Central Basin Bear River Watershed Wetland Assessment and Landscape Analysis

Diane Menuz and Miles McCoy-Sulentic
Utah Geological Survey
Utah Department of Natural Resources
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Cover (clockwise from upper left): Emergent marsh in Salt Creek Waterfowl Management Area, riparian woody wetland along the Bear River, submergent marsh in Salt Creek Waterfowl Management Area, and playa at a private duck club on the margins of Great Salt Lake.

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EXECUTIVE SUMMARY

Wetlands provide important functions including wildlife habitat, water quality improvement, floodwater storage, and erosion control as well as recreational and aesthetic values. Wetlands in the lower Bear River watershed of Utah are particularly critical because they include wetlands internationally recognized for their importance to birds, are located in an area with water quality impairment issues, and support sensitive state and federally listed species. The Utah Geological Survey conducted a study in 2017 to better understand the location, type, condition, and potential function of wetlands in the watershed. The study area was limited to the part of the watershed within the Central Basin and Range ecoregion ("Central Basin"), which excludes the mountainous Bear River Range and Wellsville Mountains. The study area is composed of two distinct sections that differ in terms of the abundance and types of wetlands present, land ownership, and land use, so we used two strata to analyze results—Great Salt Lake for the area of heavy wetland concentration near the lake and Cache-Malad for the remainder of the study area. Our study consisted of three activities: 1) creating a landscape profile using spatial data to understand the intersection of land use, ownership, and wetland distribution, 2) collecting field data on wetland condition, function, and stressors, and 3) developing an ecologically meaningful classification system for wetlands in the Central Basin.

The study area has a little more than 60,000 ha of aquatic features (including wetlands, rivers, and lakes) based on available mapped data. More than 80% of the Great Salt Lake stratum and less than 7% of the Cache-Malad stratum is composed of wetlands. The most common mapped aquatic features are emergent meadow and unconsolidated shore, making up 34% and 30% of the total aquatic feature area, respectively; the latter includes unvegetated or sparsely vegetated shorelines and playas. Shallow lake edges, including large, shallow impoundments and the edge of Great Salt Lake and other lakes, make up 19% of the study area, and emergent marsh and river and ditch channels each make up less than 10%. Woody wetlands, almost exclusively found in the Cache-Malad stratum, are the least common aquatic feature, occupying only 662 ha. Approximately 91% of aquatic resources in the Cache-Malad stratum are privately owned versus only one-quarter of wetlands in the Great Salt Lake stratum. Much of the ownership in the Great Salt Lake stratum is focused on waterfowl hunting or for birds in general at private duck hunting reserves, state waterfowl management areas, and the federal Bear River Migratory Bird Refuge. In the Cache-Malad stratum, many of the mapped aquatic features overlap with areas mapped as hay fields or crop fields and with areas mapped as irrigated, indicating that some aquatic areas have either been converted to other land covers or are heavily influenced by agriculture and irrigation practices.

We used a random stratified design to select survey sites from a sample frame composed of both vegetated (e.g., meadows, marshes, etc.) and sparsely or unvegetated (e.g., shallow impoundments, lake margins, playas, etc.) wetlands and surveyed 54 randomly selected sites and two sites recommended by land managers. Just over half the surveyed features were depressional wetlands, including depressional impoundments, and an additional 40% of wetlands in the study area were located along the fringe of impoundments or created from the release of impounded water in the Great Salt Lake stratum. Slope and riverine wetlands were uncommon overall, but each composed about 16% of wetland area in the Cache-Malad stratum.

Wetland condition varied across strata. Great Salt Lake stratum wetlands had higher overall condition scores, less landscape alteration, less soil disturbance, and higher mean C values (a measure of plant community health). Differences in condition are likely due in part to difference in land use and management—wetlands in the Cache-Malad stratum are frequently managed for pasture and are surrounded by agriculture or development, leading to more soil disturbance from livestock and motor vehicles and higher stress from the surrounding landscape compared to wetlands in the Great Salt Lake stratum, which are managed for bird habitat and recreation. Wetlands across the study area also share three key threats—non-native plant species, water quality stressors, and hydrologic alteration.

Intact plant communities are uncommon except for in a few wetland types and, at over one-quarter of wetland sites, non-native species accounted for more plant cover than native species. The noxious weed *Phragmites australis* (common reed) is particularly problematic, estimated to occupy 11% of the wetland area in the study area, mostly in the Great Salt Lake stratum. The only other noxious weed species to have high cover was *Elymus repens* (quackgrass), found with high cover at two sites along the Little Bear River in the Cache-Malad stratum. We also detected three noxious weed species having low cover in the Cache-Malad stratum that are high priority for control efforts (class 1B and class 2). Much of the non-native cover in the Cache-Malad stratum includes species such as *Alopecurus arundinaceus* (creeping meadow foxtail) and *Trifolium fragiferum* (strawberry clover) that are frequently intentionally planted for livestock forage and haying and thus may either have been directly planted in wetlands or escaped from nearby fields.

Water quality stressors are widespread. Agricultural runoff and discharge from point source polluters are estimated to reach 83% and 69% of wetland area, respectively. In the Great Salt Lake stratum, most wetlands receive water from canals off the Bear River, which is impaired everywhere in the study area. In the Cache-Malad stratum, water quality stress has multiple sources, including livestock manure and substrate disturbance directly in wetlands, runoff from adjacent lands, and inputs from impaired streams and lakes. All but a few wetlands were estimated to have some degree of hydrologic alteration that likely affects the amount, duration, and timing of flooding. Most wetlands in the Great Salt Lake stratum are either located within impoundments tightly managed to meet bird habitat goals or receive a substantial amount of water release from these impoundments. In the Cache-Malad stratum, common sources of hydrologic alteration to wetlands include direct flood irrigation to create pasture, irrigation return flows from adjacent land, and damming and water diversions along rivers.

We directly investigated two wetland functions in the study area and can infer additional functions based on the landscape profile and field notes. We rated wetlands for their ability to provide water quality and hydrologic functions (erosion and flood control) and found that functional ratings vary by wetland hydrogeomorphic class; riverine wetlands typically provide the most function and slope wetlands the least. Wetlands in the Cache-Malad stratum had somewhat higher scores, particularly for water quality improvement, but this may be an issue with the rating system rather than true differences in function between strata. We documented wildlife use in both strata and in all wetland types even though surveyors did not conduct targeted species surveys. There also appears to be an abundance of opportunity for recreational use since more than half of the aquatic resources in the study area are privately or publicly managed, at least in part, for duck hunting, and many areas are available for boating and bird watching as well.

We used data from this study and previous field surveys in the Central Basin to develop a new classification scheme that takes into account plant community composition, water regime, salinity tolerance, and geographic position. The new classification has six wetland types, including submergent marsh, emergent marsh, meadow, mudflat, playa, and woody wetland. Playas and mudflats accounted for more than three-quarters of surveyed wetlands in the Great Salt Lake stratum whereas meadows were most common in the Cache-Malad stratum. Submergent marshes and playas were typically among the top-scoring sites for wetland condition and had few non-native species, likely due to the strong environmental constraints imposed by very high soil salinity in most playas and moderately deep flooding in submergent marshes which prevent most other species from establishing. Woody wetlands were the least common wetland type and the most species-rich but typically had high cover of non-native species and low mean C values. We examined mudflats in more detail by assigning mudflats to least and most disturbed categories based on stressor data and then evaluated differences in plant community composition metrics across categories. The biggest distinguisher between the least and most disturbed mudflats was the presence and dominance of *Phragmites australis*; the species was present and generally had high cover at all but one of the most disturbed sites.

