utah. We obtained a final vegetation metric score by combining the shrub cover metric and tall forb cover metric. Sites were assigned the lower of the two metric scores if overabundance was an issue for either forbs or shrubs and otherwise assigned the highest value of the two scores. We calculated the mean metric value across the six boreal toad metrics for each site and compared values with a metric threshold developed in previous studies (Menuz, 2016a; Menuz, 2017). Both studies found that a threshold of around 3.8 was useful for separating known breeding locations from other wetland locations.

Columbia Spotted Frog

Columbia spotted frog habitat estimates were made for three separate habitat strata to differentiate between areas with different likelihood of supporting populations and suitability for introductions. We analyzed all the Central Basin ecoregion sites as one stratum and divided the Wasatch Mountains sites into prime and non-prime montane habitat. Montane Columbia spotted frog populations are only known from alongside perennial streams in Utah (K. Wilson, Utah Division of Wildlife Resources, personal communication, 2016) and tend not to move more than about 500 m from breeding areas (U.S. Fish and Wildlife Service, 2002). Therefore, wetlands in the Wasatch Mountains ecoregion within 500 m of perennial streams and <8000 ft in elevation were designated as prime habitat and wetlands in the remainder of the ecoregion as non-prime.

We dropped the waterbody substrate metric from analysis because we only had data for one year; >80% of Central Basin and >95% of Wasatch Mountains sites with at least some surface water were scored as good or excellent for this metric. We took the mean value of the remaining five habitat metrics at sites in the Wasatch Mountains sites and three metrics in the Central Basin sites to obtain an estimate of overall habitat suitability (Central Basin sites lacked estimates of north shore and slope and water depth). We did not have an established threshold at the time of analysis, so we arbitrarily considered sites with scores ≥4.5 to have excellent habitat and ≥3.5 and <4.5 to have good habitat.

Water Quality Improvement

Two of the indicators on the checklist were dropped from analysis, microtopography and riverine surface depressions. We summarized information on the most common indicators, the total number of indicators per category, and the most vulnerable sites– those with high landscape potential for water quality stress. All checklist items were weighted equally except for in the following cases. First, sites could not receive more than two credits in the capacity category for any of the three indicators related to vegetation. Second, sites could not receive more than one credit in the landscape category for any of the two indicators related to stressors in the broader contributing area. Third, sites received two credits rather than just one in the societal value category if they were in a watershed rated as impaired (category 4 or 5) in the Utah Division of Water Quality's 2014 integrated report (Utah Division of Water Quality, 2014a; Utah Division of Water Quality, 2014b).

Plant Community Ordination

We used non-metric multidimensional scaling (NMDS) with the vegan package (Oksanen and others, 2013) in R to explore plant community composition data within Level III ecoregions and within common Ecological Systems. NMDS can be used to reduce complex multivariate data, such as plant abundance values, to a few primary axes that describe most of the variation found among sites. Axes can then be overlain with vectors showing the strength (represented by vector length) and direction (represented by vector orientation) of correlation between environmental variables of interest and species composition data. We were interested in exploring relationships between plant community composition and measures of wetland condition, wetland stress, natural variation, and sampling effort.

We excluded from analysis most species only identified to genus, but did include the genera *Atriplex* (saltbush), *Carex* (sedge), *Chenopodium* (goosefoot), *Eleocharis, Epilobium* (willowherb), and *Viola* (violet). We grouped all species within the genera *Abies* (fir), *Lemna* (duckweed), *Tamarix* (tamarisk), and *Typha* (cattail) into their respective genera rather than considering these species independently. We did not include subspecies or varieties in the analysis. We used the wrapper function metaMDS within vegan to transform and standardize data, calculate a dissimilarity matrix using Bray-Curtis distance, run NMDS multiple times with random starts to avoid local optima, and rotate the axes of the final configuration so that the variance of points was maximized on the first dimension. Plant abundance data were transformed using a Wisconsin-style double standardization where taxa are normalized to percent abundance and then abundances are normalized to the maximum for each species. Species that occurred at only one site were dropped from analysis. We determined the appropriate number of axes to use by obtaining stress values for four replicate NMDS runs for each number of dimensions between one and four. We set the maximum number of random starts for each run at 500. We generally selected the lowest number of axes that had a stress value ≤0.20 as the final number of dimensions, based on rules of thumb for the threshold of usable results (McCune and Grace, 2002).

We fit site attribute and species data to the NMDS axes using the envfit function in the vegan package. We tested the strength of evidence for each site attribute variable and each species using 10,000 permutations. We analyzed a broad variety of site attributes, including categorical and overall URAP condition scores, mean C and cover-weighted mean C, and both local and watershed stress from landscape stress models (Menuz, 2015; Menuz, 2016b). We also looked at site attribute data related to natural variation among sites, including climate data, surface water cover, HGM class, strata, and Ecological System. For the climate data, we used monthly climate data from PRISM Climate Group (Daly and others, 2008) to calculate 30-year-mean temperature and precipitation values at each site. We calculated 30-year means (for water years 1984 to 2013) across the water year (October 1 to September 30) instead of the calendar year because water year is a more hydrologically relevant measure. We calculated mean, minimum, and maximum water-year temperatures and mean daily precipitation for each year, then used the mean of these values across the 30-year period of interest. We then reduced the climate data to uncorrelated axes using principal components analysis (PCA) with the function princomp. We also used PCA to reduce field estimates of current and potential cover of shallow (<20 cm) and deep surface water to fewer axes. We used the first two axes of each PCA in the analysis. We evaluated three variables related to sampling effort, the day of year, survey year, and observer team. Observer team was coded as either one of the two teams that conducted most of the field work or “other”. “Other” included sampling efforts with more than two surveyors and efforts with uncommon team pairings.

Ecological System Attributes

Reference Site Screening

We screened for high quality reference sites within common Ecological Systems using stressor indices and the relative cover of native vegetation. We set an initial screen of ≥80% relative native plant cover, ≤2 for buffer stress, ≤1 for any single aspect of AA stress, ≤4 for water quality stress, and ≤4 for hydroperiod stress (the latter two variables are from the office evaluation stressors). These values are the equivalent of one moderate severity stressor across the entire buffer, one low severity stressor across the entire AA, and one high severity hydroperiod or water quality stressor in the contributing basin. We loosened the screens as needed to obtain at least four reference sites per Ecological System.

We evaluated two metrics in the population of reference sites, mean C and overall URAP score, using a method adapted from the EPA’s National Wetland Condition Assessment (U.S. Environmental Protection Agency, 2016). EPA used the bottom 25th and 5th percentiles of vegetation multi-metric index values within their population of reference sites to set thresholds of good versus fair versus poor wetlands. We classified sites as good if they scored above the bottom 25th percentile value for the references sites but did not distinguish between fair and poor due to the limited number of reference sites within each Ecological System.

Landscape Analysis

GIS Analysis of Mapping Accuracy

We used aerial imagery in ArcGIS and Google Earth, supplemented by field data when available, to evaluate the accuracy of NWI mapping at all the randomly selected points evaluated for wetland surveys. Since we focused specifically on the random points, some sites that were surveyed were classified as non-wetland *at the point* (because the AA was shifted from the original point). We also classified points that fell on inaccessible private property using best professional judgement, though many such points were classified as "unknown." Points were classified as wetland (even if smaller than our target site size), non-wetland, unclear, or non-target aquatic feature, with the latter further classified as dry mudflats, streambeds, waterbodies >1 m deep, and industrial and sewage treatment ponds. We used the spsurvey package to obtain estimates of the percent of each stratum with each class of wetland.

Updated Wetland Mapping

We updated wetland spatial data for a section of the study area that was predominantly in the Central Basin ecoregion of Salt Lake County, with small sections of Davis and Tooele counties (figure 3). Most of this area was mapped using imagery from 1998, with small portions mapped in the early 1980s; some of the latter had a partial update in 2005. Wetlands and riparian areas were mapped following the guidance of the Federal Geographic Data Committee (2009, 2013) and the U.S. Fish and Wildlife Service (2009). Field reconnaissance was conducted in the summer of 2016, and features were delineated using heads-up digitization in ArcGIS 10.5 over 2014 NAIP imagery.

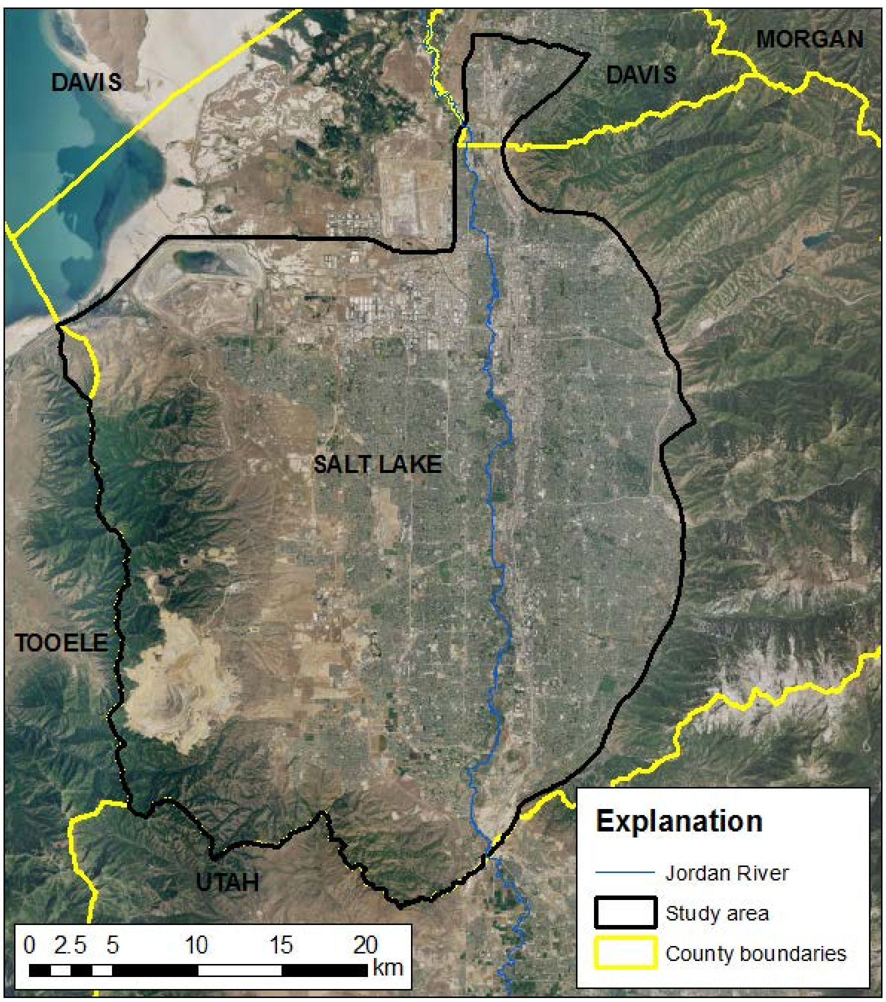

Figure 3. Overview of study area for wetland and riparian mapping project.

We compared the UGS mapping data to the original NWI data. We used the second draft of the UGS mapping data dated September 17, 2018 for the comparison, which included changes that resulted from feedback from personnel with the NWI program. We converted the Cowardin classifications into nine wetland types for ease of use, including lake, pond, riverine, scrub shrub, forested, emergent marsh, emergent meadow, palustrine unconsolidated shore, and lacustrine unconsolidated shore. Lacustrine and palustrine wetlands with an unconsolidated bottom or aquatic bed class were classified as lake and pond, respectively. Palustrine scrub shrub and palustrine forested wetlands were classified as scrub shrub and forested. Palustrine emergent wetlands were divided into two types based on water regime. Those with semi-permanently flooded regimes were classified as emergent marsh and the remainder classified as emergent meadow. The remaining wetlands were all classified as either lacustrine or palustrine unconsolidated shore. Unconsolidated shore wetlands are wetlands with <30% vegetation cover that lack surface water for at least part of the growing season. In the Central Basin, most unconsolidated shore wetlands are playas or mudflats along Great Salt Lake and Utah Lake. Seasonal ponds and unvegetated shores along streams or lakes are also classified as unconsolidated shores. Only the first class and the first water regime were used for wetland polygons with split classification.

Landscape Profile

We attributed data in the original sample frame of wetlands with land ownership, riparian status, landscape and watershed stress model values, land use, and irrigation class. This attribution allowed us to summarize information on the types, protection status, and potential vulnerability of wetlands within the watershed. Since the attribution was applied only to the sample frame, summarized information does not pertain to deepwater habitats (lacustrine limnetic) or riverine streambeds (riverine systems with unconsolidated bottom or streambed classes).

We used a modified version of the nine wetland types described above to summarize the wetland data, combining riverine, lacustrine, and palustrine unconsolidated shore into a single class for a total of seven wetland types, including lake, pond, scrub shrub, forested, emergent marsh, emergent meadow, and unconsolidated shore. We attributed wetland polygons as riparian or non-riparian based on proximity to stream and lake features in the 1:24,000-scale USGS's National Hydrography Database. We attributed wetland polygons as riparian if they were within 50 m of any NHDFlowline attributed as artificial path, connector, or streamRiver. We also attributed polygons as riparian if they were within 50 m of NHDWaterbody or NHDArea features touching one of the NHDFlowline features above, if they were coded as lakePond or reservoir, for the former, or streamRiver, for the latter. We also attributed wetland polygons that were within 10 m of the selected wetland polygons as riparian. The riparian attribution is an inexact designation. No set distance captures all riparian features and excludes non-riparian features. Features designated as riparian have a wide range of relationships with adjacent waterbodies, including slope wetlands that contribute water to streams and riparian wetlands that receive water from streams.

Land ownership data were obtained from the Utah Automated Geographic Reference Center ([AGRC], http://gis.utah.gov/data/sgid-cadastre/land-ownership, accessed on January 2016). The AGRC ownership data include information on the ownership type (private, state, federal, tribal) as well as the managing agency and property name. We used the AGRC layer in combination with an internal layer of management areas digitized by the UGS in 2013 to classify wetlands into ownership categories. The UGS management areas layer was created from a combination of parcel data and boundary data obtained from individual land managers and includes boundaries of CWMUs, privately owned mitigation and conservation reserves, private duck hunting reserves, and state and federal land managed for hunting, migratory birds, and other wildlife concerns. We used the combination of the two ownership layers to classify wetlands as one of twelve land ownership categories. Categories of privately-owned land included private duck hunting reserves, private conservation and mitigation land, CWMUs, and other private land (which include land owned by local government entities). Categories of State-owned land included sovereign land (primarily the lakebeds of Great Salt Lake and Utah Lake), Farmington Bay Waterfowl Management Area, other wildlife areas, parks, and other State-owned land, which includes trust lands. Categories of federal-owned land included wilderness and non-wilderness U.S. National Forest and other federal land, which includes U.S. Bureau of Land Management and U.S. Department of Defense.

We classified wetland polygons as having low, moderate, or high levels of local and watershed stress based on values from two GIS-based aquatic resource stress models (Menuz, 2015, Menuz, 2016b). The local landscape stress model is a 30-m resolution raster of the potential degree of wetland stress across the landscape based on geospatial predictors hypothesized to be associated with wetland disturbance, such as urban land cover and hydrologic modification. Each predictor was assigned a weight based on its probable severity and a decay function based on the distance at which the predictor was assumed to no longer impact a site. The watershed stress model estimates stress at the local catchment scale for catchments delineated by NHDPlus Version 2 (http://www.horizon-systems.com/NHDPlus/index.php) based on cumulative upstream stress (e.g., total upgradient development). Predictor variables were log transformed and normalized to range from 0 to 1 and then assigned weights based on their probable severity. The selection of final weights and a final method for combining predictors into an overall stress score was calibrated with existing wetland and, for the watershed model, other aquatic resource data. For the landscape profile, we obtained the mean stress value for each wetland polygon. We converted values to low, moderate, and high stress categories using the thresholds of ≤200 and ≤800 for the local stress model and thresholds of ≤600 and ≤1300 for the watershed stress model. The models include data only on stressors with readily available geospatial data; data on stressors such as livestock grazing intensity, off-road vehicle use, and non-native species cover are not included in the models.

Land use and irrigation data were extracted from Water Related Land Use data (Utah Division of Water Resources, 2014b and 2014c), an effort to map all agricultural areas in the state as well as other lands that consume or evaporate water other than natural precipitation (which generally excludes deserts, rangeland, and forested areas). Urban areas, open water, and riparian features are only mapped if they are near irrigated lands, so these land use classes are likely underrepresented in the data. The basins in our study area were mapped in 2014. We combined the land use categories into six categories based on their similarity to one another and prevalence in the study area, including agriculture (irrigated and unirrigated crops), hay, pasture, urban (including sewage lagoons and urban grass), riparian and aquatic (including riparian, open water, mudflats, and playas), and unmapped. We calculated the percentage of wetland area in each land use class as well as the percentage in one of two irrigation classes−irrigated and subirrigated. Subirrigated lands are naturally irrigated agricultural lands that usually have a high water table, though they sometimes also receive direct or indirect irrigation water.

Results

Survey Site Characteristics

Surveyed Sites

We evaluated 188 of the randomly selected sites to obtain 102 sampleable sites. We were unable to obtain access to 11 sites and 75 sites were non-target, including both non-wetland sites and aquatic sites that did not fall within our target population (table 3). Points in the Jordan stratum had the highest percent non-target wetland, and points in the Semiarid Foothills and Mountain Valleys had the highest percent of sites with no landowner permission to access property.

We conducted surveys at 50 randomly select sites in 2015 and 52 randomly and 7 subjectively selected sites in 2016. The subjectively selected sites included three potential high-quality Great Salt Lake sites, one potential low-quality Utah Lake site, and two potential low quality and one potential high quality site in the Wasatch Montane Zone. Surveys were conducted between June 9 and September 20 each year. Surveyed sites included 52 40-m radius circular plots, 56 freeform plots, and 1 rectangular plot. All circular plots had an area of 5010 m^2; the remaining plots ranged in area from 812 to 7496 m^2, with a median area of 3058 m^2. Sites were frequently moved in the field away from the original sample point, usually due to large inclusions of upland or water or the presence of multiple Ecological Systems; only 23 sites were not moved.

Wetland Indicators

We used wetland vegetation data collected in the field to determine whether sites met the USACE definition of hydrophytic vegetation (U.S. Army Corps of Engineers, 2008; U.S. Army Corps of Engineers, 2010). Species from sites in the Central Basin ecoregion were assigned the Arid West

Table 3. Number of sites evaluated in each stratum and estimates of the percentage of wetland area in each survey category, including surveyed, no access, and no target wetland, with standard error in parentheses.

Strata	# Sites Evaluated	Percent Surveyed	Percent No Access	Percent No Target Wetland
Central Basin Ecoregion	**106**	**57.2 (4.8)**	**3.0 (1.7)**	**39.8 (4.8)**
Great Salt Lake	30	66.7 (6.5)	0	33.3 (6.5)
Jordan	37	27.0 (6)	2.7 (2.4)	70.3 (5.9)
Utah Lake	39	51.3 (7)	5.1 (3)	43.6 (7)
Wasatch Mountains Ecoregion	**82**	**65.1 (4.2)**	**14.2 (3.4)**	**20.7 (3.6)**
Mountain Valleys	21	61.9 (9)	19 (7.3)	19 (5.3)
Semiarid Foothills	27	41.8 (8.9)	26.7 (8.3)	31.4 (10)
Wasatch Montane Zone	28	63.7 (9.9)	0	36.3 (9.9)
Alpine Zone	6	100 (0)	0	0
National Forest	*37*	*67.6 (6.7)*	*0*	*32.4 (6.7)*

indicator ratings and species from sites in the Wasatch Mountains ecoregion were assigned the Western Mountains, Valleys, and Coast indicator ratings. We used a conservative approach in this evaluation by classifying all dominant species that were not assigned wetland indicator values as upland species, unless the unidentified dominant species was a genus that was almost always wetland-associated (e.g., *Eleocharis, Tamarix*). Five sites had <5% vegetation cover and were not evaluated for this indicator. All but four of the remaining sites met the USACE definition of hydrophytic vegetation based on the dominance test, meaning the majority of the most abundant species were obligate wetland, facultative wetland, or facultative species. Two of the four sites that did not pass the dominance test met the definition of hydrophytic vegetation based on the prevalence index, meaning that sites had a majority of obligate wetland, facultative wetland, or facultative species when all species were considered. The two sites that did not meet the USACE definition of hydrophytic vegetation were both depressions that pond with water at least some years and had hydrology and hydric soil indicators.

USACE hydrology indicators were evaluated in the field except the FAC-neutral test (D5) and inundation on aerial imagery (B7), which were only evaluated in the office (using vegetation data or aerial imagery) at sites that did not otherwise have an indicator of wetland hydrology. All surveyed sites had at least one primary or two secondary indicators of wetland hydrology. The most common indicators in the Central Basin ecoregion were surface soil cracks (B6, n=22), saturation (A3, n=20), surface water (A1, n=18), and salt crusts (B11, n=14). In the Wasatch Mountains ecoregion, the most common indicators were saturation (A3, n=37), surface water (A1, n=23), oxidized rhizospheres (C3, n=14), geomorphic position (D2, n=14), drainage patterns (B10, n=12), and high water table (A2, n=11).

In the Central Basin ecoregion, soil pits were dug at 51 of the 54 sites, including 2 pits at 11 sites and no pits at 3 fully inundated marsh sites. Three pits had no indicators present, including two pits in Goshen Valley and one pit along the Jordan River. The most common indicators in the Central Basin ecoregion was depleted matrix (F3, n=39), hydrogen sulfide odor (A4, n=11), and depleted below dark surface (A11, n=9). In the Wasatch Mountains ecoregion, soil pits were dug at all 56 sites, with two pits at 8 sites. Seven soil pits had no hydric soil indicators present, including four pits in the Semiarid Foothills, two in the Mountain Valleys, and one in the Wasatch Montane Zone; one of the pits was located at a site where a second pit had indicators. The most common indicators in the Wasatch Mountains ecoregion were redox dark surface (F6, n=34), depleted matrix (F3, n=9), depleted below dark surface (A11, n=9), and histic epipedon (A2, n=8).

Hydrogeomorphic and Ecological System Classification

Sites were assigned HGM classes based on their dominant class, though some contained more than one class. Depressional and lacustrine fringe wetlands were the most common HGM classes in the Central Basin ecoregion (table 4). Two classes, depressional impoundment and impoundment release, were recorded only in Great Salt Lake, and two classes, slope and lacustrine fringe, were recorded only in Utah Lake. Four Ecological Systems were recorded in the Central Basin, including Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland ("Great Basin woodland"), Inter-Mountain Basins Playa ("playa"), North American Arid West Emergent Marsh ("basin marsh"), and Inter-Mountain Basins Alkaline Closed Depression ("alkaline depression"). Alkaline depressions were the most abundant Ecological System, though both playas and basin marshes are more abundant in the Great Salt Lake stratum (table 4). Only one wetland in the Central Basin was classified as a Great Basin woodland. This

Table 4. Hydrogeomorphic classes and ecological systems in the Central Basin ecoregion and strata within the ecoregion, including estimated percentage of wetland area in each class and standard error in parentheses.

Class	Central Basin Ecoregion	Great Salt Lake	Jordan	Utah Lake
Hydrogeomorphic Class				
Depressional	**28.1 (6.2)**	25 (8.4)	90 (8.3)	30 (9.1)
Depressional impoundment	**19.3 (4.6)**	40 (9.4)		
Depressional impoundment fringe	**4.9 (3.1)**	10 (6.4)	10 (8.3)	
Impoundment release	**9.6 (3.3)**	20 (6.8)		
Lacustrine fringe	**22.9 (3.9)**			45 (7.1)
Riverine	**7.5 (3.6)**	5 (4.1)		10 (5.9)
Slope	**7.6 (3.6)**			15 (7)
Ecological System				
Great Basin woodland	**2.5 (2.1)**			5 (4)
Alkaline depression	**55.8 (5.8)**	30 (8.7)	70 (13)	80 (7.8)
Playa	**22.0 (5.6)**	35 (9.8)		10 (6)
Basin marsh	**19.7 (4.8)**	35 (9)	30 (13)	5 (4.2)

wetland was located on the floodplain of an intermittent creek in the Utah Lake stratum and dominated by the non-native woody shrub tamarisk (*Tamarix* spp.) with very low cover of other woody species.

In the Wasatch Mountains ecoregion, depressional, riverine, and slope wetlands are about equally prevalent (table 5). Depressional wetlands dominate the Semiarid Foothills and Wasatch Montane Zone strata, and slope wetlands dominate the Alpine Zone. Six Ecological Systems were recorded in the Wasatch Mountains ecoregion, including North American Arid West Emergent Marsh (“montane marsh”), Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (“foothill shrubland”), Rocky Mountain Subalpine-Montane Riparian Shrubland (“montane shrubland”), Rocky Mountain Subalpine-Montane Riparian Woodland (“montane woodland”), Rocky Mountain Alpine-Montane Wet Meadow, and Rocky Mountain Subalpine-Montane Fen. The latter two Ecological Systems were grouped together and treated as “wet meadow” for analysis because they had indistinguishable plant community composition. Almost two-thirds of the wetland area in the Wasatch Mountains ecoregion is estimated to be wet meadow and this system was the most common in all but the Wasatch Montane Zone stratum (table 5). Only one wetland each in the Wasatch Mountains ecoregion was classified as montane marsh and montane woodland. The montane marsh was a cattail-dominated constructed marsh in the floodplain of the Provo River. The montane woodland had high cover of quaking aspen (*Populus tremuloides*) in the overstory and Kentucky bluegrass (*Poa pratensis*) in the understory with floristic affinity to wetlands in the wet meadow Ecological System.

Table 5. Hydrogeomorphic classes and ecological systems in the Wasatch Mountains ecoregion, strata within the ecoregion, and in non-alpine National Forest land, including estimated percentage of wetland area in each class and standard error in parentheses.

Class	Wasatch Mountains Ecoregion	Mountain Valleys	Semiarid Foothills	Wasatch Montane Zone	Alpine Zone	National Forest
Hydrogeomorphic Classes						
Depressional	35.3 (6)	38.5 (11.8)	66.1 (15.1)	73.3 (9)		28 (7.2)
Riverine	29.9 (5.8)	46.2 (12.8)	31.6 (14.9)	18.7 (7.4)	16.7 (13.7)	56 (8.6)
Slope	34.7 (4)	15.4 (8.3)	2.2 (2)	8 (4.2)	83.3 (13.7)	16 (6)
Ecological System						
Montane marsh	2.7 (2.2)		16 (13.1)			
Wet meadow (including fens)	63.5 (6.1)	69.2 (12)	52.4 (16.9)	16 (6.9)	83.3 (13.7)	32 (8.6)
Foothill shrubland	15.9 (4.7)	30.8 (12)	29.4 (14.8)			24 (6.4)
Montane shrubland	17.5 (4.6)		2.2 (1.9)	81.3 (7.5)	16.7 (13.7)	40 (8)
Montane woodland	0.4 (0.3)			2.7 (2.5)		4 (3.4)

Wetland Condition

Landscape Stressors

Potential water quality and hydroperiod stressors were identified prior to surveys based on GIS analysis of surrounding land cover and probable water sources. These landscape water quality stressors were most common and most severe in the Central Basin ecoregion (table 6); stressors were also common though less severe in the Mountain Valleys (table 7). Every site in the Great Salt Lake stratum was estimated to be impacted by moderate to severe point source dischargers and runoff from development. Runoff from roads was the only commonly recorded water quality stressor in the Wasatch Montane Zone and Alpine Zone.

Hydroperiod stressors were very common at the landscape scale; at least two moderate or high severity stressors were recorded at every Great Salt Lake and Jordan wetland site and 90% or more of the sites in Utah Lake and Mountain Valleys had at least one stressor recorded. A little over a quarter of the Semiarid Foothills and Wasatch Montane Zone sites had one or more hydroperiod stressors recorded; none were recorded in the Alpine Zone. Control structures, dikes or dams, irrigation return flow, runoff from impervious surface, and ditches are each estimated to affect >40% of the wetland area in the Central Basin ecoregion (table 6). Control structures blocking inflow, ditches feeding wetlands, and irrigation return flows are each estimated to occur at >61% of wetland area in the Mountain Valleys (table 7). Dams and berms blocking outflow are the most common hydroperiod stressor in the Semiarid Foothills and Wasatch Montane Zone.

Buffer Stressors

At least one stressor was recorded in each site's surrounding 100 m buffer except for two National Forest Wasatch Montane Zone sites. The mean number of buffer stressors per site was 4.0 with a maximum of 10 stressors recorded at one site. Linear disturbance features such as roads, railroad

Table 6. Landscape and buffer stressors in the Central Basin ecoregion, with estimated percentage of wetland area affected by each stressor and standard error in parentheses.

Stressor	Central Basin Ecoregion	Great Salt Lake	Jordan	Utah Lake
Landscape Water Quality Stressor				
Agricultural land	50.6 (5.1)	20 (7.1)	20 (8.3)	80 (7.5)
Development (including paved roads)	77.0 (4)	100 (0)	90 (8.3)	55 (8)
Quarries / mines	30.1 (5.6)	30 (8.2)	40 (11)	30 (8.1)
Point source dischargers	71.7 (4.2)	100 (0)	70 (12.9)	45 (8.4)
Sediment from miscellaneous sources	5.2 (2.9)	0	10 (9)	10 (5.5)
Landscape Hydroperiod Stressors				
Control structure managing inflow	51.3 (4.3)	85 (6)	20 (9.4)	20 (6.3)
Control structure managing outflow	49.9 (5.5)	40 (9.4)	0	60 (5.9)
Berm controlling inflow	46.1 (2.1)	95 (4.1)	40 (9.4)	0
Ditches bringing water	59.4 (5.5)	80 (6.6)	60 (11.3)	40 (8.5)
Ditches draining	2.5 (2.3)	0	0	5 (4.5)
Berm controlling outflow	36.4 (4.7)	70 (8.4)	10 (8.4)	5 (4.4)
Irrigation return flows	40.6 (5.4)	10 (5.2)	10 (8.3)	70 (9.3)
Impervious surface	54.7 (5.8)	75 (8.8)	90 (8.4)	35 (7.9)
Land Use Stressors in 100-m Buffer				
Agriculture	7.7 (3.5)	0	10 (8.3)	15 (6.9)
Development	10.2 (4.1)	10 (6)	40 (12.9)	10 (5.8)
Linear disturbances (roads, railroad tracks, power lines)	37.3 (6.4)	50 (10.3)	60 (14.6)	25 (8.1)
Livestock grazing	37.4 (6.2)	35 (8.8)	20 (8.3)	40 (8.7)
Human Visitation Stressors in 100-m buffer				
Trail	0.5 (0.1)	0	60 (14.8)	0
Trash	45.6 (7.3)	35 (10)	80 (10.3)	55 (10.6)
Off-road vehicles disturbance	22.3 (5.5)	30 (8.7)	20 (12)	15 (6.9)
Water Quality Stressors in 100-m Buffer				
Excessive filamentous algae	34.6 (6.6)	45 (9.7)	20 (11.9)	25 (9)
Discharges (stormwater or wastewater discharge)	0.3 (0.1)	0	40 (12)	0
Hydrologic Stressors in 100-m Buffer				
Modified channels and ditching	22.4 (5.2)	30 (7.6)	40 (14.1)	15 (7.1)
Human-made basin or pond	2.8 (2.2)	0	30 (12.5)	5 (4.4)
Dikes, dams, and water control structures	12.5 (4.2)	20 (7.5)	40 (15.1)	5 (4.4)
Riprap along shoreline	0.1 (0.1)	0	10 (8.3)	0
Vegetation Stressors in 100-m Buffer				
Vegetation control (e.g., spraying, mowing, burning)	30.2 (6.3)	30 (9.3)	50 (14.1)	30 (8.7)
Extensive damage from insects or mammals	2.4 (2)	5 (4.1)	0	0
Non-native plant species cover	95.2 (2.5)	90 (5.2)	100 (0)	100

Table 7. Landscape and buffer stressors in the Wasatch Mountains ecoregion, with estimated percentage of wetland area affected by each stressor and standard error in parentheses.

Stressor	Wasatch Mountains Ecoregion	Mountain Valleys	Semiarid Foothills	Wasatch Montane Zone	Alpine Zone	*National Forest*
Landscape Water Quality Stressors						
Agricultural land	29.9 (4.6)	69.2 (12)	32 (15)	0	0	0
Development (including paved roads)	32.3 (6.1)	46.2 (12.7)	34.2 (16.4)	32.4 (15.3)	16.7 (13.7)	24 (7.8)
Quarries / mines	9.3 (3.5)	15.4 (8.9)	16 (13.1)	8 (2.8)	0	12 (4.7)
Point source dischargers	16.3 (4.7)	38.5 (12.8)	16 (13.1)	0	0	0
Sediment from miscellaneous sources	4.2 (2.6)	0	4.5 (2.8)	24.4 (16)	0	16 (6.5)
Landscape Hydroperiod Stressors						
Control structure managing inflow	24.5 (4.9)	61.5 (11.3)	16 (13.2)	0	0	0
Control structure managing outflow	0	0	0	0	0	0
Berm controlling inflow	8.2 (3.7)	15.4 (8.8)	16 (13.1)	0	0	0
Ditches bringing water	27.6 (4.6)	69.2 (11.5)	18.2 (13.5)	0	0	4 (3.4)
Ditches draining	5.4 (2.9)	15.4 (8.5)	0	0	0	0
Berm controlling outflow	17.1 (4.7)	23.1 (10.3)	32 (15)	24.4 (15.9)	0	8 (4.3)
Irrigation return flows	24.5 (5.3)	61.5 (13.1)	16 (13.2)	0	0	0
Impervious surface	11.7 (4.4)	23.1 (11.1)	16 (13.1)	5.3 (3.5)	0	8 (4.8)
Land Use Stressors in 100-m Buffer						
Agriculture	8.2 (3.6)	23.1 (11.1)	0	0	0	0
Development	0	0	0	0	0	0
Linear disturbances (roads, railroad tracks, power lines)	37 (7.8)	38.5 (12.2)	61.3 (17.1)	51.5 (15.7)	16.7 (15)	44 (8.9)
Livestock grazing	40.1 (7.2)	69.2 (8.2)	45.4 (15.5)	16 (6)	16.7 (15)	48 (6.3)
Human Visitation Stressors in 100-m buffer						
Trail	30.2 (8)	15.4 (8.7)	20.4 (13.1)	32.4 (15)	50 (19.2)	28 (8.3)
Trash	23.2 (5.7)	23.1 (10.8)	45.4 (16.9)	51.5 (16.6)	0	44 (8.8)
Off-road vehicles disturbance	8.2 (4)	23.1 (10.6)	0	0	0	0
Water Quality Stressors in 100-m Buffer						
Excessive filamentous algae	26.5 (7.3)	38.5 (13)	22.7 (14)	24.4 (15.8)	16.7 (14.9)	20 (7.2)
Discharges (stormwater or wastewater discharge)	0	0	0	0	0	0
Hydrologic Stressors in 100-m Buffer						
Modified channels and ditching	24.9 (5.7)	53.8 (13.3)	34.2 (15.3)	0	0	4 (3.6)
Human-made basin or pond	8.2 (3.8)	7.7 (6.9)	32 (16.6)	0	0	0
Dikes, dams, and water control structures	10.9 (4.2)	15.4 (9.7)	32 (16.6)	0	0	0
Riprap along shoreline	5.8 (2.9)	7.7 (6.4)	18.2 (13.7)	0	0	4 (3.7)
Vegetation Stressors in 100-m Buffer						
Vegetation control (e.g., spraying, mowing, burning)	5.8 (2.9)	7.7 (6.3)	16 (13.2)	2.7 (2.3)	0	4 (3.6)
Extensive damage from insects or mammals	26 (7)	23.1 (10.9)	0	8 (3.7)	50 (19.8)	12 (5.3)
Non-native plant species cover	82.2 (6.2)	100 (0)	100 (0)	92 (2.8)	50 (19.7)	88 (4.1)

tracks, and utility corridors were widespread across the watershed, whereas agriculture and development were only found in buffers in the Central Basin ecoregion and in the Mountain Valleys (tables 6 and 7). Buffer livestock grazing was most common in the Mountain Valleys and least common in the Alpine Zone and Wasatch Montane Zone.

Stressors related to water quality were found in at least one site buffer per stratum. Excessive algae is estimated to occur in between 16.7% and 45% of wetland area, depending on strata. Forty percent of Jordan stratum wetlands are estimated to receive stormwater or wastewater discharge; this stressor was not recorded in any other strata. Buffer livestock grazing was estimated to have moderately severe water quality impacts on 16.0% and low impacts on 21.7% of wetland buffer area, with more severe impacts related to nutrient addition rather than sediment. Other contributors to wetland water quality stress from the buffer included dirt and gravel roads, trails, vegetation control, dikes, and off-road vehicle disturbance contributing sediment and crops, mines, and paved roads contributing other contaminants.

Hydroperiod stressors were not nearly as common within buffers as they were in the larger landscape and were, except for compaction from livestock and minor berming from roads, absent from the Wasatch Montane Zone and Alpine Zone. Human constructed ponds were common in the Jordan and Semiarid Foothills strata and compaction from livestock grazing was very common in the Mountain Valleys. Most buffer stressors were evaluated as having low impact on hydroperiods, though berms and ditches were frequently recorded as moderate to high severity, particularly in the Great Salt Lake, Semiarid Foothills, Mountains Valleys, and Jordan strata. Direct stormwater inputs and dredged depressions were also frequently recorded as having moderate to high severity hydroperiod impacts in the Jordan stratum.

Frequently recorded stressors to vegetation in the buffer included cover of non-native plants, excessive herbivory, and vegetation control. Non-native plant cover is the most common buffer stressor in the watershed, found at almost all wetlands and estimated as moderate to high severity in 72.8% of all wetland area. Excessive herbivory due to beetle kill was recorded in the Alpine Zone and Wasatch Montane Zone, and extensive mammalian browse on shrubs and trees was recorded in the Great Salt Lake, Mountain Valleys, and Wasatch Montane Zone. Vegetation control in the buffer, including spraying and mowing, was more common in the Central Basin ecoregion than in the Wasatch Mountains Ecoregion. Most of the control was aimed at non-native species, though mowing was sometimes conducted to limit fire danger or create walking paths.

Site Stressors

We recorded stressors present directly in the AA in three categories: hydroperiod, vegetation, and physical structure. An estimated 82.3% of wetland area in the Central Basin ecoregion and 65.9% of wetland area in the Wasatch Mountains ecoregion have at least one AA stressor (tables 8 and 9). Stressors affecting vegetation were the most widespread, found in approximately two-thirds of wetland area in each ecoregion. Livestock browse on vegetation and moderate to heavy filamentous algae were common vegetation stressors throughout the watershed. In contrast, excessive wildlife herbivory (including beetle-kill) was only found in the Wasatch Mountains ecoregion and impacts from off-road vehicles and vegetation control efforts were only found in the Central Basin ecoregion. The most common stressors to the physical environment were trampling from livestock grazing and, in the Central Basin only, off-road vehicle disturbance and dumping of garbage; physical stressors such as sediment

Table 8. Assessment area stressors in the Central Basin ecoregion, with estimated percentage of wetland area affected by each stressor and standard error in parentheses.

Stressor	**Central Basin Ecoregion**	**Great Salt Lake**	**Jordan**	**Utah Lake**
Any Stressor	82.3 (5.3)	85 (7.0)	70 (10.5)	80 (8.2)
Hydroperiod stressors, including dikes, channel modification, and soil compaction affecting hydrology	20.4 (5.2)	10 (4.4)	40 (14.8)	30 (9.5)
Physical stressors	55.1 (6.7)	50 (9.6)	50 (8.3)	60 (9.6)
Dumping of garbage	22.9 (5.8)	15 (7.3)	50 (8.3)	30 (8.8)
Vegetation stressors	67.4 (6.6)	70 (8.9)	60 (11)	65 (9.9)
Excessive wildlife herbivory	0	0	0	0
Moderate to heavy filamentous algae	32.3 (6.7)	40 (10.1)	30 (12.9)	25 (9)
Vegetation control (burning, spraying, mowing, etc.)	20 (5.5)	20 (7.6)	20 (9.9)	20 (8)
Chemical vegetation control	17.4 (5.2)	20 (7.6)	10 (8.5)	15 (7.3)
Vegetation mowing	2.6 (2.2)	0	10 (8.5)	5 (4.4)
Other mechanical vegetation removal	4.9 (2.3)	10 (4.7)	10 (8.5)	0
Burned wetlands	2.4 (2.2)	5 (4.5)	0	0
Livestock grazing within AA	37.4 (6.4)	30 (9.2)	0	45 (8.9)
Effect on hydroperiod	7.5 (3.3)	5 (4.1)	0	10 (5.2)
Effect on physical environment	30 (5.9)	20 (8.3)	0	40 (8.4)
Effects on vegetation / browse	20 (5.5)	15 (7)	0	25 (8.5)
Off-road vehicles or machinery	32.3 (6.2)	35 (9.2)	20 (9.9)	30 (8.8)
Effect on hydroperiod	10.4 (4.3)	0	20 (9.9)	20 (8.4)
Effect on physical environment	27.4 (5.8)	30 (8.6)	20 (9.9)	25 (8.1)
Effects on vegetation	22.4 (5.6)	25 (8.3)	20 (9.9)	20 (7.9)

deposition and anthropogenic surface erosion were rare. Similarly, compaction and entrenchment from livestock grazing in the entire watershed and off-road vehicles in the Central Basin ecoregion were the most common hydroperiod stressors. Other hydroperiod stressors, including channel modification and small dikes within sites, were uncommon and only found in the Great Salt Lake, Jordan, and Mountain Valleys strata.

At least one moderate or one high severity AA stressor is estimated to occur in 37.6% (SE 5.6) and 17.4% (SE 5.5) of the Central Basin and 37.9% (SE 8.0) and 8.5% (SE 3.7) of the Wasatch Mountains ecoregions, respectively. Livestock stressors were predominantly low severity in the Central Basin ecoregion and predominantly moderate in the Wasatch Mountains ecoregion; Mountain Valleys had the highest percent of sites with moderate (53.8%, SE 9.2) and high (7.7%, SE 6.2) severity stress from livestock. Chemical vegetation control in the Central Basin ecoregion was more often recorded as high severity than moderate or low severity. Excessive filamentous algae was usually recorded as moderate severity in both ecoregions. Off-road vehicle and dumping of garbage were almost always recorded as low severity except for at a few sites in the Utah Lake and Jordan strata.

Table 9. Assessment area stressors in the Wasatch Mountains ecoregion, with estimated percentage of wetland area affected by each stressor and standard error in parentheses.

Indicator	**Wasatch Mountains Ecoregion**	**Mountain Valleys**	**Semiarid Foothills**	**Wasatch Montane Zone**	**Alpine Zone**	***National Forest***
Any Stressor	65.9 (7.8)	92.3 (6.4)	29.4 (10.3)	81.3 (6.1)	50 (19.2)	60 (7.4)
Hydroperiod stressors, including dikes, channel modification, and soil compaction affecting hydrology	18.6 (4.3)	46.2 (11.3)	4.5 (2.8)	10.7 (5)	0	24 (7.1)
Physical stressors	36.6 (7.5)	76.9 (8.9)	8.9 (3.5)	16 (6.5)	16.7 (15)	40 (7.4)
Dumping of garbage	6.6 (3.5)	15.4 (9.8)	2.2 (2.1)	5.3 (3.8)	0	12 (6.1)
Vegetation stressors	62.4 (8)	84.6 (9.4)	27.2 (10.7)	78.6 (6.4)	50 (19.2)	52 (7.4)
Excessive wildlife herbivory	12.1 (4.9)	15.4 (8.9)	4.5 (3.1)	2.7 (2.3)	16.7 (13.7)	12 (6.1)
Moderate to heavy filamentous algae	26.9 (7.3)	30.8 (12.6)	6.7 (3.7)	65.3 (9.2)	16.7 (14.9)	24 (7.2)
Vegetation control (burning, spraying, mowing, etc.)	0	0	0	0	0	0
Livestock grazing within AA	35.8 (7.3)	69.2 (8.2)	24.9 (9.9)	10.7 (5)	16.7 (15)	32 (5.8)
Effect on hydroperiod	13.2 (3.8)	30.8 (11.1)	4.5 (2.8)	10.7 (5)	0	24 (7.1)
Effect on physical environment	33.1 (7.2)	69.2 (8.2)	8.9 (3.5)	10.7 (5)	16.7 (15)	32 (5.8)
Effects on vegetation (not including composition)	32.3 (7.1)	61.5 (10.7)	22.7 (10.4)	8 (4)	16.7 (15)	24 (5.3)
Off-road vehicles or machinery	0	0	0	0	0	0

Rapid Assessment Condition Results

The landscape condition category is composed of three metrics, whole wetland connectivity, percent intact landscape, and overall buffer condition, the latter composed of four submetrics. At least 70% of wetland area in each stratum is estimated to be in good to excellent condition for whole wetland connectivity and only two strata, Jordan and Great Salt Lake, have any wetland area estimated to be in poor condition (figure 4). Percent intact landscape and overall buffer condition is estimated to be good to excellent in ≥75% and ≥90% of wetland area, respectively, for all but the Jordan and Mountain Valleys. Buffer vegetation was in poor condition much more frequently than other aspects of the buffer; buffer vegetation is estimated to be in poor condition in 44.9% of the Central Basin and 19.1% of the Wasatch Mountains wetland area.

AA soil disturbance was generally minimal; ≥93% of wetland area in each stratum except the Mountain Valleys was in good to excellent condition (figure 5). Soil disturbance was rated fair in only the Jordan, Utah Lake, and Wasatch Montane Zone strata and was never rated as poor.

The vegetation structure category is composed of the litter accumulation, woody debris, woody regeneration, and interspersion metrics. Litter accumulation is estimated to be good-excellent (AB) in 62.3% and 83.2 of wetland area in the Central Basin and Wasatch Mountains ecoregions, respectively (figure 6). Excessive litter is estimated to occur in 27.6% of Central Basin wetlands and sparse litter is estimated to occur at 10.1% of Central Basin and 16.8% of Wasatch Mountains wetlands. Horizontal interspersion was estimated in all wetlands but excluded in the calculation of overall condition scores in alkaline depression, playas, and basin and montane marsh sites because these systems naturally have

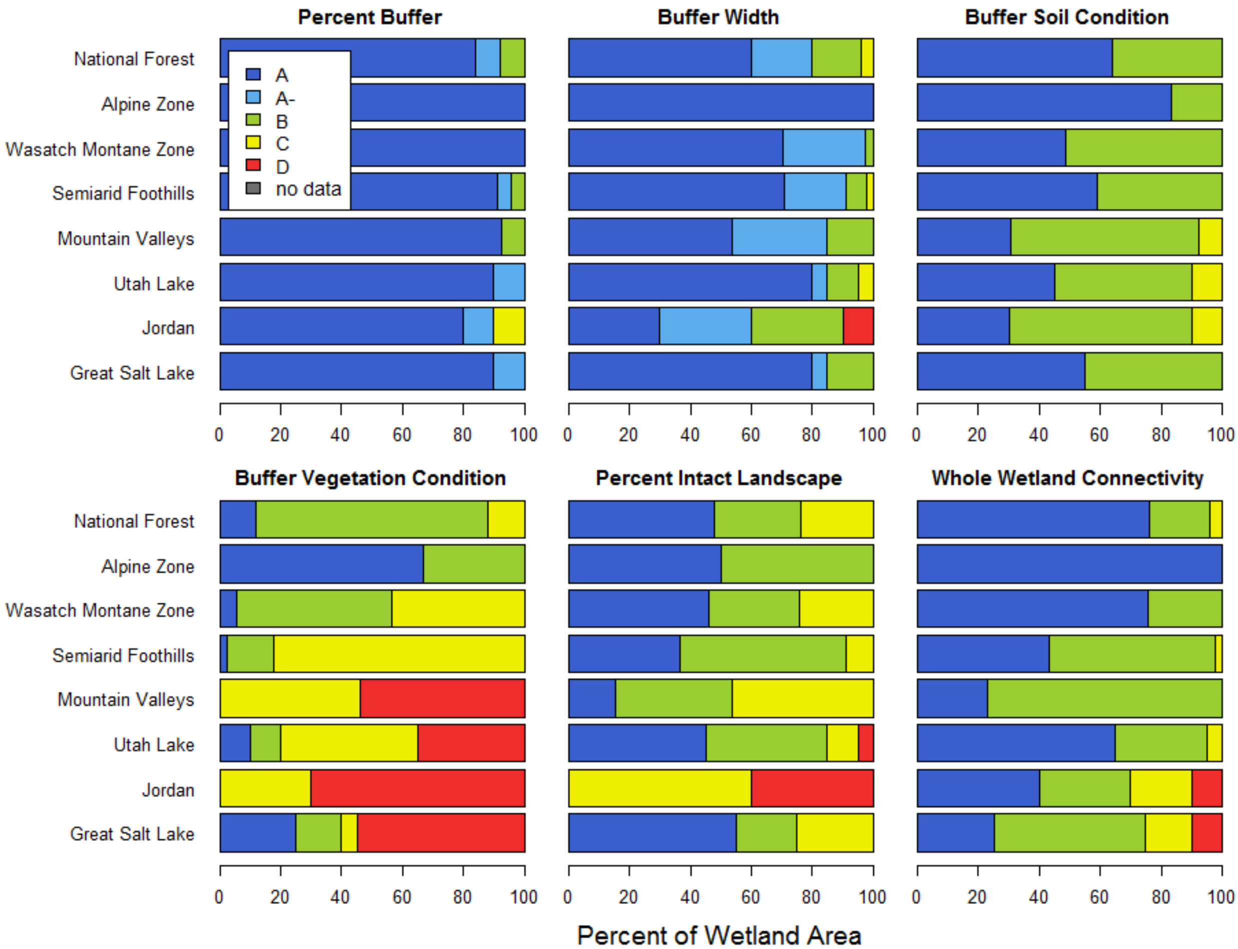

Figure 4. Estimate of percentage of wetland area in each stratum with each rank for landscape condition metrics, as well as estimates for the National Forest land.

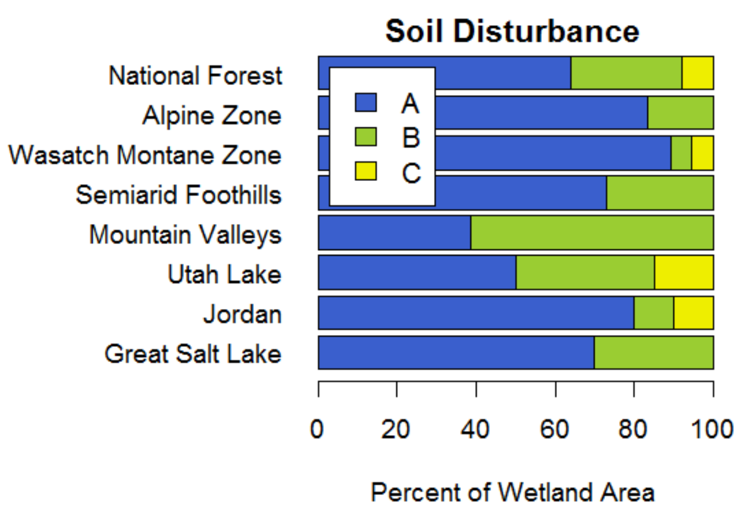

Figure 5. Estimate of percentage of wetland area in each stratum with each rank for the soil disturbance condition metric, as well as estimates for the National Forest land.

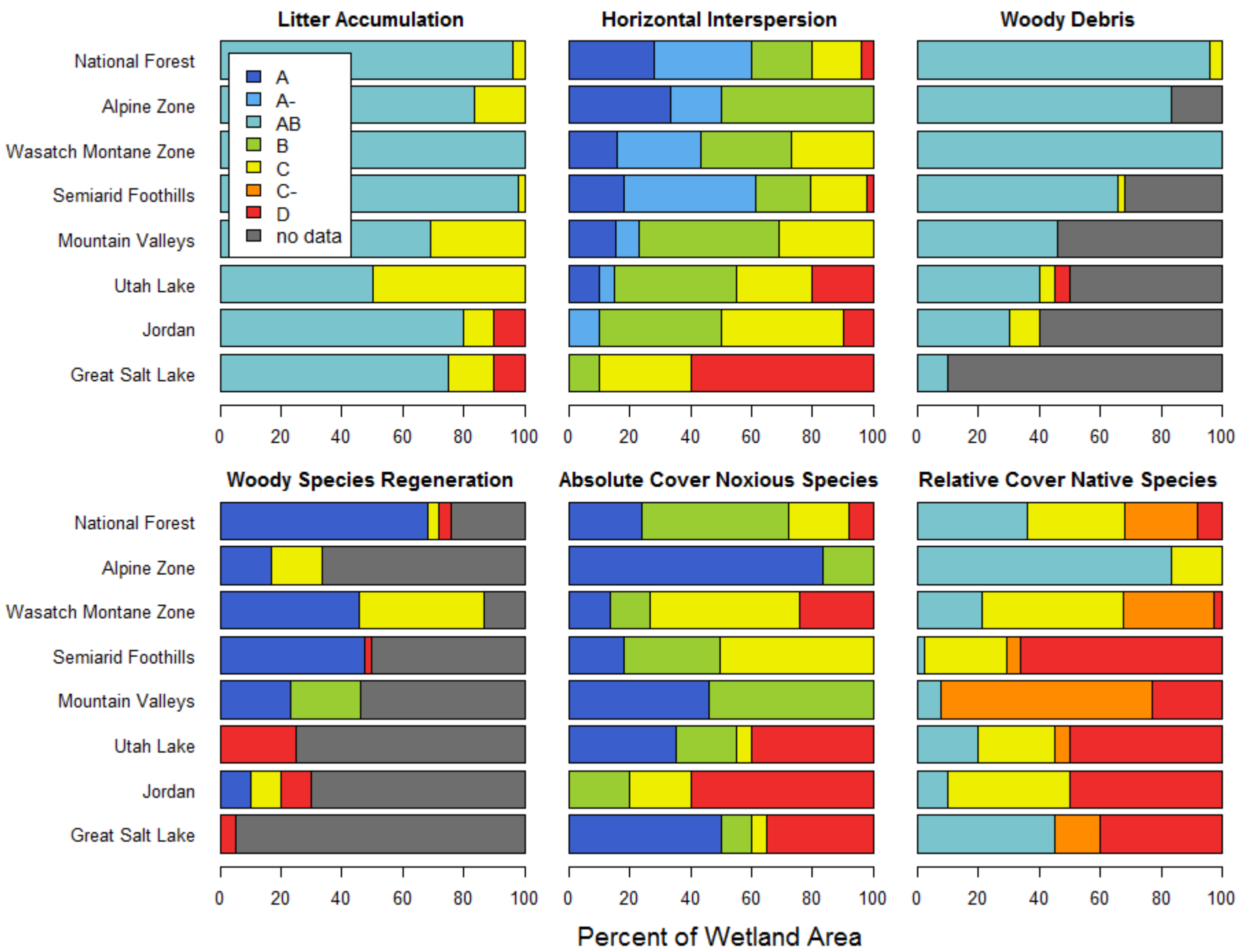

Figure 6. Estimate of percentage of wetland area in each stratum with each rank for vegetation structure and vegetation composition metrics, as well as estimates for the National Forest land.

low levels of interspersion. As expected, these Ecological Systems, and the Central Basin strata where they are found, scored poorly on the horizontal interspersion metric, though alkaline depressions showed more breadth of scores than other Ecological Systems. In the Wasatch Mountains ecoregion, wet meadows tended to have less horizontal interspersion than woody systems. The woody debris and woody species regeneration metrics were only scored at sites expected to have inputs of woody debris or woody species regeneration. Woody debris condition is estimated to be fair or poor in a small percent of wetland area in the Jordan, Utah Lake, and Semiarid Foothills strata and otherwise estimated to be good-excellent (AB). Woody species regeneration is estimated to be poor due to excessive canopy cover of invasive woody species in 5% of Great Salt Lake, 10% of Jordan, and 25% of Utah Lake wetland area. Forty percent of wetland area in the Wasatch Montane Zone is estimated to have only fair woody species regeneration with seedlings and saplings missing.

The vegetation composition category is composed of two metrics, absolute cover of noxious species and relative cover of native species. Sites that scored as excellent or good in the Central Basin ecoregion for relative native cover were frequently species-poor systems with <5 species, such as playas with only *Salicornia rubra* (red swampfire) or marshes with only one or two species of submerged aquatic vegetation. Half the Jordan and Utah Lake wetland area and 40% of Great Salt Lake is estimated to have poor relative cover of native plant species, defined as <50% relative cover of native species (figure 6). *Phragmites australis* ssp. *australis* (phragmites) was dominant at more than half of the sites with poor relative native cover; *Atriplex micrantha* (twoscale saltbush)*, Bassia hyssopifolia* (fivehorn smotherweed)*,* and *Tamarix* spp. (tamarisk) were often dominant or co-dominant at the remaining sites. *P. australis* ssp. *australis* and *Tamarix* spp. were also the most widespread noxious weeds encountered in the Central Basin ecoregion. Almost two-thirds of the Semiarid Foothills wetland area and one-quarter of the Mountain Valleys is estimated to be in poor condition for relative cover of native species. Dominant non-native species at these sites were often one or more non-native grasses, including *Agrostis gigantea* (redtop), *Alopecurus pratensis* (meadow foxtail), *Phalaris arundinacea* (reed canarygrass), *Phleum pratense* (timothy) and *Poa pratensis* (Kentucky bluegrass). Three sites in the Wasatch Montane Zone had more than 10% cover noxious weeds. All three had high cover of *Cirsium arvense* (Canada thistle). Noxious weeds were uncommon or occurred with low abundance in the Mountain Valleys and Alpine Zone.

Hydrologic condition is composed of six metrics, including wetland edge connectivity, water quality, hydroperiod, timing of inundation, turbidity and pollutants, and algae growth, though the latter two metrics are only evaluated in wetlands with standing water or desiccated filamentous algae. More than 85% of wetland area in each ecoregion is estimated to be in excellent condition for wetland edge connectivity (figure 7). Over half of the wetland area in the Great Salt Lake, Jordan, and Mountain Valleys strata is estimated to be in fair or fairly poor (C-) condition for hydoperiod and timing of inundation and half of the wetland area in the remaining strata is estimated to be good to excellent for these metrics. Water quality is estimated to be good to excellent in almost all wetland area in the Semiarid Foothills, Wasatch Montane Zone, and Alpine Zone and fair to poor in other strata, with the highest percent poor water quality in the Jordan stratum. Turbidity is estimated to be excellent in most wetland area where rated, though poor in 20% of Jordan wetland area and occasionally fair in Great Salt Lake, Jordan, Utah Lake, and Semiarid Foothills wetlands. Algae condition was fair to poor at almost all wetland area in the Great Salt Lake stratum where it was rated and occasionally fair in the Jordan, Utah Lake, Mountain Valleys, and Wasatch Montane Zone. Excessive dried algae was recorded at five Great Salt Lake, two Utah Lake, and one Semiarid Foothills wetlands.

The estimated mean overall condition scores per strata ranged from 3.5 in the Jordan to 4.77 in the Alpine Zone. Two Great Salt Lake wetlands and one Jordan wetland scored below 3.0 and one National Forest Wasatch Montane Zone wetland scored a perfect score of 5.0. At least one site in each stratum scored ≤3.9. except the Alpine Zone, where the lowest score was 4.4. Wetlands in the Semiarid Foothills had a very narrow range of scores; the estimated 10th and 90th percentile scores differed by only 0.29. The five highest scoring sites in the Central Basin, all with scores ≥4.5, included three marshes with predominantly submerged aquatic vegetation, one *S. rubra* playa, and a spring-fed wetland near Utah Lake. The five highest scoring sites in the Wasatch Mountains ecoregion, all with scores ≥4.9, were wet meadows and shrublands on National Forest land.

We compared the cumulative density functions of overall condition scores to determine whether the distributions differed by strata. We used $p < 0.01$ as the threshold to determine whether distributions differed instead of $p < 0.05$ because of the high number of comparisons being made

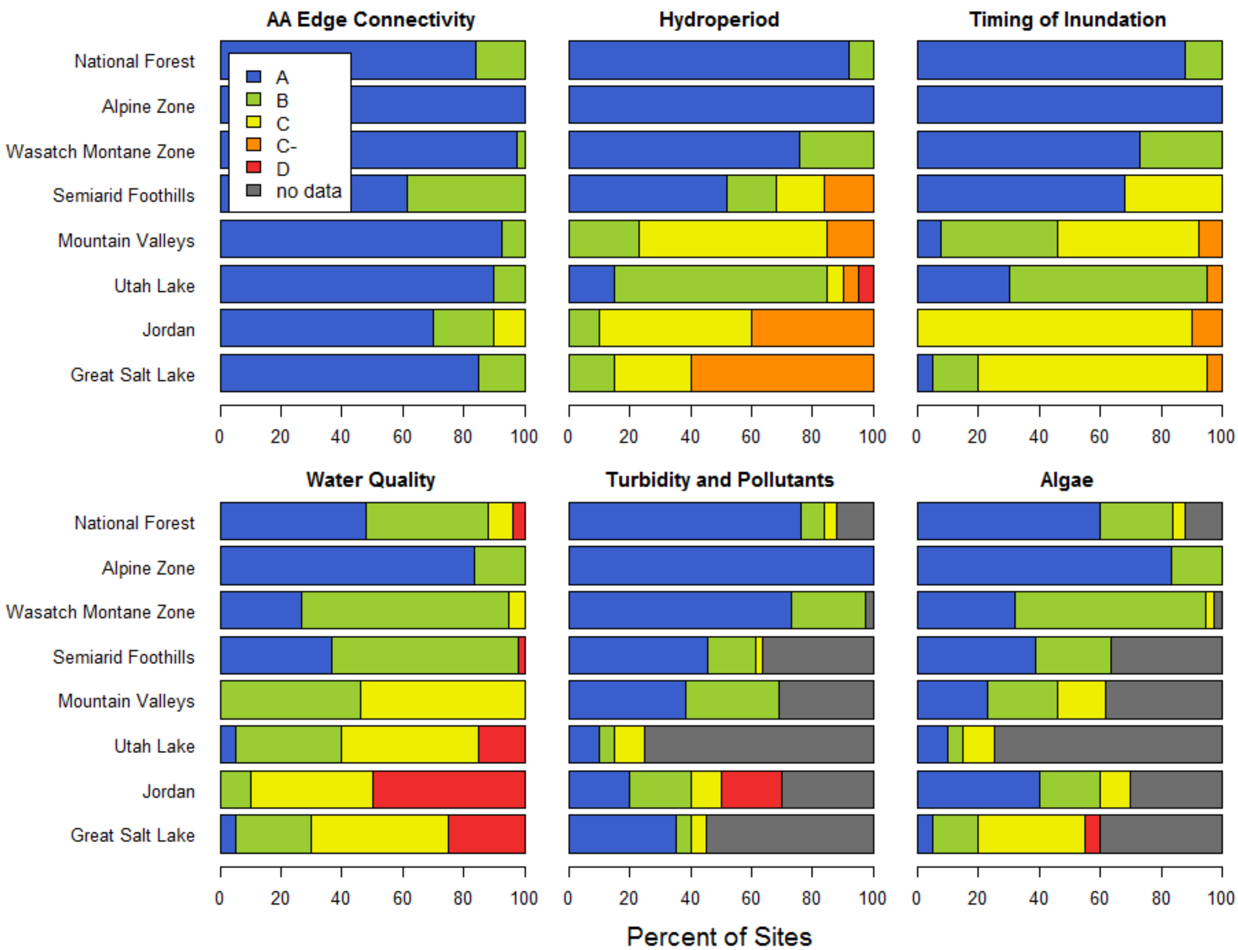

Figure 7. Estimate of percentage of wetland area in each stratum with each rank for hydrologic condition metrics, as well as estimates for the National Forest land.

(Kincaid, 2016). We could not compare the Alpine Zone to the Wasatch Montane Zone or the Jordan to the Mountain Valleys because there was too little data in different score classes for comparison. Jordan and Alpine Zone cumulative density functions differed from one another and all comparable strata, except there was no difference between the Alpine Zone and Semiarid Foothills (figure 8).

Wetland Function

Boreal Toad

We surveyed 27 sites in non-prime habitat and 25 sites in prime habitat for the boreal toad. All sites in the prime habitat scored as fair or better for the breeding waterbodies metric, indicating at least some surface water present at the sites; >90% wetland area in the prime habitat is estimated to be good or excellent for breeding waterbodies (table 10). Cover of surrounding shrub and forb vegetation, presence of north shore, and slope and water depth were the biggest limiting factors, estimated to be fair or poor in between 44% and 55% of wetland area. An estimated 68.1% (SE 9.2) of wetland area in the non-prime habitat have breeding waterbodies that scored above poor. In this subset of non-prime habitat, surrounding vegetation and presence of north shore were the two most common limiting

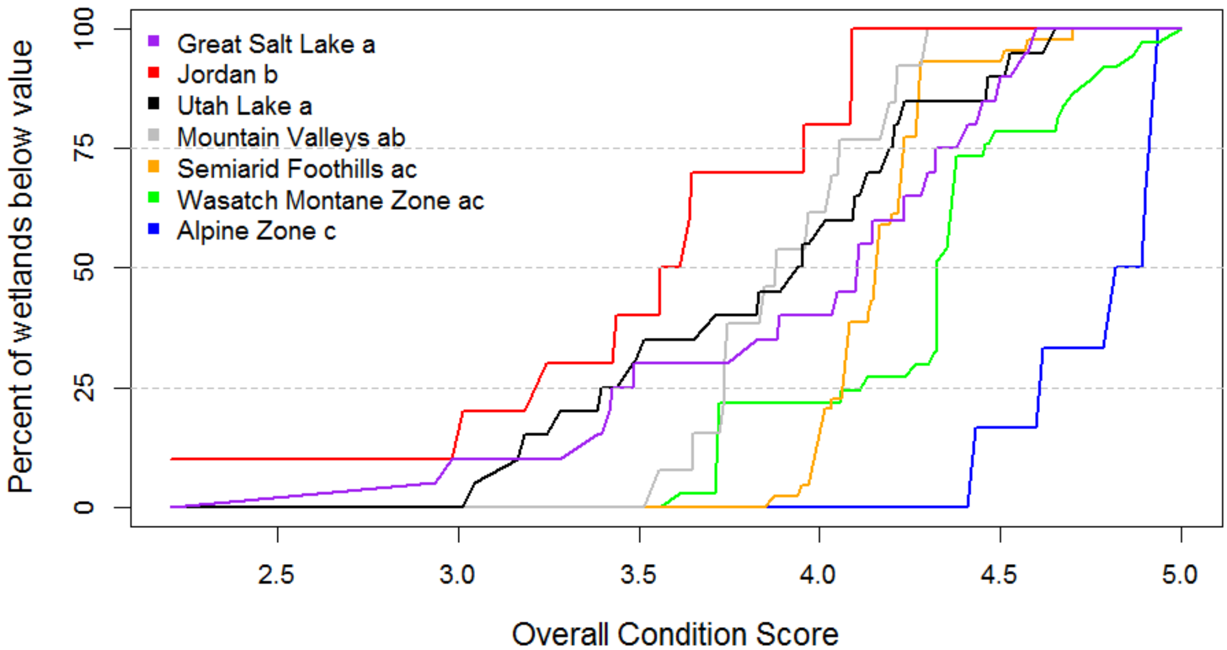

Figure 8. Cumulative density functions for overall condition scores showing the estimated percentage of wetland area with an overall URAP score at or below the indicated values. Strata that share lowercase letters do not significantly differ from one another in the shape of the density function, except for two comparisons, Alpine Zone – Wasatch Montane Zone and Jordan – Mountain Valleys, which did not have enough unique values for comparison

factors, estimated to be fair to poor at 77% and 65% of wetland area, respectively. Under-abundance of surrounding vegetation was more common than overabundance in both prime and non-prime habitat. The water temperature metric was almost always scored as good or fair and never scored as excellent. Beaver are estimated to be present in 14.0% (SE 6.0) of non-prime and 27.1% (SE 8.5) of prime wetland habitat.