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INTRODUCTION

Project Background

Utah's wetlands face numerous threats, such as hydrologic alteration, water quality stressors, and non-native plant invasion (Menuz and Sempler, 2018). Overarching these threats is the fact that basic information on Utah's wetlands is lacking (Utah Wildlife Action Plan Joint Team, 2015), which is problematic because monitoring and assessment data are needed for such crucial activities as evaluating the results of restoration, determining appropriate mitigation, planning management actions, and identifying conservation targets. To address critical data gaps, the Utah Geological Survey (UGS) developed a protocol, the Utah Rapid Assessment Procedure (URAP), to assess wetland condition and potential function and has applied the protocol to several study areas in the state.

The Bear River watershed is an ideal watershed for the focus of detailed wetland assessment. The Bear River is the single largest contributor of inflow to Great Salt Lake (Wurtsbaugh and others, 2016), providing water that sustains wetlands that are internationally recognized for their importance (Audubon, undated). Healthy wetlands are critical for maintaining and improving water quality, vital in a watershed where more than one-quarter of assessment units are listed as impaired (Utah Division of Water Quality, 2016a). Considering estimates of increased future large-scale water withdrawals and continued urban expansion in the watershed, understanding wetland extent and condition will be essential to the conservation of these resources.

The Bear River watershed spans a diversity of ecoregions, land use patterns, and wetland types. This project focuses only on the lower parts of the watershed, those areas within the Central Basin and Range and Northern Basin and Range ecoregions (henceforth: "Central Basin"). This region is susceptible to some of the greatest pressures in the watershed, including a history of wetland drainage (Cache County, undated), extensive agricultural land, and the largest concentration of development in the watershed; the Bear River itself is listed as impaired throughout the entire study area (Utah Division of Water Quality, 2016a). The study area includes a large concentration of wetlands along the shore of Great Salt Lake and more scattered wetlands elsewhere, including around Cutler Marsh, in riparian areas along the Bear River and its tributaries, in areas of high groundwater discharge, and in isolated playas.

The UGS, funded by a grant from the U.S. Environmental Protection Agency, conducted an assessment of wetlands in the Central Basin part of the Bear 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 wetlands in the study area, developing a new classification scheme and screening for reference sites, and creating a landscape profile using mapped wetland data and ancillary information to better understand the landscape setting of wetlands in the watershed.

Utah Rapid Assessment Procedure

The UGS began developing URAP in 2014 as a tool to rapidly assess the condition of Utah's wetland resources. The initial protocol was largely based on one used by the Colorado Natural Heritage Program (Lemly and Gilligan, 2013) modeled on the Ecological Integrity Assessment developed by NatureServe (Faber-Langendoen and others, 2008). Wetland condition data are collected using a series of qualitative or semi-quantitative metrics. Each metric is composed of a series of potential states, ranked from A through D, to denote a range of condition from pristine unaltered wetlands to severely altered wetlands. The UGS added metrics to assess habitat for sensitive amphibian species to the protocol in 2015 and 2016 (Menuz and Sempler, 2018) and developed draft methods for wildlife habitat and water quality improvement functionality in 2017 (Menuz, 2017). The UGS conducted a study in 2017 to validate the method and made some changes to the protocol based on those findings (McCoy-Sulentic and Menuz, 2019; Menuz and McCoy-Sulentic, 2019). Data for this project were collected using the most recent version of the protocol and associated field forms (appendices A and B).

Overview of Wetland Assessments

EPA's Three-tiered Framework

The work described in this report follows the EPA's three-tiered framework to assess wetlands 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 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 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, etc.). 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 of 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 wetland class.

Wetland Classification

We applied three classification systems to wetlands in our study and worked on developing a fourth system. We used the Cowardin classification system to select wetlands for our survey sample frame and to conduct the Level I landscape analysis. The only available spatial data for wetlands in Utah are from the National Wetlands Inventory. The National Wetlands Inventory 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).

In the field, 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). 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 developed 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 greater than 8 ha in size and less than 2 m deep and have 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") classifies terrestrial systems based on vegetation patterns, abiotic factors, and ecological processes (NatureServe, undated); 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.

The UGS has typically used Ecological Systems to separate wetland sites into ecologically distinct units for the sake of analysis and comparison, with the goal of having sites classified in a way that is useful for setting the expected condition of structural elements of wetlands, such as the relative cover of woody versus non-woody plant species, as well as expected plant species composition. However, there is considerable overlap between some of the Ecological Systems, and the Ecological Systems tend to be very broad, making them a challenge to use for such analysis (Menuz and others, 2016). As part of this project, we worked on developing a new classification system for wetlands in the Central Basin and Range.

Project Objectives

Objective 1: Baseline Data by Strata

Our first objective was to obtain baseline data on wetlands in the Central Basin part of the Bear 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 URAP to collect field data at more than 50 wetlands in the Bear River watershed. We present results for two strata within the study area, the Great Salt Lake stratum composed of the large complex of wetlands near the namesake lake and the Cache-Malad stratum composed of the remainder of the study area.

Objective 2: Classification and Reference Screening

Our second objective was to explore alternative classification systems for wetlands in Utah's Central Basin and then develop exploratory reference standards for wetlands in one of the new classes. We used this data in conjunction with data from other UGS projects in the Central Basin to develop the new classes, classifying sites based on landscape position, hydrology, vegetation structure (e.g., aquatic, woody, or herbaceous), and species similarity. We then summarized information on attributes related to water quality parameters and plant community composition for each wetland class. We also conducted an exploratory analysis to quantify reference condition for one wetland class by assigning sites to high and low stress categories and evaluating plant community composition measures that differed between stress categories.

Objective 3: Landscape Analysis

Our third objective was to create a landscape profile of wetlands in the watershed by combining information on location, type, potential stress, and ownership 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.

STUDY AREA

Geographic and Ecoregional Setting

The study area for this project is the part of the Lower Bear River watershed, as defined by the U.S. Geological Survey's (USGS) 6-digit Hydrologic Unit Code (HUC6) 160102, found within Utah and the Central Basin and Range and Northern Basin and Range ecoregions (figure 1). The study area includes all the Utah portions of the Lower Bear-Malad, most of the Middle Bear, and a small part of the Little Bear-Logan HUC8 watersheds. The study area is bordered by Idaho to the north, the Bear River Range to the east, Great Salt Lake to the southwest, and the West Hills to the west. Much of the study area is composed of two low-lying valleys separated by the Clarkston and Wellsville Mountains, with Cache Valley to the east and Malad Valley to the west. The Northern Basin and Range composes about 2.2% of

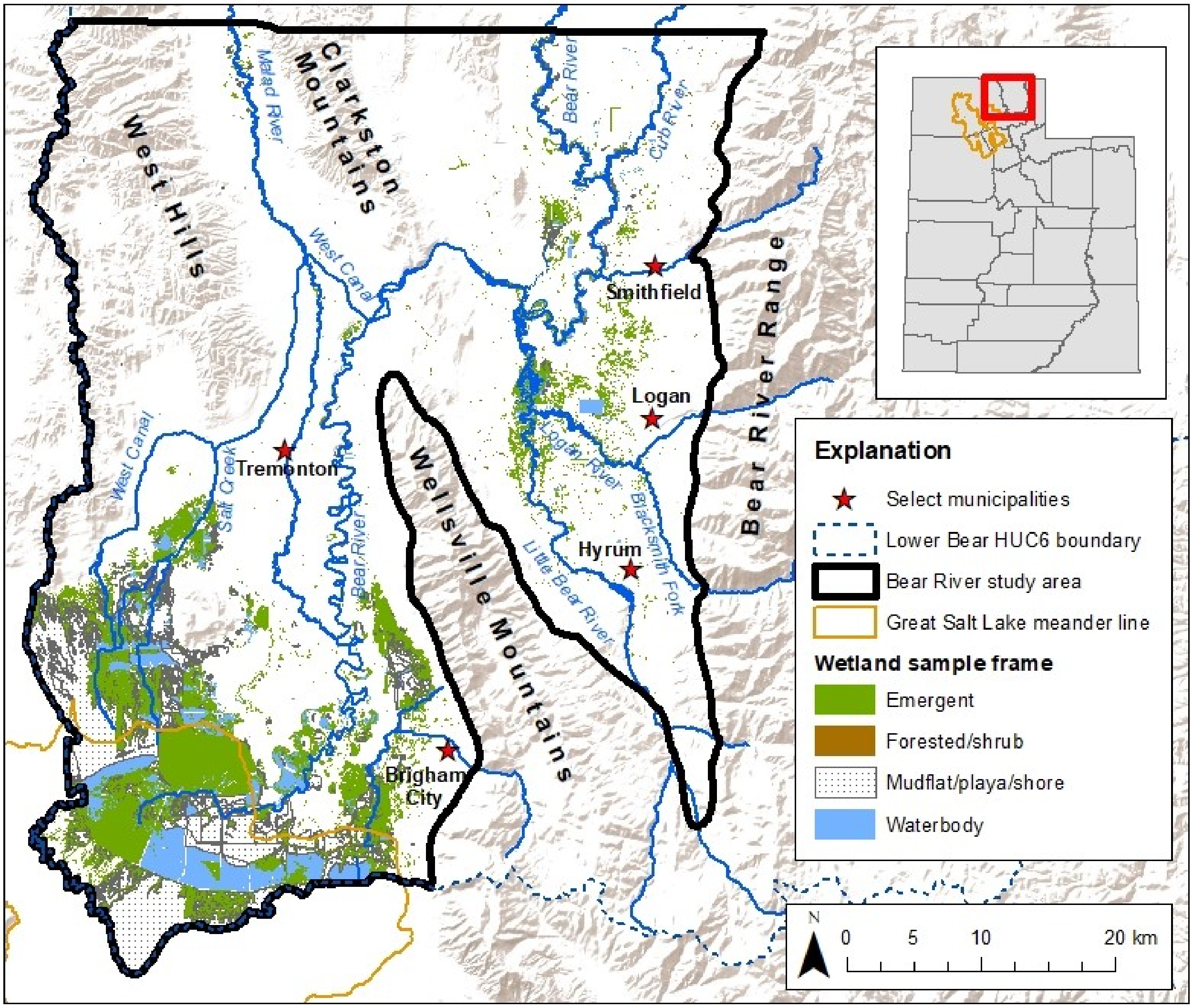

Figure 1. Overview of the Bear River study area, including select municipalities, major streams and mountain ranges, and the wetland sample frame.

the study area and is confined to the Clarkston Mountains on the Utah-Idaho border between Cache and Malad Valleys.

The Central Basin and Range ecoregion extends across western Utah, the majority of Nevada, and small parts of California, Idaho, and Oregon and is composed of a series of dry desert basins separated by northerly trending parallel mountain ranges (U.S. Environmental Protection Agency, 2013). Woodland, mountain brush, and scattered open forests are commonly found at higher elevations. Lower elevations tend to be dominated by shrub/scrub and grass or are barren. Wetlands in the watershed include spring-fed systems, riparian wetlands, and wetlands adjacent to lakes, including Cutler Reservoir in Cache County and Great Salt Lake in Box Elder County. Plant communities vary depending on water management and the availability and duration of freshwater. Bulrush (*Schoenoplectus* spp.), cattails (*Typha* spp.), common reed (*Phragmites australis*), and submerged aquatic vegetation (primarily *Stuckenia* spp.) are common in emergent marshes and artificial impoundments. Mountain rush (*Juncus* *arcticus* ssp. *littoralis*) and spikerushes (*Eleocharis* spp.) 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 rubra*) and saltgrass (*Distichlis spicata*).

Climate and Hydrology

The majority of precipitation in the Bear River watershed is snowfall in the higher mountains. Average annual precipitation in the West Hills and Clarkston Mountains is 50 cm, and these ranges have the lowest mean temperatures in the study area, about 7.7°C. The hottest and driest part of the study area is adjacent to Great Salt Lake, where mean annual temperatures are greater than 9.7°C and less than 40 cm of precipitation falls each year. Most of the study area has mean annual temperatures between 8.1 and 8.7°C and mean annual precipitation of around 44 cm.

The Bear River originates on the north slope of the Uinta Mountains in Utah and passes through Wyoming and Idaho before entering the study area at the northern end of Cache Valley, passing through Cutler Reservoir and then Malad Valley, and terminating at Great Salt Lake; a 500 mile route that ends less than 100 miles from where it begins. The Bear River is the largest source of surface water inflow to Great Salt Lake, providing about 58% of the inflow (Wurtsbaugh and others, 2016). Major tributaries to the Bear River within the study area include the Cub and Malad Rivers, which both originate in Idaho, and the Logan River, which originates in the Bear River Range to the east of Cache Valley. Cutler Reservoir is a large, shallow reservoir in Cache Valley, having a mean depth of 0.9 m and maximum surface water area of 2907 ha (Kariya and others, 1994). The reservoir was built in 1927 for hydropower generation and agricultural water storage by impounding water primarily from the Bear, Logan, and Little Bear Rivers (SWCA Environmental Consultants, 2010). The Little Bear River is also dammed above Cutler Reservoir within the study area; the resulting Hyrum Reservoir has a mean depth of 11.8 m and storage up to 18,700 acre-ft (Kariya and others, 1994).

Groundwater resources are important in the study area. Most springs in Malad Valley are east of the Bear River near the base of the Wellsville and Clarkston Mountains, though large systems to the west of the river, including Salt Springs West and springs around Jesse's Knoll, are important for wetland complexes near Great Salt Lake (Stolp and others, 2017). In Cache Valley, springs are located near the base of the mountains on either side of the valley as well as in the valley center, with a large complex of springs west of Smithfield and Logan that flow via spring creeks to the Bear River and Cutler Reservoir. Total groundwater discharge from springs is about 53,000 acre-ft per year in Malad Valley (Stolp and others, 2017) and 58,000 acre-ft in Cache Valley (Utah Division of Water Rights, 1999); the uncertainty in these estimates is at least 50%. Discharge is fresh in most of the study area and more saline in the areas west of the Bear River in Malad Valley (Utah Division of Water Rights, 1999; Stolp and others, 2017).