About half the wetland area in the non-prime habitat is estimated to have a mean metric score <2.5, whereas the lowest mean score in the prime habitat was 2.8. About 44% of wetland area in the prime habitat and 35% in the non-prime habitat is estimated to have mean habitat metric scores ≥3.8, though most of the high scoring sites in the non-prime habitat are likely too low in elevation for the species, such as along the middle section of the Provo River. An adult boreal toad was observed at one site during surveys in the watershed; this site had the highest mean habitat metric score, 4.7, of all surveyed sites.

Key threats listed for the boreal toad in the Utah Wildlife Action Plan include chytrid, drought, problematic native species (tiger salamander), prescribed fire, and improper grazing management (J. Gragg, Utah Division of Wildlife Resources, unpublished information, 2015; Utah Division of Wildlife Resources, 2015). We did not evaluate the prevalence of chytrid or drought impacts at sites. We did not observe tiger salamanders at surveyed sites, though trout and other potentially predacious fish were observed at three sites in the non-prime habitat. We did not record any fire damage within sites or their

Table 10. Boreal toad habitat metric estimates, in non-prime and prime habitat (only considering those sites that scored at least fair or higher for breeding waterbodies). Value includes percentage of wetland area with standard error in parentheses.

Habitat Metric	A	B	C	D
Non-prime wetlands with potential breeding waterbodies (68% of wetland area)				
Breeding waterbody	35.8 (11.7)	30.5 (11.9)	33.7 (12.3)	*NA*
North shore	15.2 (8.9)	19.5 (9.1)	16.3 (9.1)	48.9 (11.5)
Slope and depth	40.2 (12.5)	56.6 (12.6)	2.1 (1.1)	1.1 (1)
Temperature	0	88.1 (6.6)	11.9 (6.6)	0
Vegetation (shrub/forb)	21.6 (8.5)	1.1 (0.9)	39.2 (11.9)	38.1 (10.4)
Hibernation	50.0 (8.8)	11.9 (6.5)	7.6 (6.7)	30.5 (10.9)
Prime wetlands with potential breeding waterbodies (100% of wetland area)				
Breeding waterbody	55.4 (12.5)	38.2 (12)	6.4 (1.9)	*NA*
North shore	37.2 (12.4)	19 (10.8)	13.3 (10.5)	30.5 (13.1)
Slope and depth	35.2 (11.6)	16.5 (9.9)	47.5 (13.1)	0.8 (0.7)
Temperature	0	66.9 (14)	30.7 (13.9)	2.4 (1.2)
Vegetation (shrub/forb)	20.6 (8.4)	24.1 (12.8)	30.3 (11.2)	24.9 (11.7)
Hibernation	55.3 (13.2)	33.1 (13.8)	11.7 (9.6)	0

buffers. Livestock grazing is estimated to occur in 14.9% (SE 10.5) of prime habitat wetland area, with an additional 1.6% (SE 0.8) of wetland area with grazing in the surrounding buffer. Only 1.8% (SE 1.7) of high scoring (i.e., mean metric scores ≥3.8) prime habitat wetland area is estimated to have grazing within or surrounding the site. Grazing was more common in the non-prime habitat; over one-third of wetland area is estimated to have grazing within the wetland or its buffer.

Turbidity and recreational use are two stressors not listed in the Wildlife Action Plan that may be important for boreal toad (Menuz, 2017). Turbidity tube measurements indicated potential issues with water clarity in an estimated 25.7% (SE 13.7) of high scoring prime wetland area; none of the lower scoring prime habitat wetlands had turbidity issues. In the non-prime habitat, turbidity is a potential issue in 17.0% (SE 13.4) of high scoring and 46.7% (SE 18.2) of lower scoring wetland area. We did not directly measure evidence of recreational use within sites, but we did find that 44.7% (SE 14.3) of prime wetlands and 17.0% (SE 7.3) of non-prime wetlands are estimated to be within 100 m of recreational trails and 15.4% (SE 6.2) of prime and 30.3% (SE 9.6) of non-prime wetlands are estimated to have trash in or near the wetlands. Trash directly in wetlands was much less common than trash adjacent to wetlands.

Columbia Spotted Frog

We evaluated Columbia spotted frog habitat at 50 randomly selected sites in the Central Basin ecoregion, 28 sites in non-prime montane habitat, and 24 sites in prime montane habitat. Potential breeding waterbodies (i.e., potential surface water) was found at about 83% of wetland area in the Central Basin ecoregion and in the non-prime montane habitat and about two-thirds of wetland area in the prime montane habitat (table 11). However, potential breeding waterbodies are estimated to be

Table 11. Columbia spotted frog habitat metric estimates, only considering those sites that scored at least C or higher for breeding waterbodies. (e.g., surface water likely). Value includes percentage with standard error in parentheses. Estimates for waterbody substrate are only available for sites surveyed in 2016.

Habitat Metric	**A**	**B**	**C**	**D**	**No data**
Central basin wetlands with potential breeding waterbodies (83.4% [SE 5.2] of wetland area)					
Breeding waterbody	26.2 (5.1)	0.4 (0.2)	73.4 (5.1)	*NA*	0
Vegetation in waterbody	10.3 (3.8)	21.7 (6.8)	39.9 (7.5)	28 (6.4)	0
Waterbody substrate	21.2 (5.8)	6.3 (3.6)	0	5.9 (3.7)	66.6 (7.0)
Overwintering waterbody	0.2 (0.2)	6.5 (3.5)	45.0 (6.7)	48.3 (7.1)	0
Non-prime montane wetlands with potential breeding waterbodies (83.0% [SE 7.0] of wetland area)					
Breeding waterbody	47.2 (12.3)	9.2 (8.2)	43.6 (12.4)	*NA*	0
Vegetation in waterbody	29.6 (11.8)	30.5 (11.9)	29.6 (11.4)	10.3 (6.8)	0
Waterbody substrate	29.6 (11.7)	21.2 (10.2)	1.9 (1.2)	0	47.3 (12.6)
North shore	37.1 (12.0)	11.1 (7.8)	11.1 (8.4)	40.8 (12.8)	0
Slope and depth	40.9 (10.9)	22.3 (10.1)	36.8 (11.1)	0	0
Overwintering waterbody	65.6 (11)	1.9 (1.2)	19.6 (8.5)	12.9 (8.0)	0
Prime wetlands with potential breeding waterbodies (62.5% [SE 10.6] of wetland area)					
Breeding waterbody	36.7 (13.8)	10.0 (8.3)	53.3 (14.3)	*NA*	0
Vegetation in waterbody	24.5 (10.9)	21.1 (12)	43.3 (14.8)	11.1 (8.8)	0
Waterbody substrate	63.3 (13.9)	10.0 (8.3)	0	0	26.7 (11.8)
North shore	20 .0(11.3)	14.5 (8.9)	21.1 (11.9)	44.4 (13.8)	0
Slope and depth	41.1 (14.6)	54.4 (14.6)	3.3 (1.6)	1.1 (1)	0
Overwintering waterbody	47.8 (12.1)	22.2 (12.1)	10.0 (8.7)	20.0 (11.3)	0

good or excellent in only about one-quarter of Central Basin, just over half of non-prime montane, and just under half of prime montane wetland area. We examined the ratings of the remaining habitat features to estimate which factors were the most limiting at sites with at least some potential for breeding waterbodies (i.e., those sites that scored fair or higher for the breeding waterbody metric). Waterbody substrate is estimated to be good to excellent in between 82% and 100% of wetland area per region where it was rated. The most widespread limiting factor in the Central Basin was the presence of overwintering waterbodies, which are estimated to be good or excellent in less than 7% of wetland area. Most areas either had no potential overwintering waterbodies or potential overwintering waterbodies that may freeze or were not particularly well-oxygenated. Just over two-thirds of wetland area in the Central Basin with potential breeding waterbodies had fair to poor waterbody vegetation. The most limiting factor in the prime and non-prime montane habitat was the presence of north shore, which was rated poor in >40% of wetland area. Overwintering waterbodies were rarely a limiting factor in the Wasatch Mountains ecoregion, estimated as good to excellent in more than two-thirds of wetland area with potential breeding waterbodies. Beaver were found at 17.4% (SE 7.5) of prime and 23.9% (SE 9.0) of non-prime montane habitat; evidence of beaver was not recorded in the Central Basin ecoregion.

About 42% of the non-prime montane, 35% of the prime montane, and 15% of the Central Basin wetland area is estimated to have a mean metric score ≥3.5, and about half the wetland area in the Central Basin and prime montane habitat and one-fifth the wetland area in the non-prime habitat are estimated to have mean scores <2.5. Six sites were surveyed in regions known to be occupied by Columbia spotted frog, including five in prime montane habitat along the Provo River and one in the Central Basin. One site received a mean metric score of 5.0; a Columbia spotted frog individual was observed at this site. Three sites were rated as good with scores ranging from 3.6 to 4.4, and two sites were rated as poor. One of the poor sites was a riparian wetland along the Provo River with no surface water and the other was a Central Basin spring that appeared to be severely drying.

Key threats listed for the Columbia spotted frog in the Utah Wildlife Action Plan include invasive non-native species, groundwater pumping, housing and urban development, and droughts (Utah Division of Wildlife Resources, 2015). Bullfrogs near Mona and groundwater pumping threats in Snake Valley are considered localized issues (J. Gragg, Utah Division of Wildlife Resources, unpublished information, 2015). Invasive non-native species is the only key threat from the Utah Wildlife Action Plan that was directly evaluated; bullfrogs and tiger salamanders were not seen at any survey sites. Over half (61.1%, SE 9.4) of wetland area in the prime montane stratum had at least one observed potential predator, versus 15.4% (SE 8.6) in the non-prime montane and 8.8% (SE 3.9) in the Central Basin. Avian predators, such as hawks, heron, and raven, were the most commonly observed threat, whereas other potential predators are estimated in 8% or less of wetland area.

Though groundwater stress and drought impacts were not directly evaluated at survey sites, field surveys and landowner conversations highlighted groundwater issues in northern Juab Valley, where we surveyed two spring sites. Both sites showed evidence of drying; one was completely dry and considered no longer target wetland and the other had marsh vegetation, but no surface water or soil saturation. Landowners at both sites expressed concerns about drying water levels, which they attributed to over-allocation of water in the region. Regional well data indicate that groundwater levels declined from 2015 to 2016, likely due to large irrigation withdrawals and less-than-average precipitation, and that there has been a generally declining trend since the late 1980s (Burden and others, 2016).

We used the distance to impervious surface and percent intact landscape metrics to evaluate potential impacts from housing and urban development. Almost all (>86%) of the wetland area with good breeding habitat (mean metric values ≥3.5) in the Central Basin and non-prime montane habitat was >300 m from impervious surface and <3% was within 100 m. In contrast, one-third of the good breeding habitat in the prime montane area was within 100 m of impervious surface and only about one-fifth was >300 m from impervious surface. Approximately half the wetland area with good breeding habitat in the Central Basin, 65% in the prime montane, and 83% in the non-prime montane have at least 60% unfragmented, natural land cover within 500 m of the wetland.

We evaluated three other potential stressors at sites, off-road vehicles, trash, and livestock grazing. Off-road vehicle disturbance was only recorded at sites in the Central Basin with low mean metric scores. Trash, a surrogate for human visitation, is estimated to be present at 29.8% (SE 16.2), 16.3% (SE 14.0), and 3.3% (SE 1.6) of basin, non-prime montane, and prime montane wetlands with good breeding habitat, respectively. Livestock grazing is estimated to occur within wetlands at none of the Central Basin, 5.0% (SE 1.7) of the prime montane, and 30.1% (SE 10.2) of the non-prime montane wetland area with good breeding habitat.

Water Quality Improvement

All but one site, a sparsely vegetated playa in the Utah Lake stratum, had at least some capacity for improving water quality based on the water quality indicator checklist, and >80% of sites had at least two indicators. Herbaceous vegetation ≥13 cm in height was the most common capacity indicator, estimated to occur in ≥90% of wetland area in all strata except for Great Salt Lake and Utah Lake. Clay or organic top soil, herbaceous vegetation, seasonal ponding, no or intermittent surface outlet and vegetation extending into lake were the most common capacity indicators in the Central Basin ecoregion, estimated to occur in between 30% and 61% of wetland area. In the Wasatch Mountains ecoregion, the most common capacity indicators include herbaceous vegetation, woody vegetation, soil or clay top soil, and seasonal ponding, estimated to occur in between 30% and 98% of wetland area. Mean number of capacity indicators found per site ranged from 2.1 in the Mountain Valleys to 3.7 in the Jordan stratum (table 12).

Landscape potential for water quality improvement was most common in the Jordan stratum, with a mean of 2.8 indicators per site, and absent from the Alpine Zone (table 12). Only wetlands in the Semiarid Foothills, Wasatch Montane Zone, and Alpine Zone sometimes lacked landscape stress indicators. Sources of sediment and nutrients and sources of other pollutants in the contributing basin were the two most common indicators and were more common in the Central Basin ecoregion than the Wasatch Mountains ecoregion. Sources of sediment/nutrients and other pollutants immediately adjacent to wetlands were less common, though estimated in between 15% and 20% of wetland area in the Semiarid Foothills, Mountain Valleys, Utah Lake, and Jordan stratum. Half of the Jordan wetlands are fed by stormwater pipes.

Alpine Zone wetlands had the most indicators of societal value for water quality improvement and Great Salt Lake had the least, with a mean of 3.5 and 0.25, respectively (table 12). All wetlands on land owned by the Uinta-Wasatch-Cache National Forest, including wetlands in the Alpine Zone, are classified as anti-degradation category 1 waters. Jordan has the most wetland area in impaired water quality assessment units and Great Salt Lake has the least, though most units in Great Salt Lake stratum have not been assessed.

We categorized wetlands as likely to provide a water quality service if they had at least one landscape indicator and two or more capacity indicators. Based on these criteria, over three-quarters of wetland area in the Central Basin ecoregion is estimated to provide water quality service, including 90% of the Jordan stratum wetland area (table 13). In contrast, less than half of the wetland area in the Wasatch Mountains ecoregion is estimated to provide water quality service. We categorized wetlands as representing a potential needs gap if they had at least one landscape indicator and one or no capacity indicators. About 22% of the Central Basin wetland area and 9% of the Wasatch Mountains ecoregion may have a needs gap, with the largest gaps in the Utah Lake and Mountain Valleys strata.

Wetland Vegetation

We recorded 2467 encounters with 435 unique plant species at random and reference sites, including 149 species found at only one site. Non-native species comprised 21% of these species. We were not able to identify to species 210 of the plants we encountered, of which 165 were tentatively

Table 12. Percentage of wetland area estimated to have each water quality functional indicator, with standard error in parentheses. Values in bold indicate the mean number of capacity, landscape, and society indicators per stratum.

	Great Salt	Jordan	Utah Lake	Mountain	Semiarid	Wasatch	Alpine	*National*
Capacity	**2.70 (0.22)**	**2.55 (0.26)**	**3.70 (0.39)**	**2.08 (0.20)**	**2.32 (0.34)**	**2.87 (0.22)**	**2.33 (0.24)**	**2.16 (0.14)**
Top of soil clay or organic	40.0 (8.1)	70.0 (12.4)	25.0 (7.2)	30.8 (11.9)	36.4 (16.6)	48.9 (16)	50.0 (19.8)	24 (8.1)
Slope <1% (slope/impoundment fringe classes)	20.0 (6.8)	0	10.0 (6.1)	15.4 (8.3)	0	2.7 (2.4)	16.7 (15)	4.0 (3.6)
Herbaceous vegetation >13 cm tall	45.0 (9.9)	90.0 (8.3)	75.0 (8.4)	100 (0)	93.3 (3.5)	94.7 (3.5)	100 (0)	80.0 (7)
Herbaceous vegetation >1 m tall	35.0 (9.7)	80.0 (12.3)	35.0 (9.1)	23.1 (9.4)	47.9 (15.8)	24.4 (14.9)	0	8.0 (4.6)
Woody vegetation >1 m tall	0	10.0 (8.1)	5.0 (4.o)	30.8 (12.0)	31.6 (14.9)	84.0 (6.9)	16.7 (13.7)	68.0 (8.6)
Seasonally ponded	45.0 (10.3)	50.0 (13.5)	65.0 (8.8)	15.4 (8.3)	6.7 (3.5)	48.9 (16)	50.0 (18.9)	28.0 (8.1)
No/intermittent surface outlet	55.0 (8.4)	70.0 (9.0)	5.0 (4.1)	7.7 (6.9)	32.0 (15.5)	2.7 (2.3)	0	4.0 (3.3)
Vegetation extending into lake	30.0 (8.6)	10.0 (8.3)	35.0 (7.9)	0	0	0	0	0
Landscape	**1.05 (0.04)**	**2.15 (0.17)**	**2.80 (0.15)**	**1.38 (0.15)**	**0.84 (0.36)**	**0.52 (0.16)**	**0**	**0.28 (0.11)**
Septic systems	0	0	5.0 (4.1)	0	0	0	0	0
Stormwater pipes	0	50.0 (8.3)	0	0	0	0	0	0
Adjacent sediment/nutrient	0	10.0 (8.1)	20.0 (7.7)	15.4 (8.8)	18.2 (13.7)	5.3 (3.5)	0	12.0 (5.9)
Adjacent pollutants	0	20.0 (9.9)	5.0 (4.1)	7.7 (6.9)	0	2.7 (2.6)	0	4.0 (3.5)
Power boats	0	0	40.0 (8.1)	0	0	0	0	0
Known algal bloom issues	0	0	40.0 (8.1)	15.4 (8.8)	47.9 (15.8)	0	0	0
Other sources of pollutants	0	0	0	7.7 (6.8)	0	0	0	0
Basin generating sediment/nutrient	75.0 (6.7)	50.0 (8.9)	90.0 (5.2)	76.9 (10.3)	16.0 (13.5)	21.8 (15)	0	4.0 (3.5)
Basin generating other pollutants	100 (0)	100 (0)	65.0 (5.6)	23.1 (10.1)	18.2 (13.7)	38.2 (16.6)	0	4.0 (3.4)
Within incorporated city	5.0 (4.2)	100 (0)	15.0 (5.7)	15.4 (8.3)	0	2.7 (2.3)	0	4.0 (3.6)
Society	**0.25 (0.15)**	**1.85 (0.17)**	**2.30 (0.18)**	**1.31 (0.27)**	**1.68 (0.36)**	**2.08 (0.42)**	**3.50 (0.19)**	**2.68 (0.12)**
Discharges to stream/lake	5.0 (4.1)	50.0 (12.7)	55 (7.6)	38.5 (13.0)	63.6 (14.6)	51.1 (16.6)	50.0 (19.2)	76.0 (7.9)
Impaired (category 4 or 5) water quality	10.0 (5.9)	90.0 (8.3)	65 (6.4)	38.5 (10.8)	34.2 (16.9)	51.5 (15.6)	100 (0)	24.0 (5.9)
Anti-degradation status (category 1 or 2)	0	0	0	0	20.1 (5.8)	42.7 (12.3)	100 (0)	100 (0)
Record of water quality exceedances (category 3)	0	0	0	15.4 (8.9)	15.6 (5.0)	10.7 (3.9)	0	44.0 (7.9)

Table 13. Wetland water quality functioning, including percentage of wetland area with both landscape potential and two or more capacity indicators (i.e., providing service) and percentage of wetland area with one or fewer capacity indicators and 1 or more landscape indicators (i.e., needs gap).

Stratum	% Wetland Area Providing Service[1]	Needs Gap	
		≤1 capacity, 1 landscape	≤1 capacity, 2+ landscape
Central Basin ecoregion	**77.4 (5.7)**	**12.5 (4.5)**	**10.1 (4.3)**
Great Salt Lake	85.0 (6.8)	10.0 (6.0)	5.0 (4.2)
Jordan	90.0 (8.3)	0	10.0 (8.3)
Utah Lake	70.0 (9.2)	15.0 (6.7)	15.0 (7.4)
Wasatch Mountains ecoregion	**42.4 (5.6)**	**5.8 (3.3)**	**2.7 (2.4)**
Mountain Valleys	76.9 (11.2)	15.4 (9.5)	7.7 (6.9)
Semiarid Foothills	50.2 (15.7)	0	0
Wasatch Montane Zone	46.2 (16.1)	2.7 (2.3)	0
Alpine Zone	0	0	0
National Forest	*16.0 (6.8)*	*4.0 (3.6)*	*0*

[1]Sites with two or more capacity indicators and at least one landscape potential indicator

identified to genus only and the remainder were identified to lifeform. *Atriplex* was the most frequent genus not identified to species. Members of this genus typically fruit late in the growing season; surveyors revisited some sites in September to obtain fruiting specimens. Other genera commonly not identified to species include *Typha*, *Epilobium*, *Viola*, *Tamarix*, and *Carex*, typically because specimens lacked flowers and fruit. All *Typha* in the study area are native and have a C-value of 2 and all *Tamarix* were considered introduced and noxious, so we included unidentified members of each genus in the floristic data analysis. Excluding *Typha* and *Tamarix*, only 20 unidentified plant records had >2% cover at a site and only 5 had ≥10% cover.

Plant Community Composition Metrics

Most floristic quality assessment measures indicated that Jordan wetlands have the poorest plant community composition and Alpine Zone wetlands the best. The Jordan stratum had the lowest mean values for mean C and cover weighted mean C and the highest mean values for percent non-native species and absolute cover of noxious weeds; the reverse was true of the Alpine Zone wetlands (table 14). Great Salt Lake wetlands had the widest range of values for all five metrics. Each stratum had at least one site with close to 100% relative native cover and, except for in the Alpine Zone, one site with <37% relative native cover.

We compared the cumulative density functions of three metrics to determine whether the distribution of each metric differed by strata. Alpine Zone sites had a different distribution for relative percent native cover than all other strata, except the Wasatch Montane Zone, and Mountain Valleys differed from Great Salt Lake, Utah Lake, and Wasatch Montane Zone (figure 9). All wetlands in the Alpine Zone had very high relative native cover (≥94.8%) and wetlands in the Mountain Valleys rarely

Table 14. Plant community composition measures, with the estimated mean, standard deviation in parentheses, and range.

Strata	Relative Cover Native Species	Absolute Cover of Noxious Weeds	Percent Non-Native Species	Mean C	Cover Weighted Mean C
Central Basin Ecoregion	61.5 (34.7) 0-100	17.8 (28.4) 0-100	36.1 (22.8) 0-100	2.3 (0.9) 0-5	2.3 (1.5) 0-5
Great Salt Lake	62.8 (39.2) 0-100	23.5 (35.5) 0-100	32.4 (28.5) 0-100	2.4 (1.1) 0-5	2.3 (1.5) 0-5
Jordan	57.8 (34.1) 3.5-96.6	34.1 (33) 1-92.2	48.3 (16.6) 26.7-80	2.0 (0.7) 0.5-2.9	2.0 (1.2) 0.1-4.3
Utah Lake	60.3 (29.7) 10.5-100	12.1 (17.6) 0-70.5	39.4 (14.9) 0-66.7	2.3 (0.7) 0.8-3.5	2.3 (1.4) 0.3-4.9
Wasatch Mountains Ecoregion	75.2 (23.4) 27.6-100	1.6 (3) 0-15.5	23.3 (18.3) 0-65.4	4.0 (1.5) 1.3-6.2	4.0 (1.7) 0.6-6.7
Mountain Valleys	58.7 (14.7) 36.6-98.9	0.6 (0.8) 0-2.6	39 (8.6) 26.1-52.6	2.8 (0.4) 2.0-3.5	2.9 (0.8) 1.6-4.4
Semiarid Foothills	54.9 (21.6) 27.6-99.9	3.1 (3) 0-8.5	37.5 (13.2) 3.8-65.4	2.7 (0.8) 1.3-4.6	2.3 (1.2) 0.6-5.7
Wasatch Montane Zone	84.8 (13.3) 32.8-100	6 (4.5) 0-15.5	13.6 (6.7) 0-36.8	4.2 (0.5) 2.9-5.5	4.5 (0.8) 1.6-6.6
Alpine Zone	98.9 (1.9) 94.8-100	0.2 (0.4) 0-1	3.6 (4.5) 0-12.5	5.7 (0.8) 4-6.2	5.9 (0.7) 4.6-6.7
National Forest	83 (18.6) 32.9-100	2.9 (4.3) 0-15.5	18.7 (14.2) 0-65.4	3.9 (0.9) 1.5-5.5	4.2 (1.1) 1.6-6.6

had very low or very high relative native cover. Alpine Zone sites had a different distribution for absolute cover of noxious species than all other strata except Mountain Valleys; the Alpine Zone and Mountain Valleys distributions could not be compared. Jordan wetlands differed from Great Salt Lake and Mountain Valleys and Mountain Valleys also differed from the Wasatch Montane Zone. Sites in the Alpine Zone and Mountain Valleys all had <3% cover of noxious weeds; noxious weeds were widespread and frequently abundant in the Jordan stratum. Alpine Zone and Wasatch Montane Zone wetlands had a different distribution for mean C than all other strata; these two strata's distributions could not be compared. Mean C was consistently higher in these strata than in all others. The distribution of mean C values also differed between Jordan and Mountain Valleys.

Noxious Weed Plant Species

In the Central Basin ecoregion, *Phragmites australis* was the most widespread and abundant noxious weed species, found at over half of the surveyed sites and estimated to occupy 13.6% of wetland area (table 15). This species was most abundant in the Great Salt Lake and Jordan strata, estimated to occupy just under one-quarter of the wetland area in each. *Tamarix* spp. is common in the

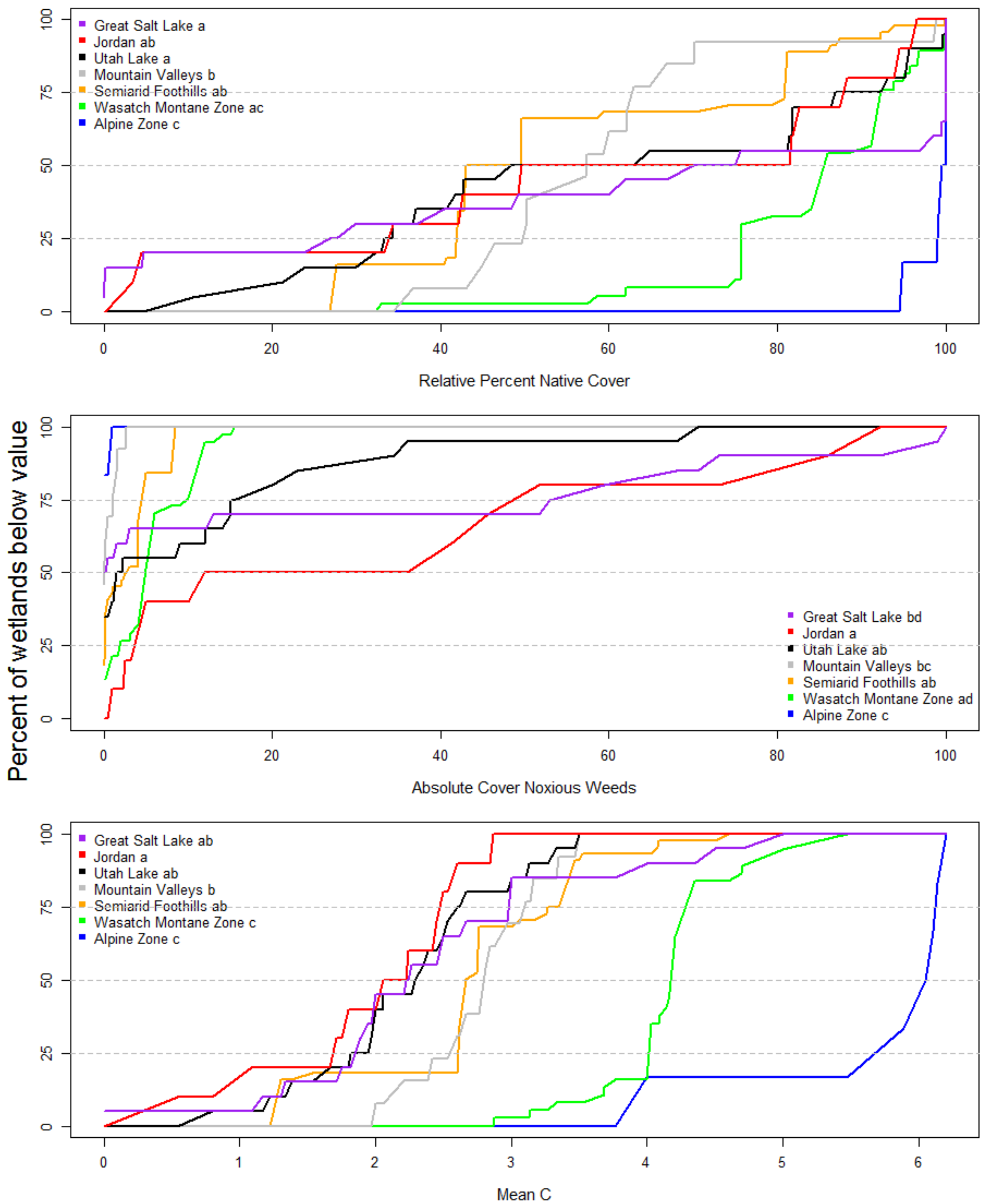

Figure 9. Cumulative density functions for plant composition metrics showing the estimated percentage of wetland area with metric value at or below the indicated values. Strata that share lowercase letters do not significantly differ from one another in the shape of the density function. Alpine Zone and Mountain Valleys could not be compared for noxious weed species and Alpine Zone and Wasatch Montane Zone could not be compared for mean C due to limited data.

Table 15. Noxious weed species detected in the Central Basin ecoregion, including ecoregion-wide and strata-specific estimates of percent cover within wetlands, followed by the standard deviation in parentheses. The number of sites per stratum with each species follows the cover estimates. Arid West wetland indicator ratings are shown.

Scientific Name (Common Name)	Noxious Weed Listing	Wetland Indicator	Central Basin Ecoregion	Great Salt Lake (n=20)		Jordan (n=10)	Utah Lake (n=20)
Cardaria draba (white top)	Class 3	None listed	0.03 (0.4)	0		2.1 (4) n=3	0.03 (0.1) n=1
Carduus nutans (musk thistle)	Class 3	FACU	0.05 01)	0		0.1 (0.1) n=2	0
Cirsium arvense (Canada thistle)	Class 3	FACU	0.2 (0.9)	0		2.1 (4.4) n=6	0.4 (1.1) n=3
Conium maculatum (poison hemlock)	Class 3	FACW	0.03 (0.6)	0		2.2 (5.9) n=3	0.03 (0.1) n=1
Convolvulus arvensis (field bindweed)	Class 3	None listed	0.002 (0.004)	0		0.02 (0.04) n=2	0
Cynoglossum officinale (gypsyflower)	Class 3	FACU	0.04 0.004)	0		0.1 (0.3) 0.1 n=4	0.005 (0.02) n=1
Elaeagnus angustifolia (Russian olive)	Class 4	FAC	0.04 (0.6)	0		2.4 (5.9) n=6	0.03 (0.1) n=2
Lepidium latifolium (broadleaved pepperweed)	Class 3	FAC	0.5 (2.4)	0.2 (0.7) n=3		0.1 (0.2) n=1	0.8 (3.3) n=2
Phragmites australis[1] (common reed)	Class 3	FACW	13.6 (27.1)	23 (35.3) n=10		24.5 (30.9) n=8	4.5 (9) n=9
Tamarix spp.[2] (tamarisk)	Class 3	FAC	3.4 (10.4)	0.3 (1.3) n=1		0.6 (1.2) n=4	6.3 (13.9) n=10

[1]Observations in the field may include both the native and the non-native subspecies of *Phragmites australis*, though all observations recorded as the European subspecies or recorded without subspecies are assumed to be non-native.
[2]Utah lists only *Tamarix ramosissimum* (saltcedar), but all species of *Tamarisk* were considered noxious for this study.

Jordan and Utah Lake strata and, in the latter stratum, sometimes occurred with high abundance. Other noxious weed species in the ecoregion typically occurred with low cover, though all except *Convolvulus arvensis* (field bindweed) and *Cynoglossum officinale* (gypsyflower) were found with ≥10% cover at one or more sites. Noxious weeds were most diverse and widespread in the Jordan stratum.

The only noxious weed species estimated to occupy >1% of the Wasatch Mountains ecoregion was *Cirsium arvense*; this species was also the most widespread noxious weed in the ecoregion (table 16). *C. arvense* often occurred with low cover but had between 5% and 15% cover at seven sites. Most of the other recorded noxious weed species in the ecoregion were facultative upland or upland species that typically occupied <1% of sites. Most of the noxious weed species found in the Jordan watershed are Class 3, widely spread species where management should focus on containing new populations. However, we recorded one Class 1B species, *Leucanthemum vulgare* (oxeye daisy), at one wetland each in the Mountain Valleys and Semiarid Foothills. Both sites were along the Provo River, one just north of Deer Creek Reservoir and one upstream from the Jordanelle Reservoir near the county boundary

Table 16. Noxious weed species detected in the Wasatch Mountains ecoregion, including ecoregion-wide and strata-specific estimates of percent cover within wetlands, followed by the standard deviation in parentheses. The number of sites per stratum with each species follows the cover estimates. Western Mountains, Valleys, and Coast wetland indicator ratings are shown.

Scientific Name (Common Name)	**Noxious Weed Listing**	**Wetland Indicator**	**Wasatch Mountains Ecoregion**	**Mountain Valleys (n=13)**	**Semiarid Foothills (n=14)**	**Wasatch Montane Zone (n=19)**	**Alpine Zone (n=6)**	***National Forest (n=25)***
Cardaria draba (white top)	Class 3	None listed	0.02 (0.1)	0.08 .03) n=1	0.1 (0.2) n=2	0	0	0.02 (0.1) n=1
Carduus nutans (musk thistle)	Class 3	UPL	0.2 (0.9)	0.05 (0.1) n=2	0.5 (1.1) n=4	0.4 (2) n=2	0	0.6 (2.4) n=4
Cirsium arvense (Canada thistle)	Class 3	FAC	1.2 (2.6)	0.2 (0.3) n=5	1.4 (1.8) n=8	5.6 (4.3) n=14	0.2 (0.4) n=1	2.2 (3.5) n=17
Conium maculatum (poison hemlock)	Class 3	FAC	0.01 (0.1)	0.04 (0.1) n=1	0	0	0	0
Cynoglossum officinale (gypsyflower)	Class 3	FACU	0.3 (0.9)	0.3 (0.6) n=5	1 (1.8) n=10	0.02 (0.1) n=2	0	0.1 (0.2) n=8
Leucanthemum vulgare (oxeye daisy)	Class 1B	FACU	0.02 (0.1)	0.008 (0.03) n=1	0.1 (0.2) n=1	0	0	0

between Summit and Wasatch. Class 1B species occur in limited populations within Utah and are a high priority for eradication to prevent further spread in the state.

Sensitive Ecological Features

Wildlife Species

Surveyors noted wildlife species observed during surveys, including signs such as tracks and droppings. Surveyors were trained to identify boreal toad by personnel at the Utah Division of Wildlife Resources and participated in a field survey for the species each year. They were asked to document through photographs when possible any amphibians observed during surveys. Identification of other wildlife was left up to the discretion and ability of surveyors; observations were sometimes recorded very generally, such as “hawk” or “riparian birds.” Wildlife observation data are presented as a minimum list of wildlife use in the watershed and should not be considered a complete list because wildlife observations were not a focal component of the survey method. Birds were documented in all strata, mammals in all but the Alpine Zone, amphibians and reptiles in all but Great Salt Lake and Mountain Valleys, and fish in the Jordan, Utah Lake, and Semiarid Foothills strata (table 17).

Three state sensitive wildlife species were observed during field surveys, including boreal toad, Columbia spotted frog, and American white pelican. One boreal toad was documented in a montane shrubland in the Wasatch Montane Zone and one Columbia spotted frog was documented in a wet meadow in the Semiarid Foothills. Identifications were confirmed by personnel with the Utah Division of Wildlife Resources. Both locations were previously known to be occupied by the respective species, though boreal toad had not been found at the location for many years. American white pelicans were observed at one location each in the Great Salt Lake, Jordan, and Utah Lake strata, including at a

Table 17. Wildlife observations during wetland surveys.

Strata	Birds	Mammals	Amphibians and Reptiles	Fish
Great Salt Lake	American avocet; American white pelican; barn owl; black necked stilt; Caspian tern; gull; heron; marsh wren; northern harrier; teal; yellow-headed blackbird; white-faced ibis	bobcat; raccoon; muskrat		
Jordan	American white pelican; Canada goose; Caspian tern; hawk; heron; hummingbird; mallard; red-winged blackbird; tree swallow; wading birds; white-faced ibis	raccoon; deer; muskrat	boreal chorus frog; snake	carp
Utah Lake	Caspian tern; Cinnamon teal; goose; gull; hawk; killdeer; pelican; swallow; western meadowlark; white-faced ibis	cottontail; coyote, deer, raccoon	garter snake	carp
Mountain Valleys	duck; heron; northern harrier; osprey; red-tailed hawk; red-winged blackbird; sandhill crane	beaver; deer; gopher		
Semiarid Foothills	duck; green-winged teal; kingfisher; warblers	bat; beaver; deer	Columbia spotted frog; garter snake	cutthroat trout
Wasatch Montane Zone	raven; red-tailed hawk; Stellar's jay	beaver; deer; elk; moose; raccoon	boreal chorus frog; boreal toad	
Alpine Zone	gray jay; mountain bluebird; raven		boreal chorus frog	
National Forest	*Green-winged teal; raven; red-tailed hawk*	*bat; beaver; deer; elk; moose; racoon*	*boreal chorus frog; boreal toad; garter snake*	*cutthroat trout*

subjectively selected Great Salt Lake site, along the southwestern shore of Utah Lake, and at Decker Lake Park in Salt Lake County. Identifications were not independently verified, though American white pelicans are very distinctive birds.

Sensitive Plant Species

We recorded *Leersia oryzoides* (rice cutgrass) at one site. This plant species is on the current draft list of Utah's plant species of greatest conservation need (M. Wheeler, Utah Department of Natural Resources, written communication, February 9, 2018) and is listed as state imperiled in Utah by NatureServe (http://explorer.natureserve.org/servlet/NatureServe?init=Species). *L. oryzoides* is a native obligate wetland grass found throughout southern Canada and the contiguous United States. Surveyors recorded the species with <1% cover in a wetland in Utah County on the north side of Provo Bay at a site that is frequently inundated by Utah Lake, but was dry at the time of survey. The site is owned by the Utah Division of Forestry, Fire, and State Lands and was difficult to access on foot. The species was not collected, but *L. oryzoides* is very distinctive due to the lack of glumes and strongly compressed lemmas.

We recorded *Callitriche heterophylla* (twoheaded water-starwort) at three sites, though identification needs to be confirmed since specimens were not obtained and the species may be confused with other members of the genus. This plant species is on the draft list of species of greatest conservation need and is listed as state critically imperiled in Utah by NatureServe. *C. heterophylla* is a native emergent obligate wetland plant known from the United States and Canada. The species was recorded at an artificial impoundment in the floodplain of the Provo River downstream from Jordanelle Reservoir, in a small snowmelt-fed meadow on U.S. Forest Service land near headwaters to Lake Creek, and in a montane shrubland on U.S. Forest Service land in Big Cottonwood Canyon. The species occupied <1% cover at each site.

Fens and Other Peatlands

Fens are groundwater-dominated wetlands that accumulate peat or muck due to persistent anaerobic conditions that prevent organic matter from decomposing. Fens are essentially irreplaceable wetlands because of the slow pace at which organic matter accumulates. This, coupled with the fact that fens often have unique biotic assemblages, often makes them a priority for identification and protection (U.S. Fish and Wildlife Service, 1999; U.S. Forest Service, 2012; U.S. Army Corps of Engineers, 2017). The U.S. Fish and Wildlife Service (1999) defines fens as groundwater-dominated wetlands with soils that are either a histosol (≥40 cm of organic matter in top 80 cm of soil) or have a histic epipedon (organic surface horizon ≥20 cm thick). We screened sites in the office to determine whether they met the U.S. Fish and Wildlife Service definition of fen by evaluating soil profiles and hydrologic inputs. Ten sites had both organic soils and substantial groundwater inputs, including one Utah Lake, four Mountain Valleys, two Wasatch Montane Zone, and three Alpine Zone wetlands. We refer to these sites as peatlands rather than fens because it was often difficult to tell whether groundwater was the *dominant* water source.

Peatlands in the Jordan River watershed spanned a range of characteristics. The peatland in Utah Lake was a spring-fed wetland in Juab Valley dominated by *Schoenoplectus americanus* (chairmaker's bulrush) that was completely dry at the time of survey and, according to the landowner, has been drying up lately. The four peatlands in the Mountain Valleys were in separate valleys from one another, with one each near the towns of Francis, Wallsburg, and Independence and one in the Heber Valley. All four sites receive water from a combination of groundwater from nearby springs and direct or indirect irrigation. Three sites were dominated by sedges, typically *Carex aquatilis* (water sedge), and the fourth was dominated by *Phalaris arundinacea*. The two peatlands in the Wasatch Montane Zone are located near the headwaters of the South Fork and Little South Fork of the Provo River in locations that receive a combination of groundwater, direct snowmelt, and flow from small spring channels or ponds. *Carex utriculata* (Northwest Territory sedge) was the dominant species at both sites. The three peatlands in the Alpine Zone were in the Uinta Mountains near the headwaters of the Provo River and received a combination of groundwater and direct snowmelt. Sites had high cover of sedge species including *Carex aquatilis* or *Carex utriculata*.

We evaluated the mapped NWI Cowardin classes that overlapped soil pit locations at peatland sites to determine whether certain Cowardin classes were indicative of peatland soils. All but one of the sites was mapped as palustrine emergent; the outlier site was mapped as beaver-influenced aquatic bed. Peatlands in the Mountain Valleys were all mapped as seasonally flooded, and peatlands in the Alpine Zone were all mapped as saturated, and one wetland each was unmapped or mapped as semipermanently flooded or intermittently exposed. Neither the seasonally flooded nor the saturated water regimes were strongly associated with peatlands in emergent wetlands. Only three of the eight soil pits mapped as emergent saturated and four of the 22 soil pits mapped as emergent seasonally flooded were peatlands.

Vegetation Community Ordination

With NMDS analysis, complex data on the presence and cover of plant species at sites is reduced to a few simple axes, each representing a large fraction of the variability in species composition data. Values along the axes are not readily interpretable (e.g., positive values are not "better" than negative values), but two sites that plot close to one another on an NMDS plot have similar species composition. Vectors for species or environmental variables can be overlain on a plot to show the strength (represented by vector length) and direction (represented by vector orientation) of correlation between the variables and the species composition data, and the statistical significance of the correlation is determined through permutation testing. Plots are useful for visually evaluating the degree to which sites with similar attributes, such as stratum or HGM class, have similar species composition (i.e., tend to cluster together). We used NMDS to evaluate whether species composition for different Ecological Systems appeared driven by sampling factors (e.g., year surveyed, observer team), natural environmental variability (e.g., climate, HGM class), and measures of wetland condition and stress.

The optimal NMDS solution for the ordination of all sites in the Central Basin led to a warning about potential insufficient data because the stress level was very close to zero. Upon examination of the results, it was clear that one site was an extreme outlier. This site had only one identified species with 0.2% total cover and did not share any species with other sites in the ecoregion. The optimal NMDS solution for the ordination of the remaining sites after that site was dropped consisted of two axes and had a stress value of 0.16 (table 18). Composition varied by Ecological System ($p < 0.001$), HGM class ($p = 0.006$), local modeled stress ($p = 0.03$) and the first axis of the water level PCA ($p < 0.001$), which was positively correlated with more surface water and potential for deep water. Playa and basin marsh sites clustered on opposite ends of the first NMDS axis with alkaline depression sites in the middle, though there was considerable overlap between alkaline depression and basin marsh sites (figure 10). Plant community composition did not vary by any of the sampling effect variables.

The optimal NMDS solution for all sites in the Wasatch Mountains ecoregion was two axes, with a stress value of 0.22 (table 18). Composition was correlated with most of the tested environmental variables. Sites were arranged along the first axis in order of the elevation of their associated strata, with some intermixing and one distinct cluster of Mountain Valleys sites in the top middle of the plot (figure 11). Sites tended to cluster near other sites within the same Ecological System, though Alpine Zone wet meadows were distinct from other wet meadows and some wet meadows and montane shrublands appear to have very similar composition.

Table 18. P-values for correlation analysis between plant community composition and wetland condition, landscape stress, natural variation, and sampling effects, based on NMDS. P-values in bold are < 0.01 and p-values < 0.05 are in light gray.

Variables	Central Basin Ecoregion	Playa	Alkaline Depression	Basin Marsh	Wasatch Mountains Ecoregion	Wet Meadow	Foothill Shrubland	Montane Shrubland
Number of sites	53	10	30	12	55	27	11	15
Stress	0.16	0.19	0.22	0.09	0.22	0.20	0.15	0.11
Axes	2	1	2	1	2	2	2	2
URAP Score								
Overall score	0.976	0.969	0.618	0.030	**<0.001**	**<0.001**	0.287	0.043
Hydrologic	0.130	0.525	0.658	0.764	**0.007**	0.018	**0.003**	0.406
Landscape	0.096	0.048	0.015	0.048	0.018	0.015	0.204	0.375
Physical structure	0.94	0.958	0.094	0.421	0.023	0.070	0.509	0.194
Vegetation composition	0.628	0.843	0.236	**0.001**	**<0.001**	**0.002**	0.098	**0.004**
Vegetation structure	0.545	NA	0.198	0.568	0.048	0.663	0.500	0.121
Vegetation Metric								
Mean C	0.659	0.602	0.910	0.012	**<0.001**	**<0.001**	0.033	**0.002**
Cover-weighted mean C	0.793	0.441	0.094	0.283	**<0.001**	**<0.001**	**0.006**	**0.001**
Landscape Stress Value								
Local stress	0.025	0.884	**0.001**	0.440	**0.006**	**0.002**	0.069	0.171
Watershed stress	0.823	0.612	0.784	0.819	0.039	0.013	0.026	0.799
Natural variation								
Climate PCA Axis 1	0.200	0.672	0.822	0.345	**<0.001**	**<0.001**	0.066	**0.009**
Climate PCA Axis 2	0.177	0.797	0.719	0.440	0.101	**<0.001**	0.652	0.327
Water level PCA axis 1	**<0.001**	[1]	0.505	0.050	0.484	0.623	0.590	0.011
Water level PCA axis 2	0.457	[1]	0.267	0.123	0.721	0.713	0.632	0.937
Hydrogeomorphic class	**0.006**	0.011	**<0.001**	0.164	**<0.001**	0.066	0.746	0.212
Strata	0.137	0.644	**0.003**	0.281	**<0.001**	**<0.001**	0.010	0.329
Ecological System	**<0.001**	*N/A*	*N/A*	*N/A*	**<0.001**	*N/A*	*N/A*	*N/A*
Sampling								
Day of season	0.101	0.794	0.082	0.130	**0.007**	**0.002**	0.999	0.283
Year	0.586	0.934	0.042	0.073	0.316	0.197	0.415	**0.035**
Observer team	0.966	0.434	0.109	0.378	0.428	0.482	0.144	0.268

[1]PCA could not be calculated due to lack of variation in surface water data.

Plant community composition in half the Ecological Systems was correlated with sampling variables (table 18). Survey year was correlated with composition of montane shrublands and alkaline depressions and day of the season was correlated with wet meadows. These correlations may be due to study design constraints rather than changes in survey methods over time (e.g., becoming more or less thorough with species' lists, changing understanding of species' identifications). For example, high elevation sites were only surveyed in the second half of the survey season; these higher elevation wet meadows may have different species composition than lower elevation wet meadows. Also, Jordan alkaline depressions were only surveyed in 2016. Composition in playas was correlated with HGM class and composition in alkaline depressions with HGM class and strata.

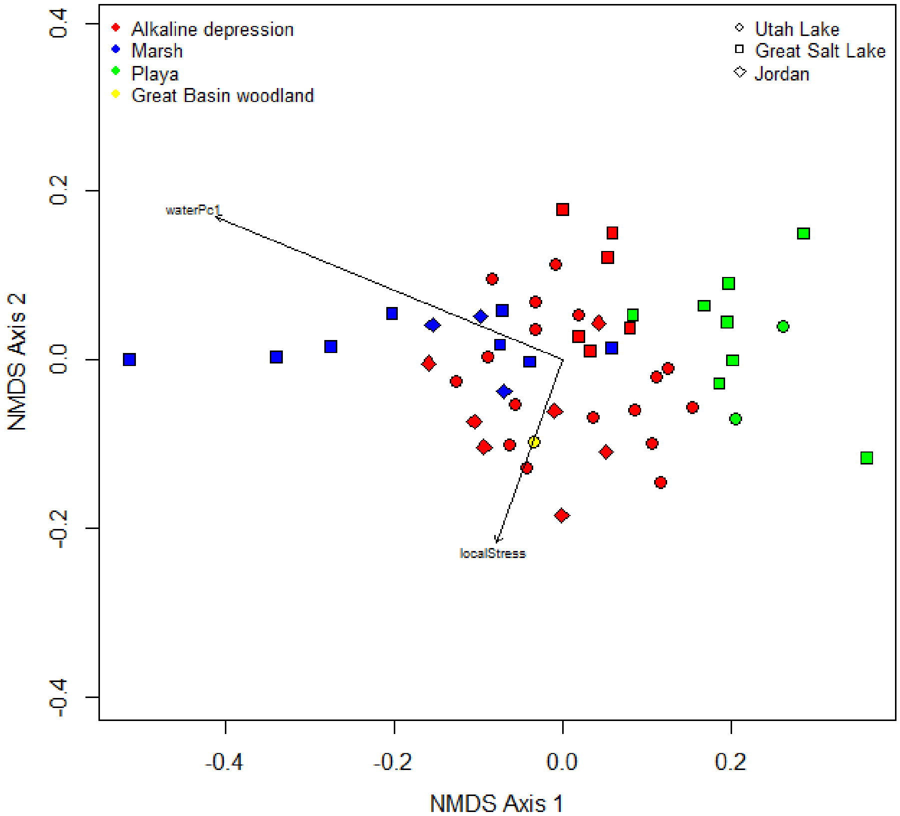

Figure 10. Plant community composition plot of Central Basin ecoregion sites, with sites symbolized by Ecological System and strata. Vectors show direction and strength of correlations with two environmental variables, local stress from the statewide stress model and the first axes of the surface water PCA.

Natural environmental variables were correlated with plant community composition for all Ecological Systems, with the most frequent correlates including water level, HGM class, and strata. Ideally, we would analyze vegetation composition for sites that varied based on condition and not on natural variation so we could determine how wetland condition influenced the plant community. Strong correlations with environmental variables may indicate that Ecological Systems should be split into additional subsystems. This appears to be particularly true for alkaline depressions, where composition varied strongly by HGM class and wet meadows, where composition varied strongly by climate and strata.

Correlations between plant community composition and measures of condition were more prevalent and generally stronger for Ecological Systems in the Wasatch Mountains ecoregion. Composition in all three Ecological Systems in the ecoregion were correlated with both vegetation metrics whereas only composition in basin marshes in the Central Basin ecoregion was correlated with mean C. Landscape stress values were correlated with composition for alkaline depressions, wet meadows, and foothill shrublands. Plant community composition by Ecological System was frequently weakly correlated with URAP landscape score and never correlated with the physical structure or

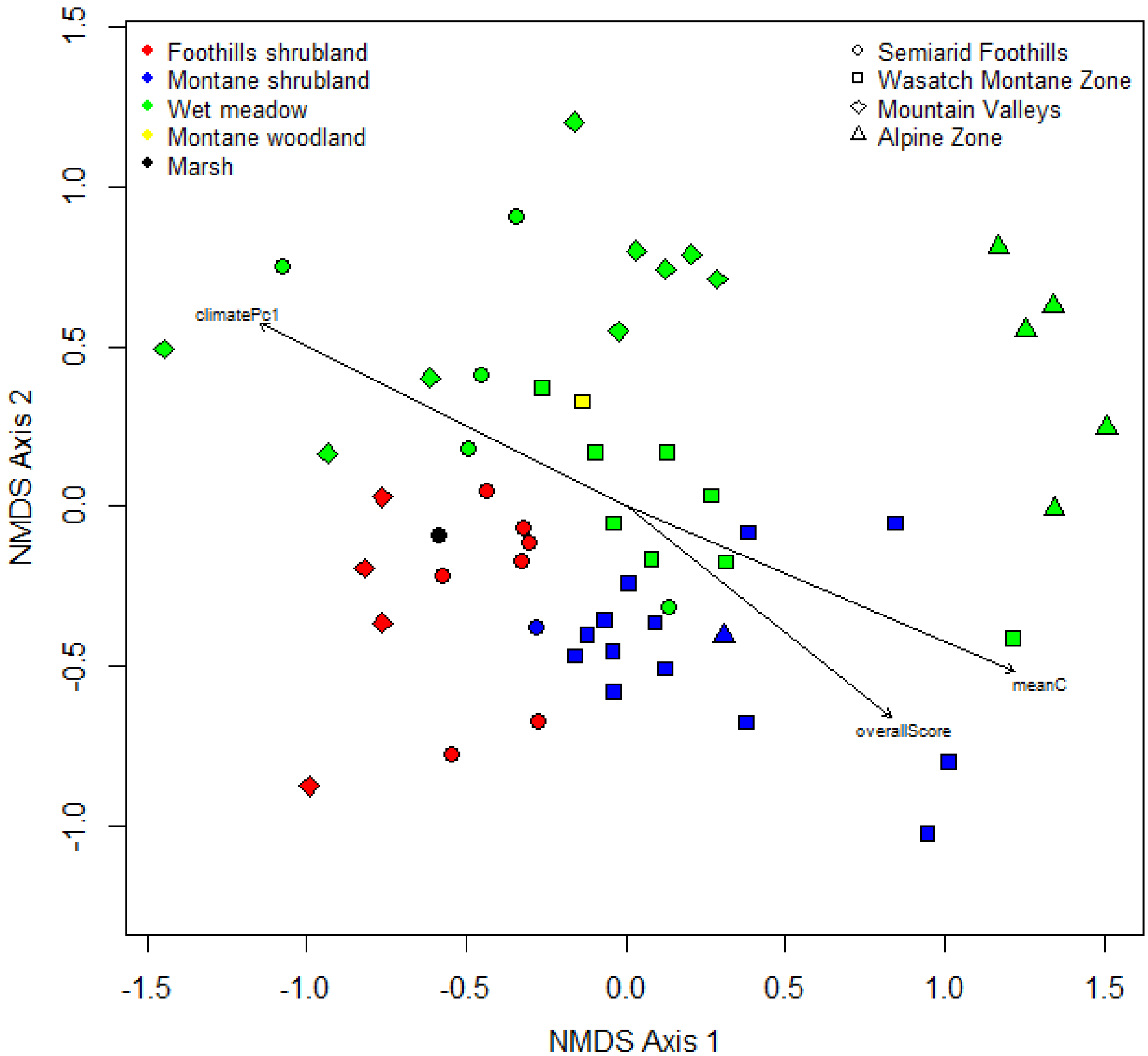

Figure 11. Plant community composition plot of Wasatch Mountains ecoregion sites, with sites symbolized by Ecological System and strata. Vectors show direction and strength of correlations with three environmental variables, overall URAP score, mean C, and the first axis of the climate PCA.

vegetation structure scores. Wet meadows showed the strongest and most frequent correlations with URAP scores, and foothill shrublands, basin marshes, and playas were each only correlated with one measure.

Characterization of Ecological Systems

Ecological System Descriptions

Six Ecological Systems were common enough to develop ecological descriptions and screen for high quality reference sites, including three in each ecoregion. In the Central Basin ecoregion, there were 10 playas, 13 basin marshes, and 30 alkaline depressions. In the Wasatch Mountains ecoregion, there were 11 foothill shrublands, 15 montane shrublands, and 27 wet meadows (including fens). Summary information on each Ecological System can be found in table 19.

Table 19. Summary of ecological attributes of wetland sites by Ecological System. Values for percent shallow water and subsequent measures include the mean, with the range in parentheses, except for number of unique species, which is the number of unique species across all sites.

Attribute	Playa	Basin Marsh	Alkaline Depression	Foothill Shrubland	Montane Shrubland	Wet Meadow
Number of sites	10	13	30	11	15	27
Elevation Range (m)	1283-1379	1282-1370	1282-1498	1652-2151	2154-2924	1654-3189
Number of Sites per Strata	Great Salt Lake (8), Utah Lake (2)	Great Salt Lake (9), Jordan (3), Utah Lake (1)	Great Salt Lake (6), Jordan (7), Utah Lake (17)	Mountain Valleys (4), Semiarid Foothills (7)	Semiarid Foothills (1), Wasatch Montane Zone (13), Alpine Zone (1)	Mountain Valleys (9), Semiarid Foothills (5), Wasatch Montane Zone (8), Alpine Zone (5)
Number of Sites per Hydrogeomorphic Class	Depressional Impoundment Fringe (2), Depressional (7), Depressional Impoundment (1)	Lacustrine Fringe (1), Depressional Impoundment Fringe (1), Depressional Impoundment (7), Depressional (4)	Slope (3), Riverine (2), Lacustrine Fringe (8), Impoundment Release (4), Depressional Impoundment Fringe (1), Depressional (12)	Slope (1), Riverine (9), Depressional (1)	Riverine (8), Depressional (7)	Slope (12), Riverine (4), Depressional (11)
% Shallow Water (<20 cm)	0 (0-0)	32.8 (0-100)	9.6 (0-100)	9.3 (0-30)	12.5 (0-36)	13.7 (0-55)
% Deep Water (≥20 cm)	0 (0-0)	56.3 (0-100)	0.1 (0-4)	12.6 (0-45)	4.4 (0-20)	3.8 (0-35)
% Total Water	0 (0-0)	89.1 (1-100)	9.8 (0-100)	22 (0-55)	17.0 (0-40)	17.5 (0-70)
pH[1]	NA	8.1 (6.4-9.5, n=13)	8.0 (7.1-8.7, n=10)	8.0 (7.0-8.7, n=9)	7.7 (5.6-9.0, n=13)	7.8 (5.1-9.1, n=21)
Electroconductivity (uS)[1]	NA	2372 (393-8690)	2957 (1401-5150)	443 (191-1062)	328 (52-1023)	230.3 (13-744)
Number of Unique Species	22	61	136	133	174	223
Forb Richness	4.9 (1-10)	9.5 (1-23)	14.5 (1-35)	28.9 (8-52)	31.9 (10-50)	26.0 (8-47)
Shrub Richness	0.2 (0-1)	0.2 (0-1)	0.2 (0-2)	4.7 (2-8)	4.6 (1-8)	0.9 (0-5)
Tree Richness	0 (0-0)	0.5 (0-4)	0.8 (0-5)	2.1 (0-5)	1.6 (0-4)	0.7 (0-3)
Absolute Forb % Cover	20 (0.6-51)	74 (0.1-136.2)	75.5 (6-121.8)	52.1 (16.8-82.3)	62.5 (16.7-92.7)	93.2 (35.2-105.3)
Absolute Shrub % Cover	0.8 (0-7)	0.4 (0-5)	1 (0-28)	39.8 (1.5-63.1)	58.0 (27.5-90.1)	2.3 (0-20)
Absolute Tree % Cover	0 (0-0)	0.3 (0-2.5)	4.5 (0-55)	12.2 (0-33)	1.9 (0-11)	0.8 (0-7.1)
Relative % Native Cover[2]	73.7 (37-100)	91.6 (42.6-100)	48.1 (0-99.7)	66.9 (36.6-99.9)	90.7 (62-100)	70.9 (27.6-100)
Mean C[3]	2.5 (1.8-5.0)	2.7 (2.2-3.1)	2.0 (0-3.3)	3.1 (2.0-4.6)	4.3 (3.5-5.5)	3.7 (1.3-6.2)
Cover-weighted Mean C	3.4 (1.6-5.0)	2.8 (1.7-4.3)	1.9 (0-4.9)	3.4 (1.6-5.7)	4.8 (3.2-6.6)	3.7 (1.6-6.7)
Absolute % Noxious Cover	1.3 (0-13)	5.8 (0-51.7)	32.7 (0-100)	1.8 (0.1-5)	2.2 (0-12)	3.3 (0-40.1)
Relative % Cover of Wetland Herbaceous[4]	64.1 (0-100)	98.9 (95.7-100)	77.7 (13-100)	55.8 (17.2-92.3)	50.3 (12.2-95.7)	61.5 (16.2-98.4)
Relative % Cover of Wetland Shrub[5]	NA	NA	NA	92.9 (80.3-99.8)	96.6 (87.3-100)	NA

[1]The mean and range of the mean water quality parameter values at each site. Number of sites with water quality data shown in parentheses.
[2]At sites where ≥80% of plant species by cover had known nativity
[3]At sites where ≥80% of the plant species had known C-values
[4]Cover of facultative wetland and obligate herbaceous species divided by all herbaceous cover, only shown for sites where ≥80% of the herbaceous cover had known wetland indicator values.
[5]Cover of facultative wetland and obligate shrub species divided by all shrub cover, only for sites with ≥5% shrub cover and where ≥80% of the shrub cover had known wetland indicator values. Data only shown for strata with more than two sites with relevant data.

Playa

Ten sites in the Central Basin were classified as playas, including one subjectively selected site. All but two were in the Great Salt Lake stratum, with the remaining near the south end of Utah Lake. Playas were typically classified as depressional, though one or two sites were each classified as depressional impoundment or depressional impoundment fringe. The playa classified as a depressional impoundment is artificially flooded in the fall; water is rarely backed up in the site the remainder of the year when a culvert is kept open. Depressional impoundment fringe sites included a mudflat and a depression filled by overflow from a nearby impoundment. Playas around Great Salt Lake were frequently flooded by canals or impoundments as well as receiving direct precipitation. None of the surveyed playas had surface water at the time of survey or internal channels or pools, though they frequently had a high amount of soil cracking. Hydric soil indicators found in playas include depleted matrix (F3) and depleted below dark surface (A11), with the former being much more widespread.

Individual sites had low diversity and typically low cover of plant species; only 22 unique plant species were recorded in playas. *Salicornia rubra* and *Distichlis spicata* were the two most frequently encountered species, and they had relatively high mean cover where they were found, 12.5% and 9.5%, respectively. Both species were found at one or two sites with 40-50% cover; no other species had more than 10% cover. *Allenrolfea occidentalis* (iodinebush), the only shrub species encountered, was recorded at two sites. *Bassia hyssopifolia* and *Frankenia pulverulenta* (European seaheath) were the two most frequently encountered non-native species.

Basin marsh

Thirteen sites in the Central Basin ecoregion, including two subjectively selected sites, were classified as basin marshes, a classification which includes both emergent and submergent-dominated systems. In the Great Salt Lake stratum, where most basin marshes occurred, all but one marsh was classified as a depressional impoundment and all marshes had managed hydrology. In contrast, the marsh in the Utah Lake stratum was a lacustrine fringe wetland on the edge of Utah Lake and marshes in the Jordan stratum were depressional wetlands that received urban run-off or treated wastewater. Marshes had ≥85% surface water cover at the time of survey, except for one depressional impoundment marsh that was mostly dry for management of *Phragmites australis*. Marshes had a wide range of pH (6.4-9.5) and EC (393-8690 µS) values. The most common hydric soil indicators were hydrogen sulfide odor (A4) and depleted below dark surface (A11).

Marsh sites were typically dominated by *Typha* spp., *Phragmites australis*, *Lemna minor* (common duckweed), submerged aquatic vegetation, or a combination thereof. *Schoenoplectus* spp. were found at just over half the sites, though frequently with low cover. Most marsh sites had ≥65% vegetation cover, though three sites had ≤22% cover, and marshes had an average of ten species per site. At least 95% of all plant cover at each site was composed of facultative wetland or obligate wetland species. Marsh sites tended to have a higher proportion of native versus introduced plant species compared to other Ecological Systems in the Central Basin ecoregion.