Wildlife and Plants

The most well-known and extensive wetland habitat in the Bear River watershed occurs in the Bear River Bay part of Great Salt Lake. The National Audubon Society has designated the Bear River Bay, including Salt Creek and Public Shooting Grounds Waterfowl Management Areas, Bear River Migratory Bird Refuge, and parts of the Bear River Bay outside the bounds of the study area as a Globally Important Bird Area. The region at times hosts at least 1%, and for some species almost 40%, of the North American populations of 15 shorebirds, waterfowl, and water birds (Audubon, undated). The area supports at least two species on the Utah Division of Wildlife Resources' sensitive species list, American white pelican (*Pelecanus erythorhynchos*) and long billed curlew (*Numenius americanus*), and large populations of black-necked silt and white-faced ibis, both Partners in Flight priority species. In Cache County, Cutler Reservoir and associated marshes have also been listed as a Globally Important Bird Area by the Audubon. The Cutler Reservoir complex supports many of the same species as Bear River Bay, though typically in smaller concentrations, and may serve as an important refuge for birds when Great Salt Lake water levels are high, such as they were in the 1980s (Audubon, undated). Other state-listed sensitive bird species that may utilize wetlands in the Bear River watershed include bobolink (*Dolichonyx oryzivorus*), short eared owls (*Asio flammeus*), and bald eagles (*Haliaeetus leucocephalus*).

Ute ladies'-tresses *(Spiranthes diluvialis)* is a federally threatened plant species known to occur in the eastern half of the study area. This species is found in moist to very wet meadows, along streams, in abandoned stream meanders, and near springs, seeps, and lake shores. The mollusk Utah physa (*Physella utahensis*), a state sensitive species, is known from the western edge of the study area and is associated with spring-fed pools. The Bonneville cutthroat trout (*Oncorhynchus clarkii utah*) was formerly found in the Bear, Malad, and other rivers throughout the study area, but now is limited to higher elevation streams in the Bear River watershed, just barely entering the study area in upper parts of the Little Bear and Blacksmith Fork Rivers.

Land Ownership and Land Use

Land ownership within the study area is 84% private, 10% federal, and 6% state (table 1). Major public land managers in the study area include the U.S. Bureau of Land Management which has parcels near Great Salt Lake, the U.S. Forest Service in the Clarkston Mountains, the U.S. Fish and Wildlife Service at the Bear River Migratory Bird Refuge, the Utah Division of Wildlife Resources at Salt Creek and Public Shooting Grounds Waterfowl Management Areas near Great Salt Lake, and the Utah Division of Forestry, Fire and State Lands on the lakebed of Great Salt Lake and the streambed of the Bear River.

The study area is composed of the western part of Cache County and the eastern part of Box Elder County and includes the most populous parts of each county. Agriculture, mainly cultivated crops, is currently the predominant land use in the region, though populations in the two counties are expected to almost double by 2065 (Kem C. Gardner Policy Institute, undated). Approximately 38% of the watershed is used for agriculture, of which about 71% is irrigated and the remainder sub-irrigated or dry farmed (Utah Division of Water Resources, 2017). Alfalfa is the most common agricultural land use, followed by winter wheat, pasture, corn, and grass or hay. Cache Valley has both more development and more agriculture than Malad Valley and is where the majority of population growth is expected to occur. The land cover adjacent to Great Salt Lake is predominantly wetlands, open water, and barren mudflats with less than 10% combined cover of agriculture, development, and upland areas. Mining in the study area is limited to a few gravel and rock mines, the largest of which is located just east of Salt Creek Waterfowl Management Area.

Water Quantity and Water Quality

The hydrology of the Bear River and major tributaries has been heavily altered by water diversions. The West Side and East Side Canals remove about 110,000 and 22,000 acre-feet of water, respectively, just below Cutler Dam for domestic and irrigation uses, and another 175,000 acre-feet of water is diverted close to Great Salt Lake for the Bear River Wildlife Refuge and other state and private wildlife areas near the lake (Utah Division of Water Resources, 2004). Often more than half of the

Table 1. Characteristics of study area strata, including extent and abundance of wetlands in the sample frame (U.S. Fish and Wildlife Service, 2018), temperature and precipitation (Daly and others, 2008), elevation, land ownership (SITLA, BLM, and partners, undated), and land cover (Multi-Resolution Land Characteristics Consortium, 2019). Tribal ownership accounts for less than 0.1% of land ownership in the Cache-Malad stratum (not shown). Climate and elevation values are followed by the standard deviation (SD) in parenthesis.

Stratum		**Great Salt Lake**	**Cache-Malad**
Area (km^2) (% of total in study area)		511 (18.5%)	2248 (81.5%)
# of wetlands (% of total in study area)		3624 (37.3%)	6082 (62.7%)
Wetland area (km^2) (% of total in study area)		424.8	101.7 (19.3%)
Mean monthly 30-year climate data	Maximum temp. (°C) (SD)	33.1 (0.2)	31.8 (1.1)
	Mean temp. (°C) (SD)	10.1 (0.2)	8.6 (0.8)
	Minimum temp. (°C) (SD)	-9.4 (0.3)	-10.9 (0.9)
	Daily precip. (mm) (SD)	1.07 (0.08)	1.24 (0.15)
Mean elevation (m) (SD)		1285 (4)	1460 (174)
Land ownership, by percentage	Federal	47.4%	2.0%
	Private	29.6%	96.0%
	State	23.0%	1.9%
Land cover, by percentage	Developed	0.6%	9.2%
	Agricultural	4.3%	51.9%
	Forest and shrubland	4.1%	25.6%
	Grassland	0.9%	7.5%
	Barren	29.4%	0.3%
	Open water	16.7%	1.3%
	Wetlands	44.1%	4.2%

natural flow of the Bear River in Cache County is diverted for agricultural uses, though much of this water returns to the system as return flow and subsurface recharge (SWCA Environmental Consultants, 2010), and a large portion of the Malad River is diverted in Box Elder County to supply water for wetland and wildlife areas near Great Salt Lake (Stolp and others, 2017). Agriculture used about 94% of the developed water in the basin in 2004 and use was projected to decrease by less than 5% through 2054 (Utah Division of Water Resources, 2004).

The Bear River is governed by the Bear River Compact, an agreement that allocates water between Utah, Idaho, and Wyoming. The Bear River Development Act was passed by the Utah Legislature in 1991 to task the Utah Division of Water Resources with developing Utah's unused portion of the river, 220,000 acre-feet. The water project would require construction of new reservoirs and transport systems and supply water to water conservation districts both within and outside the watershed; about 45% of the developed water would be delivered to Weber, Davis, and Salt Lake Counties. The Utah Division of Water Resources has been evaluating potential locations and even purchasing real estate for the plan, but there is no final plan or timeline in place. A recent study estimates that this water development would lead to an approximately 22 cm decline in Great Salt Lake's water levels and expose about 77 km^2 of lake bed (Wurtsbaugh and others, 2016).

Groundwater withdrawal is another important component of water alteration in the Bear River watershed. About two-thirds of extracted groundwater in the Malad Valley is used for municipal supply and much of the remainder is used for irrigation (Burden and others, 2017). While water use for irrigation in the Malad Valley has been relatively steady, withdrawal for municipal water supply continues to increase at a rate of about 1000 ac-ft per year from the late 1970s to early 2010s (Stolp and others, 2017). In Cache Valley, the majority of groundwater withdrawal is used for irrigation and public supply (Burden and others, 2017). Long-term trends indicate declining water levels in most monitored wells in Cache Valley, with substantial fluctuation based on climate conditions. The State Engineer considers the surface and ground waters in Cache County to be tightly interrelated and recommends that they be managed together due to the ability for withdrawals of groundwater to affect surface water and associated water rights (Utah Division of Water Rights, 1999).

Water quality in the Bear River watershed has been affected by agricultural runoff, industrial and municipal point source discharges (including animal feeding operations), hydrologic modification, bank erosion, and loss of riparian and aquatic habitat (Toole, 2011; Utah State University Water Quality Extension, 2012 and 2014). The three reservoirs assessed by the Utah Division of Water Quality in the study area, Cutler, Newton, and Hyrum, have approved Total Maximum Daily Loads (TMDLs) for dissolved oxygen and total phosphorus (Utah Division of Water Quality, 2016a). TMDLs are plans for restoring the water quality of impaired waters. The part of the Bear River within the study area and many of the tributaries to the river, including the Little Bear, Cub, Logan, and Malad Rivers, have TMDLs for total phosphorus; some segments have TMDLs for dissolved oxygen as well. Many of these same segments are also listed as impaired for dissolved oxygen, temperature, sedimentation, or aquatic macroinvertebrate communities.

FIELD STUDY DESIGN AND SURVEY METHODS

Site Selection

Target Population and Sample Frame

The target population was wetlands within the study area that were at least 0.1 ha in size and less than 1 m deep. Wetlands are areas that receive periodic substrate saturation or inundation, which often results in distinct plant communities and 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). For this study, a site was considered a wetland if it had evidence of wetland hydrology and if it had hydrophytic plants and hydric soils if vegetation or soils were present. Unvegetated wetlands and shallow water without true soils were both included in the target population.

The U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) program maps wetlands and deepwater habitat throughout the United States using the Cowardin classification system. We downloaded NWI data for the state of Utah from the online NWI mapper (U.S. Fish and Wildlife Service, 2018). We also obtained a draft version of new NWI mapping for the eastern half of Great Salt Lake in May 2018. We used the new mapping where available and the older NWI data for the rest of the study area. Most of Cache Valley was mapped using imagery from the early 1980s and most of Malad Valley was mapped using imagery from 2005.

We removed deepwater areas from the NWI data by removing all polygons mapped as lacustrine limnetic (L1); these are deepwater areas with water at least 2.5 m deep. We kept polygons mapped as lacustrine littoral (L2), which includes open water less than 2.5 m in depth, lakeshore edges, playas, mudflats, and impoundments. 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 (Federal Geographic Data Committee, 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 receive frequent overbank flooding. Wetlands were clipped to the edge of the study area.

Strata and Selection of Study Sites

Wetlands that intersected the Salt Deserts and Shadscale-Dominated Saline Basins Level IV ecoregions or the Wetlands Level IV ecoregion within Box Elder County were assigned to the Great Salt Lake stratum and all other wetlands were assigned to the Cache-Malad stratum (figure 2). A summary of characteristics of each stratum is in table 1. We used the spsurvey package (Kincaid and Olsen, 2019) in R 3.5.3 (R Core Development Team, 2019) 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 all consecutive sets of sample points are themselves spatially balanced (Stevens and Olsen, 2004). We selected sample points instead of wetland polygons because URAP evaluates fixed area plots rather than whole wetlands. We used a stratified equal weight selection design, meaning that all wetland area within each stratum had equal probability of selection. We selected 20 sample and 80 oversample points in the Great Salt Lake stratum and 30 sample and 70 oversample points in the Cache-Malad 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.

We reached out to land managers and conservation specialists in the Bear River Watershed for help identifying high-quality wetlands to supplement our randomly selected survey sites. We surveyed two subjectively selected sites based on recommendations, a site at Salt Creek Waterfowl Management Area and a site near Mendon in Cache Valley that is managed by a non-profit land conservancy.

Site Office Evaluation and Landowner Permission

Sample points were evaluated in the office to determine whether they were located near target wetlands based on true color and infrared aerial imagery, digital elevation data, data on water-related land use, and hydric soils data. Survey points were moved up to 100 m from the original location to account for spatial inaccuracies in the NWI data. We contacted landowners through phone calls and a mailer to request permission to survey sites. We rejected all sample points where access was denied or where we were unable to obtain permission.

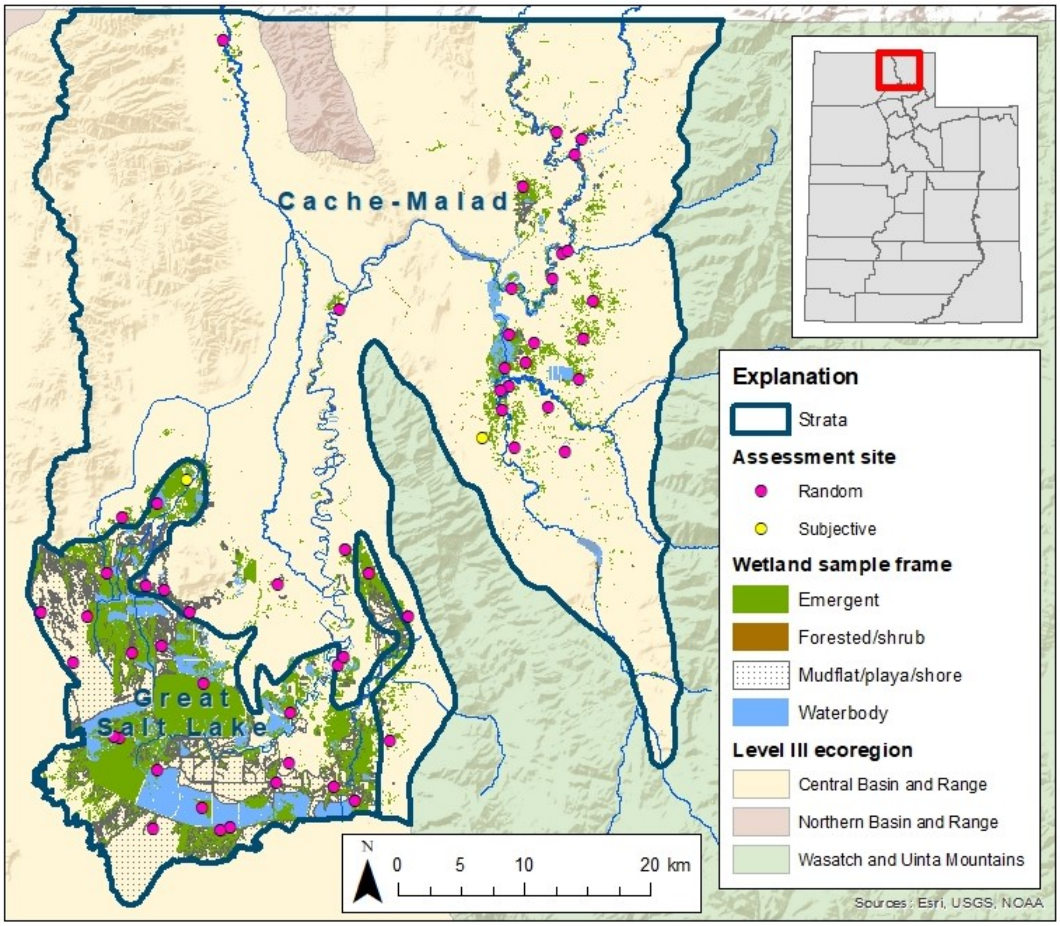

Figure 2. Strata used in site selection and surveyed wetland sites.