Alkaline depression

Thirty sites, including one subjectively selected site, in the Central Basin ecoregion were classified as alkaline depressions. Some were intermediate between alkaline depression and basin marsh based on the plant community composition, with characteristic marsh species such as *Typha* spp.

and *Schoenoplectus* spp. present. These intermediate sites were classified as alkaline depressions if they typically did not hold water ≥20 cm deep for most of the growing season, based on evaluation of conditions at time of the survey, the landscape position of the wetland, and examination of aerial imagery. All but one of the seven alkaline depression wetlands in the Jordan stratum were classified as depressional and located near the floodplain of the Jordan River; the seventh site was located on the edge of an artificial pond. These sites frequently received water from a combination of urban run-off and a seasonal high-water table. Six wetlands were classified as alkaline depressions in the Great Salt Lake stratum, including four impoundment release sites. These wetlands received water from overbank flooding from channels and ditches or from discharge from upgradient impoundments. Eight of the 17 alkaline depressions in the Utah Lake stratum were classified as lacustrine fringe; these sites were all located on the edge of Utah Lake and received most of their water from lake flooding. Other alkaline depressions in the stratum were located near Utah Lake but received water from other sources or were in the southern half of the watershed and were groundwater-fed slope wetlands. Nine sites had surface water present, including three sites with >50% water; surface water was typically <20 cm deep. Pools, swales, or channels within the AA were uncommon. pH ranged from neutral to strongly alkaline (7.1 to 8.7) and EC ranged from 1401 to 5150 µS. Thirteen hydric soil indicators were documented in soil pits. Depleted matrix (F3) was the most common, followed by histosol (A4), depleted below dark surface (A11), and hydrogen sulfide odor (A4).

Phragmites australis was found at 70% of alkaline depressions and was the most abundant species at 12 sites. The non-native species *Bassia hyssopifolia* and *Tamarix* ssp. and the native species *Juncus arcticus* ssp. *littoralis* (mountain rush), *Schoenoplectus americanus,* and *Schoenoplectus acutus* (hardstem bulrush) were among the dominant species at three or four sites each. Alkaline depressions had the lowest mean values for mean C and relative cover of native species and the highest mean value for noxious weeds of all Ecological Systems.

<u>Foothill shrubland</u>

Eleven sites were classified as foothill shrublands. These sites did not overlap in elevation with montane shrubland sites and had an upper limit of 2151 m. Foothill shrublands included both Mountain Valleys and Semiarid Foothills wetlands and were almost always classified as riverine. Wetlands included relatively narrow riparian corridors, wetlands formed along secondary channels, oxbows, and former channels of larger braided river, beaver-influenced wetlands, and wetlands along intermittent channels that probably receive a combination of snowmelt and overbank flooding. Sites had a variable amount of surface water; seven sites had between 15% and 55% surface water, three sites had <2% cover, and two sites had no surface water. Sites with more surface water were typically influenced by beaver. EC was typically ≤762 µS, though one site had an EC of 1060 µS. pH values ranged from neutral to strongly alkaline. The most widespread hydric soil indicators were redox dark surface (F6) and depleted matrix (F3).

Sites contained between two and eight shrub species and typically had at least one tree species present. *Alnus incana* (gray alder), *Cornus sericea* (redosier dogwood), *Lonicera involucrata* (twinberry honkeysuckle), and willows including *Salix exigua* (narrowleaf willow), *Salix boothii* (Booth's willow), *Salix lucida* (shining willow), and *Salix lutea* (yellow willow) were widespread and frequently dominant woody species. Herbaceous cover was typically dominated by introduced grasses, sometimes in combination with native forbs and rushes. *Phalaris arundinacea* (reed canarygrass) was the most widespread and abundant non-native grass, found at seven sites with a mean of 34.7% cover. Common native forbs included *Epilobium ciliatum* (fringed willowherb), *Maianthemum stellatum* (starry false lily of the valley), and *Geum macrophyllum* (largeleaf avens). The noxious weeds *Cirsium arvense Cynoglossum officinale* were very widespread, found at 8 and 10 foothill shrubland sites, respectively. Every site had at least one noxious weed species recorded.

<u>Montane shrubland</u>

Fifteen sites were classified as montane shrublands. These sites were all above 2150 m in elevation and were classified as either depressional or riverine. Sites were located in typically wide riparian areas, off-channel flooded depressions, headwater depressions, or, in one case, the margin of a lake. Montane shrublands were predominantly in the Wasatch Montane Zone, but also included sites in ecoregions just above and just below the Wasatch Montane Zone. The eight beaver-influenced montane shrublands had between 15% and 40% surface water; other sites had ≤15% surface water cover. At all but three sites where measurements were taken, pH was between 7 and 9 and electroconductivity was between 200 and 531 µS. Two sites had slightly to moderately acidic pH (≤6.2) and very low EC (≤74 µS) and one site had much higher mean EC (1023 µS). Redox dark surface (F6) was the most common hydric soil indicators in soil pits in the montane shrublands.

Woody cover was dominated by *Salix boothii* or *Salix drummondiana* (Drummond's willow) at all but one site, which was dominated by *Salix planifolia* (diamondleaf willow). Other common shrubs included *Lonicera involcrata* and *Ribes inerme* (whitestem gooseberry). Most sites had one or two tree species, including *Alnus incana* or species of fir or spruce. Herbaceous components of wetlands were highly variable, dominated by sedges, native grasses, non-native grasses, diverse mixtures of native forbs, or a combination thereof. Two of the most widespread and abundant species were the native sedge *Carex utriculata* and the non-native grass *Poa pratensis*. All but two montane shrublands had ≥84% relative cover of native species; six sites had no noxious weeds.

<u>Wet meadow</u>

Twenty-seven sites were classified as wet meadows, including five in the Alpine Zone, nine in the Wasatch Montane Zone, four in the Semiarid Foothills, and nine in the Mountain Valleys. Wet meadows in the Mountain Valleys were located near springs, in the floodplain of the Provo River, or along old braided channels now used for irrigation in the Heber Valley; most wet meadows in the Mountain Valleys receive substantial irrigation water inputs. Most of the remaining wet meadows were located near springs or headwaters of streams and received water from a combination of groundwater and snowmelt, though two wet meadows contained a series of created ponds, one wet meadow was adjacent to a lake that sometimes flooded the site, and one wet meadow was a shallow isolated catchment pond. About half of the sites contained small channels and four had evidence of past or current beaver activity. Seven sites were completely dry at the time of survey, 14 sites had between 2% and 25% surface water, and six sites had >40% surface water; most of the surface water was shallow. EC values were very low (≤54 µS) in the Alpine Zone and at one Wasatch Montane Zone wet meadow, somewhat higher in the southern portion (Spanish Fork and Utah Lake HUC8s) of the Wasatch Mountains (465 and 744 µS), and moderate elsewhere (139 and 590 µS). Site pH values ranged from strongly acidic to very strongly alkaline. The most common hydric soil indicator in wet meadows was redox dark surface (F6), followed by depleted below dark surface (A11), thick dark surface (A12), histic epipedon (A2), and depleted matrix (F3).

Just over half of the wet meadows were dominated by *Carex utriculata* or *Carex aquatilis*, sometimes in combination with other sedges, grasses such as *Calamagrostis canadensis* (bluejoint) or *Poa pratensis*, and non-native forbs such as *Cirsium arvense* and *Trifolium repens* (white clover). The remaining wet meadows were typically dominated by combinations of species that frequently included *Juncus arcticus* ssp. *littoralis*, non-native grasses including *Agrostis gigantea* and *Phalaris arundinacea,* and other sedge species. Woody species were by definition not abundant at wet meadow sites and about two-thirds of sites had one or fewer woody species. Willows, especially *Salix boothii*, were the most common woody species in wet meadows, followed by conifers, *Populus tremuloides,* and *Rosa woodsi* (Woods' rose).

Reference Sites

We had between four and nine reference sites per Ecological System, though thresholds for selection had to be loosened to obtain enough reference sites for Ecological Systems in the Central Basin ecoregion (table 20). The hydroperiod screen was loosened for all three Ecological Systems; each of the other screens were loosened once or twice. Two of the four subjectively selected potential high-quality sites passed the screen and were considered reference sites, including one playa and one basin marsh.

Thresholds to indicate good condition ranged from 1.98 to 5.22 for mean C and 3.96 to 4.83 for URAP scores; the lowest were in alkaline depressions and the highest in wet meadows (table 21). Thresholds. Of the four subjectively selected high-quality sites, two had mean C values and one had a URAP score above the threshold for their Ecological System, whereas one of the three subjectively selected high disturbance sites had a mean C value above the threshold. Between 16.7% and 46.7% of sites per Ecological System had both mean C and URAP values above the respective thresholds.

Sites rated as good for both metrics for an Ecological System were typically within a single stratum. Good condition wetlands were in the Great Salt Lake stratum for playas and basin marshes, the Semiarid Foothills for foothill shrublands, the Wasatch Montane Zone for montane shrublands, and the Alpine Zone for wet meadows. Alkaline depressions were the only exception, though all but one of the

Table 20. Screening values used to determine reference sites. Boxes shaded in gray indicate values that were altered from the initial threshold values to obtain enough reference sites in the category.

Ecological System	Buffer stress	AA Stress	Landscape Water Quality Stress	Landscape Hydroperiod Stress	% Relative Native Cover
Initial value	≤2	≤1	≤4	≤4	≥80
Playa	≤2	≤1	≤4	≤9	≥75
Basin marsh	≤2.12	≤2	≤4	≤15	≥80
Alkaline depression	≤2.92	≤1	≤5	≤5	≥80
Foothill shrublands	≤2	≤1	≤4	≤4	≥80
Montane shrublands	≤2	≤1	≤4	≤4	≥80
Wet meadow	≤2	≤1	≤4	≤4	≥80

Table 21. Raw values for mean and 25th percentile mean C and condition scores from reference sites by Ecological System and percentage of sites with values greater than the 25th percentile for each metric and the combination of the two.

Ecological System	# Sites	# Reference Sites	Mean Value, Reference Sites		25th Percentile, Reference Sites		Percent of Sites with Values ≥25th Percentile		
			Mean C	URAP Score	Mean C	URAP Score	Mean C	URAP Score	Mean C and Score
Playa	10	4	3.37	4.46	2.13	4.38	40.0%	40.0%	20.0%
Basin marsh	13	5	2.92	4.38	3.00	4.23	30.8%	38.5%	23.1%
Alkaline depression	30	6	2.50	4.10	1.98	3.96	60.0%	23.3%	16.7%
Foothill shrublands	11	4	3.80	4.38	3.27	4.17	27.3%	45.5%	18.2%
Montane shrublands	15	9	4.38	4.59	4.09	4.46	66.7%	60.0%	46.7%
Wet meadow	27	6	5.56	4.77	5.22	4.83	18.5%	14.8%	11.1%

good condition sites was in the Utah Lake stratum. In most cases, good condition wetlands were in the stratum that was most common for an Ecological System. However, <15% of the wet meadows were in the Alpine Zone, but all the good condition sites were located there.

Landscape Analysis

Analysis of Sample Frame Accuracy

The percent of random sample points overlapping the NWI sample frame that was actually wetland or other aquatic habitat ranged from 46% in the Jordan stratum to 86.7% in the Great Salt Lake stratum, excluding points classified as uncertain (table 22). Non-target aquatic features were common. Dry mudflats comprised 16.7% (SE 5.3) and treatment ponds comprised 6.7% (SE 3.3) of sample frame area in the Great Salt Lake stratum. Dry mudflats comprised 2.6% (SE 5.1) and water >1 m deep comprised 23.1% (SE 5.4) of Utah Lake sample frame area. Treatment ponds comprised 16.2% (SE 5.1) and water >1 m deep comprised 8.1% (SE 3.7) of Jordan sample frame area. Water >1 m deep is also estimated to comprise 13.4% (SE 7.2) of the Semiarid Foothills and 19.0% (SE 8.3) of the Wasatch Montane Zone sample frame.

There was no obvious explanation for the inaccuracy of the NWI data for most points classified as non-aquatic. Most of these points fell at locations that appeared relatively unaltered. Potential causes of mapping inaccuracy include overly inclusive mapping by NWI, loss of wetland area due to drying caused by climate trends or water diversion, or a combination of the two. Most wetlands in the study area were mapped using imagery from 1998, when Salt Lake City had almost 50% more precipitation than average, whereas precipitation in Salt Lake City was about average or just below average during the two years of the study (National Climatic Data Center, 2018). Obvious anthropogenic landscape alteration such as development did overlap wetland points in two strata, estimated at 32.4% (SE 6.9) of random points in the Jordan stratum and 5.1% (SE 3.2) of random points in the Utah Lake stratum. Given uncertainties in the original mapping accuracy and potential drying trends, we cannot be certain that development replaced wetlands that would otherwise be extant today.

Table 22. Accuracy of original NWI wetland data based on assessment of randomly selected points, including percentage of the points that were actually aquatic (including non-target deepwater) and the estimated area in hectares, with standard error in parentheses, of target wetlands, non-target aquatic features, non-wetland area, and unknown in each stratum. Features that were not surveyed in the field were classified based on inspection of aerial imagery or left as uncertain, if not able to be classified. Uncertain acreage is ignored in the calculation of percent aquatic.

Strata	% Aquatic	Target Wetland	Non-target Aquatic Feature	Non-aquatic	Uncertain
Central Basin ecoregion	82.3%	21,892 (2150)	10,215 (1597)	6892 (1483)	2418 (968)
Great Salt Lake	86.7%	10,863 (1112)	4002 (893)	2287 (662)	0 (NA)
Jordan	46.0%	150 (40)	168 (43)	374 (51)	0 (NA)
Utah Lake	80.0%	10,879 (1760)	6044 (1291)	4231 (1203)	2418 (968)
Wasatch Mountains ecoregion	75.1%	2031 (197)	662 (144)	895 (198)	773 (181)
Mountain Valleys	84.6%	541 (146)	309 (106)	155 (90)	618 (152)
Semiarid Foothills	52.8%	297 (111)	232 (94)	473 (124)	155 (86)
Wasatch Montane Zone	82.7%	405 (79)	121 (60)	110 (56)	0 (NA)
Alpine Zone	83.3%	788 (129)	0 (NA)	158 (129)	0 (NA)
National Forest	70.3%	238 (27)	43 (18)	119 (22)	0 (NA)

Updated Wetland Mapping

We mapped 3043 ha of wetland and deepwater and 291 ha of riparian area in the mapping project area (table 23). Lakes were the most abundant mapped feature, followed by riverine, emergent meadow, and lacustrine unconsolidated shore. Almost two-thirds of the wetland area was mapped as excavated or impounded (table 24). The most abundant water regime was artificially flooded, which was predominantly applied to Rio Tinto's northern tailings impoundment. Temporarily flooded and seasonally flooded were the next two most prevalent water regimes. Seasonally saturated and continuously saturated regimes, frequently associated with groundwater systems, comprised only 5.3 ha.

Approximately one-third less wetland area was mapped by UGS than is present in the original NWI data (table 23). One of the most obvious changes in the data is the absence of Rio Tinto's southern tailings impoundment in the UGS data. This impoundment, previously mapped as a 1059 ha lacustrine unconsolidated shore, has now been reclaimed. Changes in both the mapping and classification of Rio Tinto's north and south tailings ponds account for many of the largest changes between the two mapping efforts, including the increase in acreage of lakes, excavated features, and the artificially flooded water regime and decrease in acreage of lacustrine unconsolidated shores, impounded features, and the temporarily flooded water regime (tables 23 and 24).

Less wetland area was mapped as vegetated in the UGS data than in the original NWI data, with only half as much emergent meadow and a near absence of woody wetlands in the UGS data (table 23). Visual inspection of some of the largest features mapped as emergent in the NWI data showed development or other obvious land use change now in their place, though some may have been

Table 23. Hectares of mapped wetlands, by wetland class, in existing National Wetlands Inventory (NWI) data and updated UGS data and Cowardin codes associated with each wetland class.

Wetland Class	NWI Wetland Area (ha)	UGS Wetland Area (ha)	Cowardin Codes for Wetland Class
Emergent marsh	36.3	28.5	System P, Class EM, Regime D, E, F
Emergent meadow	760.0	368.3	System P, Class EM, Regime A, B, C, J
Scrub shrub	70.8	4.5	System P, Class SS
Forested	35.2	0	System P, Class FO
Pond	155.1	247.7	System P, Class UB, AB
Palustrine unconsolidated shore	112.5	155.9	System P, Class US
Lacustrine unconsolidated shore	2137.0	381.0	System L, Class US
Lake	296.2	1327.8	System L, Class UB, AB
Riverine	844.6	529.7	System R
Total wetland	**4447.7**	**3043.4**	
Emergent riparian	N/A	39.2	System Rp, Class EM
Scrub shrub riparian	N/A	252.0	System Rp, Class SS
Total riparian	N/A	**291.1**	

Table 24. Comparison of modifiers and water regime in mapped wetlands in original NWI data and UGS data.

Wetland Classification	NWI Wetland Area (ha)	UGS Wetland Area (ha)
Modifier		
Artificial substrate	0	36.0
Beaver	0	5.9
Excavated	664.6	1654.8
Impounded	1816.2	250.6
Water Regime		
Intermittently flooded (J)	0	142.9
Temporarily flooded (A)	2521.3	597.5
Seasonally saturated (B)	1.4	2.6
Seasonally flooded (C)	1160.1	517.0
Continuously saturated (D)	0	2.7
Semi-permanently flooded (F)	537.2	98.9
Intermittently exposed (G)	58.6	356.4
Permanently flooded (H)	153.7	130.0
Artificially flooded (K)	15.4	1195.4

originally over-mapped or have been lost to drying trends, as described above. Some historical emergent wetlands have been converted to ponds or lakes, including a portion of Rio Tinto's northern tailings impoundment. Much of the area mapped as woody by NWI was mapped as riparian or riverine in the UGS data.

Differences between the NWI and UGS data reflect a combination of factors, including land use change, changes in wetland mapping standards, and differences in decision-making by mappers, which makes it impossible to quantify exactly how much change in wetland area and wetland classes has occurred in the study area. Land use change has both eliminated some features and created new features. UGS likely mapped some features that were missed in the original NWI data due to the increased resolution of aerial imagery. Mappers may have interpreted the signature of marginal areas differently, leading to differences in the mapping of features with drier water regimes. Application of classification codes also likely differed between years. For example, UGS mapped the Rio Tinto's northern tailings pond as artificially flooded while NWI predominantly mapped it as temporarily flooded or semipermanently flooded.

Landscape Profile

In the Central Basin ecoregion, lakes and emergent meadows were the most abundant wetland types in the sample frame, each making up about 28% of the total wetland area (table 25). However, abundance varied by wetland strata. Unconsolidated shore and emergent marsh were the two most abundant wetland types in the Great Salt Lake stratum and only Utah Lake had a high proportion of wetlands classified as lake (figure 12). Scrub shrub, forested, and pond wetlands were the least common and most frequently stressed wetland types in the Central Basin. Local stress was highest in the Jordan stratum, where over two-thirds of the wetland area was in the high stress category and <1% in the low stress category (table 26). Over half the wetland area in the ecoregion was classified as riparian, with the least amount of riparian area in the Jordan and the most in the Utah Lake stratum.

Just over half the mapped Wasatch Mountains ecoregion wetlands were classified as emergent meadow, and emergent meadow was the most common wetland type in all strata in the ecoregion except in the Wasatch Montane Zone, where scrub shrub and ponds were most abundant (table 25, figure 12). Emergent marshes were the least common wetland type and subject to the highest levels of stress, with <2% of total wetland area and about 75% of the area in the high stress class. In contrast to the Central Basin ecoregion, scrub shrub and pond wetlands in the Wasatch Mountains ecoregion had the lowest levels of modeled local stress. Local stress was highest in the Mountain Valleys, where about half the wetland area was classified as high stress and <1% classified as low stress (table 26). Over three-quarters of wetland area was classified as riparian except in the Alpine Zone, which was about half riparian. Watershed stress at riparian wetlands was highest in the Mountain Valleys and lowest in the Wasatch Montane Zone and Alpine Zone.

Just over half of the wetland area in the Jordan River watershed is privately owned, with a similar percent private in each Level III ecoregion (table 27). Half the privately-owned wetland area in the Great Salt Lake stratum is managed for conservation, mitigation, or wildlife and between about 8% and 14% of the privately-owned wetland area in the Jordan and Wasatch Montane Zone are part of CWMUs. The remaining privately-owned wetland area is almost all unclassified. State-managed wetlands are very common in the Central Basin ecoregion, particularly in the Great Salt Lake and Utah Lake strata, with most managed as sovereign land or as part of Farmington Bay Waterfowl Management

Table 25. Wetland class by Level III ecoregion, including total wetland area and percentage of area in low, moderate, or high local landscape stress class.

Wetland Class	Area (ha)	Local Stress Class		
		Low	Moderate	High
Central Basin Ecoregion				
Emergent marsh	8,223	7.7%	87.8%	4.5%
Emergent meadow	11,791	26.2%	57.1%	16.7%
Scrub shrub	524	15.7%	43.0%	41.3%
Forested	96	0.0%	31.4%	68.6%
Unconsolidated shore	8,658	52.5%	32.2%	15.3%
Pond	507	2.7%	50.5%	46.7%
Lake (<2 m deep)	11,617	0.1%	99.4%	0.5%
Total	*41,417*	*20.2%*	*69.5%*	*10.2%*
Wasatch Mountains Ecoregion				
Emergent marsh	84	3.7%	20.7%	75.6%
Emergent meadow	2,309	19.8%	36.1%	44.1%
Scrub shrub	723	32.7%	58.6%	8.7%
Forested	213	3.7%	70.0%	26.3%
Unconsolidated shore	385	5.4%	82.1%	12.5%
Pond	424	45.0%	45.9%	9.2%
Lake (<2 m deep)	224	0.3%	98.9%	0.7%
Total	*4,361*	*21.0%*	*49.4%*	*29.6%*

Table 26. Percentage of wetland area in low, moderate, and high local and watershed stress category and percentage of wetlands classified as riparian. Only riparian wetland area tabulated for the watershed stress category.

Stratum	Local Stress Category			% Riparian	Watershed Stress Category		
	Low	Moderate	High		Low	Moderate	High
Great Salt Lake	28.3%	63.5%	8.2%	77.1%	0.0%	1.9%	98.1%
Jordan	0.7%	31.2%	68.1%	52.4%	0.1%	11.0%	88.9%
Utah Lake	15.0%	75.0%	10.0%	93.1%	0.8%	44.7%	54.5%
Mountain Valleys	0.3%	48.3%	51.4%	89.2%	0.0%	68.9%	31.1%
Semiarid Foothills	17.5%	55.2%	27.2%	87.7%	13.3%	82.3%	4.3%
Wasatch Montane Zone	40.9%	55.8%	3.3%	77.4%	29.9%	70.1%	0.0%
Alpine Zone	53.3%	40.6%	6.1%	53.6%	24.2%	75.8%	0.0%
National Forest	31.2%	67.0%	1.8%	79.4%	49.9%	49.9%	0.3%

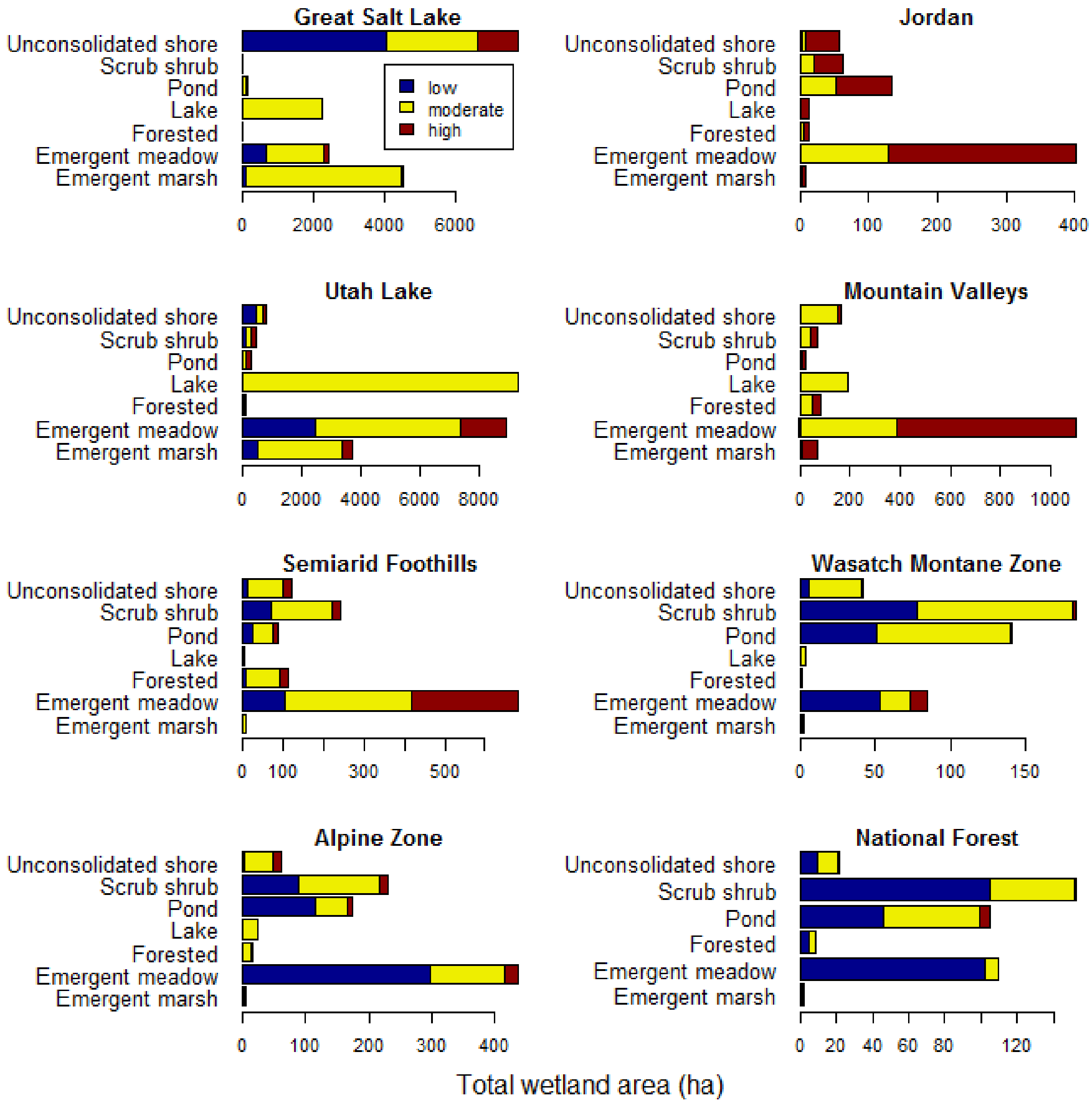

Figure 12. Wetland area by landscape stress class and wetland type for each stratum and for National Forest land.

Area. In the Wasatch Mountains ecoregion, private and state ownership declines and federal ownership increases with increasing elevation. Privately-owned wetlands comprise most of the wetland area in the Mountain Valleys and Semiarid Foothills, with state parks and, in the Semiarid Foothills, U.S. National Forest, containing most of the remaining wetlands. Over 50% of the wetland area in the Wasatch Montane Zone and over 90% of those in the Alpine Zone are on National Forest, with the remainder in both primarily on private land. In the Jordan, Utah Lake, Mountain Valleys, and Semiarid Foothills strata, wetlands are very underrepresented on federal land. For example, federal land comprises 20% of the Mountain Valleys, but only 0.7% of wetland area is on federal land (tables 1 and 20). Wetland area is

Table 27. Wetland ownership by strata, with the percentage of wetland area in each ownership category and overall percentage private, state, and federal ownership.

Ownership Class	Great Salt Lake	Jordan	Utah Lake	Mountain Valleys	Semiarid Foothills	Wasatch Montane Zone	Alpine Zone
Private	**60.8%**	**92.6%**	**42.6%**	**74.9%**	**68.4%**	**45.0%**	**8.3%**
Duck hunting reserve	22.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Conservation or mitigation	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CWMU	0.0%	7.9%	0.9%	0.1%	0.6%	14.0%	0.0%
Other private land	29.9%	84.7%	41.6%	74.8%	67.8%	31.0%	8.3%
State	**39.2%**	**7.3%**	**54.6%**	**24.4%**	**17.0%**	**1.8%**	**0.0%**
Sovereign land	19.0%	0.0%	54.3%	0.0%	0.0%	0.0%	0.0%
Farmington Bay WMA	19.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other wildlife areas	0.0%	0.0%	0.2%	0.0%	2.3%	0.1%	0.0%
State park	0.0%	1.0%	0.0%	24.3%	14.7%	1.7%	0.0%
Other state	0.9%	6.3%	0.1%	0.1%	0.0%	0.0%	0.0%
Federal	**0.0%**	**0.1%**	**2.9%**	**0.7%**	**14.6%**	**53.3%**	**91.7%**
U.S. National Forest Wilderness	0.0%	0.0%	0.0%	0.0%	0.1%	7.6%	1.0%
Other U.S. National Forest	0.0%	0.0%	0.0%	0.0%	14.0%	45.7%	90.7%
Other federal land	0.0%	0.1%	2.9%	0.7%	0.5%	0.0%	0.0%

overrepresented on State-owned land in the Jordan, Utah Lake, Mountain Valleys, and Semiarid Foothills and overrepresented on private land in the Alpine Zone.

Over two-thirds of mapped wetland area in the Wasatch Montane Zone and Alpine Zone, about 40% in the Great Salt Lake stratum, 29% in the Semiarid Foothills, and <7% in the remaining strata did not overlap the Water Related Land Use data (table 28). Over two-thirds of the remaining wetland area in the Great Salt Lake, Utah Lake, Wasatch Montane Zone, and Alpine Zone overlapped riparian or aquatic features. Wetland area mapped as pasture comprised about half the wetland area in the Mountain Valleys, around one-fifth in the Utah Lake and Semiarid Foothills strata, and <11% elsewhere. Agriculture overlapped <6% of wetland area in each stratum, as did hay except in the Mountain Valleys and Semiarid Foothills, where hay production was more common. Wetland area mapped as urban was uncommon except in the Jordan, and, to a lesser extent, Great Salt Lake strata, though urban acreage in the latter was primarily because Rio Tinto's tailings impoundment was mapped as urban. Almost half of the wetland area in the Mountain Valleys and just under one-fifth the wetland area in the Semiarid Foothills overlap areas mapped as irrigated; overlap was <6% in all other strata. Irrigated wetlands were typically mapped as pasture (69.0% of the area); hay production (17.5%) and alfalfa (11.6%) were less common.

Discussion

Target Population and Limitations on Inference

Generalizations about wetland condition and other study findings only pertain to the target population. We included sparsely vegetated playas and submergent marshes in our definition of

Table 28. Percentage of mapped wetland area overlapping each Water Related Land Use class, including area not mapped and irrigation class.

	Great Salt Lake	Jordan	Utah Lake	Mountain Valleys	Semiarid Foothills	Wasatch Montane Zone	Alpine Zone	*National Forest*
Land Use Class								
Agriculture	3.70%	5.90%	5.70%	3.60%	2.10%	0.30%	0.00%	*0.00%*
Grass hay	0.00%	0.10%	1.10%	8.40%	13.70%	0.00%	0.30%	*0.00%*
Pasture	0.50%	10.20%	22.60%	49.10%	19.50%	3.40%	3.00%	*0.80%*
Urban	11.80%	43.80%	2.40%	6.90%	3.40%	1.20%	0.50%	0.30%
Riparian and aquatic	44.20%	33.50%	67.10%	29.90%	31.90%	30.80%	30.30%	20.20%
Not mapped	39.80%	6.30%	0.90%	2.00%	29.40%	64.50%	65.90%	*78.60%*
Irrigation Class								
% Irrigated	0.10%	5.90%	4.70%	45.50%	17.60%	3.10%	2.40%	*0.00%*
% Subirrigated	0.30%	14.40%	5.40%	13.20%	10.40%	0.20%	0.70%	*0.00%*

wetland and excluded mudflats that appeared persistently dry in aerial imagery, even though these features may be briefly inundated each year or serve as refugia habitat during extremely wet years. We recommend continuing to include playas and submergent marshes in future studies because of the importance of these systems to wildlife, water quality, and other functions and reconsidering the exclusion of the drier mudflats, though additional measures may need to be collected at these sites since they often lack vegetation, surface water, and other indicators of wetland condition.

Our study design allows us to make inference to mapped wetlands, but unfortunately the NWI sample frame was imperfect for our purposes and often inaccurate. Almost one-quarter of the sample frame was comprised of non-target aquatic features and 17% was comprised of non-aquatic features, much of the latter of which may have been incorrectly mapped or lost to changes in hydrology; about 3% of wetland area appears lost to development. While we can estimate the amount of mapped wetland area that is not in fact target wetland, we cannot estimate the amount of unmapped or incorrectly classified target wetland that was left out of the sample frame (i.e., there may be more wetland area than estimated in this report). Excluded wetlands may include small or otherwise difficult to detect wetlands or newly created wetlands. If unmapped wetlands are similar in characteristic to mapped wetlands or small in proportion to the size of the mapped target population, then target population estimates will still be robust. We support efforts to update wetland maps for Utah, and we recommend conducting an accuracy assessment of mapped data for future projects to better estimate the amount of unmapped wetland area so that extent estimates can be adjusted appropriately.

Survey results could be skewed by our inability to access a large percent of sites if, for example, owners of poorly managed sites were less likely to grant permission for surveys than owners of better managed sites. We had a very high rate of participation in all but the Mountain Valleys and Semiarid Foothills strata, two of the three strata with the highest rates of private ownership. Access rates were much higher than they were in a recent study of the Weber River watershed (Menuz and others, 2016c), which we credit to sending out letters to landowners and having two years to arrange access.

Wetland Condition

In many respects, wetlands in the Jordan River watershed are in good condition. Most wetland area has minimal soil disturbance and healthy herbaceous and woody litter accumulation. Most wetland area is also embedded in relatively intact landscapes with wide buffers and intact soils, though often buffers were extensions of the assessed wetland since AAs were frequently embedded within larger wetlands. We documented three main threats to wetlands in the watershed; non-native plant species, water quality stressors, and hydrologic alteration.

Non-Native Plant Species

Altered plant communities are one of the most common disturbances to wetlands in the Jordan River watershed. About 38% of the plant cover in Central Basin wetlands and 25% of cover in Wasatch Mountains wetlands is estimated to be from non-native species and wetland buffers also frequently had high non-native plant cover. Non-native plant species can dramatically alter ecosystems; for example, non-native species can decrease native plant and invertebrate species diversity (Gerber and others, 2008), change nutrient availability (Ehrenfeld, 2003), alter disturbance regimes (Mack and D'Antonio, 1998), and threaten imperiled species (Wilcove and others, 1998). Non-native species can also serve as indicators of past or on-going disturbance and therefore may be correlated with other site stressors such as nutrient enrichment, hydrologic alteration, or livestock grazing. For example, *Poa pratensis*, the most frequently recorded introduced plant species in the Wasatch Mountains ecoregion, can be associated with livestock grazing (Uchytil, 1993). At the same time, many non-native species are considered desirable and are intentionally planted; many of the high-cover non-natives documented in this study are recommended for planting for erosion control and livestock forage (Jensen and others, date unknown).

In the Central Basin ecoregion, the most widespread introduced species is *Phragmites australis*, which is a noxious weed of high management concern due to the ecological and social impacts of its invasion. Other noxious weeds likely to impact Central Basin wetlands include *Cardaria draba* (whitetop)*, Cirsium arvense, Conium maculatum* (poison hemlock)*, Elaeagnus angustifolia* (Russian olive)*, Lepidium latifolium* (broadleaved pepperweed)*,* and *Tamarix* spp. Each of these species was documented with ≥10% cover at least once and most have wetland indicator ratings of facultative or wetter, signifying that they likely can persist in wetlands. Some of the documented impacts of these species include reduced forage quality and increased soil salinity and streambank erosion by *L. latifolium* (DiTomaso and others, 2013c), displaced native willow and cottonwood stands by *E. angustifolia* (DiTomaso and others, 2013d), reduced pasture productivity by *C. arvense,* (DiTomaso and others, 2013a), and poisoning of humans and livestock by *C. maculatum* (California Invasive Plant Council, undated). Other potential introduced species of concern in the Central Basin include *Bassia hyssopifolia* and *Dipsacus fullonum* (Fuller's teasel). *B. hyssopifolia* was widespread and occurred with very high cover (≥21%) at three Utah Lake sites. The species can be toxic to livestock in large amounts, though it is considered good forage in small quantities (DiTomaso and others, 2013b). *D. fullonum* was found in half the sites in the Jordan stratum and occurred at two sites in the Central Basin with 10% cover. The species is listed as a noxious weed in Colorado and can outcompete or shade out native plant species (California Invasive Plant Council, undated).

In the Wasatch Mountains ecoregion, several widespread and at least occasionally abundant non-native species were facultative species frequently planted for erosion control or livestock forage, including *Poa pratensis*, *Phleum pretense* (timothy), *Alopecurus pratensis* (meadow foxtail), *Trifolium repens* (white clover), all of which can displace native plant species (California Invasive Plant Council, undated). Noxious weed species of concern include *Cirsium arvense*, *Carduus nutans* (musk thistle), *Cynoglossum officinale*, *Cirsium vulgare* (bull thistle), and *Leucanthemum vulgare*, though all but *C. arvense* were typically found with low cover and are facultative upland or upland species. Two other species merit special attention. The submergent aquatic *Potamogeton crispus* (curly pondweed) was found at one site in a pond along the Provo River. This species can impede water flow and deplete nutrients when it grows in abundance; it is listed as a noxious weed in some states (California Invasive Plant Council, undated). *Phalaris arundinacea*, though sometimes considered a native species and planted for erosion control, should also be a species of concern. *Phalaris arundinacea* is listed as a noxious weed in some states and can alter plant and insect communities and change sedimentation patterns and hydrologic processes of invaded streams and wetlands (Lavergne and Molofsky, 2004). This species was common and sometimes very abundant, particularly in the Mountain Valleys and Semiarid Foothills and, as a facultative wetland species, is more likely to be problematic in wetlands than other common non-native species.

We recommend three actions to improve plant community composition of wetlands in the Jordan River watershed. First, land owners and land managers should continue control efforts for invasive plant species and coordinate efforts for widely distributed species such as *Phragmites australis* to increase effectiveness. Second, native plant species should be used for seeding efforts whenever possible; the Native Seed Network provides seeding recommendations and information on seed availability (http://nativeseednetwork.org). Third, wetlands with intact plant communities should be prioritized for protection since they are infrequent on the landscape outside the Alpine Zone, particularly in alkaline depression and foothill shrublands.

Water Quality

Most wetland area in the Great Salt Lake, Jordan, Utah Lake, and Mountain Valleys strata is subject to potentially high levels of water quality stress due to impaired source water, point source discharges, and run-off from surrounding agriculture and development. Buffers were typically over 50 m wide, which may be wide enough to remove most sediment, nitrogen, phosphorus, and pesticides before reaching wetlands (McElfish and others, 2008, Zhang and others, 2010), though about 9% of wetland area was not completely surrounded by buffer and 5% of buffers had significant soil disturbance that may render buffers less effective. Furthermore, water quality stressors often came to wetlands directly from streams, lakes, or canals, bypassing buffers entirely. Over half of the surveyed wetlands were hydrologically connected to impaired waterbodies, including ≥70% of sites in each of the Central Basin strata. Water quality stress often did not translate to visibly apparent water quality degradation; 30% of sites with poor water quality had good to excellent ratings for both the algae and turbidity metrics.

A combination of strategies may be necessary to protect and improve wetland water quality in the Jordan River watershed. First, water quality of impaired source water can be improved through development of Total Maximum Daily Load (TMDL) plans or other approaches. Fortunately, just five impaired waterbodies supply water to over one-fifth of the surveyed sites, four of which are high priorities for TMDL development or alternative approaches (Utah Lake, Jordan River-1, Jordan River-6, and Provo River-4; Utah Division of Water Quality, 2016a). State Canal, the fifth waterbody, may benefit from improvement of the upstream Jordan River-1 assessment unit. Second, land owners and land managers should continue to sustainably manage grazing, off-road vehicle use, and other activities within and adjacent to wetlands and use appropriate buffers to protect wetlands from adjacent runoff. Private land owners can often receive technical and financial assistance from agencies such as the U.S. Natural Resources Conservation Service, the Utah Department of Agricultural and Food, and the Utah Department of Natural Resource's Watershed Restoration Initiative to support good management practices. Last, the Utah Division of Water Quality may want to consider developing wetland-specific water quality standards so that impairment within wetlands can be evaluated and more directly addressed.

We recommend continuing to collect water quality data across a range of wetland types to better understand the relationship between site stress, site condition, and water quality parameters. Data could be analyzed by Ecological System or HGM class across project areas to increase sample sizes. Analysis of water quality parameters such as nutrients or total suspended solids could help elucidate the extent to which water quality stressors degrade wetland condition and may help identify thresholds above which degradation is likely to occur.

Wetland Hydropattern

Wetland hydropattern, including the frequency and duration of flooding (hydroperiod) and timing of inundation, plays a large role in determining nutrient cycling (Tanner and others, 1999) and the types of plant, invertebrate, and amphibian communities that a wetland can support (Snodgrass and others, 2000; Tarr and others, 2005; Webb and others, 2012). All or almost all wetland area in the Great Salt Lake, Jordan, Utah Lake, and Mountain Valleys strata and half the wetland area in the Semiarid Foothills are estimated to have some degree of hydropattern alteration. Alteration was most pronounced in the Great Salt Lake, Jordan, and Mountain Valleys strata, due to management for wildlife habitat, urban run-off, and direct and indirect agricultural irrigation inputs, respectively. Most wetlands in the Great Salt Lake stratum are managed for the benefit of wildlife; management should be optimized to support natural functioning within the constraints of management goals and water availability. Wetlands in the Jordan stratum frequently receive stormwater run-off; maintaining natural water inputs may help buffer these wetlands from flashy flows. In the Mountain Valleys, artificial water sources could be important for creating or supporting wetlands, especially wetlands with declining natural inputs, as has been found in other regions (Sueltenfuss and others, 2013; Berkowitz and Evans, 2014). Reducing irrigation on the landscape may allow some wetlands to return to a more natural hydropattern, but could cause the loss of other wetlands, particularly those whose natural water inputs have been impacted by water diversion.

One question meriting further study is the extent to which wetlands in the Jordan River watershed are affected by changes in water availability. Circumstantial evidence suggests that wetlands may be losing their water; many areas previously mapped as wetland by NWI no longer appear to have wetland hydrology, and field and landowner observations in Juab Valley indicate that wetlands there may be impacted by declining water levels. More focused data collection and analysis is necessary to evaluate whether a drying trend does indeed exist and, if so, to identify the main drivers of the trend. Potential drivers include anthropogenic water withdrawal, natural climate fluctuations, and changes in land use; regarding the latter, irrigated acreage has declined substantially in the Jordan and Utah basins over the past two decades (Utah Division of Water Resources, 2014b and 2014c), which could threaten wetlands supported by irrigation water.

Wetland Function

This study directly investigated two functions in the Jordan River watershed, amphibian habitat and water quality improvement. Two additional functions can be inferred from our results, wildlife use and recreational use. We documented wildlife use in each stratum, including 30 species of birds, 11 mammals, and 3 amphibians; this probably significantly underrepresents wetland wildlife use since surveyors did not conduct targeted species surveys. Wetland recreational use in the Jordan River watershed includes hunting, bird watching, and hiking near wetlands. About 15% of the wetland area in the watershed is privately or publicly managed for duck hunting. Much of the wetlands in the watershed are on public land and hiking trails near wetlands are common except in the Great Salt Lake and Utah Lake strata.

Amphibian Habitat

Wetlands in the Jordan River watershed provide habitat for two sensitive amphibian species, boreal toad and Columbia spotted frog. Almost half of the wetland area in the prime habitat for boreal toad has the potential to provide suitable breeding habitat for the species based on mean metric scores, though threats related to water quality issues (turbidity) and recreational use were common. Other threats to the species listed in the Utah Wildlife Habitat Plan were either not documented or uncommon at suitable breeding sites. Lack of adequate shrub and forb cover was the most common limiting habitat factor in the prime habitat; adult boreal toad select for areas with high shrub cover to prevent evaporative water loss (Oliver, 2006a). Wetlands in the region may naturally have low shrub cover; there is no indication that low shrub cover was associated with lack of woody species regeneration or current livestock grazing within wetlands.

Just over one-third of prime montane habitat and about 15% of Central Basin ecoregion wetland area may be suitable for Columbia spotted frog based on mean metric scores, though scoring thresholds have not been tested at known occupied sites. We found evidence of many of the threats listed in the Utah Wildlife Action Plan. Declining water levels are an important issue in northern Juab Valley, and potential fragmentation and water quality issues related to roads and other development are a common threat near wetlands in prime montane habitat; livestock overgrazing and human recreation were not widespread problems. Fair or poor waterbody vegetation and north shore exposure were common at prime montane sites, though these characteristics were almost exclusively found at sites with marginal breeding waterbodies and thus are probably either not limiting or co-limiting habitat factors. Suitable breeding habitat in the Central Basin ecoregion appears limited by an overabundance of emergent vegetation and lack of nearby suitable overwintering habitat. Further work should be done to determine whether Columbia spotted frog can breed in impoundments and rivers in the Central Basin since almost all known sites in the ecoregion are at spring complexes.

Water Quality Improvement

Most wetlands in the Jordan River watershed are estimated to currently provide some water quality improvement function, with both capacity and landscape need for improvement. Function was less common in the Semiarid Foothills, Wasatch Montane Zone, and Alpine Zone due to lack of landscape need, but wetlands in these areas have capacity for water quality improvement that could become important in the face of future landscape changes such as fires or new development. About 22% of wetland area in the Central Basin and 8.5% of wetland area in the Wasatch Mountains is estimated to have a needs gap, defined as wetlands that receive water quality stressors and only have one capacity indicator. It is important to note, however, that these wetlands may still have ample capacity to assimilate stressors, since we do not know how each indicator translates to actual level of capacity. Furthermore, lack of capacity does not necessarily mean that a wetland needs to be restored. Wetlands naturally differ in their ability to improve water quality; we evaluated data from a few randomly selected sites with a needs gap and found no obvious issues to restore.

Trends by Ecoregional Strata

We surveyed alkaline depressions, basin marshes, and playas in the Great Salt Lake stratum. Most wetlands in the stratum are embedded within large wetland complexes and thus wetlands frequently have few stressors immediately adjacent to them besides linear disturbances (e.g., roads, dikes), livestock grazing, and the invasive grass *Phragmites australis*. Hydrology at most sites is controlled by management practices via impoundments, ditches, and control structures, either directly within impoundments or indirectly due to overflow or release from impoundments. Vegetation treatment, primarily aimed at controlling *P. australis*, is also very common. Based on the landscape profile, unconsolidated shores, which include playas and mudflats, are the most common wetland type in the stratum and the most frequently associated with high local stress.

We surveyed alkaline depressions and basin marshes in the Jordan stratum. Wetlands in the Jordan stratum appear to be in poorer condition than wetlands anywhere else in the watershed. Jordan wetlands had the most buffer disturbance, highest levels of noxious weeds, most issues with turbidity and water quality stressors, and amongst the most altered hydrology. Wetlands in the Jordan stratum are predominantly classified as private, though often owned by local government entities, and frequently receive stormwater run-off. Despite their poor condition, Jordan wetlands likely provide important functions such as water quality improvement and wildlife habitat. The Jordan stratum has likely experienced the highest rate of wetland loss of all strata in the watershed and thus preserving the remaining wetlands is important for maintaining those functions on the landscape.

Utah Lake wetlands exhibited a diversity of HGM classes and wetland types, including lacustrine wetlands on the shore of Utah Lake, depressional wetlands, and the only slope wetlands surveyed in the Central Basin. This stratum also had the most sensitive ecological features observed in the Central Basin with both a peatland site and a site with a sensitive plant species. Lacustrine fringe wetlands occur in large relatively intact landscapes within complexes of wetlands and deepwater and may be affected by impaired water quality from Utah Lake. Wetlands were more frequently grazed and surrounded by agriculture compared to wetlands in other parts of the Central Basin. Landowners are concerned about groundwater levels in the southern portion of the study area. Almost all wetlands in the stratum are considered riparian, with a much higher percent considered moderately impacted by watershed stress compared to the Great Salt Lake and Jordan stratum, where virtually all riparian wetlands are classified as highly stressed.

Wetlands in the Mountain Valleys primarily fell into one of two categories, foothill scrublands along the Provo River and irrigation-influenced depressional wet meadows frequently used as pasture. Mountain Valleys also had the most slope wetland area outside of the Alpine Zone and the most peatland sites of any strata. Almost two-thirds of the wetland area in the Mountain Valleys is estimated to receive irrigation water via tail water run-off, subjecting wetlands to unnaturally timed and potentially polluted waters. Widespread livestock grazing led to sparse litter at some sites, but only had a small impact on soil disturbance. Wetlands in the Mountain Valleys are subject to more water quality stressors than other wetlands in the Wasatch Mountains ecoregion, which ranged from landscape stressors, including agriculture, development, and point source dischargers, and buffer stressors, including linear disturbances, agriculture, and livestock grazing. Most wetland area had fairly poor or worse relative native plant cover, though noxious weeds were not very abundant. Continued development in the Mountain Valleys is anticipated, with the population in the four largest towns in the region expected to more than triple from 2010 to 2060 (Utah Governor's Office of Management and Budget, 2012). Wetland conservation in the Mountain Valleys through land purchases and easements may be crucial for wetland preservation in the face of development pressure.

Wetlands in the Semiarid Foothills were predominantly depressional and included montane shrublands, montane marshes, foothill shrublands, and wet meadows. Semiarid Foothills wetlands are heavily impacted by non-native plant species; over half of the wetland area in the stratum is estimated to have <50% relative native plant cover. Semiarid Foothills wetlands also tend to have more water quality stress and hydrologic manipulation than wetlands at higher elevations. About one-quarter of wetland area is estimated to have livestock grazing, though disturbance from livestock grazing was typically low severity.

We surveyed montane woodlands, wet meadows, and montane shrublands in the Wasatch Montane Zone, with >80% of wetland area in the latter category. Wetlands were in relatively intact landscape settings with few apparent hydropattern or water quality stressors and primarily undisturbed soils. Nonetheless, woody species regeneration and plant community composition metrics were frequently rated as fair or poorer. Wetlands frequently lacked woody regeneration and relatively little area rated as good-excellent for relative cover of native species. Furthermore, almost three-quarters of Wasatch Montane Zone wetlands had ≥3% cover of noxious weeds, the majority comprised of *Cirsium arvense*. Over half the wetland area is managed by the U.S. Forest Service and much of the remaining land is privately owned and part of the CWMU program.

We surveyed montane shrubland and wet meadow in the Alpine Zone. All but one wetland was slope and half qualified as peatlands. Alpine Zone wetlands are in the best condition of all wetlands in the watershed based on most measures, with wide, intact buffers, minimal landscape and water quality stress, little if any hydrologic alteration, and very intact plant communities. Only two stressors were common in Alpine Zone buffers, trails and mountain pine beetle-killed trees. Over 90% of the wetland area in the stratum and all the surveyed sites are part of the Uinta-Wasatch-Cache National Forest.

We surveyed montane woodland, foothill shrubland, wet meadow, and montane shrubland on the National Forest, which included wetlands in the Semiarid Foothills and Wasatch Montane Zone strata. Vegetation community composition tended to be better on the National Forest than other wetlands in the the Semiarid Foothills and Wasatch Montane Zone strata; most National Forest sites had ≥80% relative native cover and ≤3% noxious weed cover. Livestock grazing is estimated to occur in about one-third of National Forest wetlands, and soil disturbance was more common in National Forest wetlands than in other wetlands in the strata, though typically low severity. Hydropattern alteration was very uncommon and water quality condition was generally good to excellent, though one site was rated as poor due to proximity to a mine. Most of the highest condition wetlands in the Jordan River watershed are on land managed by the Uinta-Wasatch-Cache National Forest, including sites in the Alpine Zone. All 13 sites with the highest condition scores, 12 of the 13 sites with the highest mean C values, and 17 of the 19 high-quality reference sites in the Wasatch Mountains ecoregion were all on Uinta-Wasatch-Cache National Forest land.

Ecological Systems and Reference Values

We conducted an exploratory analysis of high-quality reference sites in the Jordan River watershed by screening for sites with low levels of stress and then determining the 25th percentile value for mean C and overall URAP condition scores at those sites. High-quality wetlands were less common in the Central Basin than in the Wasatch Mountains ecoregion; we had to loosen the screen to obtain enough reference sites for each of the Ecological Systems in the former ecoregion and none in the latter. Mean C and condition score thresholds were lower in Ecological Systems in the Central Basin ecoregion than the Wasatch Mountains, perhaps due to the loosening of the stressor screening.

We have several recommendations based on this exploratory analysis. First, we should increase our sample of sites to obtain more high-quality reference sites in each Ecological System. We had to loosen the screen for all the Central Basin ecoregion sites, and threshold mean C values were relatively low. C-values of <3 are indicative of species frequently found in converted ecosystems such as old fields, ditches, and managed roads (Rocchio and Crawford, 2013); two of our Ecological Systems had threshold values below 3. Second, we should evaluate the Ecological Systems to determine whether they are parsimonious and complete in grouping sites to obtain meaningful and actionable data. There was considerable overlap in plant community composition between wet meadows and alkaline depressions; these Ecological Systems could be combined or parsed to create more distinct groups of sites. Wet meadows may also need to be divided into several subclasses. Wet meadows spanned the broadest elevation, included the most strata, and had the strongest correlations between plant community composition and natural environmental variability. Four of the six wet meadow reference sites were in the Alpine Zone, and none were in the Mountain Valleys; the reference sites may not represent practical restoration targets for lower elevation wet meadows. Third, we should consider whether to assess submergent marshes and playas differently and separately from other Ecological Systems. Submergent marshes were classified as part of basin marshes, but marshes with emergent vegetation may need to be assessed separately from the typically species-poor submergent marshes, at least for vegetation metrics. Four of the five high-quality reference basin marshes were comprised entirely of submergent and floating vegetation. We recommend obtaining a separate set of reference sites for emergent and submergent marshes and comparing water quality parameters across types. Playa wetlands were also species-poor systems, and half the surveyed playas had ≤6% vegetation cover. It may be important to focus on other aspects of playas, such as soil salinity, or to survey sites very early or very late in the growing season to obtain more data on the condition of playa wetlands.

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References

Anderton, L.K., and Barkworth, M.E., 2000, Grasses of the Intermountain West: Logan, UT, Utah State University, 559 p.

Bailey, C.L., Wilson, K.W., and Andersen, M.E., 2005, Conservation agreement and strategy for least chub (*Iotichthys phlegethontis*) in the state of Utah: Utah Division of Wildlife Resources publication number 05-24, 38 p.

Bailey, C.L., Wilson, K.W., and Andersen, M.E., 2006, Conservation agreement and strategy for Columbia spotted frog (*Rana luteventris*) in the state of Utah: Utah Division of Wildlife Resources publication number 06-01, 41 p.

Berkowitz, J.F. and Evans, D.E., 2014, A review of recent scientific literature on irrigation induced and enhanced wetlands: Vicksburg, Mississippi, U.S. Army Corps of Engineers ERDC/EL TN-14-5, 48 p.

Brinson, M., 1993, A hydrogeomorphic classification of wetlands: Greenville, NC, Wetlands Research Program Technical Report WRP-DE-4 prepared for the U.S. Army Corps of Engineers, 103 p.

Burden, C.B., and U.S. Geological Survey, 2016, Groundwater conditions in Utah, spring of 2016: prepared by the U.S. Geological Survey in cooperation with the Utah Division of Water Rights and Utah Division of Water Quality, Cooperative Investigations Report no. 57, 118 p.

California Invasive Plant Council, undated: Plants A to Z: Online, https://www.cal-ipc.org/plants/profiles.

Cowardin, L.., Carter, V., Golet, F.C., and LaRoe, E.T., 1979, Classification of wetlands and deepwater habitats of the United States: Washington, D.C., U.S. Fish and Wildlife Service Office of Biological Services FWS/OBS-79/31, 131 p.

Cronquist, A., Holmgren, A.H., Holmgren, N.H., and Reveal, J.L., editors, 1972, Intermountain flora—vascular plants of the intermountain West, U.S.A., Volume 1: Bronx, New York, New York Botanical Garden, 270 p.

Daly, C., Halbleib, M., Smith, J.I., Gibson, W.P., Doggett, M.K., Taylor, G.H., and Pasteris, P.P., 2008, Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States: International Journal of Climatology, v. 28, no. 15, p. 2031–2064.

DiTomaso, J.M., Kyser, G.B., Oneto, S.R., Wilson, R.G., Orloff, S.B., Anderson, L.W., Wright, S.D., Roncoroni, J.A., Miller, T.L., Prather, T.S., Random, C., Beck, K.G., Duncan, C., Wilson, K.A., and Mann, J.J., 2013a, Canada thistle, *in* Weed control in natural areas in the western United States: Davis, California, University of California Davis Weed Research and Information Center, 544 p.

DiTomaso, J.M., Kyser, G.B., Oneto, S.R., Wilson, R.G., Orloff, S.B., Anderson, L.W., Wright, S.D., Roncoroni, J.A., Miller, T.L., Prather, T.S., Random, C., Beck, K.G., Duncan, C., Wilson, K.A., and Mann, J.J., 2013b, Kochia and fivehook bassia, *in* Weed control in natural areas in the western United States: Davis, California, University of California Davis Weed Research and Information Center, 544 p.

DiTomaso, J.M., Kyser, G.B., Oneto, S.R., Wilson, R.G., Orloff, S.B., Anderson, L.W., Wright, S.D., Roncoroni, J.A., Miller, T.L., Prather, T.S., Random, C., Beck, K.G., Duncan, C., Wilson, K.A., and Mann, J.J., 2013c, Perennial pepperweed (tall whitetop), *in* Weed control in natural areas in the western United States: Davis, California, University of California Davis Weed Research and Information Center, 544 p.

DiTomaso, J.M., Kyser, G.B., Oneto, S.R., Wilson, R.G., Orloff, S.B., Anderson, L.W., Wright, S.D., Roncoroni, J.A., Miller, T.L., Prather, T.S., Random, C., Beck, K.G., Duncan, C., Wilson, K.A., and Mann, J.J., 2013d, Russian-olive, *in* Weed control in natural areas in the western United States: Davis, California, University of California Davis Weed Research and Information Center, 544 p.

Ehrenfeld, J., 2003, Effects of exotic plant invasions on soil nutrient cycling processes: Ecosystems, v. 6, no. 6, p. 503-523.

Federal Geographic Data Committee, 2009, Wetlands mapping standard: Washington D.C., Wetlands Subcommittee FGDC and U.S. Fish and Wildlife Service report FGDC-STD-015-2009, 35 p.

Federal Geographic Data Committee, 2013, Classification of wetlands and deepwater habitats of the United States: Washington D.C., Wetlands Subcommittee FGDC and U.S. Fish and Wildlife Service report FGDC-ST-002-2013, 85 p.

Fennessy, M.S., Jacobs, A.D., and Kentula, M.E., 2007, An evaluation of rapid methods for assessing the ecological condition of wetlands: Wetlands, v. 27, no. 3, p. 543—560.

Gerber, E., Krebs, C., Murrell, C., Moretti, M., Rocklin, R., and Schaffner, U., 2008, Exotic invasive knotweeds (Fallopia spp.) negatively affect native plant and invertebrate assemblages in European riparian habitats: Biological Conservation, v. 141, no. 3, p. 646—654.

Hruby, T., 2014a, Washington State wetland rating system for western Washington–2014 update: Olympia, WA, Washington Department of Ecological Publication #14-06-029, 126 p.

Hruby, T., 2014b, Washington State wetland rating system for eastern Washington–2014 update: Olympia, WA, Washington Department of Ecological Publication #14-06-030, 126 p.

Hurd, E.G., Shaw, N.L., Mastrogiuseppe, J., Smithman, L.C., and Goodrich, S., 1998, Field guide to intermountain sedges: Ogden, Utah, Rocky Mountain Research Station, 282 p.

Jehl Jr., J.R., 1988, Biology of the eared grebe and Wilson's phalarope in the nonbreeding season—a study of adaptations to saline lakes: Cooper Ornithological Society Studies in Avian Biology No. 12, 74 p.

Jensen, K., Horton, H., Reed, R., and Whitesides, R., date unknown, Intermountain planting guide: Logan, UT, USDA-ARS-Forage and Range Research Lab and Utah State University Extension AG 510, 104 p.

Jones, W.M., 2005, A vegetation index of biotic integrity for small-order streams in southwest Montana and a floristic quality assessment for western Montana wetlands: Helena, Montana Natural Heritage Program, 69 p.

June Sucker Recovery Team, 1999, June sucker (Chasmistes liorus) recovery plan: Denver, CO, prepared for the U.S. Fish and Wildlife Service, 61 p., available online at: http://ecos.fws.gov/docs/recovery_plans/1999/990625.pdf.

Kincaid, T., 2015, Analysis of a GRTS survey design for an area resource: Online, https://cran.r-project.org/web/packages/spsurvey, 14 p.

Kincaid, T., 2016, Cumulative distribution function (CDF) analysis: Online, https://cran.r-project.org/web/packages/spsurvey/vignettes/CDF_Analysis.pdf, 14 p.

Landfire, 2014, Existing vegetation type layer, U.S. Geological Survey, Online, https://www.landfire.gov, accessed January 5, 2017.

Lavergne, S. and Molofsky, J., 2004, Reed canary grass (*Phalaris arundinacea*) as a biological model in the study of plant invasions: Critical Reviews in Plant Sciences, v. 23, no. 5, p. 415—429.

Lemly, J., Gilligan, L., and Wiechmann, C., 2016, Ecological integrity assessment for Colorado wetlands—field manual version 2.1: Fort Collins, Colorado Natural Heritage Program, 116 p.

Lemly, J., Gilligan, L., Smith, G., and Wiechmann, C., 2015, Lower Arkansas River Basin wetland mapping and reference network: Fort Collins, Colorado Natural Heritage Program, 140 p.

Mack, M., and D'Antonio, C., 1998, Impacts of biological invasions on disturbance regimes: Trends in Ecology and Evolution, v. 13, no. 5, p. 195-198.

McCune, B., and Grace, J.B., 2002, Analysis of ecological communities: Gleneden Beach, Oregon, MjM Software Design, 300 p.

McElfish, J.M., Jr., Kihslinger, R.L., and Nichols, S., 2008, Setting buffer sizes for wetlands: National Wetlands Newsletter, v. 30, no. 2, p. 6–17.

Menuz, D., 2015, Landscape integrity model for Utah's wetlands: Utah Geological Survey contract deliverable for the Endangered Species Mitigation Fund Project #1215, 50 p., available online at https://geodata.geology.utah.gov/pages/home.php.

Menuz, D., Sempler, R., and Jones, J., 2015, Utah Rapid Assessment Procedure Method for Evaluating Ecological Integrity in Utah Wetlands, Version 2.0- DRAFT: Salt Lake City, 76 p.

Menuz, D., 2016a, Analysis of landscape and habitat variables associated with boreal toad (*Anaxyrus boreas*) breeding locations: Salt Lake City, Utah Geological Survey, contract deliverable for the Utah Department of Natural Resources Endangered Species Mitigation Fund, 39 p.

Menuz, D., 2016b, Development of a watershed stress model for wetlands and other aquatic systems: Salt Lake City, Utah Geological Survey, contract deliverable for the Utah Department of Natural Resources Endangered Species Mitigation Fund, 12 p.

Menuz, D., Sempler, R., and Jones, R., 2016c, Weber River watershed wetland condition assessment: Salt Lake City, Utah Geological Survey, contract deliverable for the U.S. Environmental Protection Agency, 106 p.

Menuz, D., 2017, Characterization of boreal toad breeding habitat in Utah: Salt Lake City, Utah Geological Survey, contract deliverable for the Utah Department of Natural Resources Endangered Species Mitigation Fund, 26 p.

National Climatic Data Center, 2018, Local climatological data−annual summary with comparative data: Asheville, North Carolina, available online at https://www.ncdc.noaa.gov/IPS/lcd/lcd.html, accessed August 28, 2018.

Oksanen, J., Blanchet, F.G., Kindt, R., Legendre, P., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H., Wagner, H., Simpson, G.L., and Stevens, M.H.H., 2013, vegan—Community Ecology Package, R package version 2.0-10. http://CRAN.R-project.org/package=vegan.

Oliver, G.V., 2006a, Western toad (*Anaxyrus boreas*) Ecological Integrity Table: Salt Lake City, Utah Division of Wildlife Resources Natural Heritage Program, 14 p.

Oliver, G.V., 2006b, Columbia spotted frog (*Rana luteiventris*) Ecological Integrity Table: Salt Lake City, Utah Division of Wildlife Resources Natural Heritage Program, 13 p.

Omernik, J.M., 1987, Ecoregions of the conterminous United States: Annals of the Association of American Geographers, v. 77, no. 1, p. 118–125, scale 1:7,500,000.

Paul, D.S., and Manning, A.E., 2002, Great Salt Lake waterbird survey five-year report (1997-2001): Utah Division of Wildlife Resources Great Salt Lake Ecosystem Program Publication Number 08-38, 56 p.

R Core Development Team, 2013, R—A language and environment for statistical computing: Vienna, Austria, R Foundation for Statistical Computing: Online, http://www.R-project.org.

Rocchio, J., 2007, Floristic quality assessment indices for Colorado plant communities: Fort Collins, unpublished report prepared for Colorado Department of Natural Resources and US EPA Region 8 by the Colorado Natural Heritage Program, 234 p.

Rocchio, F.J., and Crawford, R.C., 2013, Floristic quality assessment for Washington vegetation: Olympia, Washington Natural Heritage Program, 49 p.

Snodgrass, J.W., Komoroski, M.J., Jr, A.L.B., and Burger, J., 2000, Relationships among isolated wetland size, hydroperiod, and amphibian species richness—implications for wetland regulations: Conservation Biology, v. 14, no. 2, p. 414–419.

Stevens, D.L., and Olsen, A.R., 2004, Spatially-balanced sampling of natural resources: Journal of the American Statistical Association, v. 99, no. 465, p. 262–278.

Stoddard, J.L., Larsen, D.P., Hawkins, C.P., Johnson, R.K., and Norris, R.H., 2006, Setting expectations for the ecological condition of streams—the concept of reference condition: Ecological Applications, v. 16, no. 4, p. 1267–1276.