We conducted an office evaluation for each site before the field survey to gather useful landscape data to support field efforts. 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 determined whether there were stressors with potential to degrade water quality in the contributing basin, including development, agriculture, rangeland, point source dischargers, oil and gas wells, and mines. We also determined whether contributing streams or lakes were listed as impaired in the 2016 integrated report (Utah Division of Water Quality, 2016a). Information from the office evaluation was verified by observations in the field whenever possible.

Field Methods

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 wetland delineation guide for the Arid West Region (U.S. Army Corps of Engineers, 2008). 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 U.S. Army Corps delineations due to the limited time spent on each determination and the broader definition of wetland used in this study.

If a site contained a target wetland, we next set up an assessment area (AA). AAs were 40-m-radius circular survey plots centered on the sample point where possible or rectangular or free form plots between 0.1 and 0.5 ha and at least 10 m wide when necessary to avoid upland inclusions or areas with water greater than 1 m deep; no more than 10% of the AA was permitted to be non-target. 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 to a depth no less than 50 cm at a representative location within the dominant plant community at each site. An additional pit was sometimes dug if no hydric soil indicators were found in the first pit or if multiple plant communities were co-dominant. For each soil layer, surveyors recorded the layer depth, color of the matrix, presence and color of any dominant and secondary redox features (based on a Munsell Soil Color Chart), soil texture, and percent coarse (>2 mm) material. Hydric soil indicators were recorded based on the U.S. Army Corps regional wetland delineation guide for the Arid West Region (U.S. Army Corps of Engineers, 2008). 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 depth to free water. We collected soil electroconductivity (EC) data from an approximately 15-cm-deep soil sample adjacent to the soil pit. We homogenized the sample by hand, removing rocks and roots as needed. We then combined 50 ml of the soil sample with 250 ml distilled water and mixed the sample together. We measured EC using a handheld Hanna Instruments Combo meter after allowing the sediment to settle out of the sample.

Water chemistry data were also collected with a handheld Hanna Instruments Combo meter when surface water was present at sites. We measured pH, electroconductivity (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 at sites with surface water; 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 contained necessary preservatives added 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 a series of predominantly qualitative metrics (appendices A and B). 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.

Table 2. Condition metrics evaluated by the Utah Rapid Assessment Procedure, listed under metric categories.

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 (i.e., 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 Native Cover	Relative cover of native species (native species cover / total cover)
Absolute Noxious Cover	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 was present at sites or when large patches of dry algae were present at sites.

[4]Excluded from scoring for emergent marsh, submergent marsh, playa, and mudflat wetland types.

[5]Evaluted with respect to similar wetlands within Ecological System.

[6]Only evaluated when woody debris and woody species are expected at sites.

Surveyors also recorded data on stressors observed in the field. Stressor data were collected at two scales, the buffer area within 100 m of the site and the AA itself. 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 all plant species within the AA after searching the area using a progressive timed meander method adapted from the Minnesota Pollution Control Agency's Rapid Floristic Quality Assessment (Minnesota Pollution Control Agency, 2014). In this method, a base time of 30 minutes is set for each site, with 20 minutes added for each additional community. Communities were identified as distinct groupings of species having similar physiognomy (e.g., wet meadow or shrub complex). If three or more species were found in the last 10 minutes of the survey, an additional 10 minutes were added. Additional 10-minute increments were added as needed until less than three new species were encountered in the final 10 minutes. For each species found, we recorded predominant height class, 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 the U.S. Department of Agriculture (USDA) Plants Database (http://plants.usda.gov) to reference plants throughout this report.

Wetland Function

We collected data on wetland potential for water quality improvement and hydrologic functions (flood and erosion reduction) using Washington State's wetland rating system (Hruby, 2014). The wetland rating system has separate metrics for four different HGM classes of wetland—depressional, riverine, lacustrine fringe, and slope. Depressional, depressional impoundment, depressional impoundment fringe, and impoundment release wetlands were all considered depressional for the sake of the functional assessment. Indicators are grouped into three categories for each function: site potential to provide the function, landscape potential to support the function, and societal value. We did not assess the societal value of the hydrologic functions because we did not have regional flood plans or other documents to support that assessment. We also did not collect amphibian habitat data for boreal toad and Columbia spotted frog because neither species is expected in the study area.

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 proportional to the amount of area represented by the site relative to the total wetland area in the study area. For this project, sites in the Great Salt Lake stratum were assigned a higher weight than sites in the Cache-Malad stratum because the Great Salt Lake stratum has much more total wetland area. Weights allow for accurate estimation within a stratum, where all weights are the same, and across the whole study area, where weights differ. We adjusted the assigned weights based on the total number of sites evaluated in each 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 and 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 and Olsen, 2019). We also used t-tests to compare the means of some metrics across strata.

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 and for descriptions of wetland types are presented as raw data, which limits our ability to make inference to the whole study area from these results. For example, if we report that the mean cover of native plants in wet meadows in our study area is 70%, we cannot expect that the mean cover of all wet meadows in the study area is also 70% because more heavily weighted wet meadows in the Great Salt Lake stratum may have higher or lower native plant cover than those in the Cache-Malad stratum. 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 3.5.3 statistical software (R Core Development Team, 2019).

Rapid Assessment Condition Results

We used the following standard to refer to metric rankings: A=excellent, B=good, C=fair, D=poor. Rankings for the relative native cover and absolute noxious cover metrics were obtained by calculating cover estimates using plant composition data (table 3) and then converting estimates to ranks using the thresholds shown in appendix A. We considered all recorded *Phragmites australis* (common reed) to be the non-native, noxious subspecies of *P. australis* when subspecies was not recorded based on the rarity of the native subspecies in Utah (Kulmatiski and others, 2010).

We calculated categorical and overall condition scores using the following procedure. 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:

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

Table 3. Vegetation metrics evaluated to compare least and most disturbed mudflats. *x*i = percent cover i[th] species, Ci= coefficient of conservatism, Wi = percent cover of obligate and facultative wetland species, Hi = species height, Nx = percent cover of noxious weeds, Na = percent cover of native species, Si = salinity tolerance category, Ai = anaerobic tolerance category, Nt = count of all species, Ns = count of all species, Gm = percent cover by grasses, Gr = percent cover by graminoids.

Metric	Description	Calculation
Absolute noxious cover	Total cover of noxious weed species	$\sum_{\mathrm{i}=1}^{\mathrm{n}} Nxi$
Absolute wetland cover	Total cover of only OBL and FACW species	$\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{W}i$
Cover-weighted anaerobic tolerance[1]	Cover-weighted anaerobic tolerance of all species	$\sum_{i=1}^{n} (xi\mathrm{Ai}) / \sum_{i=1}^{n} xi$
Cover-weighted height	Cover-weighted height of all species	$\sum_{i=1}^{n} xi\mathrm{Hi} / \sum_{i=1}^{n} xi$
Cover-weighted mean C[1]	Cover-weighted mean C-value of all species	$\sum_{i=1}^{n} (xi\mathrm{C}i) / \sum_{\mathrm{i}=1}^{\mathrm{n}} xi$
Cover-weighted salinity tolerance[1]	Cover-weighted salinity tolerance of all species	$\sum_{i=1}^{n} (xi\mathrm{Si}) / \sum_{i=1}^{n} xi$
Mean C[1]	Mean C-value of all species	$\sum_{i=1}^{n} Ci/Nt$
Relative graminoid cover	Cover of graminoids (grasses, rushes, sedges) as a percent of total vegetation cover	$\sum_{\mathrm{i}=1}^{\mathrm{n}} Gm \,/ \sum_{\mathrm{i}=1}^{\mathrm{n}} xi$
Relative grass cover	Cover of grasses as a percent of total vegetation cover	$\sum_{\mathrm{i}=1}^{\mathrm{n}} Gs \,/ \sum_{\mathrm{i}=1}^{\mathrm{n}} xi$
Relative native cover[1]	Cover of native species as a percent of total vegetation cover	$\sum_{i=1}^{n} \mathrm{Na} \,/ \sum_{i=1}^{n} xi$
Relative wetland cover[1]	Cover of OBL and FACW species as a percent of total vegetation cover	$\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{W}i \,/ \sum_{\mathrm{i}=1}^{\mathrm{n}} xi$
Total vegetation cover	Total cover of all species	$\sum_{\mathrm{i}=1}^{\mathrm{n}} xi$

[1]Calculated using only species with known wetland indicator, nativity status, C-value, salinity tolerance, or anaerobic tolerance.

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 cover-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 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 (Rocchio and Crawford, 2013). All non-native species are assigned a C-value of 0. 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 (table 3). Both mean C and cover-weighted mean C range from 0 to 10.

C-values are often developed for individual states or regions to capture regional variability in how species respond to disturbance. The EPA contracted to convene a working group in fall 2018 to assign C-values to plant species in states where C-values had not been previously assigned (Arizona, California, Idaho, New Mexico, Nevada, Oregon, Texas, Utah), but only for those species recorded in one of the EPA's National Wetland Condition Assessment surveys. We used C-value assignments from that workshop and from previous work in nearby states, including Colorado (Rocchio, 2007), Montana (Jones, 2005), Washington (Rocchio and Crawford, 2013), and Wyoming (Washkoviak and others, 2015) to assign C-values to species in Utah. First, all introduced species were assigned a value of 0. Second, species with Utah-specific assignments retained that assignment. Next, unassigned species with assignments in one or more of the states immediately surrounding Utah, including Colorado, Wyoming, Arizona, Idaho, and Nevada, were assigned the mean value from those states. Last, unassigned species with assignments in Montana or Washington or in one or more of the other states that were part of the EPA workshop were assigned the mean value from the states where assigned. If C-values for Utah plus the surrounding states or C-values for species that only had values in more distant states varied by more than three across states, we manually inspected the values to determine whether the values should be kept, modified, or removed, based on best professional judgment.

Wetland Function

We totaled the scores in each component (site potential, landscape potential, and societal value) to assign sites to "low," "medium," and "high" categories for each component and function based on thresholds in Hruby (2014). Continuing to follow Hruby (2014), we then calculated an overall score for each of the two functions—water improvement and hydrology—by converting low to 1, medium to 2, and high to 3, so that, for example, a site that scored low in site potential, medium in landscape potential, and low in societal value would have an overall score of 4. Final scores for water quality improvement were out of 9 and for hydrology out of 6 because we did not assess societal value for the latter function.

Wetland Classification

We used data from this study and previous UGS surveys in the Central Basin (Menuz and others, 2014; Menuz and others, 2016; Menuz and Sempler, 2018), totaling 196 sites, to develop an initial wetland type classification that takes into account plant community composition, water regime, salinity tolerance, and geographic position. We started by examining the five Ecological Systems that had been recorded for wetland sites in the Central Basin, but pared this down to four systems, removing the Inter-Mountain Basins Greasewood Flat class as there was only one site in this class. We used non-metric multidimensional scaling (NMDS) with the vegan package (Oksanen and others, 2018) in R to visually evaluate how well Ecological Systems separated classes based on plant community composition. For Ecological Systems that have a high degree of variability within the Ecological System and strong overlap with other Ecological Systems, we reviewed site photos, vegetation data, and hydrology information to develop new wetland types that better distinguished sites from one another.

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 among sites. Values along the axes are not readily interpretable (i.e., 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. Plots are useful for visually evaluating the degree to which sites with similar attributes have similar species composition (i.e., tend to cluster together). We excluded from NMDS analysis most species only identified to genus, but did include the genera *Atriplex* (saltbush), *Carex* (sedge), *Chenopodium* (goosefoot), *Eleocharis* (spikerush), *Epilobium* (willowherb), and *Viola* (violet). We grouped all species within the genera *Lemna* (duckweed), *Tamarix* (tamarisk), and *Typha* (cattail) into their respective genera rather than considering these species independently because each was frequently not identified to species. We did not include subspecies or varieties in the analysis. Additionally, we only included species that occurred at a minimum of three sites and excluded sites that were unvegetated or only had species not shared by other sites.

Permutational multivariate analysis of variance (PERMANOVA) using the adonis function in the vegan package (Oksanen and others, 2018) was used to test for differences in plant community composition among classification groupings for both Ecological Systems and the new wetland types. We examined dispersion using the permutest function, a permutational test that is a multivariate analog of variance. Because PERMANOVA is sensitive to differences in dispersion as well as centroid location, this test was used to determine if significant differences detected by PERMANOVA may be due to variability within groups rather than between groups (Anderson, 2001). When the assumption of equal dispersion is not met, significant PERMANOVA results must be treated with caution. In cases where the assumption of equal dispersion was met and PERMANOVA results were significant, we used pairwise PERMANOVA comparisons to test for differences in plant community composition between each pair of wetland types (e.g., meadow versus woody wetland) using Bonferroni corrected p-values because a *post-hoc* test is not available using the adonis function.

Reference Site Screening

We selected one of the wetland types developed as described above to conduct exploratory analysis to screen for reference sites and look for parameters that would separate high quality sites from low quality sites. We chose the mudflats as the focal type because this wetland type is most common around Great Salt Lake and Utah Lake, two areas where we had extensive data. We used data from this study and previous UGS studies in the Central Basin (Menuz and others, 2014; Menuz and others, 2016; Menuz and Sempler, 2018) for a total of 58 mudflat sites. There were several important differences in how data were collected across the different survey years. Surveyors evaluated stressors within 200 m of sites in 2013 and 2014 (Great Salt Lake and Weber projects) and within 100 m in other years. Furthermore, the names of stressors differed across years, and the most differences were evident in the 2013 data. We treated stressor data from 100 and 200 m buffers equivalently and categorized stressors as either buffer stressors or one of three stressor categories within the AA—physical substrate, hydroperiod, and vegetation.

We used indices of buffer and AA stress and one URAP metric to screen for least disturbed mudflat wetlands in our data following methods used in Menuz and Sempler (2018). We first converted low-, medium-, and high-severity stressors to values of 1, 2, and 4, respectively. We then 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% to 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—physical substrate, hydroperiod, and vegetation. Relative native cover, a URAP metric, was also used as a screen.

We first searched for mudflats that met the following criteria: at least 80% relative native cover, 2 or less for buffer stress, and 1 or less for hydroperiod, vegetation, and physical stress. These values are equivalent to one moderate stressor across the entire extent of the buffer, and one low severity stressor in each category across the entire AA. We also screened for low quality, or “most disturbed” sites to establish a disturbance gradient and to examine how well vegetation metrics discriminated between low- and high-quality sites. We adjusted screens as needed so that between 15% and 20% of sites were classified as least disturbed and between 20% and 30% of sites were classified as most disturbed (U.S. Environmental Protection Agency, 2016).