Sueltenfuss, J.P., Cooper, D.J., Knight, R.L., and Waskom, R.M., 2013, The creation and maintenance of wetland ecosystems from irrigation canal and reservoir seepage in semi-arid landscape: Wetlands, v. 33, no. 5, p. 779-810.

Sutula, M.A., Stein, E.D., Collins, J.N., Fetscher, A.E., and Clark, R., 2006. A practical guide for the development of a wetland assessment method—the California experience: Journal of the American Water Resources Association, v. 42, no. 1, p. 157—175.

Tanner, C.C., D'Eugenio, J., McBride, G.B., Sukias, J.P.S., and Thompson, K., 1999, Effect of water level fluctuation on nitrogen removal from constructed wetland mesocosms: Ecological Engineering, v. 12, no. 1-2, p. 67–92.

Tarr, T.L., Baber, M.J., and Babbitt, K.J., 2005, Macroinvertebrate community structure across a wetland hydroperiod gradient in southern New Hampshire, USA: Wetlands Ecology and Management, v. 13, no. 3, p. 321–334.

Toole, T., 2011, Chapter 2.6 Utah Lake–Jordan watershed management unit assessment, *in* 2008 final Utah 305(b) report—part 2 integrated report: Utah Division of Water Quality, 14 p.

Tom, K., Olsen, T., Stevens, D., Platt, C., White, D., and Remington, R., 2012, Spatial survey design and analysis: R package "spsurvey" version 2.5, p. 92.

Uchytil, R.J., 1993, Poa pratensis, *in* Fire Effects Information System: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Online, http://www.fs.fed.us/database/feis, accessed March 2015.

U.S. Army Corps of Engineers, 2008, Regional supplement to the Corps of Engineers wetland delineation manual—Arid west region, Version 2.0: Vicksburg, Mississippi, ERDC/EL TR-08-28, 133 p.

U.S. Army Corps of Engineers, 2010, Regional supplement to the Corps of Engineers wetland delineation manual—Western mountains, valleys, and coast region, version 2.0: Vicksburg, Mississippi, ERDC/EL TR-08-28, 133 p.

U.S. Army Corps of Engineers, 2017, Final Sacramento District nationwide permit (NWP) regional conditions for Utah: 9 p, available online at http://www.spk.usace.army.mil/Missions/Regulatory/Permitting/Nationwide-Permits.

U.S. Environmental Protection Agency, 2006, Application of elements of a state water monitoring and assessment program for wetlands: Office of Wetlands, Oceans, and Watersheds, EPA 841-B-03-003, 12 p.

U.S. Environmental Protection Agency, 2016, National wetland condition assessment—2011: technical report EPA-843-R-15-006, Washington, DC, 245 p.

U.S. Fish and Wildlife Service, 1999, Peatland mitigation policy considerations: Region 6 Ecological Services Colorado Field Office, Lakewood, 35 p., available online at https://www.fws.gov/mountain-prairie/es/fen/FWSRegion6FenPolicy1999.pdf.

U.S. Fish and Wildlife Service, 2002, Status review for the Columbia spotted frog (Rana luteiventris) on the Wasatch Front, Utah, 85 p.

U.S. Fish and Wildlife Service, 2009, A system for mapping riparian areas in the western United States: Washington D.C., 42 p.

U.S. Forest Service, 2012, Groundwater-dependent ecosystems−level II inventory field guide: general technical report WO-86b, 124 p.

Utah Division of Forestry, Fire, and State Lands, 2013, Final Great Salt Lake comprehensive management plan and record of decision: Salt Lake City, Utah, 391 p, available online at http://www.forestry.utah.gov/index.php/state-lands/great-salt-lake/great-salt-lake-plans.

Utah Division of Water Quality, 2014a, Chapter 5 303(d) list of rivers and streams, *in* October 2012-2014 draft integrated report: Salt Lake City, Utah, 179 p.

Utah Division of Water Quality, 2014b, Chapter 6 303(d) list of lakes and reservoirs, *in* October 2012-2014 draft integrated report: Salt Lake City, Utah, 28 p.

Utah Division of Water Quality, 2016a, Prioritizing Utah's 303(d) list: Salt Lake City, Utah, 33 p.

Utah Division of Water Quality, 2016b, Utah's final 2016 integrated report: Salt Lake City, 294 p.

Utah Division of Water Resources, 2010, Jordan River basin—planning for the future: Salt Lake City, with input from the State Water Plan Coordinating Committee, 115 p; Online, http://www.water.utah.gov/Planning/SWP/Jord_riv/Jordan%20River%20Basin%20Final0610t.pdf.

Utah Division of Water Resources, 2014a, Utah Lake basin—planning for the future: Salt Lake City, with input from the State Water Plan Coordinating Committee, 121 p: Online, http://www.water.utah.gov/Planning/SWP/Uth_lk/UtahLake06302014A1.pdf.

Utah Division of Water Resources, 2014b Water-related land use inventories—Jordan River Basin 2014 Inventory: Salt Lake City, 9 p.

Utah Division of Wildlife Resources, 2011, Utah sensitive species list: prepared pursuant to Administrative Rule R657-48, 150 p., available online at http://dwrcdc.nr.utah.gov/ucdc/ViewReports/SSLAppendices20110329.pdf.

Utah Division of Water Resources, 2014c, Water-related land use inventories—Utah Lake Basin 2014 Inventory: Salt Lake City, 9 p.

Utah Division of Wildlife Resources, 2015, Utah's Wildlife Action Plan—A plan for managing native wildlife species and their habitats to help prevent listing under the Endangered Species Act 2015-2025: Salt Lake City, publication 15-14, 391 p.

Utah Division of Wildlife Resources, 2017, Utah sensitive species list: Salt Lake City, 7 p.

Utah Governor's Office of Management and Budget, 2012, 2012 baseline projections—sub-county population projections: Online, https://gomb.utah.gov/budget-policy/utahseconomy, accessed September 2018.

Utah Public Health Laboratory, 2013, Chemical and environmental laboratory client services manual revision 2 June 2013: Salt Lake City, 80 p.

Washkoviak, L., Heidel, B., and Jones, G., 2015, Floristic quality assessment for Wyoming flora—developing coefficients of conservatism: Lander, Wyoming, Wyoming Natural Diversity Database, prepared for U.S. Army Corps of Engineers agreement number G15AC00484, 19 p.

Webb, J.A., Wallis, E.M., and Stewardson, M.J., 2012, A systematic review of published evidence linking wetland plants to water regime components: Aquatic Botany, v. 103, p. 1–14.

Welsh, S.L., Atwood, N.D., Goodrich, S., and Higgins, L.C., editors, 2003, A Utah flora: Provo, Utah, Brigham Young University, 912 p.

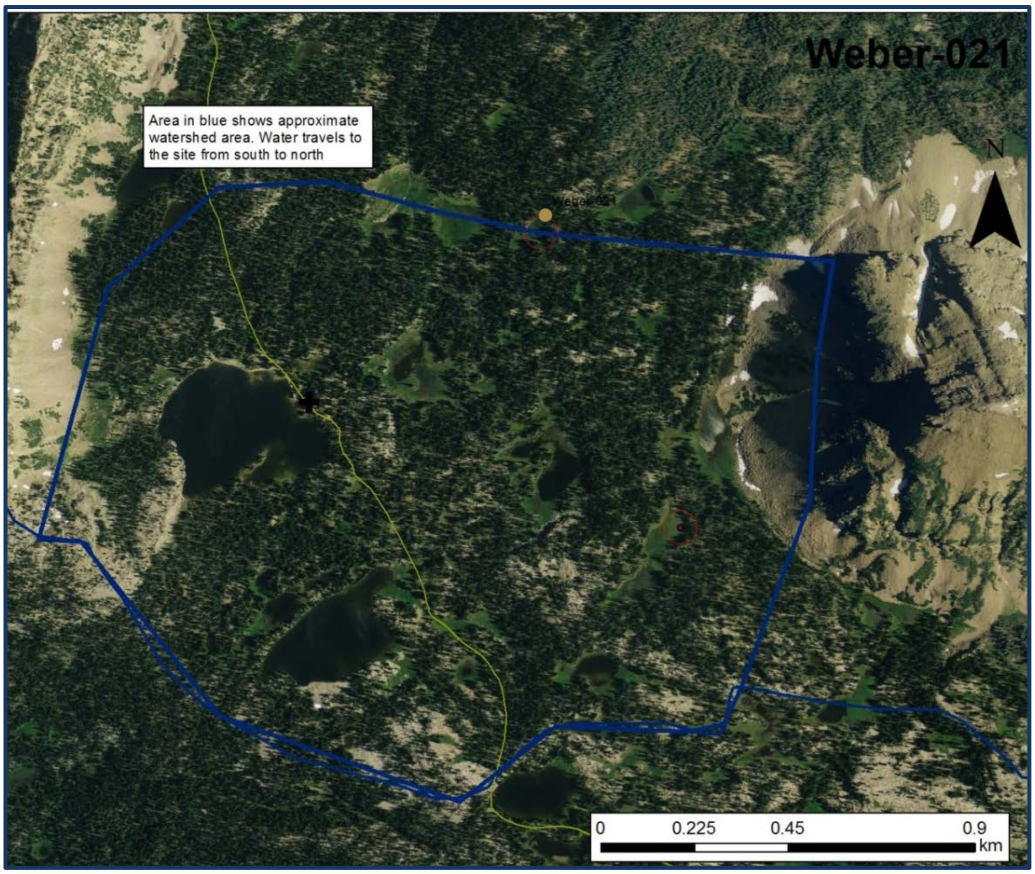
Wilcove, D. S., Rothstein, D., Jason, D., Phillips, A., and Losos, E., 1998, Quantifying threats to imperiled species in the United States: BioScience, v. 48, no. 8, p. 607—615.

Woods, A.J., Lammers, D.A., Bryce, S.A., Omernik, S.A., Denton, R.L., Domeier, M., and Comstock, J.A., 2001, Ecoregions of Utah (color poster with map, descriptive text, summary tables, and photographs): U.S. Geological Survey, scale 1:1,175,000.

Zhang, X., Liu, X., Zhang, M., Dahlgren, R.A, and Eitzel, M., 2010, A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution: Journal of Environmental Quality, v. 39, no. 1, p. 76–84.

Appendix A:
URAP Office Evaluation Method

UTAH RAPID ASSESSMENT PROCEDURE
Method for Evaluating Ecological Integrity in Utah Wetlands
Office Evaluation Method, Version 2.0- DRAFT



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Utah Rapid Assessment Procedure:
Method for Evaluating Ecological Integrity in Utah Wetlands
Office Evaluation Method
Version 2.0- Draft

Cover:

Landscape map showing approximate contributing area boundaries (blue polygon) and location of trail in relation to the wetland on the northern edge of the map (brown circle). Site is in the Uinta Mountains off the Mirror Lake Highway near the Notch Mountain trail.

UTAH DNR GEOLOGICAL SURVEY

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Section 1: Introduction

The Utah Rapid Assessment Procedure (URAP) is a survey protocol developed by the Utah Geological Survey (UGS) to evaluate the ecological condition of wetlands in the state of Utah. Ecological condition can be defined as “the ability of a wetland to support and maintain its complexity and capacity for self-organization with respect to species composition, physico-chemical characteristics, and functional processes as compared to wetlands of a similar type without human alterations” (Fennessy and others, 2007). Condition is often evaluated in terms of degree of deviation from what is known or expected to occur at sites without any anthropogenic alteration (i.e., reference standard sites).

Prior to conducting a field survey using URAP, it is important to conduct an initial office assessment of potential sites. Sites that have been randomly selected for field surveys may first need to be evaluated to determine whether they are actually wetlands and to determine land owner contact information to obtain permission to survey. All sites that will be surveyed should be assessed in the office to obtain basic landscape data, particularly in regards to site hydrology. Additionally, site maps for field surveys must be prepared in the office.

The primary focus of this document is to provide guidance for employees of the Utah Geological Survey (UGS) who are using URAP to assess condition of randomly selected wetlands for the 2014 Weber watershed project, funded under Environmental Protection Agency (EPA) grant CD-96812601-0. This document is also intended to provide guidance for other users of URAP, though full development of the office evaluation procedure for those without access to ArcGIS is not yet complete. The freely available GoogleEarth software (https://www.google.com/earth) can be used in place of ArcGIS to produce maps and evaluate landscape features. In section 5, we provide suggestions for alternative sources of landscape stressor data for those without access to specific data layers used by the UGS.

Section 2: Initial Site Evaluation

2.1 Evaluation of target site

An assessment area (AA) is the bounded wetland area within which sampling occurs. URAP was developed for use with circular fixed-area AAs of 40-m radius (~0.5 ha) whenever possible and rectangular or freeform AAs of equal or smaller area if necessary due to the shape or size of the wetland being evaluated. URAP can potentially be used to evaluate larger AAs and AAs that consist of entire wetlands, but metrics and scoring may need to be adjusted to account for these changes. Evaluation methods outlined below were adapted from methods used by the Colorado Natural Heritage Program (Lemly and Gilligan, 2013).

The location of most AAs for the Weber River watershed project are randomly selected using National Wetland Inventory (NWI) data. Before site visits, we will evaluate randomly placed points to determine whether or not they actually appear to be wetland. Wetland for this project is any area that meets the definition used by the U.S. Fish and Wildlife Service (USFWS) for NWI mapping, which includes areas at least periodically flooded or saturated by water and, if soils and vegetation are present, hydrophytic vegetation and predominantly hydric soils (Cowardin and others, 1979). Permanently flooded areas with water deeper than 2 m, where emergent plant species usually cannot grow, are considered deepwater habitat, not wetland by Cowardin and others (1979), though we will exclude areas with water more than 1 m deep for the safety of field surveyors. We will generate 40-m radius buffers around randomly selected study sites in ArcGIS and then determine whether AAs need to be moved, reshaped, or excluded. The following general principles will be followed when establishing an AA:

1) The AA should be 0.5 ha whenever possible and no smaller than 0.1 ha.
2) Regardless of AA shape, the maximum length of the AA is 200 m and the minimum width is 10 m.
3) There should be no more than 10% upland inclusions within the AA and no more than 10% water >1 m deep, including water in a stream channel or in the center of a pond. The AA should be shifted or reshaped to avoid upland and deep water on its edge (i.e., only inclusions *within*, not on the edge of, the AA are acceptable, figure 1a).
4) The AA should be established in a single wetland. Features that denote wetland boundaries include above-grade roads, major water control structures, dikes, and major channel confluences (figure 1b).
5) The majority of an AA should be placed within a single Ecological System.
6) Do not move the AA if you cannot determine whether a wetland is present in the imagery. For these sites, surveyors will determine AA location in the field.

The edge of the AA must be within 60 m of the original sample point. For standard 40-m circular AAs, this means that the new center point must be within 100 m of the original sample point. The AA should generally be established in the closest sampleable wetland to the original point. If a standard circular AA fits within this wetland, place the edge of the AA as close as possible to the original sample point to avoid arbitrary placement. More subjective placement may be necessary for rectangular or free-form AAs; avoid biasing placement towards or away from interesting features or difficult to sample vegetation.

If the AA must be moved from the original placement, first determine whether the selected point is within 60 m of land cover that could be wetland. Likelihood that land cover is wetland is classified as one of the categories listed below. All wetlands in the first category will be surveyed and a subset of wetlands in the second and third categories are surveyed in order to determine the overall accuracy of the NWI data. Features in the last category are removed from the sample frame with no further evaluation. Evaluation of whether sites are wetlands is based on examination of aerial imagery as well as topographic position and proximity to potential water sources using geospatial data listed in appendix A. The evaluation categories include the following:

1) Probably or definitely wetland: Sites that are fairly likely to be wetlands, with at least 75% certainty (figure 2).
2) Possibly wetland or unclear: Sites that have a 25 to 75% chance of being wetlands or a site that is unclear or impossible to assess based on the imagery (figure 3a).
3) Probably not wetland: Sites that are probably not wetlands (5-25% likelihood), but this fact is not unambiguously clear (figure 3b).
4) Almost certainly not wetland: Sites that are almost certainly not a wetland (<5% likelihood). Area may be clearly developed or barren.

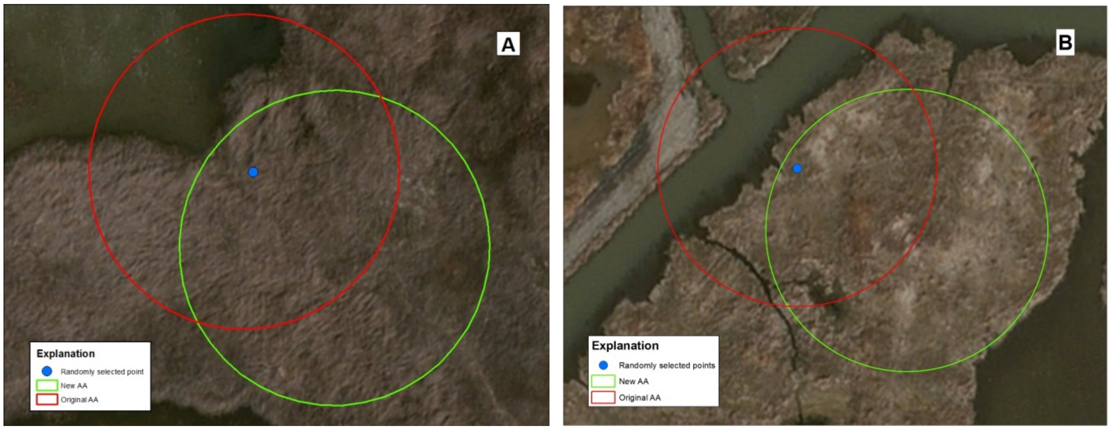

Figure 1. Examples of moving the original AA to a more appropriate survey location. On left (A), AA created by original sample point (red circle) has inclusions of open water on its edge. If this water is more than 1 m deep, AA location should be shifted so that inclusions are not directly on the AA edge (green circle), though internal inclusions are allowed. On right (B), the original AA is moved to avoid crossing the road and dike south of the canal.

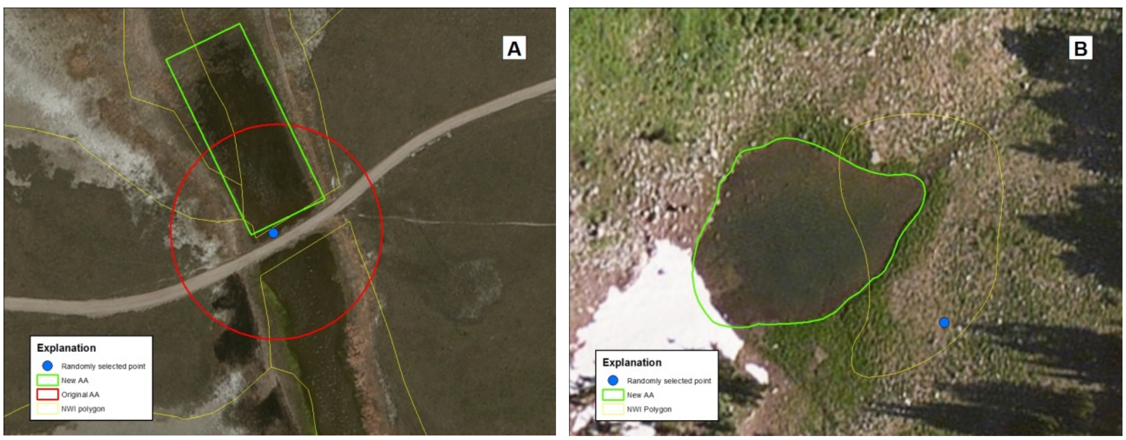

Figure 2. Sites that are probably or definitely wetlands. Site on left (A) was redrawn as a rectangular AA, though a circular AA potentially may also fit. At the site on right (B), the randomly selected point originally fell on the edge of the NWI polygon (yellow circle). A free-form AA was drawn in red around the probable wetland area. The free-form AA is large enough to sample (0.15 ha), whereas the original NWI polygon was not.

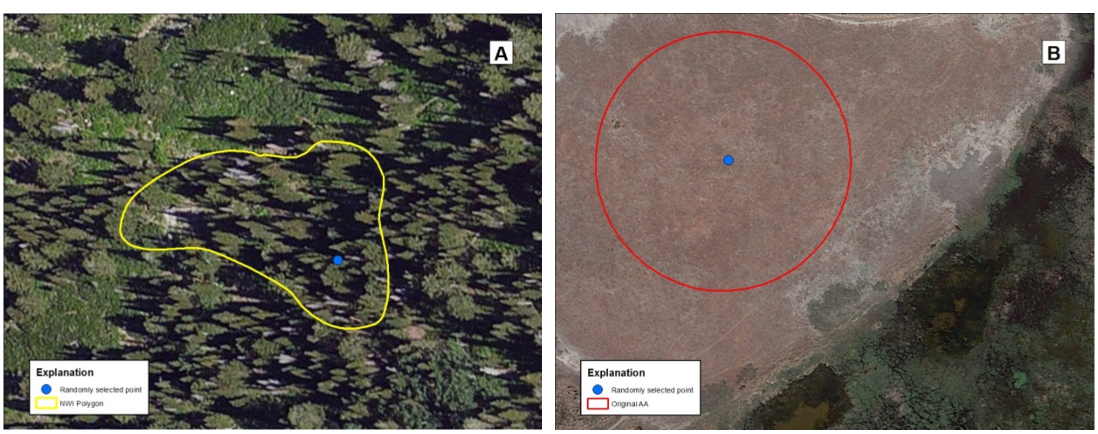

Figure 3. Site that is possibly wetland or unclear (A) and site that is probably not wetland (B). In map on left, area was mapped as scrub/forested wetland in NWI data. It is difficult to tell with the canopy cover but this site should be listed as possibly

wetland or unclear. On right, site appears to not be wetland due to the lack of green coloration, but it is still possible that the site may be wetland.

Next, determine whether the AA needs to be moved or reshaped. If the AA does not follow the general principles outlined above (e.g., <20% upland and deep water, crossing wetland boundaries), move or reshape the AA. If the potential boundaries of the wetland in the imagery are unclear, the AA boundary will be established in the field. For boundaries established in the field, make site maps appropriately to accommodate potential changes. Whenever possible, keep the AA closest to the original sample point (so that the edge is within 60 m of the original point). If a standard 40-m radius circular AA will fit in this wetland, then shift the AA to an appropriate location. Use the following rules to guide reshaping the AA:

1) *Sampleable area will fit in rectangle 0.5 ha in size and circular wetland cannot be drawn.* Rectangular AAs should be 0.5 ha, and no narrower than 10 m wide and no wider than 200 m. Example dimensions of rectangular AAs include 25 m x 200 m, 50 m x 100 m, and 70.7 m x 70.7 m. The advantage of a rectangular AA is that they are easy to set up in the field; however, many wetland edges will not conform to the edges of a rectangular AA.
2) *Neither circular nor 0.5 ha rectangular AA can be drawn***.** Draw a freeform AA that follows along parts of the wetland boundary and is between 0.1 and 0.5 ha in size. If the entire wetland is less than 0.5 ha, draw the free-form AA around the exact outline of the wetland. For larger wetlands, determine an appropriate boundary for the AA that captures approximately 0.5 ha of land. Free-form AAs must be at least 10 m wide in every direction and no longer than 200 m. If a wetland is more than 200 m long, draw the AA to encompass an area at least 0.1 ha in size that follows the wetland boundary, but is truncated to be only 200 m in length.

2.1 Landowner contact information

Obtain landowner information for sites that are selected for analysis. First, determine whether ownership is state, private, federal, or tribal. Next, determine the individual or entity that owns the land. If the land is a managed wetland area, record the name of the reserve or waterfowl management area as well as the organization or individual who owns the property. If the land is not a managed wetland area, search for additional contact information for the land owner, particularly a contact phone number. You may also add remarks about access to the site to make note of access issues visible in aerial imagery, including sites that are owned by multiple land owners. Geospatial parcel data with land owner names and mailing addresses are available for most counties.

Section 3: In-depth Site Evaluation

3.1 Obtaining soil data

The Web Soil Survey (WSS) provides soil data that give a general idea of soil properties that may be encountered in the AA. However, it is important to remember that the information provided by WSS is not 100% accurate, nor is it designed to be applied at a small scale. On-site observations take precedence to information in the WSS. The WSS should be used as a tool to help confirm observed soil characteristics and to provide additional data to characterize soil appearance.

For each site, record soil survey data for the predominant soil unit mapped for the AA and for any other soil units that make up more than 10% of the AA. Record the Map Unit Name, slope, and the percent of the AA in the map unit. Also record the hydric rating, drainage class, depth to water table, and flooding frequency. The hydric rating indicates the percentage of the map unit components that predominantly have hydric soils. A rating above 66% is considered “Predominantly hydric” and a rating below 33% is considered most likely “Nonhydric”. Drainage class indicates how frequently the map unit soil is wet under natural circumstances and is assigned one of seven classes including excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. Depth to water table is the expected depth to the zone of the soil that is saturated for at least a month. Flooding frequency is the expected frequency at which areas are flooded by overflowing streams or runoff from slopes and is assigned one of six classes including none (< once/500 years), very rare (<1%/year), rare (1-5%/year), occasional (5-50%/year), frequent (>50%/year), and very frequent (>50%/year for every month in year). Following is the process to obtain soil data using the WSS:

1) Go to the Web Soil Survey site at: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm and click on the START WSS “green” button.
2) Under the “Area of Interest” (AOI) tab on top of the screen, click on the “Quick Navigation” drop down tab, select “Latitude and Longitude”, enter the AA center coordinates, and click view. You can also manually scroll to the AA if you are familiar with the area.
3) Click on the “define AOI by rectangle” button on the tool bar of the Interactive Map and roughly highlight an area slightly larger than the AA. You will need to have a map of the AA boundary open in ArcGIS or printed out to get a rough idea of this location.
4) After you have selected the AOI, click on the “Soil Data Explorer” tab near the top of the page, then click on “Land classification” followed by “Hydric Rating by Map Unit” and finally, “View Rating”. A table will appear below the map that summarizes the hydric rating for all the different soil units in the AOI map you created.
5) The “Soil Properties and Qualities” tab contains the other information that needs to be collected for the units identified above and added to the form. The first is the drainage class. Click on the “Properties and Qualities Ratings” tab on the left side of the screen, then “Soil Qualities and Features”, next “Drainage Class” and view rating. The rating is located in the table that appears under the soil map. For the other two features, close the “Soil Qualities and Features” and click on “Water Features”. Water table data is located in “Depth to Water Table” and flooding is located in “Flooding Frequency Class” by clicking on view rating and referring to the table that appears.

The “USA Soil Survey” layer can be found in the ArcGIS online database. This spatial layer can be used to identify soil survey map unit boundaries and to obtain most of the information above except for depth to water table and drainage class.

3.2 Evaluation of site hydrology

3.2.1 Determine hydrologic contributions to site

In ArcGIS, use aerial imagery, watershed boundaries, flowlines, and elevation data to determine the likely sources of water to sites. For sites connected to streams (either directly or through canals), the contributing area to the wetland is likely to be the entire watershed upstream of the site, which can be determined by using the watershed boundary dataset. Inter-basin water transfers (e.g., aqueducts carrying water to places it would not naturally reach) can complicate the contributing area, and should only be considered if they are very close to the wetland site or likely to have a substantial influence on the site hydrology. The contributing area for depression, slope, and other wetlands not connected to streams is assumed to be the land upslope from the wetland that is likely to drain to the wetland. Breaks will generally be made on ridgelines, though breaks may also be added in relatively flat terrain such as through farmland. Using surface topography to estimate groundwater contributions is prone to error, but, in the absence of more detailed groundwater studies, is the best possible approximation. In addition to determining the overall contributing area to the site, look for evidence of potential water additions to the site such as urban run-off, agricultural return flows, and ditching. Once you have determined the contributing area, write up a brief statement on the major source(s) of water to the site, including any sources that are unclear in imagery and need to be verified in the field. Hydrologic write-ups will be verified in the field. See figures 4 and 5 for examples of hydrologic site write-ups.

Figure 4. Example write-ups of site hydrology. For site on left (A): Site may primarily receive water from runoff in surrounding area. It is unclear whether site has input to the south or an outlet to the north, but does not seem to be connected to a stream or river. Inspect site for possible inlets and outlets. For site on right (B): Site may receive water from surface flow upslope to the south (check for culverts, ditching or signs of seeps or flow near road), from the alluvial aquifer, and overbank flooding from the stream channel. Irrigation ditches north of the stream are most likely disconnected hydrologically and would generally have little to no influence on site.

3.2.2. Evaluate potential hydropattern stressors

Next, determine which of the stressors present are likely to have a major role in controlling site hydroperiod. Stressors are listed as trace/not present, low, moderate, or high and are marked to denote whether they are present within 200 m of the site or more distant. Stressors likely to be negligible, such as small areas of development far from the wetland site, should be marked as trace/not present. To determine severity of water withdrawal and groundwater pumping, evaluate the distribution and density of diversion points in the watershed. Consider the severity of each stressor in relation to the overall water budget at the site. Seepage from an irrigation ditch will have a much larger effect on a playa that is naturally dry most of the year than on a groundwater-fed slope wetland that receives a constant influx of water. Increased duration of inundation of several weeks is a major change for systems that are normally only temporarily flooded (surface water during brief periods of the growing season) but not as important of a change for sites that are semi-permanently flooded (surface water present throughout growing season). See the office evaluation field form for a list of evaluated stressors (appendix B).

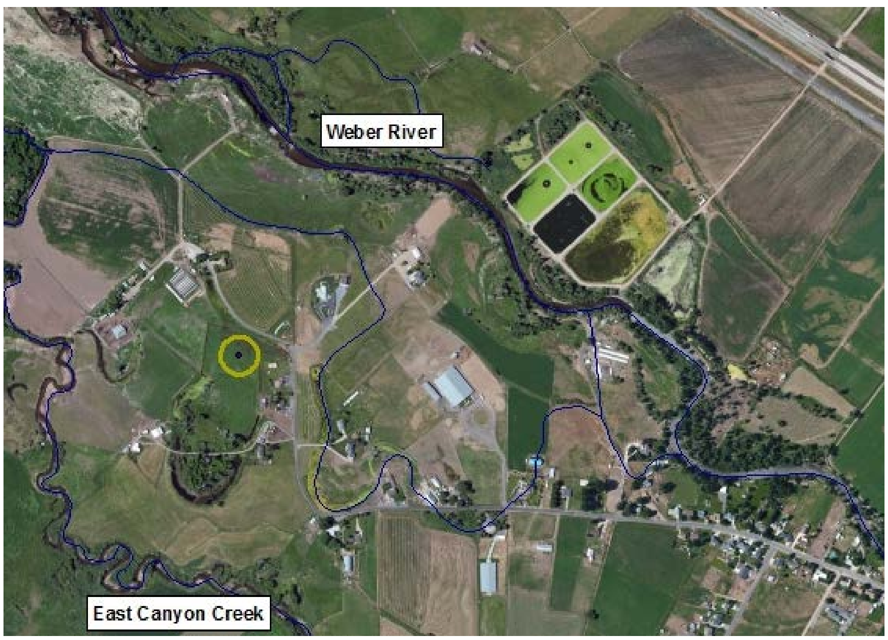

Figure 5. Example write-up of site hydrology: Site probably receives water from ditches off East Canyon Creek. Look for connection with Weber River and associated ditching, but East Canyon Creek source seems more likely.

3.3 Evaluation of water quality

3.3.1 Evaluate water quality stressors

For water quality evaluation, we are going to look at land cover, point source dischargers, Superfund sites, mines, oil and gas wells, and evidence of large sources of sediment (e.g., landslides, forest fires, quarries). Stressors will be evaluated both within 2 km of the site as well as in the contributing area and will be listed as none/trace, low, moderate, or high severity. The evaluated contributing area can be smaller than the whole watershed based on major breaks in hydrology. For example, inputs can be diluted when the input stream joins a larger river or because of dilution by major tributaries. Major reservoirs may serve as breaks in water quality (though impoundments may have less of an effect due to their often shorter water holding time [Miller and Hoven, 2007]). One or several very distant stressors can be considered none/trace. One very proximal stressor that directly feeds into the

AA can be considered moderate or severe. Land cover classes will be considered none/trace, low, moderate, or high based on whether they constitute very little, <20%, 20-60%, or >60% of the evaluated contributing area, respectively. The severity of point-based features should be evaluated based on the density of points and proximity to the AA. If there are only a few point source stressors in the area, you may want to investigate each stressor to determine likelihood of hydrologic connectivity; otherwise, look only at the aggregated total of the stressors. See the office evaluation form for a list of evaluated stressors (appendix B).

3.3.2 Obtain 303(d) Listing Information

Under the Clean Water Act, states are required to submit a list of impaired and threatened waters to the EPA every two years. This list is known as the 303(d) list. Evaluations are conducted in assessment units (AUs), areas delineated around lakes, stream segments, or watersheds that contain generally homogenous physical, chemical, and biological conditions. Wetlands located in AUs with impaired waters may be likely to have impaired water quality if the impaired waters are hydrologically connected to the wetland. This connection is most likely to exist for wetlands adjacent to major rivers and lakes. The most recent 303(d) list for Utah was produced by the Utah Division of Water Quality in the 2012-2014 Integrated Report and was not finalized at the time of the 2014 Weber watershed wetland assessments (Utah DWQ, 2014). We nonetheless obtained the preliminary data from this report for office evaluations in 2014. For each site, list the AU unique identifier and the AU category and sub-category. Category 1 AUs are fully supporting all water quality standards, Category 2 AUs were not fully assessed but supporting where assessed, and Category 3 sites have insufficient data but some record of exceedances. Categories 4 and 5 sites are both impaired; the former have approved Total Daily Maximum Loads (TMDL) studies whereas the latter do not. For these AUs, list all impaired parameters. For all sites, record whether the AU water quality is likely connected to the site's wetland water quality. Data for adjacent AUs can also be recorded if they are likely to contribute water to the site. The following process can be used to obtain AU data for each site:

1) Determine the unique identifier of the AU where the site is located. The best method to determine this identifier is to read the boundary descriptions presented in the 2012-2014 Integrated Report. Most river and stream watershed boundaries are similar to those used in the 2010 report, which can be viewed in the publically available Beneficial Use and Water Quality Assessment Map (http://mapserv.utah.gov/SurfaceWaterQuality). Boundaries from the 2010 report can also be determined in ArcGIS using the AGRC Image Server. For lake AU identifiers, search for the name of the lake in the 2012-2014 Integrated Report.
2) Determine the reporting year, assessment status, and impaired attributes of the AU. For lakes, look at the list of impaired lakes from 2014 in Chapter 6 of the 2012-2014 integrated report. This list includes both 2012 and 2014 results; look at the 2014 results starting on page 13. If a lake of interest is on the list, circle *Impaired Lake* under category and circle all impairments listed under Cause. For streams and rivers, look at the list in Chapter 5 of the integrated report. Circle the assessment unit category and write in the sub-category. List all impairments for Category 4 and 5 sites.

3) Evaluate whether the water quality of the wetland is likely to be related to the AU water quality. This is likely for wetlands that receive much of their water from assessed streams and lakes and unlikely for isolated wetlands and groundwater-fed wetlands.
4) If the AU is not assessed, determine whether an adjacent AU has been assessed and is likely to contribute water to the wetland. If so, record relevant information on the form and explain the likely connection between the assessed AU and the wetland of interest.

Section 4: Prepare Site Maps

4.1 Preparing site maps

Site maps should be prepared before wetland surveys are conducted. Useful maps include a detailed map of the AA, a buffer map showing the landscape surrounding the site, and a landscape map showing some or all of the contributing area to the AA. These maps will be important for evaluating some site attributes, in particular those related to the wetland buffer and to site hydrology. Maps can be made in GoogleEarth or ArcGIS and should contain the most detailed and up-to-date aerial imagery available for the area. Maps should include a title with the unique site identifier, scale bar in meters, north arrow, AA boundary, original sample point, and new center point if the site was moved.

The detailed AA map shows the AA as well as the potential area where the AA may be moved to in the field. To create this map, in ArcGIS, generate a 140 m buffer around the original center point for the AA. This distance is the outermost edge that a circular AA can be moved if site adjustments needs to be made in the field (figure 6a).

The buffer map shows the area that will be evaluated in the field for the Landscape Context metrics. Generate both a 100 m and 500 m buffer around the new AA boundary (not the center point) in ArcGIS to produce this map. In some cases, it may be useful to include additional information on the map, such as water related land use (figure 6b).

The landscape map will vary in scale and is an aid in identifying the contributing area and possible sources of water quality degradation and hydropattern alterations. The map should include most or all of the contributing area determined above in *3.2.1 Determine hydrologic contributions to site.* When the entire contributing area is very large, the map extent can be truncated at a major break in hydrology, such as a major reservoir or input point of a major tributary (figures 7 and 8). Some wetlands may have very limited contributing areas (figure 9). Contributing area boundaries can be manually drawn on maps or visualized with existing watershed boundary data. The landscape map should include any features useful in evaluating site hydrology and stressors that may affect the site. Data on density and types of roads, oil and gas wells, point source dischargers, mines, water related land use, and streams may all be helpful in evaluating site hydrology; see appendix A for a list of potential data sources. Add any layers and labels to the final map that will be helpful to identify features in the contributing area that will not be readily apparent on the map or in the field.

4.2 Overlaying grids on site maps

Grids can be overlain on detailed site and buffer maps in order to help with field estimates for some attributes, such as the percent cover of agriculture in the 200 m buffer. Below is a process for creating grids on maps in ArcGIS where each grid square will represent 5% of the total AA or total buffer area. Once the grids are created, they can be turned on and off by right clicking on the Data Frame, selecting Properties, and then clicking the grids on and off under the Grids tab. Custom grids will need to be made for non-standard AAs and their buffers. Following are the steps to create a grid in ArcGIS:

1) Look at the map in layout view.
2) Right click on the Data Frame (which will be called Layers) and select Properties.
3) Click on the tab labeled Grids and select New Grid.
4) Select Measured Grid from the list of options and then Properties. Under Intervals, enter the appropriate number of meters for the X and Y axis. Five percent of a 0.5 ha standard circular AA is ~250 m², so the axes should each be $\sqrt{250}$ or approximately 15.81 m. For the 200 m buffer, the distance is 93.79 (this is 5% of the 200 m buffer only, excludes area of the AA). For non-standard AAs, use the following equation to calculate axes length: *length* = $\sqrt{AA\ Area * 0.05}$. The axes length for non-standard AA buffer grids is *length*=$\sqrt{(Area\ of\ 200\ m\ buffer - AA\ Area) * 0.05}$. Once you have entered the axes lengths, select OK.
5) Select OK for the next two screens. You may want to give the grid a name under Grid Name, such as “standard AA grid” or “standard buffer grid”. This can be done in the Data Frame Properties under Grids. Double click on the reference grid to highlight and then rename.
6) If you want to get rid of the labels, highlight the grid you just created and select Properties. In the Labels tab, deselect all Label Axes. You can also change the line width and color under the Lines tab. The default width and color are generally acceptable.

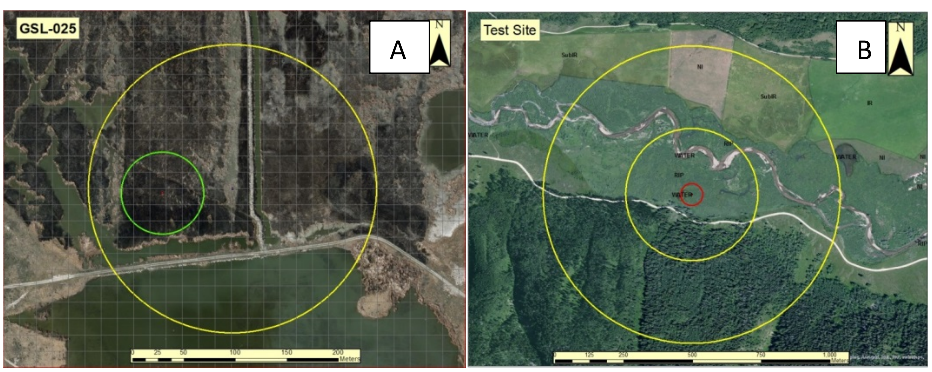

Figure 6. Detailed site map where AA was moved, with 140 m buffer (left, A), and buffer map (right, B). Buffer map includes data on water related land use to show which fields to the north are irrigated.

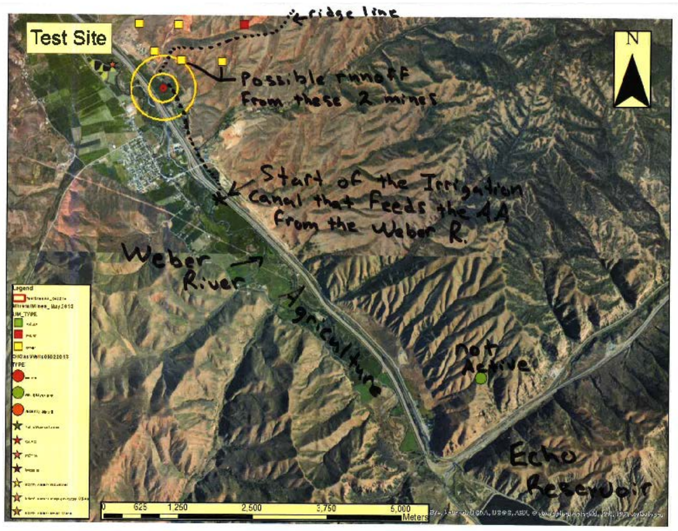

Figure 7. Landscape map showing part of contributing area to wetland site shown in center of yellow circles. Contributing area is truncated at the Echo Reservoir. Notes have been added to point out key features that relate to water source and potential water contamination. The town of Henefer and its water treatment plant are along the Weber River past the point where water is diverted from the river to the site, so they most likely do not contribute contaminants to the AA.

Figure 8. Landscape map showing part of contributing area to wetland site shown in center of yellow circles. Point source dischargers listed as major are circled on the map. The contributing area is not truncated at a major break in hydrology, but instead shows the contributing area up to the point where important stressors are included on the map.

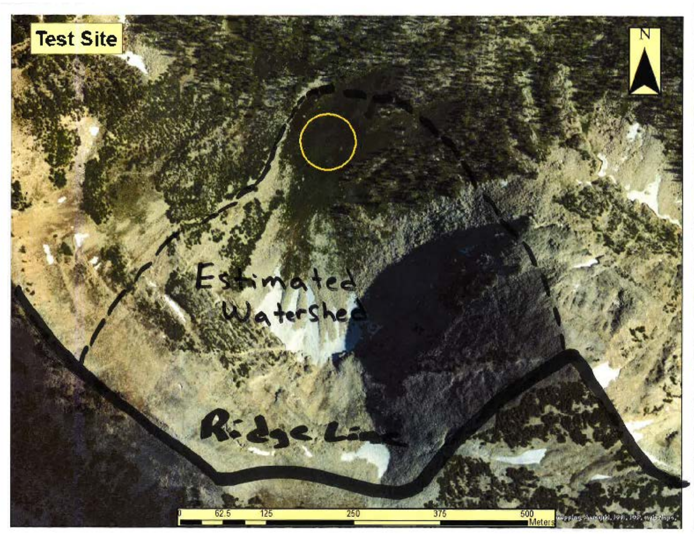

Figure 9. Landscape map showing AA (yellow circle) with very small contributing area. Main water sources may be from snow runoff, direct precipitation, and/or groundwater discharge, but will have to be evaluated in the field.

Section 5: Potential Data Sources

The UGS uses a number of geospatial data layers to assist in conducting office evaluations of survey sites. Most of these layers are publically available, and all layers used by UGS are listed in appendix A. Landscape analysis is conducted by the UGS in ArcGIS. For those without access to ArcGIS, similar analysis can be conducted with the same layers in free, open source GIS applications such as QGIS (http://www.qgis.org/en/site). Analysis can also be conducted in GoogleEarth. In many cases, aerial imagery alone may be adequate to detect stressors on the landscape.

Data on point source dischargers and other EPA-regulated stressors can be found at the Enforcement and Compliance History Online (ECHO) database (http://echo.epa.gov). ECHO can be used in a variety of ways, but one option is to search under Advanced Tools, and then Advanced Facility Search. Searches can be conducted by state and United States Geological Survey 8 digit hydrologic digit code (HUC8) watershed. Under the Facility Characteristics tab, you can filter by active/operating dischargers, major facilities, and facilities with clean water permits. You can then click on individual features to determine their receiving waters and their potential connectivity to the study site of interest. The Superfund Program is in the process of transferring data to a new database, the Superfund Enterprise Management System (SEMS). Data through November 2013 is currently publically available in the CERCLIS Public Access Database (http://cumulis.epa.gov/supercpad/cursites/srchsites.cfm). Superfund sites can be searched by state and county or by site attributes including current National Priorities List status or contaminant types.

References

Cowardin, L.., Carter, V., Golet, F.C., and LaRoe, E.T., 1979, Classification of wetlands and deepwater habitats of the United States: Washington, D.C., U.S. Fish and Wildlife Service Northern Prairie Wildlife Research Center Online http://www.npwrc.usgs.gov/resource/wetlands/classwet/index.htm.

Fennessy, M.S., Jacobs, A.D., and Kentula, M.E., 2007, An evaluation of rapid methods for assessing the ecological condition of wetlands: Wetlands, v. 27, no. 3, p. 543-560.

Lemly, J., Gilligan, L., and Fink, M., 2011, Statewide strategies to improve effectiveness in protecting and restoring Colorado's wetland resource: Fort Collins, Colorado Natural Heritage Program, 149 p.

Miller, T., and Hoven, H., 2007, Ecological and beneficial use assessment of Farmington Bay wetlands—Assessment and site-specific nutrient criteria methods development: Salt Lake City, Utah Division of Environmental Quality and Institute for Watershed Sciences, contract deliverable to the U.S. Environmental Protection Agency for grant CD988706-03, 751 p.

[Utah DWQ] Utah Department of Environmental Quality Division of Water Quality, 2014, 2012-2014 integrated report: Salt Lake City, available online at http://www.waterquality.utah.gov/WQAssess/currentIRoct.htm.

Appendix A:

Data used for office site evaluation

GIS Layers and How to Use Them

Data Sources

1) U:\GWP\Wetland\GIS\statewideReference- Statewide features that should all contain metadata (right click on file and select Item Description). The suggested way to work with these features is listed below for each feature. In some cases, data has been clipped and processed for the 2014 study area.
2) UGS SDE Features that start with the UGGP prefix are found in the UGS SDE
3) AGRC SDE Features that start with the SGID prefix are found in the AGRC SDE. Connection instructions are located here: http://gis.utah.gov/data/how-to-connect-to-the-sgid-via-sde
4) AGRC Image Server to obtain aerial imagery. Directions to connect can be found at the following url: https://gis.utah.gov/data/sgid-imagery-services/ You can also obtain elevation hillshade data and a map of the water quality assessment units here.
5) DNR SDE Features that start with the UNDR prefix are found in the UDNR SDE. Connect by downloading the file in U:\GWP\Wetland\GIS\connectionFileSDE and saving it under C:\Users\(your name)\AppData\Roaming\ESRI\Desktop10.X\ArcCatalog. For Windows XP, the path name will be C:\Documents and Settings\<youname>\Application Data\ESRI\Desktop10.2\ArcCatalog. The Application Data folder may be hidden.

Editing Files in the UGS SDE

Every day when you start working with edited files from the UGS SDE, you MUST first update your file to make sure you have the most up-to-date version. When you are done making edits, you MUST then share your edits with the rest of the team. Get in the habit of doing the following every day, even if you do not plan on making any edits. This will ensure that you and your co-workers are all working with the most up-to-date version of the data.

1) On the Editor menu in ArcGIS, select Start Editing and the name of the file you want to edit
2) On the Version Manager menu, select Reconcile. In the morning, the default settings are appropriate for bringing in any edits that your co-workers might have done. In other words, define conflicts by object and resolve conflict in favor of the Target Version.
3) If you plan on making edits, leave the file in edit mode. Otherwise, go to stop editing.
4) At the end of the day, if the file is still in edit mode, *whether or not you have made any changes*, do the following. Select Reconcile and change the conflict resolution to In favor of the Edit Version. Next, select Post. This will push changes to the database to share with co-workers.

List of Files

1) **Imagery Including Infrared (HRO collected spring or fall, NAIP collected in summer)**
   a. AerialPhotography_Color\NAIP2011_Color1Meter_4Band
   b. AerialPhotography_Color\NAIP2009_Color1Meter_4Band
   c. AerialPhotography_Color\HRO2006_Color1Foot (most of Upper and Lower Weber)

d. AerialPhotography_Color\HRO2009_Color1Foot (west side of Lower Weber)
e. AerialPhotography_Color\HRO2012Color6Inch_4Band (west side of Lower Weber)
f. Layers that are listed as 4Band can be turned to color infrared images, which helps highlight areas with high amounts of chlorophyll and thus healthy plant growth. To turn files to color infrared, first right click on the file name and select Properties. Select the Symbology tab. Change the Red channel to Band_4, the green channel to Band_1 and the blue channel to Band_2.
g. Aerial imagery can also be added as an ESRI basemap. Go to the plus sign to add layers, select Add Basemap, select Imagery, and then Add.
h. 2014 imagery from Google: To add the services to ArcMap simply go to Add Data -> GIS Servers then choose Add WMTS Server or Add WMS Server depending on your choice.
WMTS link:
https://discover.agrc.utah.gov/wmts/1.0.0/WMTSCapabilities.xml
WMS link:
https://discover.agrc.utah.gov/wms

2) Hydrology

a. Major Streams: URAP2014\URAP2014.gdb\majorWeberFlowlines File of major flowline features in the Weber River watershed. This data was taken from USGS National Hydrography Dataset (NHD) with some additional lines and attribution added and may frequently be inaccurate in the vicinity of Great Salt Lake. The Name field may be useful when referring to features.

b. **All Streams:** URAP2014\NHDH1602_20140529.gdb\Hydrography\NHDFlowline File of all mapped flowlines in the Weber watershed from NHD.

c. GSL Streams: UGGP.UGGPADMIN.GreatSaltLake\UGGP.UGGPADMIN.GSL_LiDAR_FlowPath Flowlines mapped around Great Salt Lake by UGS.

d. Lakes: URAP2014\NHDH1602_20140529.gdb\Hydrography\NHDWaterbody Polygon file with lakes, reservoirs, pond, etc. mapped by NHD.

e. Watershed boundaries: URAP2014\NHDH1602_20140529.gdb\WBD Watershed boundaries are shown at different scales. The WBDHU6 file is the entire Weber River watershed and WBDHU12 is the finest-scale watershed data available. The boundaries should generally show all the area that drains on the surface to the outlet of a watershed.

f. Statewide NHD data: statewideReference\NHDH_UT_20140529.gdb The lakes, watersheds, and flowlines can be found following a similar path to that outlined above

g. **Points of diversion:** URAP2014\URAP2014.gdb\pointsOfDiversion Points indicating the approximate location where water is diverted. Features with an A in the SUMMARY_ST field have been approved for diversion, but may or may not have been constructed yet. The SOURCE field helps indicate where the source of water for diversion is coming from. Information in the CFS and ACFT column generally indicate how much water is allowed to be diverted, but the amount of water can be aggregated over several points in a group so this number can be deceptive. Type of diversions are as follows:

i. DRAIN: Excess collection/control system (surface or groundwater) from which a point of diversion maybe established.

ii. POINT TO POINT: Point To Point diversions are not developed points of diversion. The reference is to a stream segment from which stock may drink. Often designated in 40 acre parcels.
iii. REDIVERSION: Diversion point, which diverts water which was previously diverted and released upstream. Usually associated with reservoir storage.
iv. RETURN: Point where water that has been non-consumptively used is returned back to the natural stream.
v. SPRING: Concentrated discharge of ground water coming out at the surface as flowing water.
vi. SURFACE: Streams, rivers, creeks, any water above ground.
vii. UNDERGROUND: Wells, tunnels, sumps, and underground drains.

3) Elevation

a. **GSL Elevation (1 m resolution):** L:\GEOSHARE\Elevation\DEM1m\LiDAR.gdb\GSLDEM
b. **Statewide elevation (10 m resolution):** DEM\10m_DEM_Utah_Extended.tif

4) Ownership and management information

a. **Management Units:** UGGP.UGGPADMIN.Wildlife.GSLOwnership
b. **General Land Ownership Information:** statewideReference\landOwnership\LandOwnership.gdb\LandOwnership_20140423 Private land owner specific information not available.

5) Stressors

a. **Grazing Allotments:** SGID10.FARMING.GrazingAllotments Allotments on both BLM and Forest Service Land; also, under statewideReference\landCoverLandUse\BLMGrazingAllotments_091113.gdb for more BLM-only allotments with additional meta-data.
b. **Roads:** statewideReference\roads\AGRC_Roads_20140401.gdb\Roads for statewide roads, statewideReference\roads\USFS_TransportationRoadCoreFS_20130215.gdb\TransporationRoadCoreFS_20130215 for Forest Service-only roads (which are mostly duplicated in the statewide layer, but may contain some unique roads).
c. **Trails in the Forest Service:** statewideReference\roads\Trails_UintaWasatchCacheNF.shp.
d. **Mapped water related land use data:** UDNR.WRE.WeberRiverLU2007.
e. **2011 modelled land cover data:** statewideReference\landCoverLandUse\nlcd_2011_landcover_2011_edition_2014_03_31_clipped.img.
f. **Dams:** URAP2014\URAP2014.gdb\dams Locational information on dams is often incorrect. Use the DamType field to determine size of dam and Name field to determine likely location of dam if unclear in imagery.
g. **Oil and gas wells:** URAP2014\URAP2014.gdb\oilGasWells. Field UGS_status shows whether feature is plugged and abandoned or (mostly) active. Mostly active features may be temporarily out of use, but not yet permanently removed. LA_PA_Date is the date that well was plugged and abandoned. Additional information on metadata for this file, including types of wells, is available for the statewide layer.

h. **Superfund Sites:** statewideReference\EPA_facilities\superfundPolygons.shp This file contains polygon features of the approximate location of Superfund sites in the Weber River watershed. Additional information about Superfund sites located near wetlands of interest can be found by searching for the Superfund site name under http://www2.epa.gov/region8/utah-cleanup-sites.
i. **Mines:** UDNR.OGM.MineralMines Use the field Status to determine whether or not a mine is Active or Retired. Some mines that are shown as Active may not show any surface disturbance. These mines may either be underground mines, or the mine permit may be processed but the mine not yet active (mine_stat field may say PRO).
j. **Water quality assessment units:** map server (where aerial imagery is) under SurfaceWaterQuality. Units are probably from 2010 report so may not always line up with the latest integrated report.
k. **Point source discharge permits (UPDES facilities):** statewideReference\EPA_facilities\UPDESfacilities_05092013_UTM.shp The field Permit_Typ indicates whether feature is considered “major” by the EPA. Major municipal dischargers include all facilities with design flows of greater than one million gallons per day and facilities with EPA/State approved industrial pretreatment programs. Major industrial facilities are determined based on specific ratings criteria developed by the EPA/State. MainType indicates the particular type of discharge permit received by a facility. Storm water-construction permits will often be fairly minor and temporary in nature and can be ignored. Definition of categories of dischargers follow:
    i. Biosolids - Biosolids are the nutrient-rich organic materials resulting from the treatment of sewage sludge.
    ii. Concentrated Animal Feeding Operation (CAFO) - CAFOs are animal feeding operations where there are more than 1,000 animal units.
    iii. Publicly Owned Treatment Works (POTW) - Any devices and systems used in the storage, treatment, recycling and reclamation of municipal sewage or industrial wastes of a liquid nature.
    iv. Storm Water - Construction – Permits associated with construction activities.
    v. Storm Water - Industrial - Permit requirements associated with non-construction activities at industrial facilities.
    vi. Storm Water - Medium/Large Municipal Separate Storm Sewer System (MS4s).
    vii. Storm Water - Small Municipal Separate Storm Sewer System (MS4s).
    viii. Blank (e.g., Standard-only) - A standard-issued individual NPDES permit without any additional permit components.

Appendix B:

Office evaluation field form

Site ID:________________		
FEATURES TO VERIFY IN THE FIELD (mark on maps and make comment on question)		
Verif-ied?	**ID**	**Description**
		`

Soil Survey Data

Map Unit Name: ____ Slope:_____________________________
Percent of AA: _______ Hydric Rating: ________ Drainage Class: _______________________________________
Depth to Water Table: ______________________________ Flooding Frequency: ___________________________

Map Unit Name: ____ Slope:_____________________________
Percent of AA: _______ Hydric Rating: ________ Drainage Class: _______________________________________
Depth to Water Table: ______________________________ Flooding Frequency: ___________________________

Map Unit Name: ____ Slope:_____________________________
Percent of AA: _______ Hydric Rating: ________ Drainage Class: _______________________________________
Depth to Water Table: ______________________________ Flooding Frequency: ___________________________

Sources of Site Hydrology	**Field Verified? Yes No**

Controls on Site Hydropattern

Within 200 m?	**Stressor**	**Severity, or N if trace/not present**	**Notes**
Y N	Control structures that regulate inflow into AA (e.g., dams, gates, stop logs, etc.)	N L M H	
Y N	Control structures that regulate outflow from AA	N L M H	
Y N	Impounding dam, dike, levee, weir, berm, road fill affecting outflow from AA (make note or circle feature(s) present)	N L M H	
Y N	Dam, dike, levee, weir, berm, road fill that blocks water to AA	N L M H	
Y N	Ditches or modified channels feeding AA	N L M H	
Y N	Ditches, drain tiles increasing outflow from AA	N L M H	
Y N	Pavement and other impervious surface in contributing area	N L M H	
Y N	Irrigation return flows	N L M H	
Y N	Upgradient water withdrawal (surfaced, ground)	N L M H	
Y N	Other:_________________________________	N L M H	

Potential Stressors to Water Quality

Stressor	Severity w/in 2 km of site	Severity in shed	Shed distance evaluated (km)
Severity: N: Extent none or trace, L: low severity or <20% of area, M: moderate severity or 20-60% of area; H: high severity or >60% of land cover Evaluate based on percent of area for features in italics; otherwise evaluate based on density and proximity of the stressors			
Developed land and other impervious surface with high likelihood of run-off	N L M H	N L M H	
Cropland (potential sources of pesticides, fertilizers, sediment)	N L M H	N L M H	
Facilities listed as "Major" in the UPDES program. **List types (#):**	N L M H	N L M H	
Non-major UPDES CAFO permittees	N L M H	N L M H	
Non-major UPDES biosolid and POTW permittees	N L M H	N L M H	
Non-major UPDES industrial stormwater permittees	N L M H	N L M H	
Non-major UPDES municipal separate storm sewer system (MS4) permittees	N L M H	N L M H	
Presence of Superfund sites or other sites with known groundwater or surface water contamination **List sites:**	N L M H	N L M H	
Oil and gas extraction, active mines	N L M H	N L M H	
Abandoned mines	N L M H	N L M H	
Large sources of sediment (visible in imagery and close to water sources) not from features listed above, such as from timber harvest, landslides, dirt roads, fires, construction, off-road vehicles, mining, gas/oil extraction. List sources:	N L M H	N L M H	

Additional Water Quality Questions

≥10% of the contributing basin is composed of land likely to generate sediment and/or nutrient runoff to site (fertilized cropland, dirt roads, pasture, clearcut forest, OHV tracks, golf course)	**Y N**
≥10% of the contributing basin is composed of land likely to generate pollutants (paved roads, parking lots, oil/gas wells, mines)	**Y N**
Site outside municipal boundaries and special service districts? (i.e. in areas where homes likely to be on septic systems)	**Y N**
Site is located within a mapped grazing allotment?	**Y N**
Over 25% of watershed is within a mapped grazing allotment?	**Y N**
What is the Anti-degradation category in the watershed where the wetland is located?	**1 2 No data**

Data on 303(d) assessment

Assessment Unit (AU) ID (e.g., UT16020102-019): ____

Report Year:________ Category: *1 2 3 4 5 Impaired Lake* Sub-Category for Cat 3:________________________

Circle impairment(s): *NONE OE bio./invert E. coli DO total P TDS other(s):*___________________________

Is AU water quality likely connected to wetland water quality? Yes:_____ No:_____

Explain____

Adjacent AU(s) IDs (if likely to contribute water): ____

Report Year:________ Category: *1 2 3 4 5 Impaired Lake* Sub-Category for Cat 3:_________________________

Circle impairment(s): *NONE OE bio./invert E. coli DO total P TDS other(s):*___________________________

Notes on adjacent AU(s), including distance to site:____

____

Appendix B:

URAP User’s Manual, Version 2.0

UTAH RAPID ASSESSMENT PROCEDURE: Method for Evaluating Ecological Integrity in Utah Wetlands

User's Manual, Version 2.0- DRAFT

Utah Rapid Assessment Procedure: Method for Evaluating Ecological Integrity in Utah Wetlands User's Manual, Version 2.0- DRAFT

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INTRODUCTION

The Utah Rapid Assessment Procedure (URAP) is a survey protocol designed to evaluate the ecological condition of wetlands in the state of Utah. Ecological condition can be defined as "the ability of a wetland to support and maintain its complexity and capacity for self-organization with respect to species composition, physico-chemical characteristics, and functional processes as compared to wetlands of a similar type without human alterations" (Fennessy and others, 2007). Condition is often evaluated in terms of degree of deviation from what is known or expected to occur at sites without any anthropogenic alteration (i.e., reference standard sites).

Condition assessments can be used to identify priority sites for restoration projects (those with lower scores) or conservation actions (those with higher scores). With repeat sampling, condition assessments can evaluate the success of restoration projects or the effects of new stressors on wetland condition. When applied to a random selection of wetlands, condition assessments can be used to make generalizations about the health of all wetlands in an ecoregion, management area, watershed, or other area of interest. This baseline data can be used to identify rare and/or threatened wetland types and common regional causes of wetland degradation and to inform management or conservation actions. The application of a single condition assessment protocol across the state of Utah will facilitate the compilation of a large body of standardized data on wetland characteristics that will further our understanding of these important and understudied natural resources.

Background on Wetland Assessments

Environmental Protection Agency Framework

The Environmental Protection Agency (EPA) has a three-tiered approach to wetland monitoring and assessment (U.S. Environmental Protection Agency, 2006). Level I assessments are generally applied broadly across a landscape and use geographic information systems (GIS) and remotely sensed data to evaluate wetland abundance and distribution, and surrounding land use. These assessments can provide a coarse estimate of wetland condition based on calculated metrics in the surrounding watershed, such as road density, percent agriculture, and presence of point source discharges. Level I assessments are relatively inexpensive and efficient for evaluating wetlands across broad geographic areas, but cannot provide specific information about the on-site condition of any particular wetland. Level 2 assessments evaluate wetland condition in the field using a rapid assessment approach. These assessments are intended to take two people no more than four hours of field time, plus up to half a day in the office for preparation and subsequent analysis, and often rely primarily on qualitative evaluation. Level 2 assessments can be used to understand ambient wetland condition, to determine sites appropriate for conservation or restoration, and, in some cases, for regulatory decision making. Level 3 assessments are detailed, quantitative field evaluations that more comprehensively determine wetland condition using intensive measures such as invertebrate or plant community enumeration or water quality measurements. These assessments require the most professional expertise and sampling time, including, in some cases, repeat visits to a site. Information from Level 3 assessments can be used to develop performance standards for wetland conservation and restoration, support development of water quality standards, determine causes of wetland degradation, and refine rapid assessment methods.

URAP is a Level 2 assessment method designed to require up to two hours of office time to prepare for field sampling and no more than four hours of field survey time. Office preparation is needed to create survey maps and gather Level I landscape data to assist with evaluation of metrics in the field. URAP surveys include either a time-constrained search for all plant species within the surveyed wetland or collection of more intensive Level 3 plant species composition data in subplots. Level 3 data can be used to calibrate and validate Level 2 methods, and Level 2 and 3 data can be used to calibrate and validate Level I landscape models. Evaluation of the inter-relatedness of results from all three levels is a helpful first approximation to determine the general soundness of methods. URAP methods were developed in part based on evaluation of inter-relatedness among levels, and the protocol will continue to evolve as more data at all three levels is collected.

Functional Versus Condition Assessments

Wetland assessments are commonly conducted to evaluate either condition or function of wetlands. Condition assessments, including URAP, are designed to evaluate the ecological integrity, or overall soundness, of wetlands. Wetlands with high integrity exhibit species composition, physical structure, and ecological processing within the bounds of states expected for systems operating under natural disturbance regimes (Lemly and Gilligan, 2013). Direct or indirect anthropogenic alteration may lead to changes in these states and a concomitant lowering of the overall integrity of the wetland. Wetlands are evaluated to determine the degree to which they deviate from a reference standard, or anthropogenically unaltered, wetland (see *Reference Standard,* below). Functional assessments, on the other hand, evaluate functional services provided by wetlands, such as the ability to attenuate flood waters or provide wildlife habitat, without regard to the overall naturalness of a site. Functional elements related directly to condition, such as the ability of a wetland to support natural plant species composition, can be components of functional assessments, but are usually not the primary focus. Maximizing some functional elements can require trade-offs with other elements; for example, using a wetland to improve water quality from a wastewater treatment plant may lead to reduced integrity of the plant community (Fennessy and others, 2004).

Functional assessments often evaluate wetlands based on services deemed important to society, whereas condition assessments are intended to be less directly tied to societal values. Functional assessments are useful to directly evaluate potential or actual services lost, to provide recommendations for appropriate mitigation or restoration to replace lost services, and to determine trade-offs when optimizing specific functions. However, it is difficult to reduce all wetland processes to a few functional services, and there may be services provided by naturally functioning wetlands that have not yet been recognized or valued by society. Condition assessments serve as a buffer against the subjectivity of societal valuation of services by evaluating wetlands based on a naturally functioning baseline. Not every wetland should be expected to provide every possible type of service, and even wetlands with few perceived societal functions may be more connected to larger processes than we are able to recognize.

Reference Standard

Reference standards are an important component of condition assessments. The reference standard condition is the condition that corresponds with the greatest ecological integrity within the continuum of possible site conditions (Sutula and others, 2006) and is usually specific to a particular class of wetland (e.g., montane meadow, saline depression). The reference standard condition can refer to the expected state prior to any anthropogenic disturbance or at a specified historic point in time, (e.g., pre-settlement of North America by European immigrants), or it can refer to the condition found at the least disturbed sites within the survey area or wetland type (Stoddard and others, 2006). The reference standard condition for URAP is adopted from Colorado Natural Heritage Program's Ecological Integrity Assessment (CNHP-EIA), which rates metrics based on "deviation from the natural range of variability expressed in wetlands over the past ~200–300 years (prior to European settlement)" (Lemly and Gilligan, 2013).

Reference standard conditions are ideally determined from field observations of undisturbed or minimally disturbed wetlands (i.e., reference standard sites). However, it can be difficult to obtain data from enough undisturbed sites to determine the natural range of variability, and in highly altered landscapes, there may be no or too few sites within particular wetland classes to determine the reference standard. Because of this, reference standards for URAP were developed based on field observations from minimally disturbed wetlands, review of relevant literature, and evaluation of conditions described in existing protocols. Reference standards may evolve with the collection of data from additional reference standard sites, particularly for wetland classes that were not visited during initial protocol development.

Wetland Classification

Classification is an important element of successful wetland assessments. The anticipated natural state of a wetland depends in large part on its major defining characteristics, such as whether it is located in an isolated depression or along a river and whether it is found in arid desert or snowy mountains. Effective assessments evaluate wetlands in relation to reference standard conditions in similar types of wetlands. To address the natural variability found in wetlands, metrics or entire assessment protocols can be developed for individual wetland classes or metric scoring can differ between classes. Metrics can also be developed that ask observers to evaluate condition in relation to that expected for the given class. This type of metric requires that observers are able to recognize the wetland type and have experience with or knowledge of similar wetlands.

Classification schemes that minimize variability within classes while avoiding the creation of too many classes or classes that are difficult to distinguish are the most useful. The U.S. Fish and Wildlife Service' s Cowardin classification separates wetlands and deepwater habitat into five systems (marine, estuarine, riverine, lacustrine, and palustrine) that are further divided based on substrate material and flooding regime or predominant vegetative life form (Cowardin and others, 1979). This system is used to classify wetlands for the National Wetlands Inventory, the most comprehensive wetland mapping conducted across the United States. However, the Cowardin system is overly general at higher hierarchical levels (i.e., riverine or palustrine emergent) and contains a very large number of classes at lower levels (over 150 classes at the subclass level). The International Terrestrial Ecological Systems Classification (Ecological Systems) was developed by NatureServe to provide mid-scale classification of terrestrial ecosystems based on vegetation patterns, abiotic factors, and ecological processes (http://explorer.natureserve.org). There are 15 wetland and riparian Ecological Systems that occur or potentially occur in the state of Utah. Ecological Systems have high degrees of vegetation structure and regional specificity that make them useful for assessments; however, not all wetlands fit easily into a single system, and systems may not yet have been developed for every wetland type. Hydrogeomorphic (HGM) classification was developed from the assumption that wetland function is most closely related to wetland hydrology and geomorphology (Brinson, 1993). Wetlands are classified as one of seven types based on hydrology and geomorphology, though regional subclasses are usually developed for assessments (http://el.erdc.usace.army.mil/wetlands/class.html). HGM classification is particularly useful for assessing site hydrology. Ecoregions are areas with similar ecosystems based on similarity of geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (Omernik, 1987). Ecoregions can also be useful to determine appropriate expectations for wetland condition. There are seven Level 3 Ecoregions in Utah, including three (Central Basin and Range, Colorado Plateau, and Wasatch and Uinta Mountains) that make up the majority of the area of the state.

Wetland classification is used in three different ways with URAP. First, several metrics are specific only to wetlands within the riverine HGM class. Second, some metrics require observers to evaluate condition in relation to what is expected for a reference standard site of the given wetland class. These metrics require either classification based on HGM class (for hydrologic metrics) or Ecological System (for metrics related to litter). Last, some metrics measured quantitatively or semi-quantitatively in the field receive final scores based on class-specific thresholds. These metrics require classification based on Ecological Systems, and may require additional calibration when new systems or regions are surveyed. Keys to the three classification systems being used for Utah, Cowardin, Ecological Systems, and HGM, are provided in appendix A.

Utah Rapid Assessment Procedure

Method Development

URAP was developed as a Level 2 rapid condition assessment method for wetlands in the state of Utah. The initial development of URAP began with field-testing of three previously developed rapid assessment protocols. Utah Wetlands Ambient Assessment Method (UWAAM) was developed for the state through adaptation primarily of methods used by California and Ohio (Hoven and Paul, 2010), though it has not been extensively tested or widely applied in the state. The EPA developed a rapid assessment protocol (USA-RAM) used in conjunction with more detailed surveys carried out as part of the 2011 National Wetland Condition Assessment (www.epa.gov/wetlands/survey). Colorado Natural Heritage Program (CNHP) developed a rapid condition assessment protocol (CNHP-EIA, [Lemly and Gilligan, 2013]) based on the Ecological Integrity Assessment developed by NatureServe (Faber-Langendoen and others, 2008). UWAAM and USA-RAM were field-tested in Snake Valley in 2010, and all three protocols were field-tested in Snake Valley and around Great Salt Lake in 2013.

At the conclusion of field-testing, we evaluated each tested metric to determine the strength of support for including the metric in a condition assessment (based on literature reviews and best professional judgment) and the degree to which metric states were clear to observers and consistently evaluated in the field. Appropriateness of overall site condition scores was evaluated by looking at the relationships between scores and both more intense vegetation data and nearby and within-site stressors. URAP metrics and scoring will continue to be refined as a broader variety of sites are evaluated, and we receive additional input from outside partners.

URAP Structure

URAP is composed of 16 core metrics and three additional metrics specific only to wetlands in the riverine HGM class (table 1). One of the metrics, the buffer metric, is composed of five individually scored subcomponents that are combined to produce a final value. Metrics are divided into five categories, including landscape context, hydrologic condition, physical structure, vegetation structure, and plant species composition.

Metrics are generally scored by evaluating which of four potential states most closely describes the assessed wetland. States reflect the continuum of potential conditions, from reference standard to highly degraded, that may be found for a particular aspect of wetland condition. States are assigned letter grades from A to D; table 2 shows a conceptualization of the differences among the grades in terms of degree of degradation, example conditions, and management priorities. Grades correspond with point values; A=5, B=4, C=3, and D=1. Some metrics have more than four states to account for a greater diversity of recognized states. These metrics include A- (4.5 points) or C- (2 points) states.

Reporting for URAP should include data on individual metrics as well as category and overall site scores. Scoring for URAP will be developed at the conclusion of the 2014 field season. Category and overall site scores may be the mean score for all sub-components or weighting may be applied to individual metrics to indicate their relative contribution to overall site condition.

The sixteen metrics are the essential components of URAP that allow for site scores to be calculated and compared to other sites. If there is not a trained botanist available to collect plant species identity and cover data, plant species composition metrics will be estimated in the field instead of calculated from plant species data. In addition to the metrics, additional data should be collected at sites whenever possible to assist with metric evaluation and provide more baseline information about Utah wetlands. Stressor checklists provide information about proximal landscape and site alterations and can help validate wetland condition scores. Data from soil pits are useful to better understand site hydrology and to help determine whether the site is truly wetland. Data on the types of structural features (e.g., mudflats, riffles) and ground cover (e.g., litter, bare soil) present at sites may be used to inform future metric development.

Table 1. Metrics included in the URAP method, listed under their relevant category. Metrics in italics only apply to riverine wetlands with channels within the AA. Metrics with an X in the Office Eval. column can be preliminary evaluated in the office and then confirmed in the field. Class calibration refers to whether metrics need to be evaluated (e.g., metric states considered in terms of other wetlands in a site's class) or scored (e.g., separate thresholds developed for different classes) with respect to either a sites hydrogeomorphic (HGM) class or general Ecological System.

Metric	Office Eval.	Class Calibration
Landscape Context		
Percent Intact Landscape	X	
Riparian Corridor Continuity	X	
Percent Buffer[1]	X	
Buffer Width[1]	X	
Buffer Condition- Soil and Substrate[1]		
Buffer Condition-Vegetation[1]		
Hydrologic Condition		
Hydroperiod	X	Evaluated-HGM
Timing of Inundation	X	Evaluated-HGM
Turbidity and Pollutants		
Algae Growth		
Water Quality	X	
Connectivity	X	
Channel/Bank Stability		
Entrenchment Ratio		
Physical Structure		
Substrate and Soil Disturbance		
Vegetation Structure		
Horizontal Interspersion		Scoring- System
Litter Accumulation		Evaluated- System
Woody Debris[2]		Evaluated- System
Woody Species Regeneration[2]		Evaluated- System
Plant Species Composition		
Relative Cover Native Species		
Absolute Cover Invasive Species		
Auxillary Metrics		
Structural Patch Richness		Scoring- System
Topographic Complexity		Scoring- System

[1]Buffer components are scored separately and then combined into a single metric.
[2]Only scored at sites with a woody species component.

Table 2. CNHP-EIA definition of assessment ratings from Lemly and others (2011).

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.

Criteria and Assumptions

The URAP is based on the overall assumption shared by many rapid assessment procedures that ecological condition in a wetland can be determined using measurable indicators that respond predictably along a disturbance gradient. We also presume that reference or minimally disturbed condition is a state that can be determined and that the condition of a site can be determined along the defined condition gradient. In addition to this general assumption, there are assumptions concerning the structure of the method that are described below. Assumptions made by URAP for scoring, metrics, and structure will be refined as additional data are collected and disturbance gradients are defined for specific ecoregions and wetland classes.

General rapid assessment method criteria

Development of URAP follows general criteria suggested for developing a rapid condition assessment method (Fennessy and others, 2007). Criteria suggest that a rapid condition assessment method:

1) can be used to measure condition rather than function
2) is rapid, taking less than a day to complete, including the office component
3) includes an on-site evaluation
4) can be validated using quantitative data
5) should assess extant conditions without consideration of past or anticipated conditions

SET-UP AND GENERAL SITE EVALUATION

This section describes the guidelines for plot set-up and collection of general site information for URAP. The information is presented for all potential URAP users, but also includes instructions specific to the Jordan watershed project. Other projects using URAP may differ in how sites are selected and thus how sites are included or excluded in the field and also may have project-specific data that must be collected in addition to the data listed below.

Site Selection and Office Preparation

The process used for site selection for condition assessment surveys will depend on the objectives of the surveys. Targeted surveys may be conducted at subjectively chosen wetlands based on monitoring needs associated with restoration, conservation, or mitigation projects or for other management purposes. If surveys are conducted at wetlands randomly chosen from within an appropriate sample frame (e.g., all mapped wetlands within a watershed, all slope wetlands in a particular ecoregion, etc.), inference about wetland condition can be made to all wetlands within the sample frame.

After initial site selection, several office tasks should be completed before field surveys, including: 1) verification that site is in sample frame; 2) compilation of stressor and site hydrology information; and 3) creation of field surveys maps. Full documentation of office evaluation methods used for the Jordan watershed project can be found in *The Utah Rapid Condition Assessment User's Guide for Site Office Evaluation- 2014.* In brief, first, evaluate randomly selected sites in a geographic information system (GIS) such as ArcGIS or Google Earth using imagery to determine whether they are actually wetlands within the chosen project sample frame. A similar process to that outlined in "Selection of Assessment Area in the Field", below, should be used in the office to keep, move, or reject randomly selected sites, with sites kept unchanged when the imagery is unclear. Second, use spatial data from state or federal agencies, Utah Automated Geographic Reference Center (AGRC), or other sources to make a preliminary evaluation of those metrics that require an initial office examination (table 1). Look for potential stressors within 500 m of each site, and make a note to examine in the field those stressors and land cover types that are unclear in the imagery. You may also want to examine the area at least 2 km upslope from sites for those sites that do not primarily receive water input via precipitation or groundwater discharge. Last, prepare site maps for field surveys using the most current and high resolution aerial imagery available. Maps should include a close-up of the site and a landscape map showing the site surrounded by 100 m and 500 m buffers. You may also want to prepare a map showing the upslope hydrology within at least 2 km of the site.

Determine Whether Site is Wetland

Surveyors must first determine whether a site is within the target population for the Jordan River project. The target population includes all wetlands, as defined by USFWS, that are less than 1 m deep. All USFWS wetlands must have indicators of wetland hydrology and should also have hydrophytic plants and hydric soils when vegetation and/or soils are present. Hydrophytic plants are those species that are assigned wetland indicator ratings of FAC (facultative- occurs in wetlands and non-wetlands), FACW (facultative wetland- usually occurs in wetlands), and OBL (almost always occurs in wetlands) by the 2013 National Wetland Plant List (http://rsgisias.crrel.usace.army.mil/NWPL). For increased efficiency, surveyors will try to determine the easiest characteristic to observe at a given site and evaluate the site for that characteristic first. For example, if a site is composed almost entirely of *Phragmites australis* (FACW), the site will easily meet the hydrophytic vegetation component. If a site currently has standing water on the soil surface, it will easily meet the wetland hydrology component. It will usually be easiest to evaluate sites for the presence of wetland hydrology first unless a site is dominated by one or a few species that have wetland indicator statuses of FAC, FACW, or OBL. If many of the dominant species are not able to be identified to species, you will not be able to use the hydrophytic vegetation component.

Evaluation of each wetland characteristics will loosely follow the Army Corps of Engineers wetland delineation and regional supplement guidelines (U.S. Army Corps of Engineers, 2008; U.S. Army Corps of Engineers, 2010; Environmental Laboratory, 1987). Some indicators only apply to a particular region so first determine which region (Arid West or Western Mountains) your site is located in. It is important to not only look for listed indicators, but to use best professional judgment to determine the likelihood of having false negatives or false positives. Hydrophytic vegetation and hydric soils at recently altered sites can be indicators of past rather than current conditions. Drier-than-normal conditions can lead to an absence of indicators of wetland hydrology at normally wet sites, and wetter-than-normal conditions and recent heavy rainfall events can lead to the presence of indicators of wetland hydrology at sites that are not wetland. Pay attention to seasonal norms, recent precipitation events, and signs of site alteration such as draining.

First, evaluate the site's landscape position. Concave surfaces, floodplains, nearly level areas, the fringe of open water or other wetlands, areas with aquitards within 60 cm of the surface, and areas with groundwater discharge as well as some areas with manipulated hydrology, such as pastures fed from irrigation ditches, are likely to be wetlands. If a site is unlikely to be wetland based on landscape position, you should still look for indicators of wetland hydrology and pull up a few soil samples using the Dutch auger to check for hydric soils (ignore vegetation unless most dominant species can be easily identified). Continue to look for indicators within an area 100 m from the original randomly selected sample point, focusing on areas in landscape positions most likely to contain wetland. If an area is in a landscape position that should support wetland but no wetland characteristics are present, make note of this fact, including mention of whether the site appears hydrologically altered and whether the site may have problem soils or other conditions that make it difficult to observe wetland characteristics. If the edge of the wetland must be determined in order to establish the AA, it is probably easiest to use the Dutch auger to determine the approximate boundary where hydric soil indicators are no longer present. *Do not worry about finding the exact jurisdictional boundary of the AA, as long as no more than 10% of the AA is composed of area that is definitely or possibly upland.*

The following is a list of the three wetland characteristics and how they should be evaluated:

1) Wetland Hydrology: Wetland hydrology is present if a site has surface water or a water table ≤30 cm from the soil surface over at least 14 consecutive days during the growing season in 5 out of 10 years (U.S. Army Corps of Engineers, 2008; U.S. Army Corps of Engineers, 2010). The growing season is defined as the portion of the year where the soil temperature is above 41°F (biological zero), but can be estimated as the median dates where the air temperature is ≥28°F in the spring and fall based on nearby meterological stations (see http://www.wcc.nrcs.usda.gov/climate/wetlands.html). Using the Indicators of Site Hydrology in appendix A, determine whether there are at least one

primary or two secondary indicators of wetland hydrology present at the site. Permanently flooded areas with water >2 m deep will be considered deepwater habitat, not wetland (Cowardin and others, 1979). For safety reasons, no more than 10% of the AA should be composed of water >1 m deep, even though this area may still be considered wetland.

2) Hydric Soils: Hydric soils are soils that are saturated or inundated long enough during the growing season to develop anaerobic conditions. Dig a quick soil pit to approximately 30 cm using a Dutch auger to look for indicators of hydric soils, using the Hydric Soil Indicators for the Arid West and Western Mountains in appendix A. If no indicators are found, dig additional pits or a deeper pit (up to 60 cm) to more thoroughly evaluate the area.

3) Hydrophytic Vegetation: Hydrophytic vegetation is composed of plant species that are adapted to grow in anaerobic soil conditions. You only need to assess vegetation if there is at least 5% aerial vegetation cover. Sites where over 50% of dominant plant species have wetland indicator ratings of OBL, FACW, or FAC have hydrophytic vegetation. If most of the dominant plant species at a site can be readily identified in the field, surveyors can evaluate this characteristic. This characteristic is particularly useful when sites are dominated by only a few species. The following steps will be used to determine which species are dominant, though these steps are not as stringent as a thorough U.S. Army Corps of Engineers determination because cover estimates are not made for all species present.
    a. Determine strata (vegetation layers) present in the area (table 3). Strata include trees (DBH ≥7.6 cm), saplings and shrubs (DBH < 7.6 cm), herbaceous plants, and woody vines.
    b. Estimate the percent of the assessment area covered by each strata. For example, all tree species combined (including trunks and canopy cover) may occupy 25% of the assessed area. If an individual strata has less than 5% cover, consider species in that strata part of a more abundant strata.
    c. Determine the cover values that correspond with 50% and 20% relative cover within the strata. For example, if the strata has 60% total cover, 50% relative cover will be 0.5 *60% or 30% total cover and 20% relative cover will be 0.2*60% or 12% total cover.
    d. Record the name(s) of the most prevalent plant species within each strata and their percent cover. You can stop recording plant species once the total recorded cover get to the 50% relative cover value (i.e., 30% absolute cover in our example). If any species have 20% relative cover (i.e., 12% absolute cover in our example) and are not on the list, add those species as well.
    e. Once the dominant species in each strata are listed, determine the percent of these species that are FAC, FACW, or OBL. A species can be counted twice if it is listed in two strata (e.g., trees and saplings).

All indicators can be a challenge to determine in the field. Wetland hydrology can be difficult to evaluate when sites are surveyed outside of the normal wet period, though often sites will at least have the FAC-neutral and topographic position secondary indicators. Hydric soil indicators will generally only be found in true soils that exhibit recognizable horizons and not on bedrock or boulder substrates or lakebed deposits. Hydric soil indicators such as iron reduction features are often absent from moderately to very strongly alkaline soils and are also often not visible in saturated soils until they dry to a moist condition (U.S. Army Corps of Engineers, 2008). It is often difficult to correctly identified all wetland vegetation during an initial field assessment. Some plant species that lack wetland indicators are upland species and other may be wetland species that are only locally common and have thus not received a national ranking. Surveyors should use best professional judgement to determine whether site is likely to have wetland hydrology, regardless of the indicators present in the field.

It may be challenging to determine status of mudflats around Great Salt because many lack both vegetation and true soils. Hydrology at the same site can vary from year-round inundation for several years in a row when lake levels are high to seasonal flooding when lake levels are intermediate to completely dry for many years in a row when lake levels are low. We assessed these sites in Google Earth to determine whether site appeared inundated during the growing season (approximately mid-April through October) in any of the images. There was generally data available from at least five growing seasons. Sites that appeared dry in imagery were not assigned for surveying.

Table 3. Evaluation of hydrophytic vegetation at a site.

Trees (DBH ≥7.6 cm) **Total Cover:** 0%

Saplings/Shrubs (DBH < 7.6 cm) **Total Cover:** 3%
Species considered as part of herbaceous plant layer because strata has less than 5% cover

Herbaceous Plants **Total Cover:** 60%
50% rel. cover: 30% **20% rel. cover:** 12%

Species: *Schoenoplectus americanus*	Cover: 15%	Rating: OBL
Species: *Distichlis spicata*	Cover: 10%	Rating: FAC
Species: *Helianthus annuus*	Cover: 4%	Rating: FACU
Species: *Tamarix chinensis* [1]	Cover: 3%	Rating:FAC

Together the cover of these four species is 32%, enough to meet the 50% relative cover requirement. No additional species have 12% cover, so these are the dominant species.

Woody Vines **Total Cover:** 0%

 # FAC, FACW, OBL species 3 **/ # all species** 4 = 75%

[1]Sapling/shrub species that was included as an herbaceous plant due to low cover in strata

Establishment of Assessment Area in the Field

An assessment area (AA) is the bounded wetland area within which sampling occurs. URAP was developed for use with circular fixed AAs of 40-m radius (~0.5 ha) whenever possible and rectangular or freeform AAs of equal or smaller area if necessary due to the shape or size of the wetland being evaluated. URAP can potentially be used to evaluate larger AAs and AAs that consist of entire wetlands, but metrics and scoring may need to be adjusted to account for these changes.

The location of AAs for the Jordan River watershed project will be randomly selected using National Wetland Inventory (NWI) data. Before site visits, randomly selected sample points will be evaluated in ArcGIS, but further evaluation will usually be required in the field to determine whether the

AA is appropriately located. Wetland for this project is any area that meets the definition used by the U.S. Fish and Wildlife Service (USFWS) for NWI mapping, as detailed above. Determination of whether an area is wetland will be conducted following the procedure outlined above. The following general principles will be followed when establishing an AA:

1) The AA should be 0.5 ha whenever possible and no smaller than 0.1 ha.
2) Regardless of AA shape, the maximum length of the AA is 200 m and the minimum width is 10 m.
3) The AA should be established in a single hydrologically connected wetland. Manmade features that denote wetland boundaries include above-grade roads, major water control structures, dikes, and major channel confluences. Natural features that denote wetland boundaries are mainly based on topography (figure 1A)
4) There should be no more than 10% upland inclusions within the AA, no more than 10% non-wetland riparian area, and no more than 10% water >1 m deep, including water in a stream channel or in the center of a pond. The AA should be shifted or reshaped to avoid upland and deep water on its edge (i.e., only inclusions within, not on the edge of, the AA are acceptable) (figure 1B).
5) The new AA must be completely within a buffer of 140 m from the original sample point. For standard 40-m circular AAs, this means that the new center point must be within 100 m of the original sample point. The AA should generally be established in the closest sampleable wetland to the original point. If a standard circular AA fits within this wetland, place the edge of the AA as close as possible to the original sample point to avoid arbitrary placement. More subjective placement may be necessary for rectangular or freeform AAs; avoid biasing placement towards or away from interesting features or difficult to sample vegetation.
6) The majority of an AA should be placed within a single Ecological System, though wetlands can have up to 20% inclusions of other Ecological Systems. If there is a firm boundary between two Ecological Systems, move the AA edge so that it only encompasses a single Ecological System. A mosaic of herbaceous and shrubby vegetation does not necessarily mean multiple ecological systems. Aquatic bed should in general be included as part of the Emergent Marsh system, but if they have a shallow edge with an indefinite bank, can be included in other systems. A few key notes about ecological systems:
   a. Many Ecological Systems are frequently encountered as patchworks of woody and herbaceous vegetation. These should be considered a single Ecological System, unless individual patches are at least 0.5 ha in size while meeting other AA dimensional requirements (figure 2)
   b. Aquatic beds and open water are typically considered part of the Arid Marsh Ecological System. However, the shallow shores that are found at some lakes and ponds often be considered part of adjacent, drier, systems. These shores transition gradually between open water to pioneering vegetation on the exposed surface to adjacent meadows or mudflats. There shores may typically be only sesaonally flooded and lack a clear bank, instead having water levels that slowly recede throughout the season (figure 3).

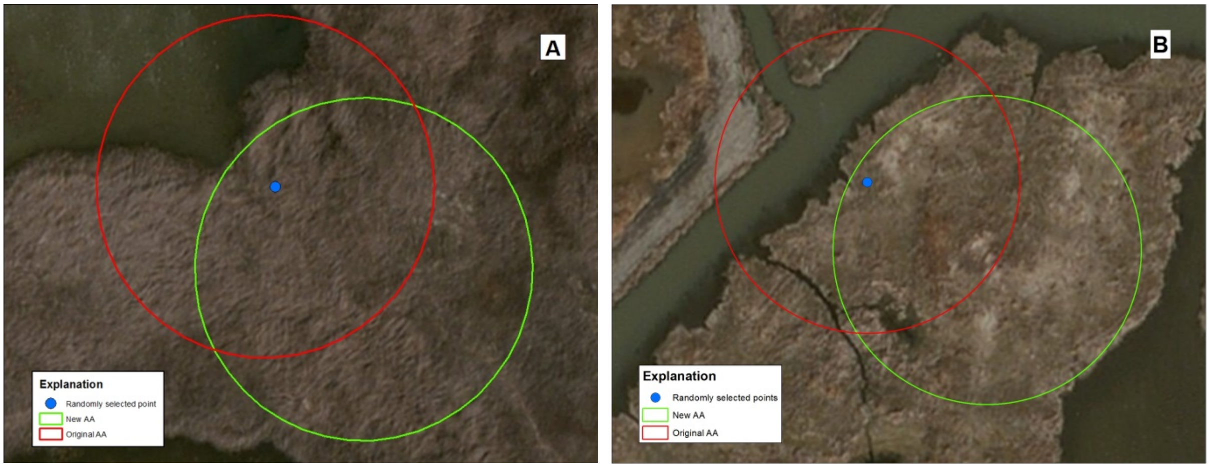


Figure 1. Examples of moving the original AA to a more appropriate survey location. On left (A), AA created by original sample point (red circle) has inclusions of water on its edge. If this water is more than 1 m deep, AA location should be shifted (green circle) so that inclusions are not directly on the AA edge, though internal inclusions are allowed. On right (B), the original AA is moved to avoid crossing the road and dike south of the canal.

Figure 2. Sites with mixture of herbaceous and woody vegetation within a single Ecological System. On left, orange polygon shows a delineated AA area of 0.5 ha. Both sites have a mixture of woody and herbaceous vegetation.

If the area in the vicinity of the sample point contains wetland, you will next determine the appropriate location of the AA. If the AA does not follow the general principles outlined above (<20% upland and deep water, crossing wetland boundaries, etc.), the AA will need to be moved or reshaped. Whenever possible, keep the AA in the wetland closest to the original sample point (so that the edge is within 60 m of the original point). If a standard 40-m radius circular AA will fit in this wetland, then shift the AA to an appropriate location. Use the following rules to guide reshaping the AA:

1) Sampleable area will fit in rectangle 0.5 ha in size. Rectangular AAs must be 0.5 ha and no narrower than 10 m wide, and no wider than 200 m (figure 4A). Example dimensions of rectangular AAs include 25 m x 200 m, 50 m x 100 m, and 70.7 m x 70.7 m. The advantage of a rectangular AA is that they are easy to set up in the field; however, many wetland edges will not conform to the edges of a rectangular AA.

2) Neither circular nor rectangular AA can be drawn. Draw a freeform AA that follows along parts of the wetland boundary and is between 0.1 and 0.5 ha in size. If the entire wetland is less than 0.5 ha, draw the freeform AA around the exact outline of the wetland (figure 4B). For larger wetlands, determine an appropriate boundary for the AA that captures approximately 0.5 ha of land. Freeform AAs must be at least 10 m wide in every direction and no longer than 200 m. If a wetland is more than 200 m long, the AA will be drawn to encompass an area at least 0.1 ha in size that follows the wetland boundary, but is truncated to be only 200 m in length.

Once you have determined the general AA shape and location, be sure to flag the AA boundary to facilitate field evaluation. For circular AAs, flag the center and points at the north, east, south, and west along the AA boundary. For rectangular AAs, flag the corner points and intermediate points along the edges to assist in delimiting the AA boundary. Flag freeform AAs frequently enough so the boundary is clear to all surveyors. For Level 3 sites, flag the corners of the plots along the AA axes while setting up the AA. Plot setup is described in more detail in the Vegetation and Ground Cover Sampling Procedure section.

Figure 3. AA placement on the edge of open water. On the left, AA was moved from the area surrounding the point because the AA overlapped both a hard edge (the dike) as well as a sharp change in elevation between the open water to the north and the dry mudflats to the left. On the right, the site could be placed anywhere along the dry or wet portions of the mudflat.

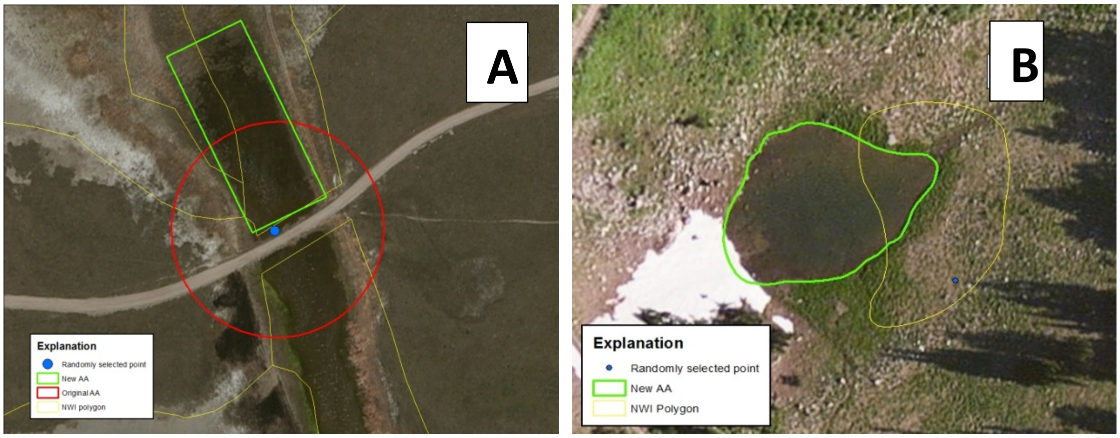


Figure 4. Reshaped survey sites. Site on left (A) was redrawn as a rectangular AA, though a circular AA potentially may also fit. At the site on right (B), the randomly selected point originally fell on the edge of the NWI polygon (yellow circle). A freeform AA was drawn in red around the probable wetland area.

Recording tracks with the OREGON 450 GPS

Stand at the location where you want to begin recording a track. Scroll on the main menu of the GPS unit until you can select the Track Manager. Select Current Track, then Clear Current Track. This creates a new, empty track. Walk around the AA boundary until you return to the location where you started. Select Current Track again, then Save Track. Save the track as UniqueSiteID_TRACK. The device will ask you if you want to clear the current track; you can select yes. Now if you select the name of the saved track and View Map, you will see the track that you just created. Touch the screen at the top where it says the track name in order to see the area. An area of about 5000 m² is equal to 0.5 ha.

General Site Information

For the Jordan watershed project, surveyors will receive an office evaluation form that includes information site ownership, hydrology, soils, and stressors. Update this information as needed once at the site, such as modifying directions or updating with additional contacts met in the field. If there is no target wetland present in the study area or the site is unable to be surveyed for another reason, fill out the "Evaluation Form For Sites Not Surveyed." Include the reason the site was rejected in the field, site photos, and any additional information that was evaluated to help make the determination. Fill in as much of the information on site vegetation as possible. This field form may also be used to help make a determination regarding whether a site is target wetland, but is not required for sites that are surveyed. For surveyed sites, record the following information on the first two and a half pages of the field forms:

Unique Site ID: Uniquely assigned site identifier that is also found on site maps and on the site cover sheet.

Site Name: Assign a professionally-appropriate site name that will make the site memorable weeks later if questions about the site come up. Names can be based on unique features of sites (e.g., Large Boulder Pond), events that occurred at sites (e.g., Bear Encounter Meadow), or any other name that helps make the site memorable.

Surveyor IDs: Record each surveyor's unique three letter ID, which will generally be the three letter initials of the surveyor. If there are surveyors at the site that are not part of the normal field crew, record their full name and their affiliation.

Date: Record the survey date using the format mm/dd/yyyy.

AA Dimensions: Select whether AA is standard circular, rectangular, or freeform in shape.

Aspect: Estimate the direction that water would flow downhill through the AA and take a compass reading in degrees in that direction (use a compass with appropriate declination; declination in Utah is approximately 10 to 13 degrees to the east; http://www.ngdc.noaa.gov/geomag-web/#declination). In some cases there may be two or more dominant aspects. For example, water may flow from a riparian edge down towards a river channel and also through a valley along the direction of channel flow. Record the aspect that best describes the aspect of the majority of the AA and make a note of the secondary aspect in the comments, below. If AA contains slopes in many different directions without a predominant aspect, such as may be found in many depressional wetlands, circle N/A. Circle Flat for wetlands with no discernable aspect.

Slope: Record slope in degrees in the AA using a clinometer or compass. Obtain a representative value that is about average for the area of the AA with the dominant aspect. As for aspect, make a note of a secondary slope for sites with two dominant slopes, circle N/A if there is no predominant slope, and circle Flat for sites with no discernable slope.

AA Placement and Dimension Comments: Make any notes necessary to describe AA placement, and AA elevation, slope, and aspect. Select the reason that best describes why the AA had to be moved for AAs that are moved, making additional notes if necessary.

Spatial Data and Site Photographs

The dimensions of the AA will dictate the type of spatial data that will be collected at each site. For circular AAs, record GPS coordinates at the center and points to the north, east, south, and west along the AA boundary. The waypoint ID for these points in both the GPS and on the field form should be *UniqueSiteID*-CEN for the center, with the C replaced by N, E, S, or W for points along the cardinal directions. For rectangular AAs, record GPS coordinates at each of the rectangle corners. Assign these waypoints as *UniqueSiteID*_COR1 through *UniqueSiteID*_COR. For freeform AAs, record a GPS track of the AA boundary and assign the track name as *UniqueSiteID*_TRACK.

Record GPS coordinates at the locations where the four AA photos are taken for rectangular and freeform AAs unless they are at the same locations as other recorded waypoints (see below, circular AA photos will be taken at the boundary points recorded above). Also record waypoint information for soil pits and water quality data locations if outside the soil pit. Assign waypoint IDs for photos as *UniqueSiteID*_P1 (P2, etc.), for soil as *UniqueSiteID*_SOIL1, etc., and for water quality as *UniqueSiteID*_WQ1, etc. At Level 3 assessment sites, take at least one photo of each intensive plot from the SW corner, facing NE into the plot for the photo. Assign IDs for photos as *UniqueSiteID*_PLOT1 for each plot 1-4.

Take at least four photos of the AA from along the AA boundary looking in towards the site. For circular AAs, these photos should be taken at the north, east, south, and west boundary points. For freeform and rectangular AAs, take photos at any four well-spaced locations that capture different views of the AA. Record a waypoint at each photo point location if there has not already been a waypoint recorded at that location. Record the aspect in the direction into the AA that the photographer is facing. Also, record the uniquely assigned camera photo number. On the Nikon CoolPix camera, this is the four-digit number followed by .jpg at the top left when you view the photo on the camera, not the number listed on the bottom right that indicates the current number of photos stored in the camera's memory.

Each of the AA photos will include a photo placard that lists the site ID, date (mm/dd/yyyy), waypoint ID, and aspect. The photo should be taken so that the placard is in the corner of the photo taking up as little of the frame as possible with little arm or body visible.

Take additional photos to capture an overview of the site (e.g., looking down on entire site from a high point) or document noteworthy features. You do not have to take a waypoint or record the aspect at each place where additional photos are taken unless the photo captures a feature that should be revisited or the photo would be useful for photo monitoring. Do record the photo number or range of numbers and a brief description when it may not otherwise be clear what the photo is capturing. At the end of the site visit, make sure that you record the unique identifier of the camera (record as camera make, either Olympus or Nikon) as well as the total number range of the photos taken at the site.

Environmental Description and Classification of AA

Collect data to describe and classify the AA. Surveyors may need to walk around the site to assess vegetation, soil, and hydrology before completing this section, particularly in regards to determining the water regime of the site. Collect the riverine-specific classification data for those sites in a stream floodplain or if AA contains a stream or river channel. Record notes and comments under the environmental and classification comments section at the end of the field form.

Composition of AA: Estimate the percent of the AA composed of true wetland, non-wetland riparian area, standing water >1 m in depth, and upland inclusions. For the Jordan watershed project, distinguish between upland and wetland using the guidelines outlined above. Non-wetland riparian areas are areas that do not meet the definition of a wetland from above, but have distinctly different plant species and/or species that grow more robust and vigorous compared to adjacent areas (U.S. Fish and Wildlife Service, 2009). Riparian areas are contiguous with rivers, streams, or lakes and influenced by surface and subsurface hydrologic processes of these features. Distinguish riparian from true wetland using the wetland determination guidelines above. If it is difficult to distinguish riparian from upland areas, estimate based on available information, take photos, and makes notes.

Wetland origin: Note the probable origin of the wetland by evaluating the degree to which the wetland's hydrology has been altered or created. Features indicating alteration or augmentation include ditches from a spring that increase the total area watered by a spring, dikes and levees that increase water retention time, and excavation to increase water depth. Wetlands are considered altered if the hydropattern or the extent of inundation are likely to be moderately to severely affected by the alterations. Created wetlands can be intentional in origin, such as for mitigation projects or stock watering ponds, or accidental, such as from irrigation seepage. Wetlands that are recreated in areas that historically had wetlands, such as the restoration of former wetlands on agricultural fields, should be considered created. Use topographic maps and aerial imagery to help with evaluation as well as discussion with land owners whenever possible. Make note of any questions or important information used in evaluation at the space at the bottom of the form.

Ecological system: Use the key in the reference cards (appendix A) to select the Ecological System(s) present within the AA and their percent cover. Select the fidelity to indicate how well the classification fits the AA. High fidelity means that the surveyors feel the AA matches the system description closely, and that they do not question its appropriateness. Medium fidelity means that the AA has many elements of the chosen system with some noticeable inconsistencies. Low fidelity should be selected when none of the systems seem like an appropriate fit and the selected system is just the best available match.

Cowardin classification: Record the Cowardin system and subsystem for the dominant type within the AA, based on information in the reference cards (appendix A). Also record any Cowardin modifers present at the site.

HGM class: Select the appropriate hydrogeomorphic (HGM) class using the key in the reference cards (appendix A). For sites that have more than one HGM class, select the dominant class and make a note of other classes present. For sites that are created, select the HGM class that most closely describes the functioning of the wetland and make notes to explain your decision; for example, a wetland created by irrigation seepage may be considered a wetland with low or medium fidelity to the slope class. Select the appropriate fidelity to classification based on the description of fidelity options from above.

Confined vs. unconfined: Determine whether the AA is in a confined or unconfined valley setting, based on comparison of the valley width and bankfull width. Bankfull width is the width of the stream channel at the beginning of flood stage and can be estimated based on indicators including the lower limit of perennial vegetation, scour marks on rocks or trees, or change in particle size. Valley width is the width of the area over which water could easily flood during high water years without encountering a hillside, terrace, man-made levee, urban development, or other confining feature. Most confined riverine wetlands will be too narrow (<10 m) for sampling.

Proximity to channel: Note whether the AA includes the channel and either stream bank (the area within the bankfull width). For sites that do not contain the channel, record the distance from the AA edge to the channel center. This distance does not need to be exact and can be estimated using aerial imagery.

Stream flow duration: Record your best estimate as to whether the stream is perennial, intermittent or ephemeral. Perennial stream flow year-round, and ephemeral streams only flow during or immediately after precipitation events. Intermittent streams flow seasonally in response to snowmelt and/or increased groundwater and subsurface flow from increased periods of precipitation.

Stream depth: Indicate whether the stream channel is dry, contains water only in pools, or is flowing. For flowing water, estimate the mean depth of the stream at the time of the survey. If streams are not able to be waded (≥ 1 m in depth, or lower if conditions are dangerous for surveyors), *do not* measure stream depth directly in the stream. Instead, either circle ≥ 1 m or make your best guess of stream depth from the shore.

AA representativeness: Note whether the AA comprises/contains the entire wetland and, if not, determine whether the AA has a low, moderate, or high degree of similarity to the surrounding wetland.

Wildlife observations: Make note of any wildlife observed during the site visit. If species cannot be identified, they can be noted more generally (e.g., dozens of small fish swimming in pools, a few tadpools, etc.). Take photographs of wildlife when possible, particular of egg masses and frogs when observed.

Major vegetation patches: List major vegetation patches within the AA. Patches are distinct vegetation patches that share similar physiognomy and species composition. Individual patches must be at least 10 m^2 (~ 3.2 m x 3.2 m) in a 0.5 ha AA and must cover a total of at least 5% of the AA. Unvegetated patches (included under water) can be listed if *individual* patches are at least 5% of the AA; otherwise, their cover should be included with the vegetation they are surrounded by. Record remaining cover as "other" and list cover type (e.g., streambed, bare ground, etc.) so that cover adds up to 100%. Record for each patch the overstory vegetation type as emergent, scrub-shrub, forested, aquatic bed or floating, or other. Record the estimated water regime for each species, referring to the water regime descriptions in the Cowardin key. When evaluating the water regime, consider survey timing (at the beginning, middle, or end of the growing season), regional precipitation patterns (drought, flood, or typical year), and site indicators of hydrology including species composition, hydric soil indicators, and presence of water during survey.

Vegetation and Ground Cover Sampling Procedure

We will collect data on vegetation and ground cover (e.g., litter, algae, sediments, etc.) at every site. Quantitative data may be collected in plots at a subset of sites designated as Level 3 Assessment Sites; information on this procedure is presented below. At both Level 2 and 3 sites, we will record a list of all plant species found within the AA during a search that will last no more than one hour. At Level 3 sites, this search will be conducted after plots have been evaluated. Plants that are unknown will be recorded and collected or keyed out after the search has ended. Record the predominant height of each species as one of six height classes and the predominant phenology as vegetative, flowering, fruiting, or standing dead. Species that are recorded as standing dead *must* have been alive during the current growing season. Cover should be recorded as the estimated percent of true vegetation cover, which is the area where shadow would be created by a species when the sun is directly overhead. This differs from the more generalized "canopy cover" that estimates cover as the area within the perimeter of any plant canopy.

Ground cover information will be recorded across the entire AA at Level 2 sites and additionally in plots at Level 3 sites. Estimate the cover of bare ground composed of different size classes of sediment. Estimate the cover of the three listed litter types and predominant litter material present at the site. Dense canopy will be divided between canopy where the litter extends to the wetland surface and canopy that has pockets and gaps at the wetland surface. Estimate the cover of water at the site during the time of the survey as well as the potential cover of shallow and deep water. Cover of bare ground, litter, and water should add up to between approximately 90 and 100%; the remaining ground cover is composed of the bare stems and trunks of plants and is usually pretty minor. Algae cover estimates will be made for desiccated algae, wet filamentous algae (algae floating in the water column that is long and stringy), and macroalgae (generally chara). Also note whether submerged vegetation has a covering of epiphytic algae, sediment, or other film and whether substrate algae covering rocks or woody debris is present. Record the litter depth, water depth for water < 20 cm, and water depth for water > 20 cm in four locations across the AA.

We will collect basic information on the vertical biotic structure at sites. We will not use this information as a condition assessment metric because we do not have enough information to determine the expected amount of vertical structuring in Utah wetlands; instead, we will compile baseline information on the type of structuring found at different wetland classes throughout Utah. For all vertical biotic structure measurements, we will allow standing (upright) dead vegetation from the current growing season to be counted as a plant layer. Check all of the plant layers that are present at the site. Each layer must occupy 5% *of the portion of the AA that is capable of supporting that layer.* In other words, submerged or floating plants must occupy 5% of the area with appropriate cover of water and emergent plants are not expected in areas with exposed bedrock or on mudflats. Plants representing each layer should have a height difference of at least 20 cm from plants representing other layers. In other words, if one species is generally around 40 cm tall and a second species is generally around 55 cm tall, these two species should be considered part of a single layer, even though based on definition one is short and the other medium. Next, estimate the cover class of the area of the AA with overlap of three or more layers and of two plant layers. A marsh composed of cattail will have no overlap. If the same marsh has only a few very small patches of duckweed, the marsh will still predominantly have no overlap. However, if there are patches of duckweed scattered throughout much of the marsh or even low cover of duckweed throughout, the marsh area would have overlap of two layers. In other words, for an area to be counted as having overlap, there does not need to be continuous overlap throughout the area but the overlap cannot be very uncommon.

Level 3 Vegetation and Ground Cover Sampling

In addition to the data collected at the AA scale (Level 2, described above), in a subset of sites vegetation and groundcover data may be collected in defined-area plots. URAP will follow a flexible-plot layout adapted from the EPA's National Wetland Condition Assessment (NWCA) that is being used by other regional condition assessment methods. Absolute cover for vegetation and ground cover will be collected in four 10 m X 10 m plots placed at set locations along the cardinal axes of the standard 0.5 hectare circular plot (figure 5). Plot 1 is located on the northern axis, 15 m north of the center. Plot 2 is located on the eastern axis, 25 m from the center. Plot 3 is located on the southern axis, 5 m from the center. Plot 4 is located on the western axis, 15 m from the center. Plots are located on the left or counterclockwise side of the axis from the center facing in the cardinal direction of the axis.

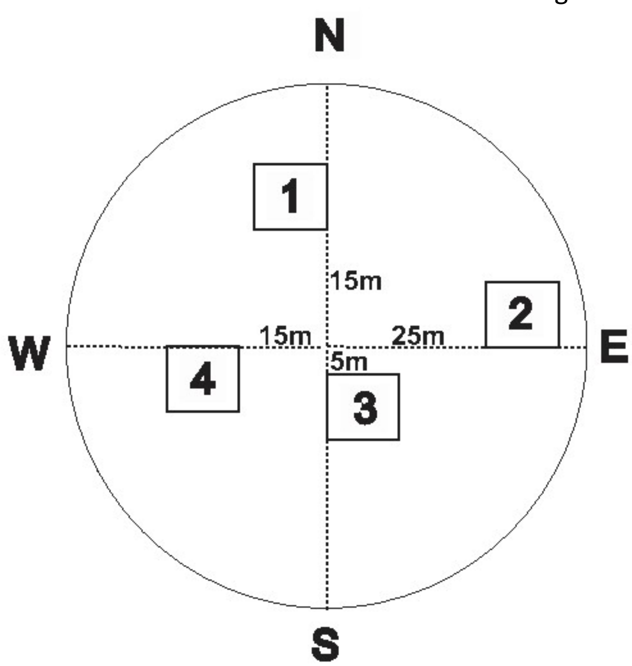


Figure 5. Level 3 plot layout for standard 0.5 hectare circular plot.

Plot placement will vary based on the layout of the AA. When a layout other than the standard layout is used, either randomly select three AA plot locations or use a methodic method that fits within the AA dimensions (e.g., placing plots every 25 m along two transects across a 60 m rectangular AA).

Setup and Documentation of Vegetation Plots

Markers placed at the AA boundary will be used to guide the 1 hour search for species at the AA scale for both Level 2 and Level 3 sites. For Level 3 sites, the cardinal axes of the AA will be used to mark quantitative vegetation plots during plot setup. Care should be taken not to trample vegetation in these areas by always walking on the right side of the axis when traveling through the AA and during setup. Plots will be located on the left or counter clockwise side of the axis when walking from the center of the AA. When setting up the AA boundaries, place a flag at 15 and 25 meters on the northern and western axes, at 25 and 35 meters on the eastern axis, and at 5 and 15 meters on the southern axis to mark one side of the Level 3 vegetation plots. Using a measuring tape or a measured 10 m rope, lay out the 10 m X 10 m plot perpendicular to the axis and flag the boundaries as much as necessary to mark the edge of the plot or use rope to demark the edge of the plot.

Prior to surveying each plot, at least one photo should be taken from the SW corner of each plot, face NE into the plot. No GPS coordinates will be collected for Level 3 vegetation plots unless plots are located in non-traditional locations.

Collection of Plant Specimen

Species not identified in the field will be collected and brought to the office for later identification. Collectors will do their best to obtain both flowering and fruiting individuals and to collect root samples of grass and forb species. Collectors will place each specimen in newspaper in a field press and write the unique survey site ID on the newspaper's edge with the collection number. No more than three percent of individuals in a population and no more than five cutting from perennial species will be collected to ensure the longevity of a species at sites. Collections will be numbered sequentially starting at one each day of sampling. If the same species is seen at two different sites during the same day, the same collection number can be used for both observations. Observers will fill out a collection slip (appendix A) for each specimen, including the site ID, date, observer initials, collection number and notes about the species height, flower color, presence of unusual odors, and any other features of note. This collection slip will be folded around the stem of specimen to aid with later identification. Once at the office, specimen that are not immediately identified will be put in an office press and placed in a drying oven set to approximately 38°C for at least 24 hours.

Soil and Water Chemistry Measurements

At all sites, surveyors will dig one soil pit in the dominant vegetation patch of the AA. A plant zone is considered dominant when it covers 30% or more of the AA, meaning that there may be up to three soil pits per AA. If standing water is present in the dominant zone patch, the pit should be dug on the edge of the water when possible to help facilitate digging the pit, as long as the vegetation near the location is representative of that zone. When the site lacks surface water, the soil pit should be dug at a representative location in the dominant vegetation zone. If no hydric indicators are present in any of the soil pits, one additional pit can be dug per plant zone, but no more than five total pits should be dug per site. The soil pit should be dug towards the beginning of the condition assessment to allow time for the water table to equilibrate and the sediments to settle out (at least 30 minutes but more time is preferred). Take a GPS point and record the waypoint for every soil pit dug (see "Spatial Data and Site Photographs", above). Water chemistry measurements will be taken from the soil pit whenever possible. If water chemistry data is taken elsewhere, record a GPS point at these locations as well.

Soil samples are collected using a sharpshooter shovel and an auger. Whenever possible, dig the soil pit to a depth of 60 cm or deeper in an attempt to reach the water table. Before digging, remove any loose litter (leaves, needles, bark) but do not remove the organic surface which typically contains plant matter in various stages of decomposition (U.S. Army Corps of Engineers, 2008). The shovel should be used first to remove the top soil core. Place the core on a tarp next to the soil pit and then use the auger to reach the desired depth. *It is important to place the cores on the tarp in the order and direction they are removed.* Once the hole is dug, measure and record the depth of the soil pit and carefully arrange the core sample collected to equal that measurement.

With the guidance of *Field Indicators of Hydric Soils in the United States* (U. S. Natural Resources Conservation Service, 2010) and the appropriate *Regional Supplement to the Corps of Engineers Wetland Delineation Manual* (U.S. Army Corps of Engineers, 2008 and 2010), examine the soils for hydric indicators and describe each distinct soil layer. For each layer, first determine the layer form, whether the layer is mineral, mucky mineral, or organic. Next, record the depth, color of matrix and any dominant and secondary redox features (based on a Munsell Soil Color Chart), soil texture (refer to soil texture flow chart in appendix A or record as peat, muck, mucky peat if organic), and percent living roots and coarse material if present. Coarse materials are sediments larger in size than sand (> 2 mm). Refer to table 4 for a description of the redox feature types. Some redox concentrations are difficult to see under saturated conditions in the darker soil colors. In this case, you should give the soil time to dry out to a moist state, allowing the iron and manganese to oxidize and redoximorphic features to show (Natural Resources Conservation Service, 2010). Once the entire soil sample has been evaluated, record the presence of any hydric soil indicators found within the soil sample (if no indicators are found, you may need to dig an additional soil pit).

Table 4. Features that may be present within soil pits.

	Concentrations	**Redox Depletions (Depleted Matrix)**	**Reduced Matrix (least common)**
Chemical reaction	Accumulation of Fe-Mn oxides (oxidation of ferrous to ferric)	Matrix of low chroma (≤2) and high value (≥ 4) where Fe, Mn oxides have been stripped out (depleted)	"Reduced" means the level of reduction necessary to change ferric Fe+2 to ferrous Fe+3
Formation and location	Found in forms of masses (soft masses), pore linings (root channels, ped faces), or nodules and concretions (firm to extremely firm bodies)	Most common along root channels or cracks and the redox depletion abundance and size tends to increase with frequency of inundation events	Soil matrixes where low chroma is the result of chemical reduction of Fe, but not total depletion of Fe
Requirements	Oxygen **must** be present and most often is formed in the upper horizons	**Must** be anaerobic (no oxygen)Should be evident within a couple of years if wetland hydrology is present during the growing season	Oxygen **must** not enter the soil (needs to be saturated) and must be biologically active to produce electrons
Color	Fe tends to be reddish/ orangeish in color (rusty), Mn tends to be darker in color	Grayish Color	In some cases Fe+2 is oxidized to Fe+3 upon exposure to oxygen within 30 min (although time can vary) resulting in rusty color

Record the time as soon as the soil pit is dug. Right before the condition assessment is complete, examine the pit and measure the water table if present by recording the depth to free water. *Record* *depth to water that is below the ground surface as a positive number and the height of surface water above the ground surface as a negative number.* Record the time once again to show how long the pit settled for. If free water table is not present, record whether or not the pit is filling with water (based on water beading on surface of pit). If the soil appears saturated, record the depth at which saturation begins. To test for saturation with organic soil, squeeze a sample between your thumb and index finger one time. If a drop of water falls out, then the soil is saturated. For mineral soil, place a chunk of the soil in your hands and shake (like dice) for a few seconds, then examine the soil for water glistening on the surface. Glistening indicates that the soil is saturated.

Whenever possible, water chemistry data will be collected in at least two locations per vegetation patch. If water is evident after the settling period in the soil pit, use a bailer or cup to obtain a water sample from just below the water surface level in the pit, being careful not to disrupt the sediments too much. Place water samples in a plastic container to minimize electromagnetic interference when measuring EC and TDS. Use a handheld multiparameter meter to measure pH, electroconductivity (EC), and temperature of the water sample. Rinse tips of meters with some of the water before collecting measurements and rinse with fresh water before storage. The total-dissolved-solids (TDS) value can be obtained based on the default meter conversion factor of 0.5 between EC and TDS. An important note: periodically test meter accuracy in known EC and pH solutions and calibrate them as needed and proper storage requirements need to be met. Water chemistry samples can also be collected from a shallow wetland well if a soil pit is not dug at a site. After all soil and water measurements are completed, make sure to fill the soil pit back in so that no hole is left in the AA that may trip a person or livestock.

Collect at least one surface water chemistry measurement per site if water is available or more if there are several representative locations. Circle whether the surface water sample is from within a channel, a pool outside the channel, immediately adjacent to a location of groundwater discharge (e.g., a springhead pool), or the base wetland surface (such as within a marsh). Record the total depth of the water where the sample is obtained and circle to indicate whether water is standing or flowing. Record the color of the water (see table 5 for an explanation of what different water colors may indicate). A transparency tube will be used to measure turbidity at selected sites where surface water is present. Transparency is inversely related to turbidity and total suspended solids (Dahlgren and others, 2004). Follow the instruction below to record an accurate measurement (adapted from Minnesota Pollution Control Agency's Water Chemistry Assessment Protocol for Depressional Wetland Monitoring Sites http://www.pca.state.mn.us/index.php/view-document.html?gid=10251). Last, record pH, EC, TDS, and temperature data using the handheld meter.

Transparency Tube Directions:

1. Carefully lower the cleaned tube into the water trying not to stir up any sedimentation that could contaminate the sample. After the tube is filled, cup the open end with your palm so no water is lost. To avoid disrupting settled particles, sample locations greater than 15 cm in depth whenever possible. If helpful, a smaller cup or container can be used to collect the water to pour into the tube.
2. Stir or swirl the tube to ensure the sample is homogenous, being careful not to induce air bubbles. Out of direct sunlight and without wearing glasses, look down the tube to try and view the black and white disk on the bottom. Your eye should be roughly 10 to 20 centimeters from the top of the tube.
3. If the disk is not visible when the 60 cm tube is filled, slowly release water out of the valve on the bottom until you can distinguish the contrast between the two colors. Record the depth of the water in the transparency tube at which you can first distinguish the two colors using the measurements on the side of the tube.

4. Circle = if water had to be released from the tube in order to see the black and white disk. Circle > if the disk was visible when the tube was filled; this indicates that the total visibility is greater than the 60 cm of the filled tube.

Table 5. Water colors and their potential causes as described by Utah Water Watch Tier 1 Monitoring, Utah State University's Water Quality Extension (http://extension.usu.edu/utahwaterwatch/).

Color	Potential Causes
Clear	Usually associated with healthy waters. However, clear waters may be polluted with colorless substances. Very clear water without any living organisms indicates a pollution problem.
Brownish	Often results from decaying organic matter or lots of sediment.
Greenish	Slightly greenish water results from the presence of microscopic plants or algae and usually indicateshealthy conditions. Deep green, or pea soup color, often results from an overabundance of algae (phytoplankton). Heavy nutrient loads from fertilizers, animal waste, and poor sewage treatments often promote heavy amounts of algae.
Reddish	May result naturally from drainage through soils rich in iron and tannins.
Blue	Clear cool waters often have a blue color. Strong blue colors can result from glacial runoff.
Orange	May indicate runoff from mines or oil well; may result naturally from drainage through soils rich in iron and tannins.

Collect water quality data for laboratory analysis from one location per site if an appropriate location is available. Water quality data should be collected from surface water, not from water within soil pits. Water can be collected from inlets providing water to the wetland, the base surface water from a marsh, from a springhead, or from a channel, pond, or lake that is hydrologically connected to the site. Water should not be collected from small pools where has collected. Photograph the sampling location and collect all other water chemistry data at the location as well. Be careful not to overfill water sampling bottles because preservatives may be flushed from the bottle.

Stressor Checklist

Background: A stressor checklist can be an easy way to identify features on the landscape that may have adverse effects on wetlands. Most of these stressors are caused by anthropogenic activities or processes, which are affecting or have affected the natural system of the wetland through modifications and degradation. Several examples are: development, diking and ditching, waste water treatment facilities, and run-off from impervious surfaces. These "threats" are graded on how they affect the AA directly and not the wetland as a whole. While this checklist will not be part of the URAP metrics, it will be used to examine the correlation between stressors present and the condition site score of the AA.

100 Meter Stressor Checklist: This stressor checklist focuses on a 100 m buffer surrounding the AA. Prior to the field visit, mark the stressors in that buffer that can be seen in the aerial imagery on the site map. Verify these stressors in the field and make the appropriate changes if needed and add any new stressors found. For every stressor identified, record the extent of the area it occupies within the 100 meter buffer and whether it is hydrologically connected to the site upstream, downstream, both directions, or neither. Then examine the severity the stressor has ***directly*** on the AA in the following categories: hydroperiod, water contaminants including nutrients and toxins, sedimentation, and vegetation stress. Also, assess the general severity of the feature- a highway will usually have a higher general severity than a low-use road. *Pay close attention to the stressor direction (slope) from the AA as the severity can vary (e.g., a gravel road down slope might not have any effects on sedimentation or water quality but it could still affect wildlife use).* When assessing for browse and herbivory, exclude normal damages by native wildlife. Extensive damage by native wildlife should be noticeable without having to spend an extended period of time searching for it. A helpful way to assess the effects of stressors such as roads, trails, and development have on vegetation in the AA is to think how they are potentially introducing invasive plant species. Examine the edges of those stressors and identify if invasive plant appear to be approaching towards the AA. The severity of timber harvest and the removal of other vegetation should be based on how well the site appears to have recovered from the disturbance. For example, if there is still evidence of soil compaction and erosion caused by machinery and lack of the expected new growth for the habitat type, then a site will be listed as more severe. If the disturbance occurred years ago and the site seemed to have recovered and is now stable, the severity will most likely be low to none. Wild/ prescribed fire severity should only be based on the effects it had at ground level and to the soil, not the woody vegetation. For example, the organic matter and mineral soil will be lightly charred ~ 1 cm deep for a low severity fire, while a server burn will have deeply charred the organic matter at depths of >10cm. Refer to table 6 for a brief description and examples of the different stressor categories the checklist assess

Table 6. Categories of stress for evaluating buffer stressors.

Category	Description and examples
Hydroperiod	Features that affect the frequency and duration of inundation and drawdown to the AA (e.g., ditching up-slope that's diverting water off-site, roads blocking natural run-off to sites).
Water Contaminates- Nutrients Enrichment/toxins	Hypertrophication to the AA (e.g., livestock defecating, fertilizers, waste treatment discharge into the AA water source leading to algae blooms and pollutants) (e.g., petroleum products, pesticides, metals and other toxic chemicals) that are released directly or indirectly in the AA water source e.g., petroleum enriched runoff from impervious surfaces or bio solid discharges into the AA water source.
Sedimentation	The settling of suspended particles into the AA (e.g., soil and debris runoff from a recently plowed field).
Vegetation Stress	How the vegetation responds to the different stressors, (e.g., soil compaction limits the plants ability for root penetration and water permeability and how the stressor helps to spread invasive and noxious plants).

AA Stressors and Physical Habitat Evaluation: Walk through the AA to mark any stressors that are present directly within the AA. AA stressors to vegetation, physical habitat, and hydrology are evaluated. For each stressor, only consider how it affects the category you are assessing. For example, livestock grazing evaluated in the vegetation stress is only for grazing and browsing, while trampling and digging falls under physical habitat component and pugging would affect the hydrology.

RAPID ASSESSMENT METRICS

Landscape Context Metrics

Metric: Percent Intact Landscape

Definition and background: The percent intact landscape metric evaluates the size of the intact landscape (i.e., area with buffer land cover) directly connected to and within 500 m of the AA. For metric evaluation, the area of this intact landscape is converted to a percent by dividing it by the total area of a 500 m radius circle surrounding the AA. Wetlands embedded in large natural landscapes are likely to be subject to less human disturbance, such as hikers that flush birds from nests. Large natural landscapes may also support more species movement through the landscape. This movement is important for processes such as seed dispersal, maintenance of genetic diversity in plants and animals, and allowing animals to access a variety of habitats. Wetlands that are surrounded by natural land cover are more likely to be connected via dispersal to other wetlands and are more likely to support animals that need both upland and wetland habitat. We have selected a distance of 500 m for the sake of this metric because 1) it is a distance commonly used in other wetland assessments, and 2) it is not too large of an area to evaluate in the field.

Measurement protocol: In the office using GIS, draw a circle that extends 500 m out from the edge of the AA on an area map with the most up-to-date aerial imagery available. Spatial data such as land cover and road layers may help in evaluating features in the landscape. Print map of buffer for use in field assessments. In the field, verify or update land cover shown on the aerial imagery. Then sketch out the area of buffer land cover within which the AA is embedded. Small non-buffer inclusions (e.g., a dwelling in the middle of an unfragmented landscape) should be subtracted from the intact landscape area. Once an intact area reaches a road (do not consider low-use dirt tracks) or other linear non-buffer landcover, a hard boundary is formed even if natural land cover exists on the other side. Table 7 shows the levels of severity and the percent intact landscape. The zone of a road's influence, such as trash and road fill along the road border, should also be considered as non-buffer land cover. Estimate the percent of the 500 m radius area that forms an intact landscape contiguous with the AA and select the appropriate state from the metric. This estimated percentage will be later verified in GIS by sketching out the new buffered land cover boundary and making changes to the estimated percentages as needed (see buffer land cover list in table 8).

Table 7. Metric Rating for Percent Intact Landscape.

Rank	State
A	Intact: AA embedded in >90–100% unfragmented, natural landscape.
B	Variegated: AA embedded in >60–90% unfragmented, natural landscape.
C	Fragmented: AA embedded in >20–60% unfragmented, natural landscape.
D	Relictual: AA embedded in ≤20% unfragmented, natural landscape.

Metric: Percent Buffer

Definition and background: Percent buffer is the percent of the edge of an AA that is surrounded by land cover that serves as a buffer against stressors. Land cover plays an important role in either mitigating or contributing stressors to a wetland. Natural or semi-natural land cover may mitigate impacts from more distant stressors by filtering out phosphorous, nitrogen, sediment, and other water quality pollutants, whereas some land cover types release these pollutants into a wetland. Surrounding land cover can also influence wetland temperature and microclimate and contribute organic matter to the wetland (McElfish and others, 2008), and sites with more natural land cover may be subject to less human visitation and thus less anthropogenic disturbance. Surrounding land cover is also important for wildlife habitat and providing wildlife and gene flow connectivity between wetland patches.

Deciding whether particular land cover classes qualify as buffer can be difficult because the impact of most land cover types varies depending on the potential stressor being evaluated. For example, low-use dirt roads may contribute sediment to a wetland but not impede movement for mammalian wildlife species. One way to evaluate contribution of land cover to wetland pollutants is via export coefficients and event mean concentration (EMC) values that are assigned to land cover classes based on the degree to which they release particular pollutants into a system. Export coefficients and EMC values can be difficult to calibrate and depend heavily on underlying conditions in a region. However, regional or national values can be useful for comparing and ranking sources of nutrient loads (Lin, 2004), and we used these values to help determine land cover types that should be considered buffer and non-buffer for this metric.

Measurement protocol: Determine the percent of the perimeter of the AA that has buffer land cover using the definitions of buffer land cover provided in the table 8 below. Very small sections of buffer land cover will not count towards the percent buffer; buffer cover must extend at least 10 meters along the perimeter of the AA and 10 meters out from the edge of the AA to be counted (see buffer percentages in table 9). When evaluating a land cover type not specifically listed, consider the extent to which that cover type contributes TSS, nutrients, and other pollutants to a wetland. Make note of any unusual cover types so that they can be reevaluated in the office if necessary.

Table 8. Land cover types considered buffer and non-buffer.

Buffer Land cover	Non-buffer Land Cover
• Vegetated natural and semi-natural areas including forests, grasslands, shrublands, wetlands, and open water • Natural unvegetated areas including permanent snow or ice cover and natural rock outcrops or sandy and gravel areas. • Old fields undergoing succession • Rangeland[1] • Partially vegetated pastures[1] • Recently burned natural land with at least some vegetative recovery[1] • Low use tracks such as single-use ATV tracks or undeveloped and unmaintained dirt tracks that are vegetated in the middle and only used once or a few times a year. • Vegetated levees, natural substrate ditches • Recreational areas with little substrate disturbance (bike, horse, and foot trails with narrow width of influence)	• Commercial and residential areas, parking lots, railroads and train yards • Lawns, sports fields, traditional golf courses • Dirt and paved roads • Mined areas • Agriculture including row crops, orchards, vineyards, clear-cuts • Animal feedlots, poultry ranches, animal holding pens with mostly bare soil • Severely burned land with little vegetative recovery • Recreational areas with substantial disturbance (wide paths, paved areas, trash/dumping) • Oil and gas wells • Wind farms

[1]These land cover types can vary considerably in the degree to which they serve as buffer cover. We will use the buffer condition-soil metric to help distinguish between soil disturbance-related features with varying degrees of buffer functionality.

Table 9. Metric Rating for Percent Buffer.

Rank	State
A	Buffer land cover surrounds 100% of the AA.
A-	Buffer land cover surrounds >75–<100% of the AA.
B	Buffer land cover surrounds >50–75% of the AA.
C	Buffer land cover surrounds >25–50% of the AA.
D	Buffer land cover surrounds ≤25% of the AA.

Metric: Buffer Width

Definition and background: The degree to which a buffer can mitigate impacts to a wetland depends in part on buffer width. Wider, intact buffers can filter out more pollutants before they reach a wetland and also often have less human visitation and associated stress. A review by the Environmental Law Institute found that effective widths for wetlands are 9 to 30 m for sediment and phosphorus removal and 30-49 m for nitrogen removal (measured as 30–100 ft and 100–160 ft by McElfish and others, 2008). Recommended widths for wetland water quality for the Minnehaha Creek Watershed District in Minnesota were between 15 and 30 m, depending on the particular function and buffer slope (measured as 50 and 100 ft by Emmons & Olivier Resources, 2001). A meta-analysis found that 30 m buffers could remove between 68 and 100% of sediment, nitrogen, phosphorus, and pesticides, with differences in effectiveness depending on pollutant, slope, and vegetative cover of buffer (Zhang and others, 2010). Unfortunately, most buffer width studies have been conducted in the eastern United States. Buffers in the arid west that are composed of natural vegetation may need to be wider than buffers examined in other studies due to generally sparser vegetation, more contributing water coming from sheet flow, and differences in common soil types (Buffler, 2005). Johnson and Buffler (2008) recommended minimum buffer widths between 21 and 67 m (and wider if certain features were present in the buffer) for agricultural areas in the intermountain west, depending on soil type, slope, and surface roughness.

Measurement protocol: On aerial imagery of the AA, draw eight transects extending 100 m from the edge of the AA along the cardinal and ordinal directions (N, NE, E, SE, S, SW, W, NW). Estimate the length of continuous transect that runs from the AA edge to the first place without buffer land cover for each transect (table 10). Estimates can be based on aerial imagery, but features that are not clear from imagery or that may have changed since the imagery was taken need to be investigated in the field.

Table 10. Metric Rating for Buffer Width.

Rank	State
A	Mean width >95 m.
A-	Mean width >75 and ≤95 m.
B	Mean width >50 and ≤75 m.
C	Mean width >25 and ≤50 m.
D	Mean width <25 or no buffer exists.

Metric: Buffer Condition- Soil and Substrate

Definition and background: Evaluating buffer soil and substrate condition allows us to better determine the state that the buffer land cover is actually in and thus its buffering capacity. For example, both rangeland and pasture areas can vary in their condition from heavily overgrazed with extensive areas of exposed soil to intact except for occasional shallow hoof prints. Areas with disturbed soils may contribute more sediment to wetlands and lose their effectiveness at filtering pollutants. Many soil disturbances cause channelization, which can provide a pathway to move water more quickly towards a wetland rather than filtering the water through buffer land cover. Sites with soil disturbance also may provide less habitat for wildlife and be more prone to plant invasion.

Measurement protocol: Walk through enough of the 100 m buffer to determine the extent to which the substrate in the buffer is altered or disturbed. Evaluation can be supplemented by examination of aerial imagery. Only evaluate area that is considered buffer, not other land cover types. Select one of the statements in table 11 that best describes the condition of the buffer land cover. The percentages expressed in the states should be used for guidance only; use on-site judgment to determine the most appropriate score and make a note if the amount of disturbance of the buffer soil differs from that expressed in the selected state. For example, a site with 5% cover of severe disturbance located very far from the wetland edge and no other more proximal disturbances would probably be rated as B instead of C. Evaluate this metric by thinking about both the severity and spatial extent of disturbed soil conditions in the buffer.

Table 11. Metric Rating for Buffer Condition – Soil and Substrate.

Rank	State
A	Intact soils. Unnatural bare patches, pugging, and soil compaction are absent or extremely rare with minimal impact (e.g., one or a few shallow vegetated single-use ATV tracks). Cryptobiotic soil, if expected, is present and undisturbed.
B	Moderately disrupted soils. Some amount of bare soil, pugging, compaction or other disturbance exists, but extent and impact are minimal. Areas with more severe disturbances are absent or rare.
C	Extensive moderately disrupted soils. Areas with more severe disturbance may occur in a few sections of the buffer or disturbance may be more widespread and of moderate inpact.
D	Unnaturally barren ground, highly compacted soils, or other severe soil disturbance covers a moderate to large portion of the buffer or more moderate disturbance covers the entire buffer.
NA	No buffer land cover present.

Metric: Buffer Condition-Vegetation

Definition and background: The condition of buffer vegetation can influence many properties in the AA. The presence of non-native plant species in the buffer can make the AA susceptible to invasion, particularly when the non-natives are hydric species. Non-native plants in the buffer can also lead to changes in nutrient cycling, fire regimes, and other processes that may in turn affect the AA. Non-native species may differ in their ability to control pollutant loads and modify hydrologic properties in the surrounding landscape.

Measurement protocol: Walk through enough of the 100 m buffer to determine the dominant vegetation, supplementing the evaluation with examination of aerial imagery. Do not forget to look for the presence of *Bromus tectorum* (cheatgrass) and for non-native grasses associated with pastures. Only evaluate area that is considered buffer land, not other land cover types. Select one of the following statements in table 12 that best describes the condition of the buffer land cover.

Table 12. Metric Rating for Buffer Condition–Vegetation.

Rank	State
A	Abundant (≥95%) ***relative*** cover native vegetation and little or no (<5%) cover of non-native plants.
B	Substantial (≥75–95%) ***relative*** cover of native vegetation and low (5–25%) cover of non-native plants.
C	Moderate (≥50–75%) ***relative*** cover of native vegetation.
D	Low (<50%) ***relative*** cover of native vegetation.
NA	No buffer exists.

Hydrologic Condition Metrics

Hydropattern is a term used to describe the frequency, duration, timing, and aerial cover of inundation of a wetland (Kadlec and Reddy, 2001; U.S. EPA, 2008). Hydropattern is a defining characteristic of wetlands that exerts substantial control on their physical and biological properties. We use two metrics to evaluate components of hydropattern: hydroperiod (frequency and duration of inundation) and timing of inundation. Changes in site microtopography caused by soil disturbance within the site that may impact water distribution are captured in the soil and substrate disturbance metric and not specifically addressed in the hydrologic condition metrics. Hydropattern and timing of inundation are often interrelated; for example, a site that receives water inputs later in the year than is natural may have a shorter duration of inundation due to increased evapotranspiration. We are most interested in stressors to hydropattern that occur during the growing season (period between last spring freeze and first fall freeze) because water availability during this time drives plant species composition and thus the biotic structure of wetland plants. Furthermore, many aspects of nutrient cycling, such as decomposition, mineralization, nitrification, and denitrification, are likely to occur much more slowly at lower temperatures due to decreased plant and microbial activity (Picard and others, 2005; Kadlec and Reddy, 2001). Changes to hydropattern outside the growing season can also affect functional services such as flood attenuation; this metric does not emphasize these potential changes.

Metric: Hydroperiod

Definition and background: Hydroperiod is the term used to describe the frequency and duration of inundation of a wetland (U.S. EPA, 2008). Hydroperiod is a defining characteristic of wetlands that exerts substantial control on their functioning. Duration of wetland inundation has been shown to affect richness and community composition of invertebrate (Tarr and others, 2005) and amphibian (Snodgrass and others, 2000) species. Hydroperiod, including inundation frequency, also may affect nutrient cycling in wetlands (Tanner and others, 1999). A review by Webb and others (2012) found that changes in the duration of wetland inundation lead to changes in plant species composition and frequently (though not consistently) altered measures of plant establishment, plant growth, and species richness. The same review found insufficient evidence due to paucity of studies to evaluate most effects of inundation frequency on wetland vegetation, though they did find that changing frequency generally did not affect plant richness. Similarly, Robertson and others (2001) found that frequency of flooding (one annual flood versus two) did not affect macrophyte species richness and biomass in floodplain wetlands in Australia. Frequency of inundation refers both to the number of flood events within a year (intra-annual frequency) as well as to the number of years when flooding at a site occurs (inter-annual frequency). Large changes in inter-annual frequency are likely to change plant species composition because some species that require flood or dry conditions to germinate may not establish often enough to maintain a viable seed bank and absence from flooding for one or more seasons in sites that are naturally regularly flooded will allow less tolerant species to invade.

Measurement protocol: First, identify of all ***major*** sources of water to the site (table 13). For example, most sites in Utah will receive some water via snowmelt and precipitation, but these sources will only be major for sites that are relatively isolated from other water sources (e.g., rain-filled depressions, snow-melt created lakes). Alluvial aquifer refers to locations with elevated water tables adjacent to rivers and streams. Next, use the stressor checklist and description of site hydrology obtained during the office evaluation to assist in evaluation of this metric, making sure to consider each stressor's impact relative to the overall water budget at a site (table 14). . The inundation duration can be longer or shorter due to increases or decreases in the amount of water reaching a site or due to modifications that affect the inflow and outflow at sites, including obstructions to flow, channelization, and geomorphic modifications like soil compaction or pugging. The frequency of inundation will sometimes change with the removal of natural water sources or the addition of new water sources. Sites that receive more controlled inputs of water (e.g., due to controlled release from dams) will often be inundated less frequently but for longer duration. Sites that receive more flashy inputs (e.g., due to large input of runoff from impervious surfaces rather than via groundwater infiltration) will often be inundated more frequently for shorter duration.

Table 13. List of major water sources.

Natural Sources	*Unnatural Sources*
overbank flooding from channel	irrigation via direct application (incl. managed ditch)
overbank flooding from lake	irrigation via seepage (e.g., leaking ditch)
groundwater discharge	irrigation via tail water run-off
alluvial aquifer (subsurface floodplain flow)	discharge from impoundment release
natural surface flow	urban run-off/culverts
direct precipitation	pipes directly feeding wetlands
direct snowmelt	other (list)

Metric: Timing of Inundation

Definition and background: This metric evaluates the degree to which wetlands receive water during seasonally appropriate times. Timing associated with water levels can be important for wetland flora and fauna; for example, species' development stages may need to be synchronized with particular water levels in order to successfully reproduce (U.S. EPA, 2008). A review of the effects of changes in hydropattern on wetland plants found that changes in inundation timing frequently affect the establishment, growth, and species richness of wetland plant communities (Webb and others, 2012) and timing of flooding affected macrophyte species richness and biomass in floodplain wetlands in Australia (Robertson and others, 2001). For the sake of this metric, we assume that artificial flooding or drawdowns near the end of the growing season will have a smaller effect on sites than events at the beginning or middle of the growing season. These earlier periods are likely to be more critical for the reproduction and development of many avian, amphibian, and plant species.

Measurement protocol: Use the stressor checklist and description of site hydrology to assist in evaluation of this metric (table 15). Consider each stressor's impact relative to the natural timing of inundation at the site and the overall water budget. For example, a site that now only receives water from irrigation return flows during periods of the growing season that were normally dry would score lower than a site that receives a natural spring influx of water as well as an equal amount of return flows as the first site. When evaluating artificial sources of water, consider whether the site would have normally received any water during the time at which the artificial water source is inputting water into the AA. Examples of potential stressors are listed under each possible state, though a state that has most of the listed stressors may fall into a lower state due to their cumulative effect. Think of timing of inundation as related to the timing of pulses of water, not the overall amount of water, reaching a site.

Table 14. Metric rating for hydroperiod.

Rank	State
A	The hydroperiod, including frequency and duration of inundation and drawdown, within the AA is natural. There are no major hydrologic stressors that impact the hydroperiod. There may be long-established, distant sources of groundwater or surface water extraction within contributing area to the AA, but these only have minimal impact on dampening the water levels in the AA and do not change the overall pattern of water level fluctuation within the AA.
B	Hydroperiod is predominantly controlled by natural hydrologic processes, but deviates slightly from natural conditions. The duration may be slightly longer or shorter due to decreases or increases in the amount of water reaching the AA or due to minor modifications affecting the inflow and outflow of water. The frequency of major inundation periods within a year is natural, though there might be one or two fewer or additional minor peaks of inundation. The site may be somewhat more susceptible to a change in inter-annual inundation frequency, but only in response to more severe drought or flood years. Potential deviations include: • small decrease in inundation duration (e.g., small diversions that remove water during peak inundation, small enlargement of channel exiting AA, small noticeable effects of nearby water withdrawals, slightly flashier floods due to cover of impervious surfaces in the contributing area) • small increase in inundation duration (e.g., minor inputs of tailwater irrigation, outflow slowed by small amount of sedimentation blocking channels, small increase in natural berm height, slightly more controlled water input due to dams on tributaries feeding the AA) • change in intra-annual frequency by one or two minor periods of inundation (e.g., secondary flooding in fall with duration and depth much less than primary flooding) • rare (only in extreme years) change in inter-annual flood frequency (e.g., due to impact of groundwater pumping or water withdrawals or management priorities).
C	The hydroperiod of the AA deviates moderately from natural conditions. The pattern of inundation and drawdown is still predominantly natural, but may be more noticeably shifted in duration or may occur in conjunction with more noticeable changes in frequency. Some potential deviations include more moderate examples of stressors to duration listed above as well as occasional (2 or 3 years out of 10) change in inter-annual flooding frequency.
C-	The hydroperiod of the AA deviates substantially from natural conditions. A natural pattern of inundation and drawdown is still evident, but may be more dramatically shifted in duration and frequency, or may be secondary to anthropogenically created hydropatterns. The hydropattern may be predominantly or entirely created, though it still somewhat resembles a natural analogue. For example, seepage from a canal during the growing season may create conditions somewhat similar to a natural seep or spring. Artificially impounded sites that are inundated and allowed to draw down in a somewhat natural pattern will usually fall into this category. Some potential deviations include more severe examples of stressors to duration listed above as well as frequent (every 3 or 4 years) change in inter-annual flooding frequency.
D	The hydroperiod is dramatically different from any natural wetland analogue. The duration and frequency of inundation may be completely artificially controlled. Natural hydrologic inputs to the wetland may be severely limited or eliminated. The wetland may be in steady decline and may not be a wetland in the near future. Sites are more likely to rate in this category when they experience drying conditions rather than simply because they receive artificial water inputs because the latter sites will often be at least tangentially analogous to a natural wetland. Sites in this category will often experiences extreme changes in the frequency of flooding. Examples of conditions that may lead to sites being rated in this category include: • extreme(relative to natural period) alteration of inundation duration (e.g., groundwater pumping causing spring to run dry except briefly in the spring) • extreme (almost every year or several times per year for sites that are flooded annually) change in flooding frequency (e.g., dikes blocking all flow to site except during years of extreme floods, groundwater pumping or water withdrawal that leave sites dry most years, detention basins that undergo short fill and release cycles following heavy precipitation events).

Table 15. Metric Rating for Timing of Inundation.

Rank	State
A	Site inundation has no to very little deviation from natural timing. Sites that fall into this category generally have no or only very distant stressors to the water sources in their contributing area and no on-site stressors that affect water input, including artificial water sources.
B	Sites have a small shift in inundation timing of hours up to several days or inundation timing is natural for the majority of inflow to sites, but there are either small additional inputs of water during the growing season at times when the site would not normally receive water input or moderate additional inputs of water near the end of the growing season. Examples of potential deviations include: • accelerated timing of water input due to straightening of input channels • accelerated timing of water input due to small or distant areas of impervious surface in the contributing area • delayed timing of water input due to flow regulation on tributaries • small inputs of irrigation water via seepage or tailwater runoff in addition to naturally timed influxes of water • moderate levels of artificial fall inundation due to increased flow in channels at the end of irrigation season or moderate amount of water released from impoundments.
C	Sites have a moderate shift in inundation timing of several days up to three weeks or inundation timing is mostly natural (shifted up to hours or days) for the majority of inflow to sites, but there are either moderate additional inputs of water in the middle of the growing season at times when the site would not normally receive water input or large additional inputs of water near the end of the growing season. Examples of potential deviations include: • accelerated timing of water input due to moderate to large areas of impervious surface in the contributing area • delayed timing of water input due to water control structures that more directly control input to sites • water added to impoundments according to management schedule only somewhat in tune with seasonal patterns • moderate inputs of irrigation water via seepage or tailwater runoff in addition to naturally timed influxes of water • pumping of water into site at times when site would normally not receive input • large levels of artificial inundation in the fall for management purposes.
C-	Sites have a large shift in inundation timing of three weeks up to two months or inundation timing is somewhat natural (shifted up to days or weeks) for the majority of inflow to sites, but there are large additional inputs of water during the growing season at times when the site would not normally receive water input. Examples of potential deviations include: • naturally timed water input almost entirely absent (or naturally small) and majority of water influx is now from irrigation return-flows, irrigation seepage, or wastewater effluent pipes during times that site would normally be dry • site managed with very little regard to natural timing of water inputs (e.g., multiple large additional inundations throughout the dry season with only a little inundation during normal flood periods).
D	Sites have an extreme shift in inundation timing of over two months or there is a large shift of weeks to months in inundation timing as well as large additional inputs of water in the middle of the growing season during times when the site would not normally receive water. Sites that no longer receive natural water inputs due to anthropogenic stressors most years will also score in this category. Examples of potential deviations include: • site completely dry except when it rains because pumping has eliminated natural groundwater supply • site only flooded late in the growing season when water from up-gradient impoundments are released.

Metric: Turbidity and Pollutants

Definition and background: Water quality is difficult to assess visually in the field, but there are some water quality problems that are frequently visually apparent. Turbidity is the most readily apparent water quality indicator. Water with high turbidity has high amounts of suspended or dissolved particles in the liquid that scatters light, giving it a cloudy or murky look (http://water.epa.gov/type/rsl/monitoring/vms55.cfm). High turbidity can alter the chemical and physical structure of that water. The increased amount of particles absorbs more heat, increasing temperature and decreasing the concentration of dissolved oxygen the water holds. Turbid water also limits light penetrating into the water column, decreasing the potential for photosynthesis. The settling of the particles can have significant effects on the life cycle of aquatic organisms by covering spawning beds and benthic macroinvertebrates communities, especially in slow moving waters.

High turbidity can occur naturally; for example, due to natural erosion following high runoff events and staining in the water caused by the release of tannins from the breakdown of certain vegetation types. However, turbid waters can often be an indicator of anthropogenic stressors degrading water quality. Storm-water runoff and anthropogenic soil disturbance, such as certain agricultural practices and off-road travel, can potentially contribute to sedimentation that affects turbidity.

The particles found in turbid waters provide a host for other detriments to water quality such as bacteria and metals. Turbidity therefore can be a useful indicator of potential pollution in water (http://water.usgs.gov/edu/turbidity.html). Water color can be a more direct indicator of pollutant issues; for example, red-orange tint to water can be caused by mine tailings (Lemly and Gilligan, 2013). Another indicator of pollutants is the presence of an unnatural oily sheen on the surface of the water caused by petroleum products. This unnatural sheen will swirl and join back together when an object is pulled through it. This is a key difference from naturally produced sheens, which are formed by iron and manganese oxidizing bacteria and pull apart, breaking into plates when they are disturbed.

Measurement protocol: When water is present in the AA, select the state that best describes the AA in table 16. For sites that score C or D, take a photo of the water so it can be referenced later, and record possible sources of water quality degradation (e.g., substrate disturbance, urban runoff, extensive livestock use, etc.). High turbidity may be natural in riverine wetlands during times of peak runoff and in filled playas due to their fine sediments, whereas other depressional wetlands are generally not naturally turbid though they may be affected by recent weather events (Lemly and Gilligan, 2013). Record the presence of turbid water even when it appears natural, but check off that contamination appears natural at these sites.

Table16. Metric Rating for Turbidity and Pollutants.

Rank	State
NA	No water present in AA.
A	No visual evidence of degraded water quality. No visual evidence of turbidity or other pollutants.
B	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.
C	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.
D	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.

Metric: Algae Growth

Definition and background: Although algae occur naturally in the environment and can provide beneficial values, high concentrations of algae or algal blooms can be detrimental to ecosystem health. Thick algal mats block sunlight from penetrating into the water column, reducing photosynthesis potential. Decaying algae cells consume high levels of oxygen, leading to potential die-offs of oxygen-dependent aquatic life. Similarly to turbidity, the presence of algae can be an indicator of water quality issues. Excessive algal growth is typically a response to high levels of nutrients, mainly phosphorus and nitrogen, in combination with warm temperatures and exposure to sunlight.

Measurement Protocol: See table 17

Table 17. Metric Rating for Algae Growth.

Rank	State- Wet Sites	Rank	State- Dry Sites
A	Water is clear with minimal algal growth and there is no visual evidence of degraded water quality.	AB	Site has little to no evidence of dried algal mats.
B	Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness.	C	Site has moderate to large patches of dried algal mats.
C	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).	D	Site has extensive dried algal mats. Mats may be relatively thick, cover much of the AA, and/or are matted around vegetation.
D	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).		

Metric: Water Quality

Definition and background: Water quality is an important component of wetland condition. Changes in nutrient loads and sediment input and input of metals and potential toxins can sometimes lead to toxic algal blooms, plant species composition shifts including species invasion or dominance by one or a few species, die-offs of wildlife species, shifts in macroinvertebrate composition and abundance, and food web effects. About one-third of all streams and lakes assessed for the 2010 Utah Integrated Report Water Quality Assessment 305(b) Report (Utah DEQ Division of Water Quality, 2010) were found to be impaired. In streams, total phosphorus, total dissolved solids, sedimentation, water temperature, physical substrate alteration, and benthic macroinvertebrate community impairment were the most common reasons for impairment.

Direct measures of wetland water quality are impossible to obtain without laboratory analysis of water samples that are collected at multiple points in time. This metric evaluates possible or likely nutrient, sediment, and toxin impacts to water quality via analysis of nearby water quality stressors, the degree to which they are buffered from sites, and the severity with which they are expected to occur. Evaluation predominantly focuses on areas likely to contribute surface water to sites due to the difficulty in determining contributing areas of groundwater, though known or likely groundwater contamination should also be taken into account.

Measurement protocol: Potential impacts to water quality at sites will be evaluated both with pre-screening in the office as well as an on-the-ground assessment. In the office, determine the area likely to contribute surface water to the AA based on aerial imagery, topographic maps, and/or elevation data. This can be done using Google Earth, ArcGIS, or paper maps. The contributing area to an isolated wetland may be composed of a small hillside upgradient from the site whereas some sites that receive input from streams and rivers may have very large contributing areas. When considering the severity of stressors in the contributing area to these latter AAs, consider the degree to which stressors are buffered from the sites by major changes in hydrology. For example, major reservoirs upstream from a riverine site may act as a buffer from stressors upstream of the reservoir, though this buffer effect is likely to be smaller for managed impoundments with short water retention times (Miller and Hoven, 2007). Stressors to a small stream will be diluted when that stream joins a larger river, and stressors to a large river can be diluted by major tributaries. Within the contributing area, determine the degree to which the landscape is composed of development, cropland, and livestock grazing. Also look for the presence of oil and gas extraction close to the site. Determine whether there are Superfund sites (http://cumulis.epa.gov/supercpad/cursites/srchsites.cfm) or major clean water act permittees (http://echo.epa.gov) likely to influence your site. Also determine whether the major water source to the AA has been listed as impaired by the state of Utah (http://mapserv.utah.gov/SurfaceWaterQuality). See *The Utah Rapid Condition Assessment User's Guide for Site Office Evaluation- 2014* for additional guidance for conducting an office evaluation for this metric.

During the field survey, you will collect data on water quality stressors within 200 m of the site as part of the buffer stressor checklist. Evaluation of buffer water quality stressors should consider the severity of the stressor, how the inputs of the stressor reach the AA (e.g., through direct surface flow, overland travel across dirt or pavement, or overland travel across well-vegetated land cover), and the distance from the AA to the stressor. In some cases, the AA and the entire 200 m buffer may encompass the same wetland. Surveyors may use their discretion to consider inputs directly on the wetland edge and how they may affect the AA water quality when they are overland inputs found just outside the 200 m buffer in these wetlands.

Determine the state that best describes the water quality of the AA (table 18). Use the examples of stressors listed under each state as guidance only. For example, a site that has many of the stressors listed under the B state may be rated C due to the aggregation of all of the stressors. Remember to evaluate stressors based both on their severity and the frequency with which they are likely to reach a site. For example, sediment from a burned hillside may only reach the site during run-off events whereas irrigation return flows to a connected stream may reach a riverine site more frequently. Water that sits in a reservoir may lose a lot of sediment before being released, and water that runs through wetland before reaching a site may be buffered from many water quality stressors.

Metric: Connectivity

Definition and background: This metric is a measure of the degree to which water within the wetland is connected to the surrounding landscape. Unaltered connectivity between a wetland and adjacent uplands or wetlands is important for increasing complexity by the formation of varied saturation zones (California Wetlands Monitoring Workgroup, 2013a) and for maintaining natural inputs into the wetland. Sites with unimpeded connectivity are more likely to accommodate rising floodwaters without dramatically changing water levels in a manner that increases stress to wetland plants and animals (Lemly and Gilligan, 2013). This metric is evaluated both on the immediate edge of the AA and for the actual wetland edge. The former value provides information on the percent of wetland area within a survey sample frame that is connected to adjacent land, and the latter value provides information on the actual connectivity of individual wetlands with surrounding land cover.

Measurement protocol: Score this metric at both the edge of the AA and the edge of the whole wetland (table 19). If wetlands are very expansive in size, assessment can be made at the edge of the area approximately 500 m from the AA instead of for the whole wetland. Wetland edge will be defined by major breaks in hydrology or transitions from wetland to upland or deepwater habitat (e.g., the edge of a wetland adjacent to water will be considered at the location where the water becomes deepwater habitat instead of wetland). Determine the percent of edge that consists of features, such as very steep banks, levees, concrete walls, rip-rap, and road grades, which could restrict the lateral movement of rising waters. When evaluating features to determine whether they interfere with connectivity, consider the extent to which they create gradual versus abrupt transition zones between edges and the surrounding landscape.

Table 18. Metric Rating for Water Quality.

Rank	State
A	There are no water quality stressors likely to impact site. Within the AA, soils are intact with no evidence of damaging livestock grazing. Any anthropogenic stressors within 500 m up-gradient from the AA must be minor (e.g., small areas with unnatural bare ground or lightly grazed pasture, a few fertilized lawns, etc.) and unlikely to impact the site (e.g., separated from site by at least 50 m of thick vegetation and on a shallow slope from site). The land cover of the contributing area for any channels reaching sites is predominantly natural with no oil and gas extraction, mines, Superfund sites, or point source dischargers that are likely to impact the site's water quality.
B	Site likely to receive infrequent or minor inputs of water quality stressors. Stressors may include: • occasional/light livestock grazing within site (evaluate based on soil disturbance that could lead to sedimentation and density of animal dung- if grazing appears very light and infrequent, may be an A) • up-gradient stressors within 500 m of site that are minor or somewhat buffered from site or well-buffered if more severe (e.g., run-off from dirt road with narrow buffer or expansive area of exposed sediment within 100 m vegetated buffer) For sites receiving most water from channels : • entire contributing area has <20% development or cropland, though these land uses are absent or trace within 2 km of site • entire contributing area has few oil and gas wells, mines, or point source dischargers and all are distance from site • streams and lakes that contribute directly to the site are not listed on the 303d list.
C	Site likely to receive moderate input of water quality stressors. Stressors may include: • moderate livestock grazing within site (evaluate based on soil disturbance that could lead to sedimentation and density of animal dung) • up-gradient stressors that occur within 500 m of the site that are more moderate in extent or severity and less well-buffered from site (e.g., run-off from low-density development directly reaching site or nutrient input from a farm; consider both the buffer between the stressor and slope; vegetated very low slope may be B and unvegetated very steep slope may be D) For sites receiving most water from channels: • entire contributing area has ~20-60% development or cropland, though these land uses are less prevalent within 2 km of site • entire contributing area has a moderate number of oil and gas wells, mines, or point source dischargers that are distant from site or potentially a few that are closer to the site • streams and lakes that contribute to the site are not listed on the 303d list unless water quality is likely to improve before reaching the wetland (site is distant from impaired section, water flows through reservoirs or emergent vegetation that may help attenuate water quality stressors, etc.). • streams and lakes that contribute to site are listed as impaired on 303d list, but pass through vegetated areas before reaching site.
D	Site likely to receive substantial water quality stressors. Stressors may occur immediately adjacent or within sites or may be minimally buffered from sites (e.g., up a steep hill with very narrow or unvegetated buffer). Stressors may include: • very high intensity livestock grazing, irrigation water return flow, fertilizer and pesticide application, and erosion from fires, construction, off-road vehicles, and dirt roads *directly discharging into sites.* These stressors may be considered C if run-off from the features is likely to only occur infrequently, if slope is shallow, or if only a small area of the AA receives these stressors • frequent heavy grazing within AA with large patches of bare earth and extensive addition of manure For sites receiving most water from channels: • entire contributing area has>60% development or cropland • entire contributing area has a high number of oil and gas wells, mines, or point source dischargers • streams and lakes that directly contribute to the site are listed as impaired on the 303d list.

Table 19. Metric Rating for Connectivity.

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

Physical Structure

Metric: Substrate and Soil Disturbance

Definition and background: This metric evaluates the degree to which the soil or substrate of the AA has been disturbed by anthropogenic stressors. Common sources of disturbance include ATV tracks, human trails, trampling or pugging by livestock, fill or sediment dumping, and dredging or other excavation. Soil disturbances can alter wetland hydrology, affect vegetation, and disrupt natural soil processes such as organic accumulation. Unnaturally bare soil can increase sediment inputs into water and unnaturally compacted soils may affect plant species cover and community composition.

Measurement protocol: Evaluate the AA for evidence of soil disturbance including features such as bare ground, formation of pugs, and compacted soil. Keep in mind that all of these features can also occur naturally so it is important to use best professional judgment to determine whether features are caused by natural or anthropogenic processes. For example, playas and mudflats can be naturally bare, and pugging formed by livestock grazing can appear somewhat similar to naturally formed hummocks. Select the statement that most closely matches the soil or substrate condition in the AA (table 20).

Table 20. Metric Rating for Substrate and Soil Disturbance.

Rank	State
A	No soil disturbance within AA. Little bare soil OR bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails OR soil is naturally bare (e.g., playas). No pugging, soil compaction, or sedimentation.
B	Minimal soil disturbance within AA. Some amount of bare soil, pugging, compaction, or sedimentation present due to human causes, but the extent and impact are minimal. Mild disturbance that does not show evidence of altering hydrology or causing ponding or channeling may occur across a large portion of the site, or more moderate disturbance may occur in one or two small patches of the AA. Any disturbance is likely to recover within a few years after the disturbance is removed.
C	Moderate soil disturbance within AA. Bare soil areas due to human causes are common and will be slow to recover. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts. Sedimentation may be filling the wetland. The site could recover to potential with the removal of degrading human influences and moderate recovery times.
D	Substantial soil disturbance within AA. Bare soil areas substantially degrade the site and have led to severely altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Sedimentation may have severely impacted the hydrology. The site will not recover without active restoration and/or long recovery times.

Vegetation Structure

Metric: Horizontal Interspersion

Definition and background: Horizontal interspersion is the number and degree of interspersion of component patches within a wetland. Degree of interspersion can also be thought of as the amount of edge between patches. A site composed of open water and one dominant vegetation patch type will be more interspersed if the open water and vegetation occur in small patches rather than if each occupies a single large patch. Greater complexity of interspersion between open water and vegetation is positively related to breeding density and diversity of marsh birds (Rehm and Baldassarre, 2007). Patches considered for this metric include open water without vegetation and vegetation patches with different dominant species. Patches are expected to differ in features such as density of cover, usability of litter for nesting, and quality and quantity of food produced within the patch, which leads to a broader range of habitat features.

Measurement protocol: Evaluate the presence and distribution of patches of open water and vegetation within the AA, using figure 6 for guidance (table 21). Distinct vegetation patches are patches that share similar physiognomy and species composition that are "arrayed along gradients of elevation, moisture, or other environmental factors that affect the plant community organization in a two-dimensional plan view" (California Wetlands Monitoring Workgroup, 2013a). Individual patches must be at least 10 m² (approximately 3.2 m x 3.2 m in a 0.5 ha AA) and each patch type must cover at least 5% of the AA (e.g., 250 m² in a 0.5 ha AA). List all of the patches present in the AA. Consider both the number and arrangement of patches when evaluating this metric. For example, a site can be rated as B if it has *either* three patches that not very interspersed or two very interspersed patches with a lot of edge area (figure 6).

Table 21. Metric Rating for Horizontal Interspersion.

Rank	State
A	High degree of horizontal interspersion: AA characterized by a very complex array of nested or interspersed zones with no single dominant zone.
A-	Moderate to high degree of horizontal interspersion: AA is characterized by a complex array of nested or interspersed zones with no single dominant zone.
B	Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed zones with no single dominant zone.
C	Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed zones. One zone may dominate others.
D	No horizontal interspersion: AA characterized by one dominant zone.

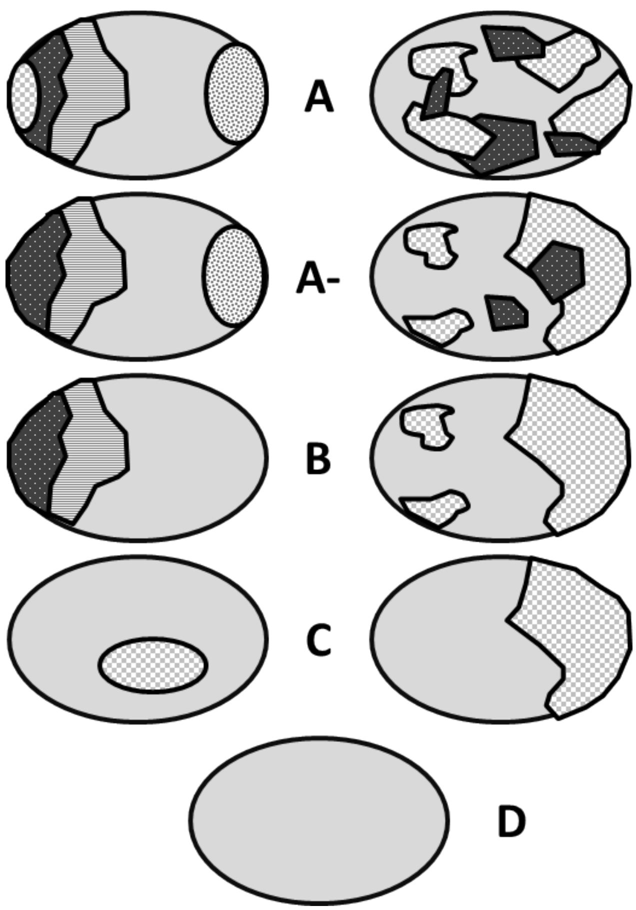


Figure 6. Diagram for rating horizontal interspersion.

Metric: Litter Accumulation

Definition and background: This metric evaluates the degree to which the abundance and distribution of herbaceous and/or deciduous detritus at a site resembles expected patterns at similar pristine wetlands.

Litter input and decomposition rates are important determinants of rates of nutrient cycling at sites. Litter can provide shade that lowers wetland soil and water temperatures. Litter provides cover to protect animals from predation and nesting material for birds and other wildlife. Unnatural patterns of litter accumulation can be indicative of underlying stressors and are likely to be accompanied by other changes in wetland condition, such as changes in invertebrate communities (Christensen and Crumpton, 2010) and plant community composition (Larkin and others, 2011). Livestock grazing (Dobkin and others, 1998), changes in hydroperiod (Anderson and Smith, 2002; Atkinson and Cairns, 2001; Straková and others, 2012), and invasion by aggressive plant species (Eppinga and others, 2011) are some potential causes of abnormal litter accumulation. Fires, grazing, and haying frequently lead to lowered litter accumulation, invasive plant species frequently lead to excessive litter accumulation, and changes in hydroperiod can affect litter in either direction.

Measurement protocol: Note the quantity and distribution of litter throughout the AA and compare to what might be expected at reference sites of a similar wetland type (table 22). Litter evaluation should occur under water as well as on the wetland surface. All dead plant material from previous years will be considered litter for the sake of this evaluation. Playas and other wetlands with sparse vegetation typically have low levels of litter whereas marshes and other densely vegetated wetlands can accumulate large amounts of litter in normal conditions. Fire, overgrazing, and mechanical plant removal (e.g., mowing, haying) can reduce litter levels and may sometimes, though not always, be accompanied by little plant recruitment. Common causes of excessive litter include reduced water levels, aggressive plant colonization, and herbicide treatment. Wetlands may naturally have large amounts of litter; wetlands with naturally high litter levels should still have seasonally appropriate levels of plant recruitment. Areas with extremely thick litter and either little plant recruitment or complete dominance by a single species may have increased litter levels. Note that recruitment levels will be naturally low early in the growing season. Select the appropriate statement from the list below and check whether the site has limited, normal, or excessive litter. If the site receives a score below A, briefly describe the evidence that suggests that the litter is abnormal, note potential causes, and document with photographs. Sites with small patches of abnormal litter can be considered AB, whereas sites with larger patches lacking litter or with extensive litter may be considered C instead of D if otherwise the litter is normal.

Table 22. Metric Rating for Litter Accumulation.

Rank	State
AB	AA characterized by normal amounts of herbaceous and/or deciduous litter accumulation for the wetland type. In some wetlands, this may mean that new growth is more prevalent than previous years' and that litter and duff layers in pools and topographic lows are thin. Undisturbed playas may be lacking in litter altogether. Marshes may have high levels of litter accumulation, but litter should not prevent new growth or be too dense to allow more than one species to persist.
C1	AA characterized by small amounts of litter compared to what is expected.
C2	Litter is somewhat excessive.
D1	AA lacks litter.
D2	Litter is extensive, often limiting new growth.

Metric: Woody Debris

Definition and background: Woody debris is dead or decomposing wood, including fallen trees, rotting logs, and smaller woody inputs from twigs or branches or broken down from larger inputs. The importance of woody debris in riverine systems is well-documented. In-stream woody debris is important for fish communities because it provides cover to protect individuals from predation, reduces contact between fish, and allow fish to lower energy expenditures in velocity refuges (Crook and Robertson, 1999). Woody debris in streams has been shown to increase salmonid species abundance (Whiteway and others, 2010) and macroinvertebrate richness (Miller and others, 2010). While the role of woody debris in other wetland systems is not as well studied, woody debris additions to constructed depressional wetlands in Delaware led to increased overall insect richness and biomass as well as increased biomass of insect species intolerant of environmental degradation (Alsfeld and others, 2009). In systems where it is naturally found, woody debris is expected to provide habitat for aquatic and wetland species and help with retention of nutrients and organic matter.

Measurement protocol: Evaluate woody debris accumulation within the AA, compared to what is expected for the Ecological System and particular site (table 23). Sites that lack woody species may nonetheless accumulate woody debris if they are hydrologically connected to nearby landscapes with woody species. Score this metric as N/A for naturally herbaceous wetlands that lack opportunity for inputs from woody species in the surrounding landscape.

Table 23. Metric Rating for Woody Debris.

Rank	State
NA	There are no obvious inputs of woody debris. Inputs are not available within site, along site edge, or along nearby up-gradient hydrologically connected flowpaths.
AB	AA characterized by moderate amount of coarse and fine woody debris, relative to expected conditions. For riverine wetlands, debris is sufficient to trap sediment, but does not inhibit stream flow. For non-riverine wetlands, woody debris provides structural complexity, but does not overwhelm the site.
C1	AA characterized by small amounts of woody debris.
C2	Debris in AA is somewhat excessive.
D	AA lacks woody debris, even though inputs are available.

Metric: Woody Species Regeneration

Background and definition: Woody species regeneration evaluates the age class structure of woody species at sites. Sites should generally contain a range of age classes, including seedlings, small shrubs or saplings, and mature shrubs or trees. Woody species age class structure is a good indication of chronic stressors or major changes at sites due to the long maturity time required to reach adult size. The presence of natural regeneration at sites expected to have woody species is important for providing wildlife habitat and woody debris inputs. Overgrazing by livestock or native species can lead to high mortality of seedlings and saplings and thus little recruitment to the adult age class (Russell and others, 2001). Younger age classes may also dominate sites recovering from intense fire or sites that experience frequent fires (Grady and Hoffmann, 2012). Chronic changes in hydrology can also affect regeneration. Riparian sites that experience abrupt changes in flow levels due to river regulation or water withdrawal may have decreased regeneration (Amlin and Rood, 2002). Invasive woody species can replace native woody species or invade sites that previously had little woody species cover. These species may provide some of the same functional services as native woody species, but also have a high potential to impact natural processes at sites such as nutrient cycling (Ehrenfeld, 2003), hydrologic processes (Huddle and others, 2011), and plant community composition. Sites with high levels of invasive woody species receive a low score for this metric regardless of the structure of native woody species regeneration occurring at the site.

Measurement protocol: Select the statement that most accurately describes the age structure of native woody species within the AA (table 24). If woody species are naturally uncommon or absent at sites, select N/A. If sites have more than 5% cover of Russian olive or tamarisk, circle both the last statement indicating this and one of the first six statements that describes the regeneration status of native woody vegetation.

Table 24. Metric Rating for Woody Regeneration.

Rank	State
NA	Woody species are naturally uncommon or absent.
A	All age/size classes of desirable (native) woody species present.
B	Age/size classes restricted to mature (full size) individuals and young sprouts. Middle age/size groups absent.
C1	Stand comprised of mainly mature (full size) individuals, with seedlings and sapling (smaller individuals) absent.
C2	Stand mainly evenly aged/sized young sprouts that choke out other vegetation.
C3	Stand predominantly composed of individuals re-sprouting from mature rootstock that appear superficially as young sprouts due to over-browsing; overall cover of woody species may be low due to suppression of larger size classes.
D1	Woody species predominantly consist of decadent or dying individuals.
D2	AA has >5% canopy cover of *Elaeagnus angustifolia* (Russian olive) and/or *Tamarix* (tamarisk) or other invasive woody species. If you select this state, select an additional statement that describes native regeneration in AA.

Plant Species Composition

Metric: Relative Cover Native Species

Definition and background: This metric is the measure of the relative percent cover of native plants species at a site. Wetlands in good ecological condition are expected to have high cover of native species both because non-native species are most likely to enter a wetland when there is associated disturbance and because intactness of the plant community is one component of wetland condition. Non-native plants in a wetland can displace native plants, change nutrient cycles, affect food web dynamics, modify hydrology, and alter the physical structure used by wildlife. The degree to which non-native plants affect wetlands is assumed to be related to their abundance at a site. One or a few individuals of a non-native species may not be an issue of concern whereas greater numbers have more likelihood of altering natural processes in the wetland.

Measurement protocol: Relative cover of native species is calculated as the total cover of native plant species divided by the total cover of all species (table 25). Relative cover estimates can be calculated from species lists obtained in the field or using ocular estimates of relative percent cover. Species that are common and not able to be identified in the field should be collected for office identification to assist in calculation of this metric. Species that are not able to be identified should be excluded from the calculation unless their nativity is known.

Table25. Metric Rating for Relative Cover Native Species.

Rank	State
AB	AA contains >95% relative cover of native plant species.
C	AA contains 80–95% relative cover of native plant species.
C-	AA contains 50–80% relative cover of native plant species.
D	AA contains <50% relative cover of native plant species.

Metric: Absolute Cover Invasive Species

Definition and background: Certain non-native plant species are known to be particularly disruptive to natural processes. These species, which we term invasive species, generally are able to spread aggressively to take over native vegetation and usually have documented negative ecological impacts. Several methods can be used to determine which species should be considered invasive. Some species are designated as noxious weeds by individual states or the federal government. This designation applies to species that are known to cause harm to agriculture, horticulture, natural habitats, humans, or livestock, and species with this designation often must be controlled or contained based on state or federal regulations. Noxious weed lists highlight species of economic and political concern; however, some species may not make the list due to political constraints (i.e., species is deemed too difficult to regulate) and the political process may be slow to list emerging threats. The Environmental Protection Agency developed a list of invasive species for the National Wetland Condition Assessment that included species with known ecosystem impacts that were readably identified in the field, and have national distributions. This list includes 24 species, including 18 known to occur in Utah. This list was developed specifically for wetland surveys, but is not meant to be regionally comprehensive. Regional planning documents and expert knowledge can be used to supplement invasive species lists with additional species of concern. For example, the Utah Division of Wildlife Resources action plan for addressing species of concern at Waterfowl Management Areas includes information for two species not listed as noxious weeds in Utah, *Cicuta douglasii* and *Cirsium vulgare* (Berger, 2009).

Measurement protocol: Estimate the total percent cover of all plants considered invasive species using either a species list or field ocular estimates (table 26). If not using a species list, surveyors will have to have a list of all invasive species with them in the field in order to make estimates. We will use species listed by USA-RAM as invasive and species on noxious weed lists in Utah and surrounding states (Arizona, Colorado, Idaho, Nevada, and Wyoming) as our designated invasive species. Additional species will be added based on expert recommendation.

Table 26. Metric Rating for Absolute Cover Invasive Species.

Rank	State

A	Noxious weeds absent.
B	Noxious weeds present, but sporadic (<3% absolute cover).
C	Noxious weeds common (3–10% cover).
D	Noxious weed abundant (>10%) cover.

Riverine-Specific Metrics

Placeholder for Riverine Metrics, need some clean-up

Auxiliary Metrics

Auxiliary metrics include those metrics that will not be included in scoring but will be collected to increase our understanding of structure and dynamics in Utah wetlands and the differences between wetland classes.

Metric: Structural Patch Richness

Definition and background: Structural patch richness is a measure of the number of different physical surfaces or features present in a wetland. Physical processes such as energy dissipation and water storage contribute to the development of natural physical features (California Wetlands Monitoring Workgroup, 2013b) and thus the presence of expected structural patches may indicate that natural physical processes are occurring appropriately. Natural physical complexity is assumed to promote "natural ecological complexity, which in turn generally increases ecological functions, beneficial uses, and the overall condition of a wetland" (California Wetlands Monitoring Workgroup, 2013b). Not all potential structural patch types are expected to occur in all wetland types; for example, many structural patches are specific to wetlands with channels.

Measurement protocol: We do not yet have enough data to determine the expected number and types of structural patches in Utah wetlands. We will obtain baseline data on the presence and cover of different structural patches and develop metric statements once adequate data across the condition gradient have been collected for each wetland type. Record the cover for each patch type present in the AA (see cover reference diagram in the appendix). For features that occupy less than 1% of the AA, record the approximate number of square meters that they cover. Otherwise, select the appropriate cover class that represents the percent of the AA occupied by the feature. Where indicated, also select whether the majority of a particular patch type is currently wet or dry by circling W or D (e.g., most pools are filled with water at the time of the survey). Features have been organized into categories to facilitate selection in the field. Use patch descriptions and the CRAM photo dictionary (http://www.cramwetlands.org/documents) to properly identify each patch type.

Metric: Topographic Complexity

Definition and background: Topographic complexity refers to the variability in vertical, physical structure in a wetland. The topographic complexity metric considers the presence and abundance of micro- and macro-topography at a site. Micro-topography refers to features such as the patches listed under the structural patch richness metric (above), whereas macro-topography refers to the larger-scale heterogeneity in structure caused by elevational features such as benches and slopes of varying steepness. The Wetland Science Institute defines micro-topography as vertical features with less than 15 centimeters of relief including "small depressions, swales, wallows, and scours that would hold water for a short (hours to days) time after a rainfall, runoff, or flooding event" (The Natural Resources Conservation Service's Wetland Science Institute, 2003). For the purposes of this assessment, macro-topography include any vertical, physical features greater than 15 cm and larger, such as deep depressions, terraces, swales, or sloughs, but also include topographic elevation gradients that support distinctly different vegetation communities and/or hydrologic regimes. Both macro and micro-topographic features are important to moisture gradients and/or alter water flow paths across wetlands.

Measurement Protocol: Record a description of each distinct macro-topographic feature (i.e., elevation gradient) that occurs within site. Elevation gradients must be at least 15 cm in height difference and can include features such as benches, slopes of varying steepness, channels, and pools. Gradients must have an edge of at least 8 m (e.g., length of channel, perimeter of pools or higher elevation "island", length of edge between two slopes) or cover at least 5% of the AA. Also record the amount of AA area with micro-topography features including woody debris, boulders, sediment mounds, vegetation hummocks, tufted herbaceous litter, and other similar features. If not certain whether feature is considered micro-topography, make note in comments.

REFERENCES

Alsfeld, A.J., Bowman, J.L., and Deller-Jacobs, A., 2009, Effects of woody debris, microtopography, and organic matter amendments on the biotic community of constructed depressional wetlands: Biological Conservation, v. 142, no. 2, p. 247–255.

Amlin, N.M., and Rood, S.B., 2002, Comparative tolerances of riparian willows and cottonwoods to water-table decline: Wetlands, v. 22, no. 2, p. 338–346.

Anderson, J.T., and Smith, L.M., 2002, The effect of flooding regimes on decomposition of Polygonum pensylvanicum in playa wetlands (Southern Great Plains, USA): Aquatic Botany, v. 74, no. 2, p. 97–108.

Atkinson, R.B., and Cairns, J., 2001, Plant decomposition and litter accumulation in depressional wetlands— functional performance of two wetland age classes that were created via excavation: Wetlands, v. 21, no. 3, p. 354–362.

Berger, R., 2009, Information document for invasive and noxious weed control project on Utah's waterfowl management areas— 2006-2018: Utah Division of Wildlife Resources Publication 09-14, 129 p.

Brinson, M.M., 1993, A hydrogeomorphic classification for wetlands: U.S. Army Corps of Engineers, Wetlands Research Program Technical Report WRP-DE-4, 79 p.

Buffler, S., Johnson, C., Nicholson, J., and Mesner, N., 2005, Synthesis of design guidelines and experimental data for water quality function in agricultural landscapes in the Intermountain West: U.S. Forest Service/UNL Faculty Publications Paper 13, 59 p.

California Wetlands Monitoring Workgroup, 2013a, California rapid assessment method for wetlands— depressional wetlands field book, version 6.1, 43 p.

California Wetlands Monitoring Workgroup, 2013b, California rapid assessment method (CRAM) for wetlands, user's manual, version 6.1, 67 p.

Christensen, J.R., and Crumpton, W.C., 2010, Wetland invertebrate community responses to varying emergent litter in a prairie pothole emergent marsh: Wetlands, v. 30, no. 6, p. 1031–1043.

Cowardin, L., Carter, V., Golet, F.C., and LaRoe, E.T., 1979, Classification of wetlands and deepwater habitats of the United States: Washington, D.C., U.S. Fish and Wildlife Service Biological Report FWS/OBS-79/31, 131 p.

Crook, D.A., and Robertson, A.I., 1999, Relationships between riverine fish and woody debris— implications for lowland rivers: Marine and Freshwater Research, v. 50, no. 8, p. 941–953.

Dahlgren, R., Nieuwenhuyse, E., and Litton, G., 2004, Transparency tube provides reliable water-quality measurements: California Agriculture, v. 58, no. 3, p. 149-153.

Dobkin, D.S., Rich, A.C., and Pyle, W.H., 1998, Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin: Conservation Biology, v. 12, no. 1, p. 209–221.

Ehrenfeld, J.G., 2003, Effects of exotic plant invasions on soil nutrient cycling processes: Ecosystems, v. 6, no. 6, p. 503–523.

Emmons & Olivier Resources, 2001, Benefits of wetland buffers— a study of functions, values, and size: Oakdale, MN, unpublished consultant's report prepared for Minnehaha Creek Watershed District, 41 p.

Eppinga, M.B., Kaproth, M. A., Collins, A.R., and Molofsky, J., 2011, Litter feedbacks, evolutionary change and exotic plant invasion: Journal of Ecology, v. 99, no. 2, p. 503–514.

Faber-Langendoen, D., Kudray, G., Nordman, C., Sneddon, L., Vance, L., Byers, E., Rocchio, J., Gawler, S., Kittel, G., Menard, S., Comer, P., Muldavin, E., and Schafale, M., Foti, T., Josse, C., and Christy, J. 2008, Ecological performance standards for wetland mitigation—an approach based on ecological integrity assessments: Arlington, Virginia, NatureServe, 38 p.

Fennessy, M.S., Jacobs, A.D., and Kentula, M.E., 2004, Review of rapid methods for assessing wetland condition,U.S. Environmental Protecton Agency EPA/620/R-04/009, 75 p.

Fennessy, M.S., Jacobs, A.D., and Kentula, M.E., 2007, An evaluation of rapid methods for assessing the ecological condition of wetlands: Wetlands, v. 27, no. 3, p. 543–560.

Grady, J.M., and Hoffmann, W.A., 2012, Caught in a fire trap: recurring fire creates stable size equilibria in woody resprouters.: Ecology, v. 93, no. 9, p. 2052–60.

Hoven, H.M., and Paul, D.S., 2010, Utah wetlands ambient assessment method, version 1.2: Kamas, Utah, The Institute for Watershed Sciences, 45 p.

Huddle, J.A., Awada, T., Martin, D.L., Zhou, X., Pegg, S.E., and Josiah, S.J., 2011, Do invasive riparian woody plants affect hydrology and ecosystem processes? Great Plains Research, v. 21, no. 1, p. 49–71.

Johnson, C., and Buffler, S., 2008, Riparian buffer design guidelines for water quality and wildlife habitat functions on agricultural landscapes in the Intermountain west— case study, U.S. Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-203, 29 p.

Kadlec, R.H., and Reddy, K.R., 2001, Temperature effects in treatment wetlands: Water Environment Research, v. 73, no. 5, p. 543–447.

Larkin, D.J., Freyman, M.J., Lishawa, S.C., Geddes, P., and Tuchman, N.C., 2011, Mechanisms of dominance by the invasive hybrid cattail Typha × glauca: Biological Invasions, v. 14, no. 1, p. 65–77.

Lemly, J., and Gilligan, L., 2013, Ecological integrity assessment for Colorado wetlands—field manual version 1.0—review draft: Fort Collins, Colorado Natural Heritage Program, 92 p.

Lin, J.P., 2004, Review of published export coefficient and event mean concentration data: U.S. Army Corps of Engineers Wetlands Regulatory Assistance Program Technical Notes Collection EDRC TN-WRAP-04-3, 15 p.

McElfish, J.M., Jr., Kihslinger, R.L., and Nichols, S., 2008, Setting buffer sizes for wetlands: National Wetlands Newsletter, v. 30, no. 2, p. 6–17.

Miller, S.W., Budy, P., and Schmidt, J.C., 2010, Quantifying macroinvertebrate responses to in-stream habitat restoration— applications of meta-analysis to river restoration: Restoration Ecology, v. 18, no. 1, p. 8–19.

Miller, T.G., and Hoven, H.M., 2007, Ecological and beneficial use assessment of Farmington Bay wetlands— Assessment and site-specific nutrient criteria methods development: Progress Report to U.S. Environmental Protection Agency and Final Report for the Grant CD988706-03, p. 50

Natural Resources Conservation Service, 2003, Wetland Restoration, Enhancement, and Management: Wetland Science Institute, USDA, p. 1

Omernik, J.M., 1987, Ecoregions of the conterminous United States. Map (scale 1:7,500,000): Annals of the Association of American Geographers, v. 77, no. 1, p. 118–125.

Picard, C.R., Fraser, L.H., and Steer, D., 2005, The interacting effects of temperature and plant community type on nutrient removal in wetland microcosms: Bioresource Technology, v. 96, no. 9, p. 1039–1047.

Rehm, E.M., and Baldassarre, G.A., 2007, The influence of interspersion on marsh bird abundance in New York: The Wilson Ornithological Society, v. 119, no. 4, p. 648–654.

Robertson, A., Bacon, P., and Heagney, G., 2001, The responses of floodplain primary production to flood frequency and timing: Journal of Applied Ecology, v. 38, no. 1, p. 126–136.

Russell, F.L., Zippin, D.B., and Fowler, N.L., 2001, Effects of white-tailed deer (Odocoileus virginianus) on plants , plant populations and communities— a review: The American Midland Naturalist, v. 146, no. 1, p. 1–26.

Snodgrass, J.W., Komoroski, M.J., Jr, A.L.B., and Burger, J., 2000, Relationships among isolated wetland size, hydroperiod, and amphibian species richness— implications for wetland regulations: Conservation Biology, v. 14, no. 2, p. 414–419.

Stoddard, J.L., Larsen, D.P., Hawkins, C.P., Johnson, R.K., and Norris, R.H., 2006, Setting expectations for the ecological condition of streams—the concept of reference condition: Ecological Applications, v. 16, no. 4, p. 1267–1276.

Straková, P., Penttilä, T., Laine, J., and Laiho, R., 2012, Disentangling direct and indirect effects of water table drawdown on above- and belowground plant litter decomposition— consequences for accumulation of organic matter in boreal peatlands: Global Change Biology, v. 18, no. 1, p. 322–335.

Sutula, M.A., Stein, E.D., Collins, J.N., Fetscher, A.E., and Clark, R., 2006. A practical guide for the development of a wetland assessment method—the California experience: Journal of the American Water Resources Association, v. 42, no. 1, p. 157–175.

Tanner, C.C., D'Eugenio, J., McBride, G.B., Sukias, J.P.S., and Thompson, K., 1999, Effect of water level fluctuation on nitrogen removal from constructed wetland mesocosms: Ecological Engineering, v. 12, no. 1-2, p. 67–92.

Tarr, T.L., Baber, M.J., and Babbitt, K.J., 2005, Macroinvertebrate community structure across a wetland hydroperiod gradient in southern New Hampshire, USA: Wetlands Ecology and Management, v. 13, no. 3, p. 321–334.

U.S. Army Corps of Engineers, 1987, Corps of Engineers wetlands delineation manual: Wetlands Research Program Technical Report Y-87-1, 92 p.

U.S. Army Corps of Engineers, 2008, Regional supplement to the Corps of Engineers wetland delineation manual—Arid west region, Version 2.0: Vicksburg, Mississippi, ERDC/EL TR-08-28, 133 p.

U.S. Army Corps of Engineers, 2010, Regional supplement to the Corps of Engineers wetland delineation manual— Western mountains, valleys, and coast region, version 2.0: Vicksburg, Mississippi, ERDC/EL TR-08-28, 133 p.

U.S. Environmental Protection Agency, 2006, Application of elements of a state water monitoring and assessment program for wetlands: Office of Wetlands, Oceans, and Watersheds, EPA 841-B-03-003, 12 p.

U.S. Environmental Protection Agency, 2008, Methods for evaluating wetland condition— wetland hydrology: EPA-822-R-08-024, 37 p.

U.S. Fish and Wildlife Service, 2009, A system for mapping riparian areas in the western United States: Arlington, VA, Division of Habitat and Resource Conservation Branch of Resource and Mapping Support, 42 p.

U.S. Natural Resources Conservation Service, 2010, Field indicators of hydric soils in the United States, version 7.0, Vasilas, L.M., Hurt, G.W. and Noble, C.V., editors, NRCS in cooperation with the National Technical Committee for Hydric Soils, 44 p.

Utah DEQ Division of Water Quality, 2010, Draft 2010 Utah integrated report, water quality assessment 305(b) report: 786 p.

Webb, J.A., Wallis, E.M., and Stewardson, M.J., 2012, A systematic review of published evidence linking wetland plants to water regime components: Aquatic Botany, v. 103, p. 1–14.

Whiteway, S.L., Biron, P.M., Zimmermann, A., Venter, O., and Grant, J.W.A., 2010, Do in-stream restoration structures enhance salmonid abundance? A meta-analysis: Canadian Journal of Fisheries and Aquatic Sciences, v. 67, no. 5, p. 831–841.

Zhang, X., Liu, X., Zhang, M., Dahlgren, R. a, and Eitzel, M., 2010, A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution: Journal of Environmental Quality, v. 39, no. 1, p. 76–84.

APPENDIX A

Reference Materials for URAP Surveys

Checklist of Field Equipment (items in italics may be found in the Core Center)

Paperwork In Folder (one folder per crew)

- standard field forms
- waterproof field forms
- plant collection slips
- list of emergency contact numbers
- User's Manual
- Army Corps Regional Supplements
- laminated photo card
- site maps
- site office evaluation information

Group Field Gear

General

- GPS
- Camera
- Spare pencils
- spare AA batteries
- spare camera battery
- compass
- flagging tape
- measuring tape (50 m)
- rope to measure out Level 3 plots
- dry erase marker for photo card
- *large tarp for keeping gear dry*

Plant collection

- *weeder to dig plant specimen*
- plant press with newspaper
- handheld measuring tape
- Vascular Plants of Northern Utah
- Field Guide to Colorado's Wetland Plants

Water quality

- plastic measuring container
- water quality meters (high and low)
- cooler with ice
- *three plastic containers for water quality samples*
- *transparency tube*
- *bailer*

Soils

- *sharpshooter or auger*
- *soil tarp*
- pocket knife
- Munsell or other soil color chart
- handheld measuring tape

Misc. (Leave in vehicle)

- *scrub brush for cleaning shoes*
- *Sparquat and container with spray nozzle and pump*
- *large water jug*
- first aid and car emergency kit

Suggested Plant Identification Aids

- Field Guide to Intermountain Rushes
- Field Guide to Intermountain Sedges
- A Utah Flora
- Desert Plants of Utah
- Vascular Plants of Northern Utah
- Field Guide to Colorado's Wetland Plants
- Grasses and Grasslike Plants of Utah

Individual Field Gear

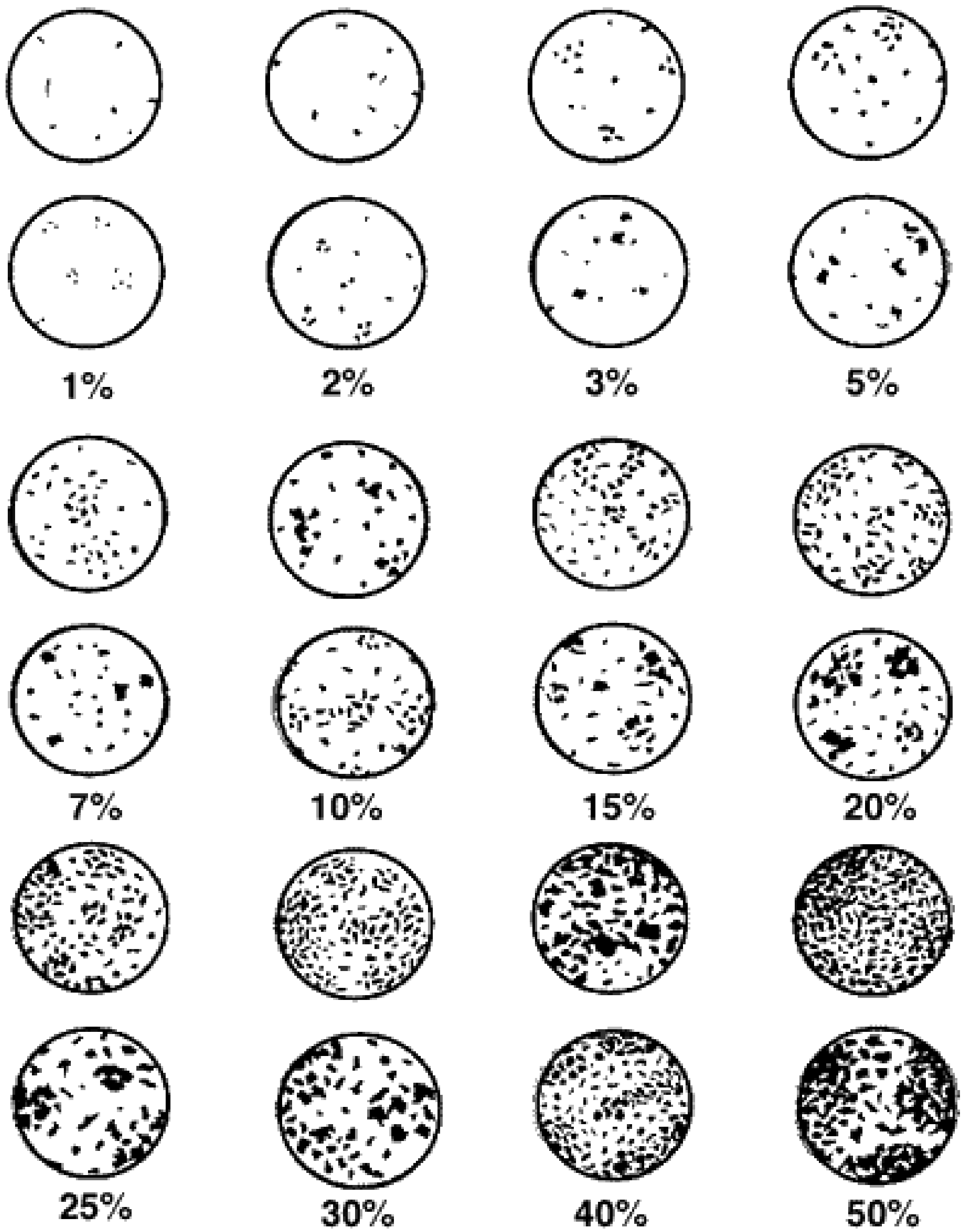
Office gear assigned to individuals

- waders
- laminated reference guides
- pencils
- clipboard
- hand lens

Personal gear

- knee boots or other field shoes
- large backpack
- watch or other timer
- water bottle
- food for field
- insect repellent, head net
- sun screen
- cell phone (for emergencies)
- personal plant identification guides

Plant Cover Reference Cards[1]



[1] From http://www.for.gov.bc.ca/hts/risc/pubs/teecolo/fmdte/veg.htm

Field Order of Operations and To Do Checklist

1) Determine whether site can be sampled (wetland present and at least 0.1 ha)
2) Determine placement of AA
3) Flag out boundary and collect GPS coordinates and photos. Spatial data will be named in the GPS as *UniqueSiteID* followed by a hyphen and unique identifier following the naming conventions below.

Feature Type	Identifer	Feature Type	Identifer
Center point	CEN	Photos (if not at cardinal pts or corners)	P1, P2, P3…
Cardinal points	N, E, S, W	Soil pit	SOIL1, SOIL2...
Rectangle corners	COR1, COR2…	Water Quality (if not in soil pit)	WQ1, WQ2...
Freeform track	TRACK	Vegetation plot	PLOT1, PLOT2…

AA type	Spatial Data	Photos	Flag
Circular	Center and N, E, S, W points	N, E, S, W points	Center and N, E, S, W points, 40 m from center
Rectangular	Corner of rectangle and photo points	Four locations along boundary facing in	Corner of rectangle and in middle of long edges
Freeform	GPS track on edge plus photo points	Four locations along boundary facing in	Along boundary as needed

4) Classify wetland by Ecological System, Cowardin Class, and HGM and ensure AA does not cross Ecological System boundaries. Determine the number of vegetation patches within AA and which need to be sampled (those with ≥30% cover within AA). Fill out remaining descriptive fields on page 1 and 2 of field forms.
5) Dig soil pits and describe soil profile. Record time so that total settling time of pit can later be determined.
6) Record plant species in AA for no more than 1 hour. This can occur simultaneously with steps 4 and 5, but should be done to minimize altering surface water chemistry samples. Record litter and water depth measurements during this process.
7) Estimate cover for listed plant species and for ground cover and vertical strata components
8) Draw site sketch and write site description, if site is well understood before sampling (can be done simultaneously with step 6)
9) Start to fill out metrics and stressor data. Walk around buffer and AA as needed to complete metrics
10) Collect water quality data in soil pits and final soil pit measurements.
11) Conduct gear check, remove all flagging, and ensure that all unknown plant species have been collected. Clean shovel and augur if water is available on site.
12) Look over datasheet to ensure that all data is complete and accurate
13) Update site office evaluation form as needed, either verifying site hydrology or making changes to hydrology and stressors present at site
14) Visit any uncertain features in the buffer on the hike out of the site. Label on site map and update metric data as needed.

Checklist Before Leaving the Field

□ QC all data sheets

□ Make sure office evaluation forms are updated; check off that site hydrology was field verified and make any necessary changes to the hydrology, stressors present, etc.

□ Remove all flags

□ Make sure all spatial data is recorded in GPS

□ Take all necessarily site photos including:

1. Four site photos from AA edge facing towards center
2. Algae, if site scored below an A
3. Turbidity and pollutants, if site scored below an A
4. Litter accumulation, if site scored below an A
5. Photos to illustrate unusual features or features that cannot be identified
6. Any photos that may be illustrative for future training purposes

□ Collect all unknown plant species

□ Record soil pit settling time and water level data and fill in soil pits

□ Check to make sure you have all field gear, especially

1. Camera
2. GPS
3. Water quality meters
4. 50-m tape
5. Handheld tapes
6. Compasses

□ Assess uncertain buffer features and update datsheets accordingly

Key to Ecological Systems

Ecological Systems in this key have been divided based on geographic location in the three main ecoregions in Utah, the Central Basin and Range or Inter-Mountain Basins, Colorado Plateau, and Wasatch/Uinta Mountains. If a site is located near the border of the Inter-Mountain and Mountain regions in the state, try both Key A and Key B. There has been limited time devoted to the use of the Ecological Systems classification for wetlands in Utah, specifically around Great Salt Lake, so there may be some wetland types that are not accounted for in this key.

Key A. WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS AND COLORADO PLATEAU
These regions cover the majority of the state of Utah, with the exception of the Uinta, Wasatch, and Rocky Mountains. Wetlands in this region often have alkaline or saline soils (alkalinity in water chemistry can be highly variable in the Emergent Marsh system) due to evaporative loss of water and concentration of salts in surface water and soils. One system localized to the Colorado Plateau Ecoregion keys here, Colorado Plateau Hanging Garden.

Key B. WETLANDS AND RIPARIAN AREAS OF THE WASATCH AND UINTA MOUNTAINS
This region includes mountain ranges in the central and northeastern corner of the state as well as a few small ranges in the Colorado Plateau Region.

Key A. WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS AND COLORADO PLATEAU

1a. Herbaceous wetlands restricted to canyon wall seeps in the Colorado Plateau region. Hanging gardens are dominated by primarily by herbaceous plants, a number of these being endemic to the Utah High Plateau and Colorado Plateau regions. Composition varies based on geology and ecoregion. Common species include *Adiantum capillus-veneris*, *Adiantum pedatum*, *Mimulus eastwoodiae*, *Mimulus guttatus*, *Sullivantia hapemanii*, *Cirsium rydbergii*, and several species of *Aquilegia*…………………………………………**Colorado Plateau Hanging Garden**

1b. Wetlands not restricted to canyon seeps as above…………………………………………………………………………………**2**

2a. Wetland systems most often immediately associated with riparian areas, floodplains, or permanent, intermittent or ephemeral streams. Though wetlands associated with Great Salt Lake may be considered part of a delta in the HGM classification system, in this classification those wetlands are considered based on their geographic and physical location within a terminal basin and are not considered to be riparian unless they are within an active floodplain………**3**

3a. Wetlands dominated by herbaceous species within the floodplain with standing water at or more typically >15 cm above the surface throughout the growing season, except in drought years. Vegetation typically dominated by species of *Typha*, *Scirpus*, *Schoenoplectus*, *Carex*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*. The floodplain expression of this system is located in the floodplain, but may be disconnected from flooding regimes. Hydrology may be entirely managed. Soils are highly variable. This system includes sloughs and other natural floodplain marshes as well as a variety of managed wetlands on the floodplain (e.g., recharge ponds, moist soil units, shallow gravel pits, etc.)…………………………………………………………………**North American Arid West Emergent Marsh**

3b. Wetlands dominated by a mix of woody species with herbaceous species common, but not often dominant, there is not often standing water for long periods of time……………………………………………………………**4**

4a. Barren and sparsely vegetated wetlands restricted to intermittently flooded streambeds and banks that are often lined with shrubs such as *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Fallugia paradoxa*, *Artemisia tridentata* ssp. *tridentata*, and/or *Artemisia cana* ssp. *cana* (in more northern and mesic stands) that form relatively dense stringers in open dry uplands. *Grayia spinosa* may dominate in the Great Basin. Shrubs form a continuous or intermittent linear canopy in and along drainages but do not extend out into flats. Patches of *Distichlis spicata* common where water remains for the longest periods……………………….. …….**Inter-Mountain Basins Wash**

4b. Typically tree-dominated wetlands with a diverse shrub component often occurring as a mosaic of multiple communities, though can lack or have a limited tree component. The system is highly variable depending on landscape context and is diagnostic only in its ecoregional location and association with lotic systems. Sites span a broad elevation range from 1220 m (4000 feet) to over 2135 m (7000 feet). The variety of plant associations connected to this system reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include *Abies concolor*, *Alnus incana*, *Betula occidentalis*, *Populus angustifolia*, *Populus balsamifera* ssp. *trichocarpa*, *Populus fremontii*, *Salix laevigata*, *Salix gooddingii*, and *Pseudotsuga menziesii*. Dominant shrubs include *Artemisia cana, Cornus sericea, Salix exigua, Salix lasiolepis, Salix lemmonii,* or *Salix lutea*. Herbaceous layers are often dominated by species of *Carex* and *Juncus*, and perennial grasses and mesic forbs such *Deschampsia caespitosa, Elymus trachycaulus, Glyceria striata, Iris missouriensis, Maianthemum stellatum*, or *Thalictrum fendleri*. Introduced forage species such as *Agrostis stolonifera, Poa pratensis, Phleum pratense*, and the weedy annual *Bromus tectorum* are often present in disturbed stands. *These sites may also be included in the **Columbia Basin Foothill Riparian Woodland and Shrubland** class, not described here until additional information is collected on the difference between these types and occurrence in Utah*................................. …………………………………………..**Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland**

2b. Wetland Ecological Systems of Inter-Mountain Basins not immediately associated with riparian areas, floodplains, or permanent, intermittent or ephemeral streams……………………………………………………..……………...**5**

5a. Small (<0.1 ha), herbaceous wetlands occurring in wind-deflated depressions of dune fields. These wetlands occur in the Pink Coral Dunes in Utah and potentially occur in other Great Basin dune fields………………………………………………………………………….**Inter-Mountain Basins Interdunal Swale Wetland**

5b. Wetlands not associated with wind-deflated depression in dune fields……...…………………………………..**6**

6a. Wetland includes an open to moderately dense shrub layer dominated or codominated by *Sarcobatus vermiculatus*, but often occurs as a mosaic of multiple plant communities. Sites typically have saline soils, a shallow water table and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations…… ……………………………………………………………………………………………**Inter-Mountain Basins Greasewood Flat**

6b. System dominated by herbaceous species, vegetation can be dense or sparse, soil and water chemistry is saline or not………………………………………………………………………………………………………..**7**

7a. Total vegetation cover is sparse to barren and site experiences intermittent to temporarily flooded water regime. Vegetation cover is generally <10% plant cover, though there can be patches of denser vegetation and edges are often ringed by more dense vegetation; the site is predominantly sparsely vegetated in most years). Sites typically experience intermittent flooding (i.e., flooded without detectable seasonal periodicity), though may have a temporarily flooded water regime (i.e., flooding early in the growing season and then drying). Sites are located in closed depressions or occur as part of large terminal basins (Great Salt Lake, Sevier Lake, Salt Marsh Lake). Salt crusts are common throughout, with small *Distichlis stricta* beds in depressions, sparse shrubs around the margins, and pioneering annual species such as *Salicornia*. The water is often prevented from percolating through the soil by an impermeable soil subhorizon. Soil salinity varies with soil moisture, greatly affecting species composition. Characteristic species may include *Allenrolfea occidentalis, Sarcobatus vermiculatus, Grayia spinosa, Puccinellia lemmonii, Leymus cinereus, Distichlis spicata, and/or Atriplex spp* ....**Inter-Mountain Basins Playa**

7b. Total vegetation cover is moderate to dense (generally > 10% plant cover), usually with at least a seasonally flooded water regime, though may vary…………………………………………………………..**8**

8a. Located in similar locations as the **Inter-Mountain Basins Playa**, but with generally higher herbaceous vegetation cover (>10%) and usually with seasonal to semi-permanently flooded water regime**,** though water tables can vary due in areas with high levels of management. This system can also experience seasonal drying to expose mudflats colonized by both annual and perennial vegetation. Can be associated with hot and cold springs, located in basins with internal drainage. Soils are alkaline to saline clays with variable, fine texture soils and may have hardpans. Typical species include *Distichlis spicata, Puccinellia lemmonii, Poa secunda, Muhlenbergia* spp., *Leymus triticoides*, *Schoenoplectus maritimus, Schoenoplectus americanus, Triglochin maritima, and Salicornia* spp. Communities found within this system may also occur in floodplains (i.e., more open depressions), but probably should not be considered a separate system unless they transition to areas outside the immediate floodplain. Types often occur along the margins of perennial lakes, in alkaline closed basins, with extremely low-gradient shorelines……………………………………………**Inter-Mountain Basins Alkaline Closed Depression**

8b. Herbaceous wetlands with standing water at or more typically >15 cm above the surface throughout the growing season, except in drought years. Water levels are often high at some point during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of *Typha, Scirpus, Schoenoplectus, Carex, Eleocharis, Juncus*, and floating genera such as *Potamogeton, Sagittaria*, and *Ceratophyllum*. The isolated expression of this system can occur around ponds, as fringes around lakes including Great Salt Lake, and at any impoundment of water, including irrigation run-off. The hydrology may be entirely managed or artificial. Water may be brackish or not. Soils are highly variable…**North American Arid West Emergent Marsh**

Key B. WETLANDS AND RIPARIAN AREAS OF THE ROCKY MOUNTAINS

1a. 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.] **2**

1b. 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……….**4**

2a. W oodlands and shrublands of the foothill and lower montane zones. There are no exact elevation cut-offs to distinguish lower montane from montane, though sites that key to this system often are surrounded by sage steppe uplands. Woodlands are dominated by *Populus* spp. (*Populus angustifolia*, *P. deltoides,* or the hybrid *P. acuminata*), *Acer negundo*, *Pseudotsuga menziesii, Picea pungens,* and *Salix amygdaloides*. Common native shrub species include *Salix* spp., *Alnus incana*, *Acer glabrum, Prunus virginiana, Rhus trilobata, Betula occidentalis, Cornus sericea*, *Symphoricarpos* spp. and *Crataegus* spp. Exotic shrub species include *Tamarix spp.* and *Elaeagnus angustifolia.* Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can also occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditch ………………………………………….**Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

2b. Woodlands and shrublands of the montane or subalpine zone, typically surrounded by aspen or conifer forest …….**3**

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 or sometimes as moderate-wide valley bottoms on large floodplains or on pond margins. Common tree species include *Abies lasiocarpa*, *Picea engelmannii*, *Pseudotsuga menziesii*, and *Populus tremuloides* ……………………………………………………………………………**Rocky Mountain Subalpine-Montane Riparian Woodland**

3b. Montane or subalpine shrub wetlands (canopy dominated by shrubs with sparse or no tree cover). Narrow bands of shrubs along streambanks or wide, extensive shrub stands in low-gradient valley bottoms (sometimes referred to as a *shrub carr*). Beaver activity is common within the wider occurrences. In addition, this system can occur around the edges of fens, lakes, seeps, and springs on slopes away from valley bottoms. This system can also occur within a mosaic of multiple shrub- and herb-dominated communities within snowmelt-fed basins. In all cases,vegetation is dominated by species of *Salix*, *Alnus*, or *Betula.*...**Rocky Mountain Subalpine-Montane Riparian Shrubland**

4a. Wetland defined by groundwater inflows and organic soil (peat, mucky peat, muck) accumulation of at least 40 cm in the upper 80 cm. Vegetation can be woody or herbaceous. If the wetland occurs within a mosaic of non-peat forming wetland or riparian systems, then the patch must be at least 0.1 hectares (0.25 acres). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criteria. Common plant species include *Carex aquatilis, Carex limosa, Carex lasiocarpa, Betula glandulosa, Kobresia myosuroides, Kobresia simpliciuscula,* and *Trichophorum pumilum* ………………………………..………**Rocky Mountain Subalpine-Montane Fen**

4b. Wetland does not have at least 40 cm of 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…………………………………………..5

5a. Herbaceous wetlands with a permanent water source throughout all or most of the year. Water is at or more typically >15 cm 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**

5b. Herbaceous wetlands associated with a high water table or overland flow and sometimes seasonally flooded, but water table typically lowers by the end of the growing season. These wetlands include large meadows in valleys, narrow strips bordering ponds, lakes, and streams, and along seeps. 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 to HGM Classes

1a. Wetland is located on the shore of or adjacent to a waterbody (i.e., lake, impoundment) or in a valley, floodplain, or near a stream channel. Dominant water source is from waterbody or surface/subsurface connections with stream and not from precipitation or groundwater………**2**

2a. Wetland located on the shore of or adjacent to a lake, pond, or impoundment AND wetland hydrology is predominantly influenced by bidirectional flows related to changes in waterbody level…………………………………………**3**

3a. Wetland adjacent to waterbody that is greater than 8 ha (20 acres) and ≥2 m deep at its deepest point. Waterbody may be natural (i.e., Great Salt Lake, Utah Lake) or artificial (many reservoirs)….**Lacustrine Fringe**

3b. Wetland adjacent to smaller and/or shallower waterbody……………………………………….**go to 6b in the key**

2b. Wetland is located in a valley, floodplain or near a stream channel OR downslope from a waterbody. Wetland's dominant water source is unidirectional and horizontally spreading……………………………………………………………………**4**

4a. Wetland is located in a valley, floodplain or near a stream channel and water is from horizontal water movement from channel overbank flooding or subsurface hydrologic connections to the stream channel. Oxbows that receive overbank flooding are included in this classification, though beaver ponds are considered depressional…….**Riverine**

4b. Wetland is located immediately downstream from an impoundment and receives water from impoundment release. Water typically does not reach site through a well-defined channel, instead spreading horizontally from the release site, though some shallow channels may be present……**…Impoundment Release**

1b. Wetland not as above. Main water source may be from precipitation, overland flow, or groundwater or water may be impounded stream water……**5**

5a. Wetland meets ***all*** of the following criteria: a) is located on a slope (can be very gradual or nearly flat); b) groundwater is the primary water source; c) surface water, if present, flows through the wetland in one direction and usually originates 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 < 3 ft diameter and less than 1 foot deep)*..**Slope**

5b. Wetland does not meet all of the above criteria……………………………………………………………………………………….**6**

6a. Wetland is topographically flat with precipitation as the primary water source. Surface water and groundwater inputs may be present, but not significant (<10%). ……………………………………….**Mineral Soils Flats**

6b. Wetland not as above. Wetland either in flat area with high groundwater inputs (check water table) or in topographic depression or impounded area. **7**

7a. Wetland located within or hydrologically controlled by artificial impoundment >8 ha (20 acres) in size (but <2 m deep- otherwise see Lacustrine Fringe)……………………………………………………………………………**8**

8a Wetland located within impounded area. Primary water fluctuations are vertical with rising and falling water levels due to steep impoundment sides and relatively even bottom surface level ……………………………………………………………………………………………………….**Depressional Impoundment**

8b. Wetland hydrologically controlled by impounded area. Primary water fluctuations are bidirectional, with water spreading and receding horizontally with changing water levels. Sites often on mudflats that gently slope toward impoundments………**Depressional Impoundment Fringe**

7b. Wetland is located in a topographic depression or impounded area where water ponds or is saturated to the surface at some time during the year OR wetland in flat area with no obvious depression with water level maintained by high groundwater.Water typically from precipitation, snowmelt, overland runoff, or intersection with groundwater table, but can also be from small (<8 ha) natural or artificial impoundment of streams. Outlet, if one exists, is generally higher than the deepest part of the depression……….**Depressional**

Key to Cowardin Systems, Subsystems, and Classes of Utah[2]

Consider the entire wetland when determining which system and subsystem to assign to the AA. palustrine.

Systems

(ESTUARINE and MARINE systems omitted)

1a. Persistent emergents, trees, shrubs, or emergent mosses cover ≥30% of the area. Persistent emergents are herbaceous species that remain erect year-round even when senesced, such as cattails and bulrushes. ....**Palustrine**

1b. Persistent emergents, trees, shrubs, or emergent mosses cover <30% of substrate, but non-persistent emergent may be widespread during some seasons of the year……………………………**2**

2a. Situated in a channel; water, when present, usually flowing…………………………..**Riverine**

2b. Situated in a basin, catchment, or on level, sloping ground; water usually not flowing…………………**3**

3a. Area 8 ha (20 acres) or greater……………………………………………………**Lacustrine**

3b. Area less than 8 ha...**4**

4a. Wave-formed or bedrock shoreline feature present or water depth 2 m or more….**Lacustrine**

4b. No wave-formed or bedrock shoreline feature present and water less than 2m deep…………… ……………………………………………………………………**Palustrine**

Subsystem[3]

Riverine

1a. Flowing water in channel throughout the year……………………………………………………**2**

1b. Channel contains flowing water for only part of the year. When water is not flowing it may remain in isolated pools or surface water may be absent……………………………………………**Intermittent**

2a. Gradient low and water velocity slow; No tidal influence and some water flows throughout the year; the substrate consists of mainly of sand and mud; oxygen deficits may sometimes occur, the fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common; floodplain is well-developed………………………….**Lower Perennial**

2b. Gradient high and water velocity fast; No tidal influence and some water flows throughout the year; the substrate consists of rock, cobbles, or gravel with occasional patches of sand; natural dissolved oxygen concentration is normally near saturation; fauna is characteristic of running water, and there are few or no plankton forms; very little floodplain development…………….**Upper Perennial**

Lacustrine

1a. Water greater than 2 m deep, not all Lacustrine habitats include this subsystem…………………**Limnetic**

1b. Water less than 2 m deep, all wetland habitats in the Lacustrine System include this subsystem. Extends from the shoreward boundary of this system to a depth of 2 , below low water or to the maximum extent of non-persistent emergent, if these grow at depths >2 m…………………………….**Littoral**

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[2] Modified from Artificial Keys to the Systems and Classes, Cowardin et al. 1979, Appendix E

[3] Subsystems are applied to Riverine and Lacustrine Systems only, there are no Subsystems for Palustrine Systems

***Classes*[4]**

1a. During the growing season of most years, areal cover by vegetation is <30%……………..…………………….**2**

2a. Water regime very wet: permanently flooded (H), intermittently exposed (G), semipermanently flooded (F). Substrate usually not soil………………………………………………………………….…………………..**3**

3a. Substrate of bedrock, boulders or stones occurring singly or in combination covers ≥75 of the area (rock >25.4 cm)………………………………………………………………………………………….…**Rock Bottom**

3b. Substrate of organic material, mud, sand, gravel, or cobbles with <75% aerial cover of stones, boulders or bedrock (rock >25.4 cm)….……………………………………………….…**Unconsolidated Bottom**

2b. Water regime drier: seasonally flooded (C), temporarily flooded (A), intermittently flooded (J), seasonally flooded/saturated (E), saturated (B), or artificially flooded (K). Substrate often soil….**4**

4a. Contained within a stream channel that does not have permanent flowing water (i.e., Intermittent Subsystems of Riverine System)……………………………………………………………**Streambed**

4b. Contained in channel with perennial water or not containing a channel…………………………….**5**

5a. Substrate of bedrock, boulders, or stones occurring singly or in combination cover ≥75% of the area………………………………………………………………………………………..**Rocky Shore**

5b. Substrate of organic material, mud, sand, gravel, or cobbles; <75% of the cover consisting of stones, boulders, or bedrock……………………………………**Unconsolidated Shore**

1b. During the growing season of most years, areal cover by vegetation is ≥30%……………..…………………….**6**

6a. Vegetation composed of pioneering annuals or seedling perennials, often not hydrophytes, occurring only at time of substrate exposure…………………………………………………………………………………**7**

7a. Contained in a channel that does not have permanent flowing water…**Streambed (Vegetated)**

7b. Contained within a channel with permanent water or not contained in a channel…………………….. ……………………………………………………………………………………….**Unconsolidated Shore (Vegetated)**

6b. Vegetation composed of algae, bryophytes, lichens, and vascular plants that are usually hydrophytic perennials……**8**

8a. Vegetation composed predominately of nonvascular species……………………………………….…**9**

9a. Vegetation macrophytic algae, mosses, or lichens, growing in water or the splashzone of shores……**Aquatic Bed**

9b. Vegetation mosses or lichens usually growing on organic soils and always outside the spashzone of shores……………………………………………………………………….**Moss-Lichen Wetland**

8b. Vegetation composed predominant of vascular species……………………………………………….**10**

10a. Vegetation herbaceous…………………………………………………………………………………………….**11**

11a. Vegetation emergent……………………………..**Emergent Wetland**

11b. Vegetation submergent, floating-leaved, or floating………………..**Aquatic Bed**

10b. Vegetation trees or shrubs……………………………………………………………………………………..**12**

12a. Dominants less than 6m tall……………………………………..**Scrub-Shrub Wetland**

12b. Dominants 6m taller or more…………………………………………**Forested Wetland**

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[4] Classes apply to all Systems

Cowardin Water Regime Modifiers (in order from driest to wettest)* [5]*:

Consider the likely length of inundation at sites in relation to the Army Corps definition of typical wetland hydrology, *"The site is inundated (flooded or ponded) or the water table is ≤12 inches* (~30 cm) *below the soil surface for ≥14 consecutive days during the growing season at a minimum frequency of 5 years in 10* (U.S. Army Corps of Engineers, 2005)*.* The growing season is often approximated as the period between last spring freeze and first fall freeze.

Intermittently Flooded (J): The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this regime may changes as soil moisture conditions change. Some areas exhibiting this regime do not fall under the Cowardin et al. definition of wetland because they do not have hydric soils or support hydrophytes. This water regime is limited to describing habitats in the arid western portions of the United States. This water regime has been used extensively in vegetated and non-vegetated situations including some shallow depressions (playa lakes), intermittent streams, and dry washes.

Temporarily Flooded (A): Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime.

Saturated (B): The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present. This modifier is often applied to groundwater dependent ecosystems with stable water tables (fens) in this region.

Seasonally Flooded (C): Surface water is present for extended periods especially early in the growing season, but is absent by the end of the season in most years. When surface water is absent, the water table is often near the surface, but may vary extending from saturated to the surface to well below the ground surface.

Seasonally flooded/saturated (E) – The wetland has surface water present at some time during the growing season exhibiting flooded conditions (especially early in the growing season). When surface water is absent the substrate remains saturated near the surface for much of the growing season.

Semi-permanently Flooded (F): Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface.

Intermittently Exposed (G): Surface water is present throughout the year except in years of extreme drought. This is applied to wetland such as inland saline lakes and marshes where there is standing water throughout the year in most years.

Permanently Flooded (H): Water covers the land surface throughout the year in all years. Vegetation is composed of obligate hydrophytes. Mostly applied to deepwater habitats where there is little chance of drying.

[5] For nontidal, inland freshwater and saline areas. From Cowardin et al. (1979), additional description for some modifiers have been included based on regional use.

Cowardin Special Modifiers

Beaver: Created or modified by beaver activity.

Partially ditched/drained: The water level has been artificially lowered, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes. Drained areas are not considered wetland if they can no longer support hydrophytes.

Farmed: The soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become reestablished if farming is discontinued.

Diked: Created or modified by a man-made barrier or dam which obstructs the inflow of water

Impounded: Created or modified by a man-made barrier or dam which obstructs the outflow of water

Artificial substrate: Concrete-lined canals and areas with Rock Bottom, Unconsolidated Bottom, Rocky Shore, and Unconsolidated Shore that were emplaced by humans, using either natural materials such as dredge spoil or synthetic materials such as discarded automobiles, tires, or concrete.

Excavated: Lies within a basin or channel excavated by humans.

Examples of Palustrine System[6]:

Combine the codes for the system, class, and water regime with any special modifiers to classify wetlands. The following are examples of types of wetlands and how they would be coded for wetland mapping purposes.

1. Cattail marsh that has standing water for most of the year: **PEMF**
2. A prairie pothole dominated by grasses and sedges that is only wet at the beginning of the growing season: **PEMA**
3. A fen in the subalpine zone: **PEMB**
4. A small shallow pond that has lily pads and other floating vegetation and holds water throughout the growing season: **PABF**
5. A small shallow pond with less than 30% vegetation and a muddy substrate that holds water for most of the year: **PUBF**
6. A wetland dominated by willows adjacent to a stream that is only periodically flooded: **PSSA**

[6] Descriptions of Palustrine Systems with water regime modifiers are borrowed from Lemly, J., and Gilligan, L., 2013, Ecological integrity assessment for Colorado wetlands—field manual version 1.0- review draft: Fort Collins, Colorado Natural Heritage Program, 92 p.

Buffer Land Cover

Buffer Land cover	Non-buffer Land Cover
• Vegetated natural and semi-natural areas including forests, grasslands, shrublands, wetlands, and open water • Natural unvegetated areas including permanent snow or ice cover and natural rock outcrops or sandy and gravel areas. • Old fields undergoing succession • Rangeland[1] • Partially vegetated pastures[1] • Recently burned natural land with at least some vegetative recovery[1] • Low use tracks such as single-use ATV tracks or undeveloped and unmaintained dirt tracks that are vegetated in the middle and only used once or a few times a year. • Vegetated levees, natural substrate ditches • Recreational areas with little substrate disturbance (bike, horse, and foot trails with narrow width of influence)	• Commercial and residential areas, parking lots, railroads and train yards • Lawns, sports fields, traditional golf courses • Dirt and paved roads • Mined areas • Agriculture including row crops, orchards, vineyards, clear-cuts • Animal feedlots, poultry ranches, animal holding pens with mostly bare soil • Severely burned land with little vegetative recovery • Recreational areas with substantial disturbance (wide paths, paved areas, trash/dumping) • Oil and gas wells • Wind farms

[1]These land cover types can vary considerably in the degree to which they serve as buffer cover. We will use the buffer condition-soil metric to help distinguish between soil disturbance-related features with varying degrees of buffer functionality.

Wetland Determination Reference

REGIONS	Arid West	Western Mountains, Valleys, and Coast
Climate	Generally hot and dry with a long summer dry season. Average annual precipitation mostly <15 in. (380 mm). Most precipitation falls as rain.	Cooler and more humid, with a shorter dry season. Average annual precipitation mostly >20 in. (500 mm). Much of the annual precipitation falls as snow, particularly at higher elevations.
Vegetation	Little or no forest cover at the same elevation as the site and, if present, usually dominated by pinyon pine (e.g., *P. monophylla* or *P. edulis*), junipers (*Juniperus*), cottonwoods (e.g., *Populus fremontii*), willows (*Salix*), or hardwoods (e.g., *Quercus, Platanus*). Landscape mostly dominated by grasses and shrubs (e.g., sagebrush [*Artemisia*], rabbitbrush [*Chrysothamnus*], bitterbrush [*Purshia*], and creosote bush [*Larrea*]). Halophytes (e.g., *Allenrolfea, Salicornia, Distichlis*) present in saline areas.	Forests at comparable elevations in the local area dominated by conifers (e.g., spruce (*Picea),* fir *(Abies),* hemlock *(Tsuga),* Douglas-fir *(Pseudotsuga),* coast redwood (*Sequoia*), or pine *(Pinus)* except pinyon) or by aspen (*Populus tremuloides*). Open areas generally dominated by grasses, sedges, shrubs (e.g., willows or alders [*Alnus*]), or alpine tundra.
Soils	Mostly dry, poorly developed, low in organic matter content, and high in carbonates. Soils sometimes highly alkaline. Surface salt crusts and efflorescences common in low areas	Generally better developed, higher in organic matter content, and low in carbonates. Surface salt features are less common except in geothermal areas.
Hydrology	Drainage basins often lacking outlets. Temporary ponds (often saline), salt lakes, and ephemeral streams predominate. Water tables often perched. Major streams and rivers flow through but have headwaters outside the Arid West.	Streams and rivers often perennial. Open drainages with many natural, freshwater lakes. Water tables often continuous with deeper groundwater. Region serves as the headwaters of the major streams and rivers of the western United State

Adapted from: U.S. Army Corps of Engineers. (2010). Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region Version 2.0 (No. ERDC/EL TR-10-3). Vicksburg, MS.

Determining Dominance by Hydrophytic Vegetation

We will consider sites to have hydrophytic vegetation if more than 50% of the dominant plant species present have wetland indicator ratings of OBL, FACW, or FAC. If we need to evaluate dominance of hydrophytic vegetation before surveying a site, we will make a coarse estimate of which species are dominant rather than estimating percent cover of all species present. Following are the general steps to take:

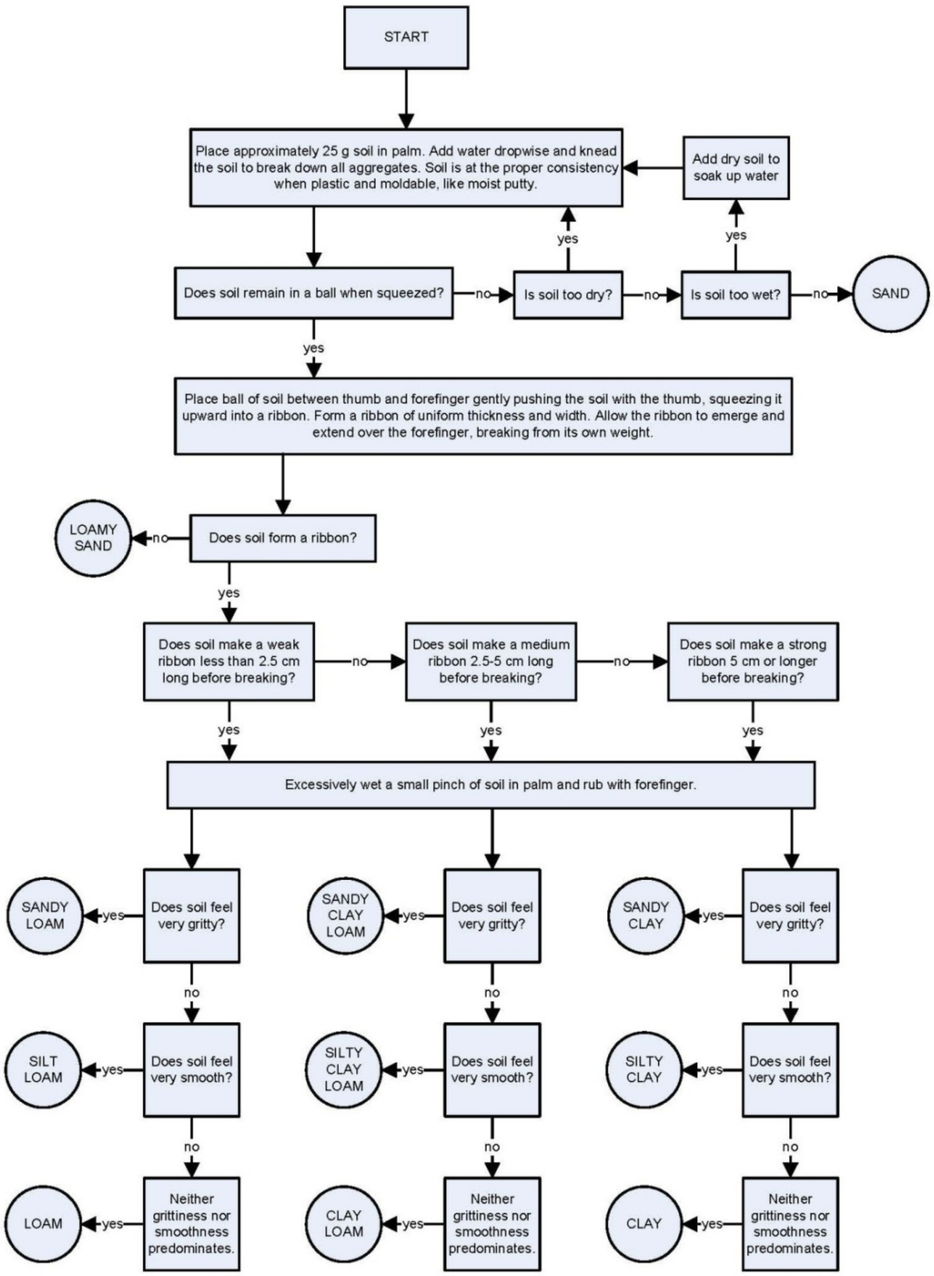
1. Determine strata (vegetation layers) present in the area. Strata include trees (DBH ≥7.6 cm), saplings and shrubs (DBH < 7.6 cm), herbaceous plants, and woody vines.
2. Estimate the percent of the assessment area covered by each strata. For example, all tree species combined (including trunks and canopy cover) may occupy 25% of the assessed area. If an individual strata has less than 5% cover, consider species in that strata part of a more abundant strata.
3. Determine the cover values that correspond with 50% and 20% relative cover within the strata. For example, if a strata has 60% total cover, 50% relative cover will be 0.5 *60% or 30% total cover and 20% relative cover will be 0.2*60% or 12% total cover.
4. Record the name(s) of the most prevalent plant species within each strata and their percent cover. You can stop recording plant species once the total recorded cover get to the 50% relative cover value (i.e, 30% absolute cover in our example). If any species have 20% relative cover (i.e., 12% absolute cover in our example) and are not on the list, add those species as well.
5. Once the dominant species in each strata are listed, determine the percent of these species that are FAC, FACW, or OBL. A species can be counted twice if it is listed in two strata (e.g., trees and saplings)

Indicators of Site Hydrology

Presence of at least one primary (P) or two secondary (S) features indicates that site has wetland hydrology. Features in italics apply to only one region; indicators that begin with a single * apply to the Western Mountains region and those with ** apply to the Arid West region. *** under type refers to indicators that are secondary in riverine systems in the Arid West and primary in Western Mountains and all other Arid West wetland types. List adapted from the Arid West and Western Mountains supplements to the Corps of Engineers wetland delineation manual and excludes indicators B7 and C9 related to aerial imagery.

Indicator	Description	Type
Group A – Observation of Surface Water or Saturated Soils		
A1 – Surface water		**P**
A2 – High water table	Within 30 cm of the soil surface	**P**
A3 – Saturation	Within 30 cm of soil surface (i.e., glistening or water shakes off soil), with water table or restrictive soil layer below	**P**
Group B – Evidence of Recent Inundation		
B1 – Water marks	Stains on bark of woody vegetation, rocks, bridge supports, fences, etc.	**P** ***
B2 – Sediment deposits	Thin layers of silt or clay or organic matter on tree bark, plant stems, rocks, etc.	**P** ***
B3 – Drift deposits	Rafted debris on the ground or entangled in vegetation	**P** ***
**B4- Algal mat or crust*	*Mat or dried crust of algae left on soil surface (see B12)*	***P***
**B5- Iron deposits*	*Thin orange/yellow crust/gel of oxidized iron on soil surface or objects near surface*	***P***
B6 – Surface soil cracks	Excluding shrink-swell cracks in clay soils and cracks in temporary puddles that lack hydric soils and veg	**P**
**B8- Sparsely veg. concave surface*	*<5% cover of vegetation in depressions and swales due to long-duration of ponding*	***P***
B9 – Water-stained leaves	Tannin-leached leaves that have turned grayish or brownish from inundation and contrast with nearby leaves outside of the wetland. Oak, ash, maple, sycamore exhibit this indicator, cottonwoods and aspens probably do not.	**P**
B10 – Drainage patterns	Flow patterns visible on the soil surface or eroded into soil or low vegetation bent over in the direction of flow or absence of litter due to flowing water	**S**
B11 – Salt crust	Hard or brittle deposits (NOT fluffy or powdery) of salts from evaporation of saline surface water	**P**
***B12 – Biotic crust*	*Ponding-remnant biotic crusts including benthic microflora or free-floating algae (see B4)*	***P***
B13 – Aquatic invertebrates	Live individuals, diapausing eggs, crustacean cysts or dead remains of aquatic invertebrates (should be more than just a few)	**P**
Group C – Evidence of Current or Recent Soil Saturation		
C1 – Hydrogen sulfide odor	Hydrogen sulfide odor within 30 cm of soil surface	**P**
C2 – Dry-season water table	Water table between 30 and 60 cm during dry season or during drier-than-normal year	**S**
C3 – Oxidized rhizospheres along living roots	Soil layer within 30 cm of surface with ≥2% iron-oxide coatings or plagues on the surface of living roots or soil pores around roots	**P**
C4 – Presence of reduced iron	Soil layer within 30 cm of surface with reduced iron based on ferrous iron test or color change upon exposure to air	**P**
C6 – Recent iron reduction in tilled soils	Soil layer within 30 cm of surface with ≥2% redox concentrations as pore linings or soft masses in the tilled surface of soils cultivated within 2 years	**P**
***C7 – Thin muck surface*	*Layer of muck ≤2.5 thick on soil surface*	***P***
***C8 – Crayfish burrows*	*Openings in ground up to 5 cm in diameter, usually surrounded by excavated mud*	***S***
Group D – Evidence from Other Site Conditions or Data		
**D2 – Geomorphic position*	*Depression, swale or drainage way, concave position within floodplain, at the toe of a slope, on an extensive flat, or in area of groundwater discharge except on rapidly permeable soils (sand and gravel substrates)*	***S***
D3 – Shallow aquitard	Relatively impermeable soil layer or bedrock within 30 cm of the surface with hydric soils and veg. also present. Layer can be identified by lack of root penetration through layer	**S**
D5 – FAC-neutral test	Drop FAC species from dominant plant list. Are >50% of remaining species FACW or OBL?	**S**
**D7 – Frost-heave hummocks*	*Not hummocks from livestock pugging or shrink-swell clay soils*	*S*

Soil Texture Flow Chart[7] and Triangle



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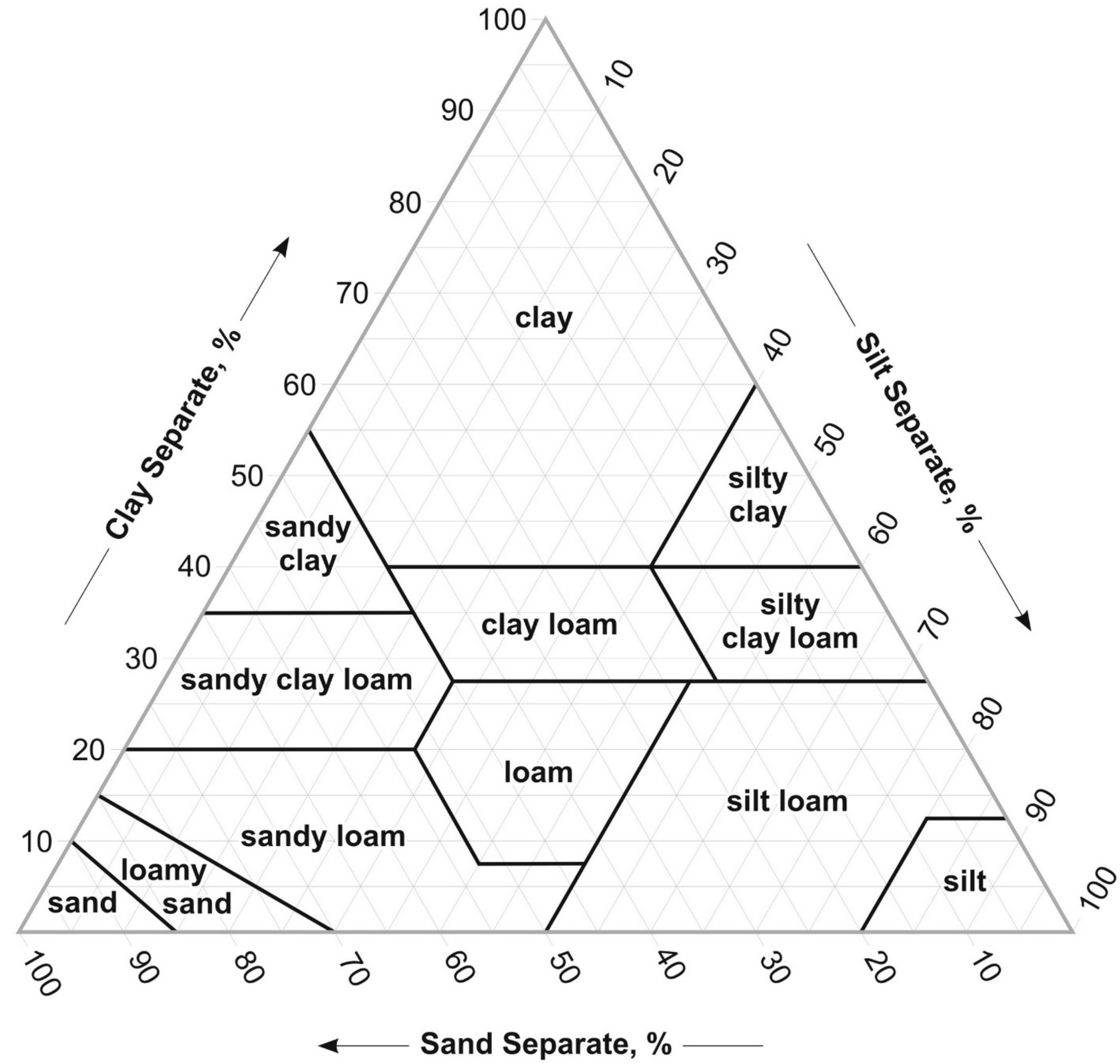
[7] Modified from S.J. Thien, 1979.*A flow diagram for teaching texture by feel analysis.* Journal of Agronomic Education. 8:54-55, by the NRCS. [Accessed 2013](#).

Soil Textural Triangle



Reference for Assessing Hydric Soil Indicators

Steps for assessing soil indicators

1. For each layer, use table of soil characteristics to determine which, if any, hydric soil characteristics may be present.
2. For characteristics that may be present, go to the indicated number(s) under the key to soil characteristics and determine if indicator(s) are actually present by going through key. Remember that indicators that begin with A apply to all soils, F to clayey/loamy soils, and S to sandy soils. Sandy soils are those that are textured as sand or loamy sand. Layers may be combined to reach necessary thickness.
3. Make sure that all layers above any of the indicators have chroma ≤2 or are <15 cm thick (except for F8).

Problem soil indicators can only be selected for sites where other hydric soil indicators are present. Indicators of wetland hydrology and hydrophytic vegetation ***must be*** present to record these features.

Table of Hydric Soil Characteristics

#	Value/Chroma	Description
1	*NA*	Organic soil layer
2	*NA*	Mucky mineral soil layer
3	*NA*	Hydrogen sulfide odor
4	≥5/1, ≥6/≤2	Depleted matrix
4	4/2, 5/2, 4/1	Depleted matrix: Must have ≥2% distinct/prominent redox concentrations
5	≥4/1 (except hues of 5G or N)	Gleyed: Hues include N, 10Y, 5GY, 10GY, 5G, 10G, 5BG, 10BG, 5B, 10B, 5PB, chroma of 1 except 5G can have chroma 1 or 2 and N any chroma
6	≤3/≤2	Need depletions or redox features to qualify
7	*NA*	Site a closed depression; soil with ≥5% redox concentrations
8	≤4/≤4	**Problem soils only**, Hue must be 7.5YR or redder, ≥2% redox depletions or concentrations
9	≤3/≤1	**Problem soils only,** must be shallow depression with bedrock within 25 cm of soil surface
10	Usually ≥5/≤2 mixed with areas with chroma 3 or 4, but not required	**Sandy soils only,** Layer with areas stripped of organic matter or iron/manganese oxides, leading to faintly constratsting patterns of two or more colors

Key to Hydric Soil Characteristics

1. **Layer of organic (peat, mucky peat, muck) present**
    a. **Problem soil, Layer of *muck* at least 2 cm thick**, value≤3, chroma ≤1, within 15 cm of surface. (***mountain region only***)……………………………………………………………………..……………A10
    b. **Not a problem soil, Layer of organic at least 20 cm thick** (note about rock, etc.) (all of the below could apply)
        i. **Organic layer of 40 cm in the top 80 cm of soil** (or organic matter over bedrock or in layers with >90% rocks)?…………………………………………………………………….……………………A1
        ii. **Organic layer starts on surface**, soil below has chroma ≤2 (aquic conditions must be present).. ……A2
        iii. **Organic layer starts within 15 cm of surface**, has hue 10YR or yellower (5Y, etc.), value ≤3, chroma ≤1, underlain by soil with chroma ≤2………………………………………...A3

c. **Arid West only, layer of muck 1 cm or more thick**, value ≤3 and chroma ≤1, starting within 15 cm of soil surface……………………………………………………………………………………………………A9

2. **Layer of mucky mineral soil** starting within 15 cm of soil surface
   a. **Layer 10 cm thick** ………………………………………………………………………………………………..F1
   b. **Sandy soil: layer 5 cm thick**…………………………………………………………………………………….S1
3. **Hydrogen sulfide odor** within 30 cm of soil surface…………………………………………………………………….A4
4. **Depleted at least 60% of matrix** (see table above)
   a. **layer 5 cm thick** entirely within the top 15 cm of soil…………………………………………………..F3
   b. **Layer 15 cm or more thick**
      i. **Layer starts within 25 cm of soils surface**……………………………………………………………F3
      ii. **Layer starts within 30 cm of soil surface,** layer **above** depleted matrix has value ≤3 and chroma ≤2 (if loamey/clayey) ……………………………………………………………………A11
      iii. **Layer starts below 30 cm of soil surface,** layer(s) **above** depleted matrix must have value ≤2.5 and chroma ≤1 to depth of 30 cm and value of ≤3 and chroma ≤1 in any remaining layers ……………………………………………………………………………………………A12
   c. **Sandy soil: layer 10+ cm thick starting within 15 cm of soil surface, must have 2% or more redox conctrations**...S5
5. **Gleyed at least 60% of matrix** (see table above)
   a. **Layer starts 30 cm of soil surface,** ………………………………………………………………………………F2
   b. **Layer starts within 30 cm of soil surface,** layer **above** depleted matrix has value ≤3 and chroma ≤2……A11
   c. **Layer starts below 30 cm of soil surface,** layer(s) **above** depleted matrix must have value ≤2.5 and chroma ≤1 to depth of 30 cm and value of ≤3 and chroma ≤1 in any remaining layers. ……A12
   d. **Sandy soil: Layer starts within 15 cm of soil surface**...S4
6. **Layer with matrix value ≤3 and chroma ≤2**, 10 cm thick layer entirely within top 30 cm of mineral soil
   a. **Chroma ≤1**
      i. ≥2% distinct/prominent redox concentrations as soft masses or pore linings……….F6
      ii. ≥10% redox depletions (value ≥5 and chroma ≤2)…………………………………………..F7
   b. **Chroma=2**
      i. ≥5% distinct/prominent redox concentrations as soft masses or pore linings……….F6
      ii. ≥20% redox depletions (value ≥5 and chroma ≤2)…………………………………………F7
7. **In closed depressions**,
   a. **≥5% distinct/prominent redox concentrations** as soft masses or pore linings in ≥5 cm layer entirely within upper 15 cm of soil…………………………………………………………………………F8
8. **Problem soil, Red parent material (meets definition above),** at least 5 cm thick entirely within 30 cm of soil surface, 2% or more redox depletions or concentrations………TF2
9. **Problem soil, depression or other concave landform with shallow bedrock (mountain region only)**
   a. **Bedrock between 15 and 25 cm of surface**, layer 15 cm thick starting within 10 cm of surface with value ≤3 and chroma ≤1, remaining soil to bedrock must have chroma ≤2…TF12

b. **Bedrock within 15 cm of soil surface,** more than half of soil thickness has value ≤3 and chroma ≤1, remaining soil to bedrock must have chroma ≤2……………………………………….TF12

10. Sandy soils, stripped matrix

a. Layer starting within 15 cm of surface, colors listed in table are common, but not required………S6

Evaluating Soil Texture

Soil layers are only likely to be organic or mucky mineral if they are very frequently saturated or inundated. Base evaluation in part on whether site has hydrology and vegetation indicative of consistently wet conditions.

Determine whether soil is organic, mucky mineral, or mineral:
Gently rub soil material between forefinger and thumb. If soil feels gritty after first or second rub, you have mineral soil. If soil feels greasy after the second rub, rub the material two or three more times. If the soil now feels gritty or plastic, than it is mucky mineral. If the soil remains greasy, it is organic soil and further divisions need to be made (see below)

Determine whether organic soil is muck, mucky peat, or peat
Use the chart below to differentiate between types of organic soils based on the percentage of visible fibers in a rubbed and unrubbed sample and nature of material extruded when sample is squeezed

Soil Texture	% Visible Fibers		Nature of Material Extruded When Squeezing
	Unrubbed	Rubbed	
Muck	<33%	<17%	From ½ to all of sample squeezed out, water very turbid, thick and pasty, or no free water
Mucky peat	33-67%	17-40%	From no organic solids squeezed out to 1/3 of sample squeezed out; water dark brown
Peat	>67%	>40%	No organic solids squeezed out, water from clear and colorless to brown and turbid

Adapted from USDA Natural Resources Conservation Service (1999) and U.S. Army Corps (2010)

Assessment Area Soil and Substrate Disturbance Reference Card

Consider the following when assessing soil and substrate disturbance

1) **How widespread is damage?**
2) **What is the impact on vegetation? Areas with compacted soils often have little or no vegetation growing**
3) **What is the depth of disturbance? Is the disturbance deep enough to unnaturally channelize or pool water or to serve as an artificial dike?**

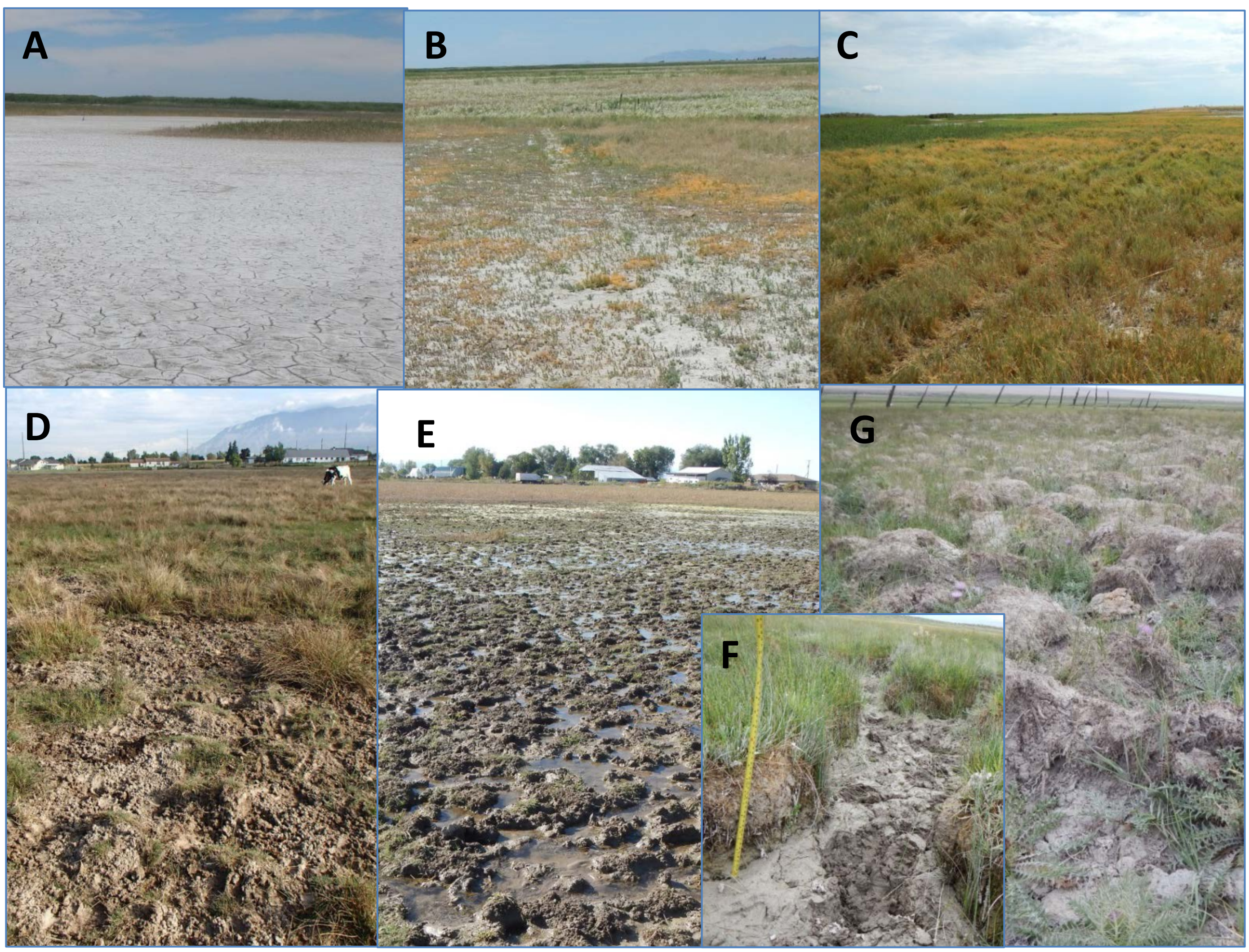
Explanation of figures:

A is a site with naturally bare soil with no signs of soil disturbance in this photograph, scored as A

B shows some soil disturbance where the ground is less vegetated than surrounding areas due to compaction; height of disturbance is too low to affect hydrology; site may be scored as A if this is only disturbance because mostly revegetated or as B if this level of disturbance is more frequent across site

C shows tracks through vegetation. If vegetation is merely toppled over due to tracks, site may be scored as A. If vegetation is stunted or not growing in due to compaction, site would likely score as B. May need to also take into account depth of any soil damage.

D, E, F, and **G** show soil disturbance due to grazing. Disturbance at site pictured in D was shallow and localized to only a few locations in site; site was scored as B. Disturbance at site pictured in E was moderately deep and found throughout entire site; site should be scored as C because damage is likely to recover on its own if cattle are removed. F and G show deep pugging that alters site hydrology and changes vegetation; site was scored as D.



Plant Collection Form

Location ID: ________________ GPS ID: _________________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___
Observer Name: _____________________ Additional Observers:____________________ Survey Date: ________________________

Collection #: ___________ Plant Family: _________________________ Sci. Name: ____
Height: __________ cm m (circle one) Features Present? (circle) Rhizome Stolon Caespitose Basal Rosettes Flowers Fruit
Flower Color: _______________ Other Species Notes: (odor, stickiness, leaf/stem color, habitat , etc.):____________________________________
____

Location ID: ________________ GPS ID: _________________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___
Observer Name: _____________________ Additional Observers:____________________ Survey Date: ________________________

Collection #: ___________ Plant Family: _________________________ Sci. Name: ____
Height: __________ cm m (circle one) Features Present? (circle) Rhizome Stolon Caespitose Basal Rosettes Flowers Fruit
Flower Color: _______________ Other Species Notes: (odor, stickiness, leaf/stem color, habitat , etc.):____________________________________
____

Location ID: ________________ GPS ID: _________________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___
Observer Name: _____________________ Additional Observers:____________________ Survey Date: ________________________

Collection #: ___________ Plant Family: _________________________ Sci. Name: ____
Height: __________ cm m (circle one) Features Present? (circle) Rhizome Stolon Caespitose Basal Rosettes Flowers Fruit
Flower Color: _______________ Other Species Notes: (odor, stickiness, leaf/stem color, habitat , etc.):____________________________________
____

Location ID: ________________ GPS ID: _________________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___
Observer Name: _____________________ Additional Observers:____________________ Survey Date: ________________________

Collection #: ___________ Plant Family: _________________________ Sci. Name: ____
Height: __________ cm m (circle one) Features Present? (circle) Rhizome Stolon Caespitose Basal Rosettes Flowers Fruit
Flower Color: _______________ Other Species Notes: (odor, stickiness, leaf/stem color, habitat , etc.):____________________________________
____

Location ID: ________________ GPS ID: _________________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___
Observer Name: _____________________ Additional Observers:____________________ Survey Date: ________________________

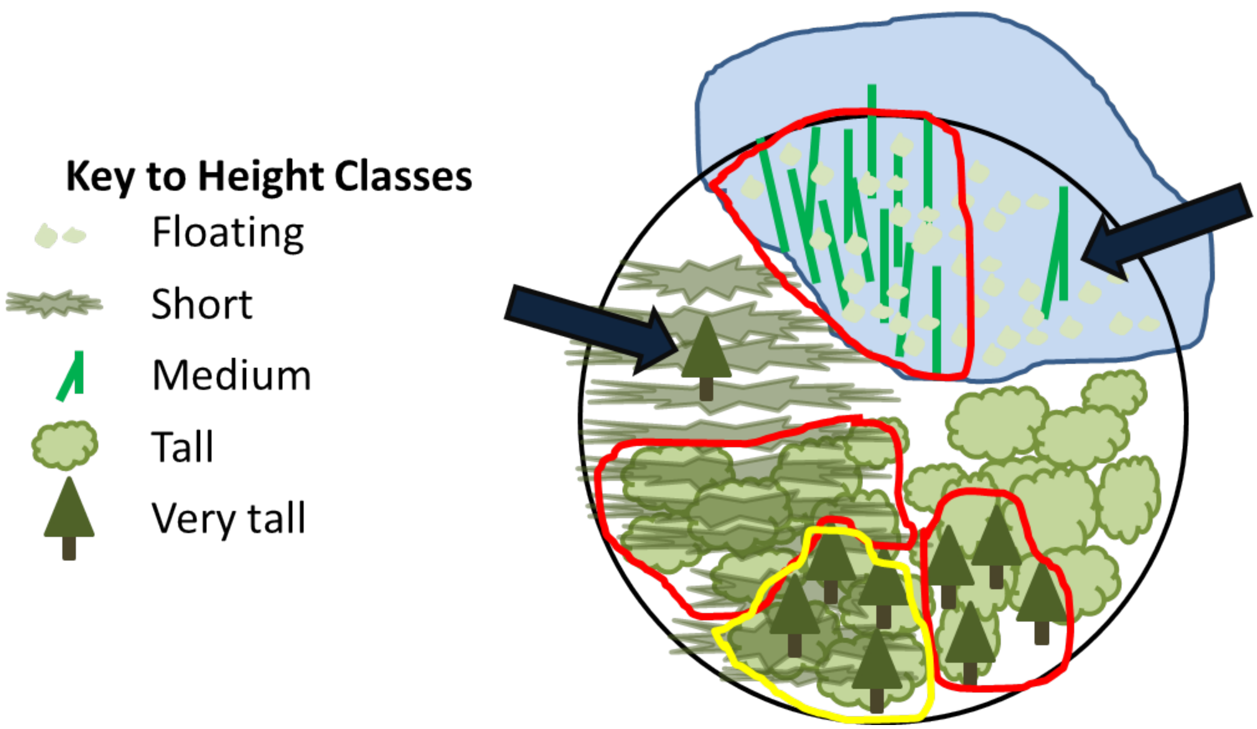
Collection #: ___________ Plant Family: _________________________ Sci. Name: ____
Height: __________ cm m (circle one) Features Present? (circle) Rhizome Stolon Caespitose Basal Rosettes Flowers Fruit
Flower Color: _______________ Other Species Notes: (odor, stickiness, leaf/stem color, habitat , etc.):____________________________________
____

Location ID: ________________ GPS ID: _________________ UTM E: ___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___
Observer Name: _____________________ Additional Observers:____________________ Survey Date: ________________________

Collection #: ___________ Plant Family: _________________________ Sci. Name: ____
Height: __________ cm m (circle one) Features Present? (circle) Rhizome Stolon Caespitose Basal Rosettes Flowers Fruit
Flower Color: _______________ Other Species Notes: (odor, stickiness, leaf/stem color, habitat , etc.):____________________________________
____

Reference Card for Overall Estimates

The diagram below shows a potential assessment area (bounded by black lines) with the distribution of different height classes of vegetation. The assessment area should be divided into regions with different overlap statuses before making overlap estimates. In the example below, areas with overlap of two heights is circled in red and three heights is circled in yellow, yielding estimates of approximately 38% and 10%, respectively. The minor regions of overlap depicted by the arrows may add an additional 1 or 2% to the overall estimation.



Appendix C:

2016 Field Forms

2016 UTAH RAPID ASSESSMENT PROTOCOL FIELD SURVEY FORM

LOCATION AND GENERAL SITE INFORMATION

Unique Site ID: ______________________ **Site Name**:____

Surveyor IDs: ____ **Date (mm/dd/yyyy):** _____________________________

AA Dimensions:
__ 40-m radius circle
__ Rectangle, width___, length___
__ Freeform (collect GPS track of edge)

Site is ◯ Level II ◯ Level III

Aspect (deg): _____________ OR Flat OR N/A

Slope (deg): ______________ OR Flat OR N/A

Circle Flat when you cannot discern the aspect because the site is so flat and N/A when there are multiple aspects and none are dominant

AA Placement and Dimension Comments:

Reason Moved: ◯ not moved ◯ more than one wetland ◯ no wetland present ◯ inclusions too large
◯ multiple Ecological Systems ◯ other:

SPATIAL DATA OF ASSESSMENT AREA (NAD83 UTM Zone 12)

Waypoints should be entered in GPS as [siteID]-[waypointCategory][#], such as JOR-257-SOIL1, but can be listed just as SOIL1, WQ1, etc.
Categories include: CEN, N, E, S, W- center, cardinal points of circular AA; COR- corner of rectangular plot; P- photo location (if not associated with rectangular plot corners or circular AA cardinal points); SOIL- soil pit; WQ- water quality data collection outside of soil pit; PLOT- level III subplot

Freeform: Track ID:_________________________ Area: _____________ m²

Photo Locations	**Soil/Water Quality Locations**	**Other Coordinate Locations**	Waypoint ID:_________________
Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________
Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________
Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________
Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________
Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________	Waypoint ID:_________________

ASSESSMENT AREA PHOTOS

Photo categories: standard ***AA*** photo, ***site*** overview, or ***other***- include description (O)

Camera ID: ________________________
Photo # Range:_____________________

Category	Waypoint ID	Aspect (deg)	Photo #	Description
Site overview				
AA				
AA				
AA				
AA				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				
AA Site Other				

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF AA

Composition of AA	Wetland origin
___ % AA with target wetland	___ Natural feature with minimal disturbance
___ % AA with non-wetland riparian area	___ Natural feature, but altered or augmented
___ % AA with >1 m standing water	___ Non-natural feature created by passive or active management
___ % AA with upland inclusions	___ Origin unknown

Livestock grazing (evaluate based on freshness of dung and tracks, presence of livestock and fencing, etc.)

__ AA grazed in current year prior to survey
__AA likely routinely grazed but not yet grazed in current year
__ AA historically or rarely grazed
__ No physical evidence suggests that AA has ever been regularly grazed

Ecological System Basin and Colorado Plateau
___% Hanging Garden
___% Emergent Marsh
___% Great Basin Wood/Shrub
___% Greasewood Flat
___% Interdunal Swale
___% Playa
___% Alkaline Depression

Rocky Mountains Woody
___% Lower Mtn Wood/Shrub
___% Subalpine-Mtn. Wood
___% Subalpine -Mtn Shrub

Rocky Mountains Herbaceous
___% Fen
___% Emergent Marsh
___% Wet Meadow

Fidelity to Dominant Ecological System: High Med Low

Classification Comments:

Cowardin System/Subsystem **Riverine :** Intermittent__ Lower Perennial__ Upper Perennial__ **Lacustrine:** Limnetic __ Littoral__ **Palustrine:** __

Cowardin System Fidelity: High Med Low

Site Features (select all that apply; see reference card for definitions) __partly drained/ditched __beaver
__farmed __ diked (obstruct inflow) __ impounded (obstruct outflow) __ artificial substrate __ excavated

Classification Comments:

HGM Class (pick only one) Fidelity: High Med Low

___ Riverine ___ Depressional ___ Mineral Soil Flats ___ Lacustrine Fringe ___ Slope

___ Depressional Impoundment ___ Depressional Impoundment Fringe ___ Impoundment Release

Classification Comments, including whether more than one HGM class present:

RIVERINE-SPECIFIC CLASSICATION OF AA: Fill out if AA has a stream/river channel or is located in stream floodplain

Confined vs. Unconfined Valley Setting

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

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

AA Proximity to Channel

AA includes: ___ channel and one bank ___ channel and two banks

___ no channel and one bank ___ no channel and no bank

For sites with no channel, record distance from AA edge to channel center: ______ m

Stream Flow Duration

______ Perennial

______ Intermittent

______ Ephemeral

Stream Depth at Time of Survey (if evaluated):

Channel is : Dry In Pools Only Flowing

Depth: _____ cm OR ≥ 1 m

AA REPRESENTATIVENESS

Is AA the entire wetland/riparian area? ___ Yes ___ No

If no, how representative is AA of larger wetland/riparian area ___ Low ___ Moderate ___ High

Provide comments:

WILDLIFE OBSERVATIONS (please take photos of egg masses, frogs, or other wildlife when possible)

MAJOR VEGETATION PATCHES ZONES WITHIN AA

Patches are distinct vegetation patches that share similar physiognomy and species composition. Individual patches must be at least 10 m² (~ 3.2 m x 3.2 m) in a 0.5 ha AA and must cover a total of at least 5% of the AA. Unvegetated patches (included under water) can be listed if individual patches are at least 5% of the AA; otherwise, their cover should be included with the vegetation they are surrounded by. Record remaining cover as "other"; <u>cover should add up to 100%</u>

Type: E for emergent, S for Scrub-scrub, F for forested, AB for aquatic bed/floating, and O for other

If <u>Other</u>, write Rock Bottom, Unconsolidated Bottom, Streambed, Rocky Shore, or Unconsolidated Shore for Dominant Species based on the Cowardin key

Water Regimes: A (brief then low wt); B1 (seasonal sat.); B2 (continuous sat.); C (early, wt variable); E (B + C) ; F (all growing season); G (all year – drought); H (all year, all years); J (intermittent)

P1: Type: E S F AB O Regime: _____ Dominant Species:____ Height:______ cm % AA:______

P2: Type: E S F AB O Regime: _____ Dominant Species:____ Height:______ cm % AA:______

P3: Type: E S F AB O Regime: _____ Dominant Species:____ Height:______ cm % AA:______

P4: Type: E S F AB O Regime: _____ Dominant Species:____ Height:______ cm % AA:______

P5: Type: E S F AB O Regime: _____ Dominant Species:____ Height:______ cm % AA:______

P6: Type: E S F AB O Regime: _____ Dominant Species:____ Height:______ cm % AA:______

BUFFER STRESSORS (Evaluate in 100 m buffer around site. *Each individual stressor should only be recorded in one category*).

Extent: 0= 0%, 1 = trace, 2=1–10%, 3 = >10–25%, 4 = >25–50%, 5 = >50–75%, 6 =>75%. Severity 0: not affecting 1: Not severe 2: Moderate 3: Severe

Extent is the area the stressor occupies the in the 100-m buffer (whether buffer or non-buffer land cover). The degree of severity should be based on how the stressor affects the AA and not the 100-m buffer. Determine whether stressors are hydrologically connected. Circle both Up and D if stressor is hydrologically connected both upstream and downstream from site. Take into consideration stressor location and connectivity when determining impacts to hydroperiod and water quality, but not when considering general severity.

Stressors	Extent	General Severity	Hydrologically Connected **Up, Down, Unknown, Not**	Hydroperiod (Severity)	Contaminates Nutrients / toxins (Severity)	Sedimentation (Severity)	Vegetation Stress (Severity)
Dikes/dams/levees/berm (excluding roads and railroads)			Up D Un N				
Water level control structure (Gates, Spring Boxes, Stop Logs, Weirs, etc.)			Up D Un N				
Ditching (man-made channels)			Up D Un N				
Modification of natural flow paths (channelization, widening, deepening etc.)			Up D Un N				
Dredged depression (pond, basin)			Up D Un N				
Active or visibly evident that it is recent excavation/ dredging **Describe in comments**			Up D Un N				
Spoil banks or fill (dumped material)			Up D Un N				
Stabilizing Shorelines (e.g., riprap)			Up D Un N				
Plugging of natural channels draining AA (intentional or through unnatural sedimentation)			Up D Un N				
Discharge from wastewater plants, factories List Types:_____________________________			Up D Un N				
Obvious spills, discharges or odors; unusual water color or foam			Up D Un N				
Moderate to heavy formation of filamentous algae			Up D Un N				
Stormwater inputs via discharge pipes, culverts, sewer outfalls)			Up D Un N				
Pasture/rangeland/Managed grazing **Check if grazing appears to be from current year** ○			Up D Un N				
Livestock Barn/Holding pens/ CAFO			Up D Un N				
Agricultural crops/ row crops (e.g., corn, wheat, cotton, potatoes, etc....)			Up D Un N				
Haying crops (e.g., alfalfa, clover and grasses)			Up D Un N				
Fallow field (severity based on vegetation cover)			Up D Un N				
Substrate disturbance/rutting, compaction (off-road travel by vehicle, machinery, ATV, etc.)			Up D Un N				
Nursery			Up D Un N				
Orchard			Up D Un N				
Tree plantation present			Up D Un N				
Timber Harvest/ logging (severity is based on recovery)			Up D Un N				

Ext.: 0= 0%, 1 = trace, 2=1–10%, 3 = >10–25%, 4 = >25–50%, 5 = >50–75%, 6 =>75%. Sev. 0: not affecting 1: Not severe 2: Mod. 3: Severe							
	Ext.	**Gen Sev**	**Hydro**	**Hy.**	**Nut.**	**Sed.**	**Veg.**
Extensive mammalian tree herbivory (exclude normal browse from wildlife)			Up D Un N				
Extensive mammalian shrub layer browse (exclude normal browse from wildlife)			Up D Un N				
Extensive insect damage to woody species (i.e. beetle kill)			Up D Un N				
Extensive insect damage to herbaceous species			Up D Un N				
Fire lines (fire breaks) (severity based on vegetation cover)			Up D Un N				
Recently burned forest/ shrub land (severity based on veg. cover)			Up D Un N				
Recently burned upland grassland (severity based on veg. cover)			Up D Un N				
Recently burned wetlands (severity based on veg. cover)			Up D Un N				
Removal of large woody debris **Check if for invasive management** ◯			Up D Un N				
Shrub cutting/ brush hogging **Check if for invasive management** ◯			Up D Un N				
Mowing of non-agriculture vegetation **Check if for invasive management** ◯			Up D Un N				
Other mechanical plant removal (note type below) **Check if for invasive management** ◯			Up D Un N				
Chemical vegetation control **Check if for invasive management** ◯			Up D Un N				
Cover of non-native/invasive plant species			Up D Un N				
Railroad tracks			Up D Un N				
Residential Homes + associated lawns, driveway, etc. (inc. rural, suburban, urban)			Up D Un N				
Industrial/commercial buildings including parking lots, landscaping, etc.			Up D Un N				
Construction/ Development site			Up D Un N				
Abandoned dwelling			Up D Un N				
Trails (e.g., hiking paths, bike trails)			Up D Un N				
Dirt road or high use tractor/ ATV trail **at grade**			Up D Un N				
Improved dirt road **above grade**			Up D Un N				
Gravel Road (road surface has been imported)			Up D Un N				
Paved Roads (consider size and use on road and hydrologic connection to site)			Up D Un N				
Recreational Park			Up D Un N				
Golf course			Up D Un N				
Landfill			Up D Un N				
Trash/ dumping			Up D Un N				
Presence of power lines or utility corridors (continual maintenance)			Up D Un N				
Oil/gas wells			Up D Un N				
Quarry (extraction of stone, sand, soil, etc..)			Up D Un N				
Mine (including surface/ sub-surface mining of minerals, gases)			Up D Un N				
Soil subsidence or surface erosion (not from previously listed sources)			Up D Un N				
Other:			Up D Un N				

FLAG	Comments:

LANDSCAPE CONTEXT	
Percent buffer (Evaluate at edge of AA; buffer must extend 10 m along perimeter and 10 m from edge of AA to count)	
Rank	**State**
A	Buffer land cover surrounds 100% of the AA.
A-	Buffer land cover surrounds >75–<100% of the AA.
B	Buffer land cover surrounds >50–75% of the AA.
C	Buffer land cover surrounds >25–50% of the AA.
D	Buffer land cover surrounds ≤25% of the AA.
FLAG	Comments:

<table>
<tr><th colspan="4">Buffer Width (Evaluate up to 100 m from AA edge</th></tr>
<tr><th>Transect</th><th>Length (m)</th><th>Rank</th><th>State</th></tr>
<tr><td>N</td><td></td><td>A</td><td>Mean width >95 m</td></tr>
<tr><td>NE</td><td></td><td>A-</td><td>Mean width >75 and ≤95 m</td></tr>
<tr><td>E</td><td></td><td>B</td><td>Mean width >50 and ≤75 m</td></tr>
<tr><td>SE</td><td></td><td>C</td><td>Mean width >25 and ≤50 m</td></tr>
<tr><td>S</td><td></td><td>D</td><td>Mean width <25 or no buffer exists</td></tr>
<tr><td>SW</td><td></td><td colspan="2" rowspan="4">Buffer land cover includes all natural land cover, rangeland, vegetated pastures that are not subject to mechanical vegetation removal (but not feedlots or holding pens with mostly bare soil), low-use tracks at grade that are predominantly vegetated and not maintained, vegetated levees, natural substrate ditches, and recreational features with low substrate disturbance (narrow, natural substrate hiking or biking trails)</td></tr>
<tr><td>W</td><td></td></tr>
<tr><td>NW</td><td></td></tr>
<tr><td>Mean Length</td><td></td></tr>
<tr><td>FLAG</td><td colspan="3">Comments:</td></tr>
</table>

Buffer Condition- Soil and Substrate (Evaluate in *buffer land cover only* within 100-m of AA edge)	
Rank	**State**
A	Intact soils. Unnatural bare patches, pugging, and soil compaction are absent or extremely rare with minimal impact (e.g. one or a few shallow vegetated single-use ATV tracks). Cryptobiotic soil, if expected, is present and undisturbed.
B	Moderately disrupted soils. Some amount of bare soil, pugging, compaction or other disturbance exists, but extent and impact are minimal. Areas with more severe disturbances are absent or rare
C	Extensive moderately disrupted soils. Areas with more severe disturbance may occur in a few sections of the buffer or disturbance may be more widespread and of moderate inpact.
D	Unnaturally barren ground, highly compacted soils, or other severe soil disturbance covers a moderate to large portion of the buffer or more moderate disturbance covers the entire buffer.
NA	No buffer land cover present.
Flag	Comments:

Buffer Condition-Vegetation (Evaluate in *buffer land cover only* within 100-m of AA edge; collect dominant plant species if nativity is unknown)	
Rank	**State**
A	Abundant (≥95%) ***relative*** cover native vegetation and little or no (<5%) cover of non-native plants.
B	Substantial (≥75–95%) ***relative*** cover of native vegetation and low (5–25%) cover of non-native plants.
C	Moderate (≥50–75%) ***relative*** cover of native vegetation.
D	Low (<50%) ***relative*** cover of native vegetation.
NA	No buffer land cover present.
Flag	Comments:

Percent Intact Landscape (Evaluate in 500 m buffer)	
Rank	**State**
A	Intact: AA embedded in >90–100% unfragmented, natural landscape.
B	Variegated: AA embedded in >60–90% unfragmented, natural landscape.
C	Fragmented: AA embedded in >20–60% unfragmented, natural landscape.
D	Relictual: AA embedded in ≤20% unfragmented, natural landscape.
Flag	Comments:

ASSESSMENT AREA STRESSORS (Evaluate directly in AA)

Extent: 0= 0%, 1 = trace, 2=1–10%, 3 = >10–25%, 4 = >25–50%, 5 = >50–75%, 6 =>75%. Severity 1: Low 2: Moderate 3: Severe

Stressors to Vegetation		
Stressor	**Extent**	**Severity**
Timber harvest/ logging (severity is based on recovery)		
Moderate to heavy formation of filamentous algae		
Evidence of planting of non-native vegetation		
Mowing of vegetation **Check if for invasive management** ○		
Chemical vegetation control, e.g., herbicide application, defoliant use **Check if for invasive management** ○		
Other mechanical plant removal Describe in comments **Check if for invasive management** ○		
Off-road travel by vehicle, machinery, ATV, ORV, etc..		
Recreation/human visitation (trampling of Vegetation)		
Upland plant species encroaching into AA (due to drying of wetland)		
Die-off of trees within AA due to increased ponding (exempting beaver impounded sites)		
Excessive shading from large artificial structure, e.g., bridge, boardwalk, dock		
Grazing and browsing by domestic or feral animals (evaluate browse impacts, not composition)		
Excessive wildlife herbivory (deer, muskrat, geese, carp, beaver, etc.)		
Excessive insect herbivory of tree canopy, shrub stratum		
Recently burned wetlands (if regeneration is healthy- check low severity) **Check if for invasive management** ○		
Fire lines (fire breaks)		
Other:		
Stressors to Physical Substrate		
Anthropogenic caused surface erosion (not from natural flooding)		
Soil subsidence		
Soil compaction by off-road vehicles, dirt roads, mountain biking, trails cut, etc.		
Recent dredging or other prominent excavation in AA		
Trampling, digging, wallowing by domesticated/ feral animals **Check if current year grazing** ○		
Current filling, grading, or other prominent deposition of sediment		
Dumping of garbage or other debris		
Mechanical plant removal disturbing substrate (rutting, grubbing by heavy machinery, etc.)		
Fire lines (fire breaks) dug in AA		
Other:		
Stressors to Hydrology		
Dredged inlets and outlets (channelization/ ditching)		
Livestock pugging and entrenchment from paths		
Rutting and soil compaction from vehicles or other types of machinery		
Siphons, pumps moving water out of AA		
Siphons, pumps moving water into AA		
Stormwater inputs directly into the AA from impervious surfaces		
Water level control structure controlling flow WITHIN AA		
Dikes/dams/levees/ berm		
Other:		

Flag	Comments

HYDROLOGIC CONDITION	
Major Water Sources **(only check those that are substantial contributors to sites, put a star by dominant water source)**	
Natural Sources ___ overbank flooding from channel ___ overbank flooding from lake ___ groundwater discharge/high groundwater from spring or seep ___ alluvial aquifer (elevated water table, us. near river/stream) ___ natural surface flow ___ direct precipitation ___ direct snowmelt	*Unnatural Sources* ___ irrigation via direct application (incl. managed ditch) ___ irrigation via seepage (e.g. leaking ditch) ___ irrigation via tail water run-off (irrigation return flows) ___ discharge from impoundment release ___ urban run-off/culverts ___ pipes directly feeding wetlands ___ other (list)_________________________________

Hydroperiod **(Evaluate state in relation to natural hydroperiod- i.e. a week change in duration is much longer for a playa than for a marsh)**

Rank	State
A	The hydroperiod, including frequency and duration of inundation and drawdown, within the AA is natural. There are no major hydrologic stressors that impact the hydroperiod. There may be long-established, distant sources of groundwater or surface water extraction within contributing area to the AA, but these only have minimal impact on dampening the water levels in the AA and do not change the overall pattern of water level fluctuation within the AA.
B	Hydroperiod is predominantly controlled by natural hydrologic processes, but deviates slightly from natural conditions. The duration may be slightly longer or shorter due to decreases or increases in the amount of water reaching the AA or due to minor modifications affecting the inflow and outflow of water. The frequency of major inundation periods within a year is natural, though there might be one or two fewer or additional minor peaks of inundation. The site may be somewhat more susceptible to a change in inter-annual inundation frequency, but only in response to more severe drought or flood years. Potential deviations include: • Small decrease in inundation duration (e.g., small diversions that remove water during peak inundation, small enlargement of channel exiting AA, small noticeable effects of nearby water withdrawals, slightly flashier floods due to cover of impervious surfaces in the contributing area) • Small increase in inundation duration (e.g., minor inputs of tailwater irrigation, outflow slowed by small amount of sedimentation blocking channels, small increase in natural berm height, slightly more controlled water input due to dams on tributaries feeding the AA) • Change in intra-annual frequency by one or two minor periods of inundation (e.g., secondary flooding in fall with duration and depth much less than primary flooding) • Rare (only in extreme years) change in inter-annual flood frequency (e.g., due to impact of groundwater pumping or water withdrawals or management priorities)
C	The hydroperiod of the AA deviates moderately from natural conditions. The pattern of inundation and drawdown is still predominantly natural, but may be more noticeably shifted in duration or may occur in conjunction with more noticeable changes in frequency. Some potential deviations include more moderate examples of stressors to duration listed above as well as occasional (2 or 3 years out of 10) change in inter-annual flooding frequency
C-	The hydroperiod of the AA deviates substantially from natural conditions. A natural pattern of inundation and drawdown is still evident, but may be more dramatically shifted in duration and frequency, or may be secondary to anthropogenically created hydropatterns. The hydropattern may be predominantly or entirely created, though it still somewhat resembles a natural analogue. For example, seepage from a canal during the growing season may create conditions somewhat similar to a natural seep or spring. Artificially impounded sites that are inundated and allowed to draw down in a somewhat natural pattern will usually fall into this category. Some potential deviations include more severe examples of stressors to duration listed above as well as frequent (every 3 or 4 years) change in inter-annual flooding frequency
D	The hydroperiod is dramatically different from any natural wetland analogue. The duration and frequency of inundation may be completely artificially controlled. Natural hydrologic inputs to the wetland may be severely limited or eliminated. The wetland may be in steady decline and may not be a wetland in the near future. Sites are more likely to rate in this category when they experience drying conditions rather than simply because they receive artificial water inputs because the latter sites will often be at least tangentially analogous to a natural wetland. Sites in this category will often experiences extreme changes in the frequency of flooding. Examples of conditions that may lead to sites being rated in this category include: • extreme(relative to natural period) alteration of inundation duration (e.g., groundwater pumping causing spring to run dry except briefly in the spring) • extreme (almost every year or several times per year for sites that are flooded annually) change in flooding frequency (e.g., dikes blocking all flow to site except during years of extreme floods, groundwater pumping or water withdrawal that leave sites dry most years, detention basins that undergo short fill and release cycles following heavy precipitation events)
Flag	Comments:

Timing of Inundation	
Rank	**State**
A	Site inundation has no to very little deviation from natural timing. Sites that fall into this category generally have no or only very distant stressors to the water sources in their contributing area and no on-site stressors that affect water input, including artificial water sources.
B	Sites have a small shift in inundation timing of hours up to several days or inundation timing is natural for the majority of inflow to sites, but there are either small additional inputs of water during the growing season at times when the site would not normally receive water input or moderate additional inputs of water near the end of the growing season. Examples of potential deviations include: • accelerated timing of water input due to straightening of input channels • accelerated timing of water input due to small or distant areas of impervious surface in the contributing area • delayed timing of water input due to flow regulation on tributaries • small inputs of irrigation water via seepage or tailwater runoff in addition to naturally timed influxes of water • moderate levels of artificial fall inundation due to increased flow in channels at the end of irrigation season or moderate amount of water released from impoundments
C	Sites have a moderate shift in inundation timing of several days up to three weeks or inundation timing is mostly natural (shifted up to hours or days) for the majority of inflow to sites, but there are either moderate additional inputs of water in the middle of the growing season at times when the site would not normally receive water input or large additional inputs of water near the end of the growing season. Examples of potential deviations include: • accelerated timing of water input due to moderate to large areas of impervious surface in the contributing area • delayed timing of water input due to water control structures that more directly control input to sites • water added to impoundments according to management schedule only somewhat in tune with seasonal patterns • moderate inputs of irrigation water via seepage or tailwater runoff in addition to naturally timed influxes of water • pumping of water into site at times when site would normally not receive input • large levels of artificial inundation in the fall for management purposes
C-	Sites have a large shift in inundation timing of three weeks up to two months or inundation timing is somewhat natural (shifted up to days or weeks) for the majority of inflow to sites, but there are large additional inputs of water during the growing season at times when the site would not normally receive water input. Examples of potential deviations include: • naturally timed water input almost entirely absent (or naturally small) and majority of water influx is now from irrigation return-flows, irrigation seepage, or wastewater effluent pipes during times that site would normally be dry • site managed with very little regard to natural timing of water inputs (e.g., multiple large additional inundations throughout the dry season with only a little inundation during normal flood periods)
D	Sites have an extreme shift in inundation timing of over two months or there is a large shift of weeks to months in inundation timing as well as large additional inputs of water in the middle of the growing season during times when the site would not normally receive water. Sites that no longer receive natural water inputs due to anthropogenic stressors most years will also score in this category. Examples of potential deviations include: • site completely dry except when it rains because pumping has eliminated natural groundwater supply • site only flooded late in the growing season when water from up-gradient impoundments are released
Flag	Comments:

Algae Growth **(Evaluate for wet sites whenever possible; can do both if site hydrology is very variable, take photo if rated below B). Focus on dry, filamentous, or planktonic algae but take photos and make note if substrate algae appears especially excessive.**			
Rank	**State- Wet Sites**	**Rank**	**State- Dry Sites**
A	Water is clear with minimal algal growth and there is no visual evidence of degraded water quality.	AB	Site has little to no evidence of dried algal mats.
B	Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness	C	Site has moderate to large patches of dried algal mats.
C	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).	D	Site has extensive dried algal mats. Mats may be relatively thick, cover much of the AA, and/or are matted around vegetation
D	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).		
Flag	Comments:		

Turbidity and Pollutants	
Rank	**State**
NA	No water present in AA
A	No visual evidence of degraded water quality. No visual evidence of turbidity or other pollutants.
B	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.
C	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.
D	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
Flag	Comments, including possible sources of contamination.

Connectivity (Evaluate both for the area immediately adjacent to the AA edge and the whole-wetland. For very large wetlands, assessment can be made at the edge of the area approximately 500 m from the AA instead of the whole wetland, but make a note in the comments. Also, if wetland area narrows below 10 m in width, can consider that point the wetland edge)

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

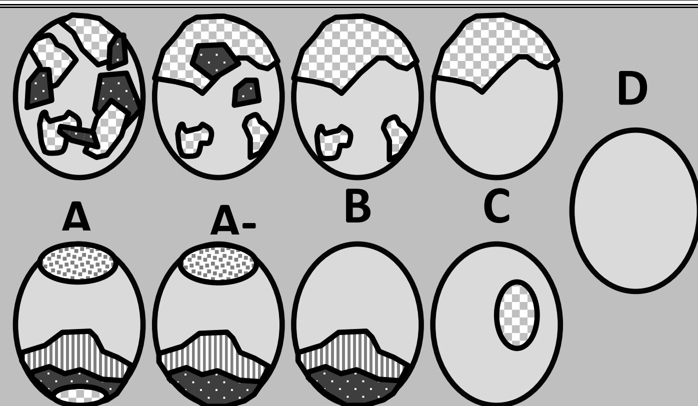
Water Quality: For all wetlands, assess directly within AA and area within 500 m of AA that is likely to contribute runoff. Also, consider the frequency with which water travels through each stressor to reach the wetland. For depressional and riverine wetlands, also assess the contributing area of any channels that provide water to the site and for lacustrine sites, consider the water quality of the adjacent lake. If sites have *most* of the features listed under a rank, consider selecting one rank lower.	
A	There are no water quality stressors likely to impact site. Within the AA, soils are intact with no evidence of damaging livestock grazing. Any anthropogenic stressors within 500 m up-gradient from the AA must be minor (e.g., small areas with unnatural bare ground or lightly grazed pasture, a few fertilized lawns, etc.) and unlikely to impact the site (e.g., separated from site by at least 50 m of thick vegetation and on a shallow slope from site). The land cover of the contributing area for any channels reaching sites is predominantly natural with no oil and gas extraction, mines, Superfund sites, or point source dischargers that are likely to impact the site's water quality.
B	Site likely to receive infrequent or minor inputs of water quality stressors. Stressors may include: • occasional/light livestock grazing within site (evaluate based on soil disturbance that could lead to sedimentation and density of animal dung- if grazing appears very light and infrequent, may be an A) • up-gradient stressors within 500 m of site that are minor or somewhat buffered from site or well-buffered if more severe (e.g., run-off from dirt road with narrow buffer or expansive area of exposed sediment within 100 m vegetated buffer) For sites receiving most water from channels : • entire contributing area has <20% development or cropland, though these land uses are absent or trace within 2 km of site • entire contributing area has few oil and gas wells, mines, or point source dischargers and all are distance from site • streams and lakes that contribute directly to the site are not listed on the 303d list
C	Site likely to receive moderate input of water quality stressors. Stressors may include: • moderate livestock grazing within site (evaluate based on soil disturbance that could lead to sedimentation and density of animal dung) • up-gradient stressors that occur within 500 m of the site that are more moderate in extent or severity and less well-buffered from site (e.g., run-off from low-density development directly reaching site or nutrient input from a farm; consider both the buffer between the stressor and slope; vegetated very low slope may be B and unvegetated very steep slope may be D) For sites receiving most water from channels: • entire contributing area has ~20-60% development or cropland, though these land uses are less prevalent within 2 km of site • entire contributing area has a moderate number of oil and gas wells, mines, or point source dischargers that are distant from site or potentially a few that are closer to the site • streams and lakes that contribute to the site are not listed on the 303d list unless water quality is likely to improve before reaching the wetland (site is distant from impaired section, water flows through reservoirs or emergent vegetation that may help attenuate water quality stressors, etc.). • streams and lakes that contribute to site are listed as impaired on 303d list, but pass through vegetated areas before reaching site
D	Site likely to receive substantial water quality stressors. Stressors may occur immediately adjacent or within sites or may be minimally buffered from sites (e.g., up a steep hill with very narrow or unvegetated buffer). Stressors may include: • Very high intensity livestock grazing, irrigation water return flow, fertilizer and pesticide application, and erosion from fires, construction, off-road vehicles, and dirt roads *directly discharging into sites.* These stressors may be considered C if run-off from the features is likely to only occur infrequently, if slope is shallow, or if only a small area of the AA receives these stressors • Frequent heavy grazing within AA with large patches of bare earth and extensive addition of manure For sites receiving most water from channels: • entire contributing area has>60% development or cropland • entire contributing area has a high number of oil and gas wells, mines, or point source dischargers • streams and lakes that directly contribute to the site are listed as impaired on the 303d list
Flag	Comments

PHYSICAL STRUCTURE	
Substrate and Soil Disturbance (Evaluate in terms of the combination of severity and extent)	
A	No soil disturbance within AA. Little bare soil OR bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails OR soil is naturally bare (e.g., playas). No pugging, soil compaction, or sedimentation.
B	Minimal soil disturbance within AA. Some amount of bare soil, pugging, compaction, or sedimentation present due to human causes, but the extent and impact are minimal. Mild disturbance that does not show evidence of altering hydrology or causing ponding or channeling may occur across a large portion of the site, or more moderate disturbance may occur in one or two small patches of the AA. Any disturbance is likely to recover within a few years after the disturbance is removed.
C	Moderate soil disturbance within AA. Bare soil areas due to human causes are common and will be slow to recover. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts. Sedimentation may be filling the wetland. The site could recover to potential with the removal of degrading human influences and moderate recovery times.
D	Substantial soil disturbance within AA. Bare soil areas substantially degrade the site and have led to severely altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Sedimentation may have severely impacted the hydrology. The site will not recover without active restoration and/or long recovery times.
Flag	Comments

VEGETATION STRUCTURE

Horizontal Interspersion

Evaluate number and arrangement of patches of water and distinct vegetation patches. Individual patches must be at least 10 m² (approximately 3.2 m x 3.2 m in a 0.5 ha AA) and each patch type must cover at least 5% of the AA. Distinct vegetation patches are patches that share similar physiognomy and species composition.
A SITE CAN HAVE A PATCH THAT IS >50% OF THE AREA BUT NOT <u>DOMINANT</u>; USE DIAGRAM TO INTERPRET TEXT.



Rank	State
A	High degree of horizontal interspersion: AA characterized by a very complex array of nested or interspersed zones with no single dominant zone.
A-	Moderate to high degree of horizontal interspersion: AA is characterized by a complex array of nested or interspersed zones with no single dominant zone
B	Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed zones with no single dominant zone.
C	Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed zones. One zone may dominate others.
D	No horizontal interspersion: AA characterized by one dominant zone.
Flag	Comments

Woody Debris

Rank	State
NA	There are no obvious inputs of woody debris. Inputs are not available within site, along site edge, or along nearby up-gradient hydrologically connected flowpaths
AB	AA characterized by moderate amount of coarse and fine woody debris, relative to expected conditions. For riverine wetlands, debris is sufficient to trap sediment, but does not inhibit stream flow. For non-riverine wetlands, woody debris provides structural complexity, but does not overwhelm the site.
C1	AA characterized by small amounts of woody debris
C2	Debris in AA is somewhat excessive.
D	AA lacks woody debris, even though inputs are available.
Flag	Comments:

Woody Species Regeneration (see ratings chart, below)	
Rank	**State**
NA	Woody species are naturally uncommon or absent.
A	All age/size classes of desirable (native) woody species present.
B	Age/size classes restricted to mature (full size) individuals and young sprouts. Middle age/size groups absent.
C1	Stand comprised of mainly mature (full size) individuals, with seedlings and sapling (smaller individuals) absent
C2	Stand mainly evenly aged/sized young sprouts that choke out other vegetation.
D1	Woody species predominantly consist of decadent or dying individuals. Decadent individuals are those with greatly reduced growth, such as which often occurs at sites where species have been over-browsed.
D2	AA has >5% canopy cover of *Elaeagnus angustifolia* (Russian olive) and/or *Tamarix* (tamarisk) or other invasive woody species. If you select this state, select an additional statement that describes native regeneration in AA.
Flag	Comments

Litter Accumulation	
Rank	**State**
AB	AA characterized by normal amounts of herbaceous and/or deciduous litter accumulation for the wetland type. In some wetlands, this may mean that new growth is more prevalent than previous years' and that litter and duff layers in pools and topographic lows are thin. Undisturbed playas may be lacking in litter altogether. Marshes may have high levels of litter accumulation, but litter should not prevent new growth or be too dense to allow more than one species to persist.
C1	AA characterized by small amounts of litter compared to what is expected
C2	Litter is somewhat excessive.
D1	AA lacks litter
D2	Litter is extensive, often limiting new growth.
Flag	Comments (If site scores below AB, briefly describe litter and note potential causes):

Woody Species Regeneration Age Classes
Information for <u>guidance only</u>; classes may differ for certain species. Classes are from Burton, T.A., Smith, S.J., And Cowley, E.R., 2011, Multiple indicator monitoring of stream channels and streamside vegetation: U.S. Bureau of Land Management technical reference 1737-23, 155 p.

	Single-stemmed species (e.g., cottonwood)	**Multi-stemmed species (e.g., most willows and alder)**
Seedling	Stem is <1 m tall or <2.5 cm in diameter at 50% of height from ground level.	1 stem <0.5 cm in diameter at the base and <0.5 m tall.
Young (Middle)	Stem is >1 m tall and 2.5 cm to 7.6 cm in diameter at 50% of height from ground level.	2 to 10 stems less than 1 m tall or 1 stem >0.5 cm in diameter at the base and less than 1 m tall
Mature	Stem is > 1 m tall and >7.6 cm in diameter at 50% of height from ground level.	>10 stems over 1 m tall

AUXILIARY METRICS

Topographic Complexity

Elevation gradients must be at least 15 cm in height difference and can include features such as benches, slopes of varying steepness, channels, and pools. Gradients must have an edge of at least 8 m (e.g., length of channel, perimeter of pools or higher elevation "island", length of edge between two slopes) or cover at least 5% of the AA. Micro-topography includes woody debris, boulders, sediment mounds, vegetation hummocks, tufted herbaceous litter, gently undulating terrain and other similar features.

Elevation Gradient	**Description** (e.g., pools throughout site, main channel, high bench, etc.)	Micro-topography
Gradient 1		<10% micro-topography
Gradient 2		≥10-29% micro-topography
Gradient 3		≥30-49% micro-topography
Gradient 4		≥50% micro-topography
Flag	List features creating microtopography:	

Structural Patch Richness (only list patch size for features with <1% total cover, i.e. features that occupy less than 50 m^2 in standard AA)

	Structural Patch	Description	% Cover	Patch Size (m^2)	Wet or Dry?
Bare Ground	Mudflats, sandflats	A flat is a non-vegetated area of silt, clay, sand, or a mix of abiotic substrates (mud) that adjoins the wetland foreshore and can be intermittently flooded or exposed.			**W D**
Bare Ground	Salt flat/alkali flat	Dry open area of fine-grained sediment and accumulated salts. Often wet in the winter months or with heavy precipitation.			
Bare Ground	Soil cracks	Cracks formed by repeated wetting and drying of fine grain soil. Cracks must be a minimum of 2.5 cm deep to qualify.			
Bare Ground	Wallows or similar animal excavations	Any depression in the land surface that is caused by animals sitting, lying, or rolling on the ground surface or digging into it.			
Bare Ground	Animal tracks	Native (e.g. elk) or introduced (e.g. cattle) tracks that are deep enough to hold water.			
Litter	Wrack or organic debris in channel or on floodplain	Wrack is an accumulation of natural or unnatural floating debris along the high water line of a wetland. The organic debris must be free of its original growth position. Senesced plant material that is still attached to the parent plant does not count (for example, last year's cattail or bulrush growth)			
Mounds and Rocks	Animal mounds or burrows	Mounds or holes associated with animal foraging, denning, predation, or other behaviors.			
Mounds and Rocks	Plant hummocks (naturally formed)	A mound composed of plant material resulting in a raised pedestal of persistent roots or rhizomes.			
Mounds and Rocks	Sediment mounds	Depositional features formed from repeated flood flows depositing sediment on the floodplain, similar to hummocks but lacking plant cover.			
Mounds and Rocks	Cobbles and boulders	The middle axis of a cobble ranges from 6.4 cm to <25.6 cm and for a boulder is ≥ 25.6 cm. The middle axis is the longest axis that is perpendicular to the true longest axis of the rock			
Channel and Channel-Like	Swales on floodplain or along shoreline	Swales are broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flow to and from vegetated floodplains. They lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels.			**W D**
Channel and Channel-Like	River/stream	Areas of flowing water associated with a sizeable channel			**W D**
Channel and Channel-Like	Tributary/Secondary channel/Rivulet	Channels of varying size that convey flood flows, including the diverging and converging secondary channels found in braided and anastomosing fluvial, channels that originate in the wetland and that only convey flow between the wetland and the primary channel, and diffuse channels found near outlets of wet meadows or at the very headwaters of a stream. Also includes channels leaving springheads			**W D**
Channel and Channel-Like	Oxbow/backwater channel	Areas holding stagnant or slow moving water that have been partially or completely disassociated from the primary river channel.			**W D**
Channel and Channel-Like	Pools or depressions in channels	Pools are areas along fluvial channels that are much deeper than the average depths of their channels and that tend to retain water longer than other areas of the channel during periods of low or no surface flow			**W D**

Structural Patch		Description	% Cover	Patch Size (m^2)	Wet or Dry?
Channel, continued	Riffles or rapids	Riffles and rapids are areas of relatively rapid flow, standing waves and surface turbulence in fluvial channels. A steeper reach with coarse material (gravel or cobble) in a dry channel indicates presence.			**W D**
	Interfluves on floodplain	The area between two adjacent streams or stream channels flowing in the same general direction			
	Point bars	Patches of transient bedload sediment that can form along the inside of meander bends or in the middle of straight channel reaches, sometimes supporting vegetation. They are convex in profile and their surface material varies in size from finer on top to larger along their lower margins.			
	Debris jams/woody debris in channel	Aggregated woody debris in a stream channel deposited by high flows.			
Pool or Pond-Like	Pond or lake	Natural water body with areas of open water deeper than 2 m in depth that do not support emergent vegetation			**W D**
	Beaver dam	Debris dam clearly constructed by beaver (note gnawed ends of branches)			
	Beaver pond	Areas that hold stagnant or slow moving water behind a beaver dam.			**W D**
	Springhead pools	Pools associated with groundwater discharge at springheads. Associated channels will be listed under "Tributary/Secondary channel/Rivulet"			**W D**
	Pools- filled by overland flow	A shallow topographic basin lacking vegetation but existing on a well-vegetated wetland plain that fills with water at least seasonally due to overland flow.			**W D**
	Pool- other	Pool other than those described above. Add comment below on type of pool.			**W D**
Shore or Bank	Bank slumps in channel or along shoreline	A bank slump is the portion of a stream or other wetland bank that has broken free from the rest of the bank but has not eroded away.			
	Undercut banks in channel or along shoreline	Undercut banks are areas along the bank or shoreline of a wetland that have been excavated by waves or flowing water.			
	Variegated or crenulated foreshore	As viewed from above, the foreshore of a wetland can be mostly straight, broadly curving (i.e., arcuate), or variegated (e.g., meandering). In plan view, a variegated shoreline resembles a meandering pathway.			
Miscellaneous Water-Associated Features	Seeps	Localized point of emerging groundwater not associated with a definite pool			**W D**
	Floating mat	Mats of peat held together by roots and rhizomes of sedges. Floating mats are underlain by water and /or very loose peat and are found on the edges of ponds and lakes and are slowing encroaching into open water.			
	Marl/limonite beds	Marl is a calcium carbonate precipitate often found in calcareous fens. Limonite forms in iron-rich fens when iron precipitates from the groundwater incorporating organic matter.			
	Beaver canals	Canals cut through emergent vegetation by beaver.			
	Water tracks/hollows	Depressions between hummocks or mounds that remain permanently saturated or inundated with slow moving surface water.			
	Islands (exposed at high-water stage)	An island is an area of land above the usual high water level and, at least at times, surrounded by water. Islands differ from hummocks and other mounds by being large enough to support trees or large shrubs			
	Woody vegetation in water	Live trees or woody vegetation in water. This does not including riparian woody vegetation at the edge of the wetland but rather trees or large shrubs that are within the water.			
	Concentric or parallel high water marks	Evidence of repeated variation in water level in the wetland, such as water marks etched in substrate or concentric bands of vegetation that result from water level-driven differences in soil moisture, chemistry, etc. The variation in water level might be natural (e.g., seasonal) or anthropogenic.			
Flag	Comments				

Columbia Spotted Frog Habitat Assessment

Site ID:	**Date:**

For the following, select only for waterbodies *within* the AA

	Breeding Waterbodies
A	Waterbodies large enough not to dry up in summer and deep enough not to freeze solid at night during summer with minimal flow. Examples include **beaver ponds, oxbows,** and **springs-fed pools**
B	Stock ponds (excluding those that are spring-fed, which belong above); shallower sections of spring complexes.
C	Lotic: flowing rivers or streams OR lentic but very small or uniformly shallow: temporary pools, small puddles.
D	No surface water typically present at site (skip the next three metrics)

	Waterbody substrate
A	Deep organic mud or silt is common at bottom of waterbodies (soft enough to be burrowed into)
B	Substrate of deep mud/silt present but uncommon.
C	Gravel/sand predominant waterbody substrate with deep mud/silt absent.
D	Cobble, boulder, bedrock predominant substrate with deep mud/silt absent.

	Vegetation growing in waterbody shallows (areas <1 m deep) in potential breeding waterbodies
A	Adequate “vegetation” (including emergent, aquatic bed, filamentous algae and macroalgae) growing in water to attach egg masses to and provide cover from aquatic predators without completely shading out water. At least 20% of waterbody shallows have some type of vegetation and no more than 50% of shallows have emergent vegetation (score one grade lower if emergent vegetation is very dense, e.g., hard to see through to water surface)
B	Waterbody shallows either have between 10 and 20% cover of any vegetation or between 50 and 80% of emergent vegetation, potentially over-shading site (score one grade lower if emergent vegetation is very dense, e.g., hard to see through to water surface).
C	Waterbody shallows with either >1 to 10% vegetation or between 80 and 95% emergent vegetation with few openings in the water (score one grade lower if emergent vegetation is very dense, e.g., hard to see through to water surface)
D	No or <1% vegetation in waterbody shallows or emergent vegetation densely covers entire waterbody.

	Waterbodies for overwintering habitat (needs non-freezing water and oxygenation) (within 100 m of AA)
A	Waterbodies include well-oxygenated areas unlikely to freeze, particularly perennially flowing streams (including oxbows), springhead pools, or ponded water at least 1 m deep at deepest point. Waterbodies include ample hibernation features such as overhangs, holes, log debris, or loose soil that can provide protection from freezing.
B	Waterbodies include the above types, but hibernation features less common.
C1	Waterbodies include the above types, but hibernation features extremely rare or absent
C2	Hibernation features present , but there are only marginally suitable waterbodies present (water not particularly well oxygenated or may only some years not freeze; this includes areas of shallow spring overflow)
D	No potential overwintering habitat near AA (e.g. there is no water present or all water is likely to freeze or dry up.)

	Livestock [both boreal toad and CSF]		**Distance to impervious surface**
A	No evidence of livestock grazing in AA or buffer	A	>300 m
B	Low intensity grazing in buffer; no grazing in AA.	B	200-300
C	High intensity buffer grazing or winter AA grazing, or low intensity AA summer grazing.	C	100-200
D	High intensity grazing in AA in summer	D	<100 m

Notes for any of the above metrics:

Predators observed? (incl. tracks, dens) ___ Crayfish ___ Bullfrogs ___Tiger Salamander ___ Trout
___ Other fish ___ Snake ___ Jay / Raven / Crow / Robin / Hawk/ Heron /Gull ___ Badger / Fox / Raccoon

Y N	Beaver at site?	Y N	Evidence of current/historic mining in AA or buffer (mine tailings, mine shafts, etc.)?

Boreal Toad Habitat Assessment

Score metrics below only at sites within the Wasatch and Uinta Mountains Ecoregion.	
Rank egg mass habitat found within or immediately adjacent to AA. If surface water typically present, but dried up due to drought or survey late in the growing season, select C for types of waterbodies and estimate slope & north shoreline.	
Types of Waterbodies Within AA (including part of shore in AA and main waterbody outside AA)	
A	lentic and large enough not to dry up and deep enough not to freeze solid at night during summer including lakes, ponds (especially beaver ponds), and large pools (including artificially created ponds and pools).
B	lotic: low-velocity, low-gradient streams or springs.
C	lotic: rivers, streams OR lentic but very small or uniformly shallow: temporary pools, small puddles.
D	No surface water typically present at site (skip the next three metrics))
Presence of North Shore (Long Axis of Waterbody)	
A	Ample north shore present. Long axis of waterbod(ies) arranged E-W and/or waterbod(ies) with ample shoreline along both axes (i.e. rounded pond).
B	Moderate amount of north shore present. Long axis of waterbod(ies) arranged NE-SW or NW-SE or may be N-S if minor axis almost as long as major axis (i.e., wide oval pond).
C	Minor amount of north slope present. Long axis of waterbod(ies) may be NNE-SSW or NNW-SSE or arranged N-S with moderately wide minor axis (if pond) or some meandering (if stream) creating some north shore.
D	Little or no north shore present. Long axis of waterbod(ies) north to south with little shoreline along minor axis (typically narrow waterbodies such as a stream).

	Slope and Water Depth Near Shore		**Daytime Summer Temp. in Shallows**
A	Mostly gentle slopes and/or large area, esp. along north shores, with gentle slopes; water <10 cm common.	A	28–34 °C
B	Mixture of gentle and steeper slopes with some areas with <10 cm deep water; gentle slopes common but not predominant, not occupying the majority of the north shores.	B	16–27 °C or 35 °C
C	Gentle slopes present, but uncommon. Few areas with water <10 cm deep.	C	11–15 °C or 36 °C
D	All shorelines with steep slopes. Water <10 cm not present.	D	≤10 °C or ≥37 °C

	Hibernation Features (within AA and 100 m buffer)
A	Features such as burrows (esp. ground squirrels), interstices of beaver dams, old beaver lodges, overhanging stream banks, rocky chambers near streams, cavities under boulders or tree roots, loose soil, and/or woody debris piles common and connected to summertime habitat.
B	Above features present but not abundant. Some area with features may be disconnected from summertime habitat due to low use roads or other low severity fragmentation, but some connected features present.
C	Above features present but rare and/or only present on very steep slopes or disconnected from summertime habitat by busy roads, development, or other severe fragmentation.
D	None of the above features present.
Observed Hibernation Features (circle one or more feature): None observed Burrows Beaver Dam Beaver Lodge Undercut Stream Bank Boulders Loose Soil Woody debris piles	

Shrub	**Tall Forbs**	**Understory-Forming Shrubs or Tall Forbs (e.g., goldenrod, coneflower);** Evaluate along stream floodplain or in valley bottom within AA and buffer. Cover estimates pertain to area without standing
A	A	Ample cover near waterbodies. Generally this will entail 33 to 60% of the area along a stream floodplain or valley bottom near a pond or lake with moderate to dense cover of understory-forming species.
B	B	Moderate cover near waterbodies, with approximately 21 to 33% of area with moderate/dense cover, or cover abundant, but very patchy
C1	C1	Low cover near waterbodies, with approximately 5 to 20% of area with moderate/dense cover.
C2	C2	Overly abundant cover near waterbodies. Between 60% and 80% of non-water area along stream floodplain or valley bottom with understory species. Little basking habitat present
D1	D1	No or only a few scattered areas with cover present (<4% cover)
D2	D2	Extremely abundant cover near waterbodies. Over 80% of non-water area along stream floodplain or valley bottom with understory cover. Basking habitat extremely rare.
Habitat metric notes		

Water Quality Improvement Functional Assessment

Site ID:	Date:

<u>Capacity to improve water quality</u>

☐ 1. The top 5 cm of soil is true clay (clay, silty clay, sandy clay) or true organic.

☐ 2. At least ½ of AA is covered by **<u>persistent</u>** <u>(meaning dead stalks will be standing in winter)</u> **<u>herbaceous vegetation ≥13 cm tall</u>** (~height of clipboard) and dense enough to obscure ground; estimate vegetation height based on likely flood season conditions. Ignore areas with water >1 m deep for percent estimates.

☐ 3. At least 1/3 of AA is covered by **<u>persistent herbaceous vegetation ≥1 m tall</u>** and dense enough to obscure ground (see definitions from above). Ignore areas with water >1 m deep for percent estimates.

☐ 4. At least 1/3 of AA has over-story cover from **<u>tree or shrubs at least 1 m tall</u>** (ignore stream channels).

☐ 5. At least ¼ of AA is **<u>seasonally ponded</u>** (surface water ≥2 consecutive months, but drying annually).

☐ 6. At least 1/3 of AA has **<u>microtopography</u>** at least 5 cm above the wetland surface that may help slow down and spread flood flows, such as rocks, litter, and woody debris.

☐ 7. Wetland is **lacustrine fringe**, **depressional impoundment**, or **depressional** and waterbody either has no surface water outlet or an intermittently flowing outlet.

☐ 8. Wetland is **riverine** and at least 1/5 of wetland has surface depressions that can trap sediments during flooding events.

☐ 9. Wetland is **lacustrine fringe, depressional impoundment,** or **depressional impoundment fringe** and the average width of vegetation (including aquatic bed) extending into the lake or impoundment is at least 5 m.

☐ 10. Wetland is **slope** or **impoundment release** and average surface slope is 1% or less (1.75°).

<u>Landscape potential</u>

☐ 11. There are homes within 75 m of wetland that are likely to be on septic system (outside special service district and municipal boundaries- see office evaluation).

☐ 12. Stormwater pipe directly feeds wetland or both feeds waterbodies that directly feed wetland and are within 500 m of wetland.

☐ 13. At least 10% of the area within 50 m that could run-off to AA is in land use likely to generate sediment (fertilizer, animal manure, etc.) or nutrient (cropland, dirt roads, pasture, clearcut forest, OHV tracks, golf course, etc.) runoff to site. If surrounding land use is pasture/rangeland, check box only if 10% of area has disturbed soils or if animal dung density is very high.

☐ 14. At least 10% of the area within 50 m that could run-off to AA is in land use likely to generate <u>pollutants</u> besides nutrients/sediment (paved roads, parking lots, houses, commercial buildings, oil and gas wells, mines, etc.)

☐ 15. Wetland is immediately adjacent to a lake used by power boats.

☐ 16. Wetland is immediately adjacent to lake or stream with known algal blooms issues.[1]

☐ 17. There are other sources of pollutants coming into wetland not listed above. List:

<u>Valued by society</u>

☐ 18. Wetland is within 50 m of and at least occasionally dischargers to stream, river, or lake.

[1]May include Deer Creek Reservoir, East Canyon Reservoir, Flaming Gorge Reservoir, Gunlock Reservoir, Huntington Creek, Jordanelle Reservoir, Lost Creek Reservoir, Millsite Reservoir, Minersville Reservoir, Pineview Reservoir, Provo River, Red Fleet Reservoir, Rockport Reservoir, Sand Hollow Reservoir, Scofield Reservoir, Starvation Reservoir, Steinaker Reservoir, Otter Creek Reservoir, Utah Lake, Wide Hollow Reservoir, and Yuba Reservoir; from Pendrod, E., 2015 August 7, It's not just Utah Lake—toxic algae plagues 20 waterways, including drinking water sources: The Salt Lake Tribune, available online at http://www.sltrib.com/news/2815139-155/its-not-just-utah-lake-toxic.

Site ID:	Surveyors:	Date:

Ground Cover and Vertical Strata (all estimates in % unless otherwise stated)

To help with estimation of soil versus litter, drop a pin in 10 locations near one another in each quadrat of the plot to determine soil vs. litter

Ground Cover Type **AA/Plot**	**AA**	**1**	**2**	**3**	**4**
Cover of *visibly exposed* soil / sand / sediment (including mudflats and salt encrustations)[1]					
Cover of *remaining* soil / sand / sediment (e.g., bare ground hidden by vegetation)[1]					
Cover of gravel / cobble (~2–250 mm)[1]					
Cover of bedrock / rock / boulder (>250 mm)[1]					
Area of AA with dense canopy of litter mostly >10-20 cm ***above*** wetland surface (dense enough to obscure boots) incl. litter in water					
Area of AA with dense canopy of litter mostly reaching down to wetland surface (dense enough to obscure boots) incl. litter in water					
Cover of remaining litter (too low to hide a boot in- i.e. all litter not as above) incl. litter in water					
Total litter cover in areas with surface water (WetLit)	–	–	–	–	–
Predominant litter type (C = coniferous, E = broadleaf evergreen, D = deciduous, S = sod/thatch, F = forb)					
Actual *cover of water (any depth, vegetated or not, standing or flowing)*					
Sum of above covers (subtract WetLit, should add up to 95-100%)					
Actual cover of shallow water <20 cm					
Actual cover of deep water ≥20 cm					
Actual cover of open water with no vegetation					
Actual cover of water with submergent or floating aquatic vegetation[2]					
Actual cover of water with emergent vegetation					
Potential cover of shallow water <20 cm at ordinary high water					
Potential cover of deep water ≥20 cm at ordinary high water					
Cover of standing dead trees (>5 cm diameter at breast height (DBH)- 1.4 m)					
Cover of standing dead shrubs/small trees (<5 cm DBH- 1.4 m)					
Cover of downed coarse woody debris (fallen trees, rotting logs, >5 cm diameter)					
Cover of downed fine woody debris (<5 cm diameter)					
Cover bryophytes (<u>including under water, vegetation or litter</u>)					
Cover lichens (<u>including under water, vegetation, litter, and on trees</u>)					
Cover algae(<u>including under water, vegetation or litter</u>)					
Cover of desiccated/dried algae					
Cover of wet filamentous algae					
Cover of macroalgae (chara, etc.)					
Epiphytic "algae" ("biofilm" covering submerged vegetation)[3]	N L M H	N L M H	N L M H	N L M H	N L M H
Substrate algae (algae covering rocks, litter, etc.)[3]	N L M H	N L M H	N L M H	N L M H	N L M H
For measures below, do not look at the exact cover (i.e. the shadow produced when the sun is directly overhead). Rather, identify regions of overlap.					
Circle all layers present (in at least 5% of suitable area), Submerged (Su), Floating (Fl), Short <0.5 m (Sh), Medium 0.5-1.5 m (Me), Tall 1.5-3.0 m (Ta), and Very Tall > 3.0 m (VT); height of layers must also be at least 20 cm apart	Su Fl Sh Me Ta VT	Su Fl Sh Me Ta VT	Su Fl Sh Me Ta VT	Su Fl Sh Me Ta VT	Su Fl Sh Me Ta VT
Area of AA with overlap of three or more plant layers (layers listed above)					
Area of AA with overlap of two plant layers (layers listed above)					

[1]Features should not be covered by litter or water, but can have algae cover.
[2]Can overlap with other water cover, such as emergent vegetation
[3]Select Not present/trace (N), low (L), medium (M), or high (H)

FLAG	Comments:

Site ID:	Surveyors:	Date:
Site Sketch: Define scale for grid, add north arrow. Mark inlets and outlet if present in or adjacent to AA.		

Site ID:	Surveyors:	Date:

Plant Species Table: List all plant species found in AA and estimate height, percent cover and dominant phenology

Height class (H): A: <0.5 m **B**: 0.5–1 m **C**: 1-2 m **D**: 2–5 m **E**: 5- 10 m **F:** >10 m **G:** submerged/floating **50 m² = 1% of standard circular AA**

2 m= 6 ½ ft person; 7.5 m ~ 2 story house; conifers with heights of 5 and 10 m commonly have DBHs around 6 cm and 12 cm, respectively

Phenology (P): V: Vegetative , **Fl:** Flowering **Fr:** Fruiting **SD:** standing dead (current year only!)

Record low cover species as either <1 or T for Trace; the latter for very small cover.

Search site for 60 minutes. You may pause timer when you are keying out species. If more than 3 species with trace cover are found in the last 10 minutes of the survey, add an additional "overtime" 10 minutes to the survey time. Keep adding time in 10 minute increments until no more than 3 species are found during the 10 minute block of time. Keep a tally of the number of additional species found in each survey period below.

# Species In Last 10 min.	# Species In 1st OT	# Species In 2nd OT	# Species In 3rd OT	# Species In 4th OT	# Species In 5th OT

Scientific Name/Pseudonym	Coll #	Photos	H	P	% AA	% 1	% 2	% 3	% 4

Measure litter depth and water depth at four representative locations in the AA or, for Level III, in four locations within each plot. If there is no litter or water of the specified depth, enter a dash, NOT a zero.

All measurements in cm	AA		Plot 1		Plot 2		Plot 3		Plot 4	
Litter depth										
Water depth < 20 cm										
Water depth ≥ 20 cm										

Site ID:	Surveyors:	Date:

Plant Species Table: List all plant species found in AA and estimate height, cover, and dominant phenology

Height class (H): A: <0.5 m **B**: 0.5–1 m **C**: 1-2 m **D**: 2–5 m **E**: 5- 10 m **F:** >10 m **G:** submerged/floating **50 m² = 1% of standard circular AA**

2 m= 6 ½ ft person; 7.5 m ~ 2 story house; conifers with heights of 5 and 10 m commonly have DBHs around 6 cm and 12 cm, respectively

Phenology (P): V: Vegetative , **Fl:** Flowering **Fr:** Fruiting **SD:** standing dead (from current year, not previous years)

Record low cover species as either <1 or T for Trace; the latter for very small cover.

Scientific Name/Pseudonym	Coll #	Photos	H	P	% AA	% 1	% 2	% 3	% 4

Site ID:_____________ Veg Patch Number:________ PHOTOGRAPH SOIL PIT AND LAB WATER QUALITY LOCATION, LIST ON MAIN FORM

PIT # In Patch:______ Waypoint ID:______________________ Pit Depth (cm): ______ Settling Time Begin (Time):_________________ Settling Time End (Time):__________________

Settling Time (mins): ___________ Depth to saturated soil OR NA[1] (cm): __________ Depth to free water OR NA[1] (cm): _____________ Check: ☐Pit is filling slowly OR ☐Pit not filling

[1]depths below the soil surface are recorded as positive values and depths above the soil surface are recorded as negative

List dominant plant species within 1 m of soil pit (ask vegetation specialist for assistance):

Layer Form[1]	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Feature Type[2]	Dominant Redox Features Color (moist)	Dominant Redox Features %	Secondary Redox Features Feature Type[2]	Secondary Redox Features Color (moist)	Secondary Redox Features %	Texture	% Coarse	% Roots
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______

[1]Mineral, Mucky Mineral, Organic (list peat, muck, mucky peat under Texture) [2] Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered/Coated Sand Grains, SC- Secondary Color

Hydric Soil Indicators: See field manual for descriptions and circle all that apply

Oraganic Soil Layer: A1 A2 A3
Muck Layer*: A9 A10
Mucky Mineral: S1 F1
Hydrogen Sulfide Odor: A4
**A9 only Arid West, A10 only Mtn problem soils*

Gleyed Matrix: S4 F2 A11 A12
Depleted Matrix: A11 A12 F3
Redox Concentrations: S5 F6 F8
Redox Depletions: S6 F7
Other (list):_________________________

Indicators of Site Hydrology: See field manual for descriptions and circle all that apply

Observation of Surface Water or Saturated Soils: A1 A2 A3
Evidence of Recent Inundation: *B1* *B2* *B3* B4 B5 B6 B8 B9 **B10** B11 B12 B13
Evidence of Current or Recent Soil Saturation: C1 **C2** C3 C4 C6 C7 C8
Evidence from Other Site Conditions or Data: **D2** **D3** **D5** **D7**
Bold- Secondary Indicators; *Italics-* Secondary Indicator for Riverine

Water Chemistry for Soil Pit

GPS Waypt ID	Location (circle)	Water Depth (cm)	Surface OR Ground	Meter	pH	EC/TDS Out of Range	EC (mS or uS)	TDS (ppm or ppb)	Temp (C°)
	Soil Pit OR Well		Ground	Low		☐			
				High		☐			

Soil Salinity Measurements: Collect soil sample from top 15 cm of soil at location near soil pit. Remove rocks and roots and homogenize sample.

Soil sample size (typically 50 ml): _____ ml **Distilled water sample size (typically 250 ml, 5 x soil):** _____ ml **EC reading after stir & settle**: _______ _uS or mS

Soil and Water Quality Comments (include potential problem soils if no hydric indicators present):

Site ID:_____________ Veg Patch Number:________ PHOTOGRAPH SOIL PIT AND LAB WATER QUALITY LOCATION, LIST ON MAIN FORM

PIT # In Patch:______ Waypoint ID:______________________ Pit Depth (cm): ______ Settling Time Begin (Time):_________________ Settling Time End (Time):__________________

Settling Time (mins): ___________ Depth to saturated soil OR NA[1] (cm): __________ Depth to free water OR NA[1] (cm): _____________ Check: ☐Pit is filling slowly OR ☐Pit not filling

[1]depths below the soil surface are recorded as positive values and depths above the soil surface are recorded as negative

List dominant plant species within 1 m of soil pit (ask vegetation specialist for assistance):

Layer Form[1]	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Feature Type[2]	Dominant Redox Features Color (moist)	Dominant Redox Features %	Secondary Redox Features Feature Type[2]	Secondary Redox Features Color (moist)	Secondary Redox Features %	Texture	% Coarse	% Roots
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______
________	_______	_______________	____________	_______________	_______	____________	_______________	_______	_____________	______	______

[1]Mineral, Mucky Mineral, Organic (list peat, muck, mucky peat under Texture) [2] Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered/Coated Sand Grains, SC- Secondary Color

Hydric Soil Indicators: See field manual for descriptions and circle all that apply

Oraganic Soil Layer: A1 A2 A3
Muck Layer*: A9 A10
Mucky Mineral: S1 F1
Hydrogen Sulfide Odor: A4
**A9 only Arid West, A10 only Mtn problem soils*

Gleyed Matrix: S4 F2 A11 A12
Depleted Matrix: A11 A12 F3
Redox Concentrations: S5 F6 F8
Redox Depletions: S6 F7
Other (list):_________________________

Indicators of Site Hydrology: See field manual for descriptions and circle all that apply

Observation of Surface Water or Saturated Soils: A1 A2 A3
Evidence of Recent Inundation: *B1* *B2* *B3* B4 B5 B6 B8 B9 **B10** B11 B12 B13
Evidence of Current or Recent Soil Saturation: C1 **C2** C3 C4 C6 C7 C8
Evidence from Other Site Conditions or Data: **D2** **D3** **D5** **D7**
Bold- Secondary Indicators; *Italics*- Secondary Indicator for Riverine

Water Chemistry for Soil Pit

GPS Waypt ID	Location (circle)	Water Depth (cm)	Surface OR Ground	Meter	pH	EC/TDS Out of Range	EC (mS or uS)	TDS (ppm or ppb)	Temp (C°)
	Soil Pit OR Well		Ground	Low		☐			
				High		☐			

Soil Salinity Measurements: Collect soil sample from top 15 cm of soil at location near soil pit. Remove rocks and roots and homogenize sample.

Soil sample size (typically 50 ml): _____ ml **Distilled water sample size (typically 250 ml, 5 x soil):** _____ ml **EC reading after stir & settle**: _______ _uS or mS

Soil and Water Quality Comments (include potential problem soils if no hydric indicators present):

Site ID:________________ **Observer Initials:_________________**

WQ Start Time: _________ (24-hr time) **End Time:** _________ (24-hr time) **Wind:** Calm Light Strong **72 hour rainfall est [1]:** none <0.1'' 0.1-1'' >1''

Current Weather (circle): Clear (0% cloud) Mostly Clear (<25%) Partly Cloudy (25-50%) Mostly Cloudy (50-99%) Overcast (100%) Light rain Heavy rain Snow

Feature 1, Waterbody notes:

Type: active beaver pond inactive beaver pond springhead pool GSL impoundment impoundment release (no channel) impoundment fringe temporary pool/pond permanent pond/lake stream/river backwater stream/river, other springhead channel ditch other channel other:___________________

Size of wetted area[2]: <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m² **If channel-like, average channel width:** _________ cm

Waterbody with Depth of…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (add to 100)

Feature 2, Waterbody notes:

Type: active beaver pond inactive beaver pond springhead pool GSL impoundment impoundment release (no channel) Impoundment fringe temporary pool/pond permanent pond/lake stream/river backwater stream/river, other springhead channel ditch other channel other:___________________

Size of wetted area[2]: <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m² **If channel-like, average channel width:** _________ cm

Waterbody with Depth of…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (add to 100)

Feature 3, Waterbody notes:

Type: active beaver pond inactive beaver pond springhead pool GSL impoundment impoundment release (no channel) Impoundment fringe temporary pool/pond permanent pond/lake stream/river backwater stream/river, other springhead channel ditch other channel other:___________________

Size of wetted area[2]: <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m² **If channel-like, average channel width:** _________ cm

Waterbody with Depth of…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (add to 100)

Water Chemistry Colors include Cl (clear), Br (brownish), Gr (greenish), Re (reddish), Bl (blue), or Or (orange)

GPS ID (WQ1, 2, etc.)	Feature #	Lab Sample ?	Shore (N, NE, E, etc.)	Water depth (cm)	Standing OR Flowing	Color	Tube Depth (cm)	Visibility = or > than depth?	Shaded >1/3 day?	Meter	pH	EC/TDS Out of Range	EC (mS or uS)	TDS (ppm or ppb)	Temp (C°)
		Y N			Standing	Cl Br Gr		= OR	Y N	Low		□			
					Flowing	Re Bl Or		>		High		□			
		Y N			Standing	Cl Br Gr		= OR	Y N	Low		□			
					Flowing	Re Bl Or		>		High		□			
		Y N			Standing	Cl Br Gr		= OR	Y N	Low		□			
					Flowing	Re Bl Or		>		High		□			
		Y N			Standing	Cl Br Gr		= OR	Y N	Low		□			
					Flowing	Re Bl Or		>		High		□			
		Y N			Standing	Cl Br Gr		= OR	Y N	Low		□			
					Flowing	Re Bl Or		>		High		□			

[1]Weather data for the last three days can be found on the following website by selecting Last 3 Days under Available Precipitation Image (http://www.srh.noaa.gov/ridge2/RFC_Precip)
[2]Regular Full Size Ford F-150 (excluding mirrors) is about 12.5 m², Baseball diamond is about 750m², football field is about 5300 m²

Site ID:_______________ **Observer Initials:________________**

Buffer: **Walk the N, E, S, W buffer transects if possible, substitute NE, SE, etc. if necessary, or walk a portion of transects (and estimate percent walked) to estimate hibernation features and grazing impacts. Search an area about 1 m to either side of transect.**

Transect Direction (N, E, etc.)	% Walked	# of Cow Patties	Livestock trails	Livestock prints/ pugging >22 cm deep (width of paper)	Unnatural bare soil patches at least 1 m^2	Woody Debris Piles	Animal Burrows	Loose Soil	Other Hibernation Features (rocky chambers near streams, rotted tree root channels, abandoned beaver lodges, overhanging stream banks
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed	None Few >Few	None Few >Few	None Few >Few	None Few >Few
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed	None Few >Few	None Few >Few	None Few >Few	None Few >Few
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed	None Few >Few	None Few >Few	None Few >Few	None Few >Few
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed	None Few >Few	None Few >Few	None Few >Few	None Few >Few
AA: **Visually divided AA into four quadrats and search each quadrat for signs of the following.**						**Entrenched streambank?**			
AA	100%	0 1-10 >10-100 >100	Not observed Present, rare Present and more common	Not observed <1% AA 1- 10% AA >10% AA	Not observed Present, but rare (1-2 small patches) Present and more common	N/A (no streams) Not observed Present, but rare Present along much of stream			

Comments

Wetland Water Quality Monitoring Program | **2016 Sampling** | Agency: [27]
Monitoring Run: UGS Wetland Survey (2016) | Project Code [304]

TRIP ID:	**UGSWET2016**
Collector(s):	

Sampler Contact Information (name and phone number): Diane Menuz (801) 538-7436

Monitoring Location ID:

Time:

Site Name:

Date:
Y Y M M D D

Sample Type: 4

FIELD TESTS

Water Temperature (C°): .

pH: .

Sp Cond (µS/cm): , .

TEST REQUESTS:

General Chemistry (1) :
Partial List: TSS, TDS, pH, CL, SO4, ALK, COND, TVS

Comments:

Total Metals (1):
Partial List: T-CA, T-MG, T-K, T-NA

Comments:

Total Non-filtered Nutrients (1):
Partial List: NH3, NO2+3, TPO4, T-TN **TOC** (*)

Comments:

Field Comments:
[*] TOC (UV) per agreement for analysis from Total Nutrients Bottle