After classifying sites as least and most disturbed, we calculated a variety of vegetation metrics to see whether they could be used to distinguish between the two site categories (table 3). We calculated metrics related to nativity, noxious cover, wetland indicator, C-values, cover by lifeform, total cover, and cover-weighted height. We also calculated cover-weighted anaerobic and salinity tolerance with tolerance values taken from the USDA Plants Database and Palmquist and others (2017). Box plots were created for each metric comparing least and most disturbed sites to examine how well the metrics differentiated sites, and t-tests were performed to determine if differences were significant based on Bonferroni adjusted p-values.

Landscape Profile

We used the most recent published data from NWI for the landscape profile (U.S. Fish and Wildlife Service, 2019), though this data differed from the draft data used as the sample frame. We included all mapped NWI data for the landscape profile, including deepwater and other aquatic features not used in the sample frame. We attributed the data with land ownership, stress model values, land use, and irrigation class. This attribution allowed us to summarize information on the types, protection status, and potential vulnerability of aquatic features within the watershed.

We classified aquatic features into nine classes based on Cowardin attributes, including riverine, lake deepwater, lake edge, pond, unconsolidated shore, emergent marsh, emergent meadow, scrub shrub, and forested (table 4). We used water regime to separate emergent wetlands into marsh and meadow classes even though there is considerable overlap in wetland types for some of the water regimes. We used only the first class when we classified split class features, so that a feature mapped as PEM/USA would be considered emergent meadow and not unconsolidated shore. Aquatic feature classes are only as good as the original mapped data and do not take into account changes that have occurred on the landscape.

We used land ownership data from SITLA, BLM, and partners (undated) to classify aquatic features as private, state, federal, and tribal and by management agency. Categories of State-owned land include sovereign land (primarily the lakebed of Great Salt Lake and the Bear River), waterfowl management areas (including Salt Creek and Public Shooting Grounds), and other State-owned land, which includes trust lands, state parks, and land managed by the Utah Department of Transportation. Categories of federal-owned land include the Bear River Migratory Bird Refuge, the Bureau of Land Management, and other federal land, which includes U.S. Forest Service and Bureau of Reclamation. We

Table 4. Aquatic feature classes used in the landscape analysis, with description and list of Cowardin codes used to define the class. Only the first class was considered for split classes (e.g., PUS/EM would be classified as unconsolidated shore).

Class	**Description**	**Cowardin Code**
Riverine	River, streams, and ditches, including the main channel and sparsely vegetated bars.	System R
Lake deepwater	Water and submergent vegetation >2.5 m deep in lakes >8 ha; surface water present in all but years of extreme drought.	System L1
Lake edge	Water and submergent vegetation ≤2.5 m deep in lakes and shallow impoundments >8 ha; water typically present all growing season most years.	System L2; Class AB, UB, RB
Pond	Water and submergent vegetation in waterbodies < 8 ha in size; water typically present all growing season most years.	System P; Class AB, UB, RB
Unconsolidated shore	Intermittently or seasonally flooded lakes and ponds, mudflats, and playas.	System L2 or P; Class US
Emergent marsh	Herbaceous emergent wetlands that are saturated or flooded all growing season most years, such as marshes and fens.	System P; Class EM; Water Regime D, E, or F
Emergent meadow	Herbaceous emergent wetlands that are saturated or flooded less than the entire growing season.	System P; Class EM; Water Regime A, B, C, J, K
Scrub shrub	Wetlands dominated by woody vegetation <6 m tall, such as willows or tamarisk.	System P; Class SS
Forested	Wetlands dominated by woody vegetation >6 m tall, such as cottonwood.	System P; Class FO

used an internal layer of management areas digitized by the UGS in 2013 to classify private lands as duck hunting reserve, mitigation bank, or other private land.

We classified aquatic features as having low, moderate, or high levels of local stress based on values from a GIS-based aquatic resource stress model (Menuz, 2015). The local 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 selection of final weights and a final method for combining predictors into an overall stress score was calibrated with existing wetland 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 thresholds of 200 or less and 800 or less. The stress model only includes data on stressors that have 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 model. Furthermore, the model does not take into account stressors that originate higher in a watershed and travel to a site via streams or canals.

Land use and irrigation data were extracted from Water Related Land Use (WRLU) data (Utah Division of Water Resources, 2017), 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. We combined the land use categories in the WRLU data into seven categories based on their similarity to one another and prevalence in the study area, including agriculture (irrigated and unirrigated crops), hay and turf, pasture, urban, sewage lagoons, riparian and aquatic (including riparian, open water, mudflats, and playas), and unmapped. We calculated the percentage of aquatic feature 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, and irrigated lands are lands that are irrigated through flood, sprinkler, or drip irrigation.

RESULTS

Survey Site Characteristics

Surveyed Sites

We evaluated 79 randomly selected sites to obtain 54 sites that could be surveyed. In the Great Salt Lake stratum, we were unable to obtain access to one site and there was no target wetland at one site. In the Cache-Malad stratum, we were unable to obtain access to 11 sites and there was no target wetland at 12 sites. Most of the non-target wetland sites still had aquatic features; seven sites had water greater than 1 m deep, two had wastewater ponds, and one was too narrow to meet dimension requirements (table 5). We surveyed 32 randomly selected sites in the Cache-Malad stratum, 22 randomly selected sites in the Great Salt Lake stratum, and one subjectively selected site in each stratum. Surveys were conducted between June 21 and October 3, 2018. Sites were frequently moved away from the originally selected center point, though all but eight assessment areas included the original randomly selected point within the assessment area boundary.

Table 5. 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. Sites classified as no target wetland are further divided into four classes–no wetland present, water >1 m deep, wastewater pond, and too small.

Site Evaluation	Study Area	Great Salt Lake	Cache-Malad
# Sites Evaluated	79	24	55
Total Area in Sample Frame (ha)	52,640	42,476	10,164
Percent Surveyed	85.2 (2.7)	91.7 (3.5)	58.2 (<0.1)
Percent No Access	7.2 (2.8)	4.2 (3.5)	20.0 (3.9)
Percent No Target Wetland	7.6 (2.8)	4.2 (3.4)	21.8 (3.9)
No wetland present	4.1 (2.8)	4.2 (3.4)	3.6 (2.2)
Water >1 m deep	2.5 (0.6)	*NA*	12.7 (3.0)
Wastewater pond	0.7 (0.4)	*NA*	3.6 (2.3)
Too small	0.4 (0.3)	*NA*	1.8 (1.5)

We evaluated our data to look for the presence of U.S. Army Corps wetland indicators to verify that our survey sites were in the target population (U.S. Army Corps of Engineers, 2008). All sites had at least two of the three indicators (hydrology, soils, vegetation) present. Hydric soil indicators were absent in almost one-third of sampled sites; however, hydric soil indicators were developed to help delineate the boundary of wetlands and thus may not always be present in the interior of wetlands where we typically sampled (U.S. Army Corps of Engineers, 2008). Two sites had no hydrophytic vegetation; both sites appeared to be in decline due to severe hydrologic modifications.

Hydrogeomorphic and Wetland Type Classification

Sites were assigned HGM classes based on their dominant class, though some contained more than one class. Depressional features were the most common HGM class in both strata; more than one-third of the wetland area in the study area is estimated to be depressional (table 6). In the Great Salt Lake stratum, depressional impoundments, depressional impoundment fringe, and impoundment release were also common, each occupying between 18% and 23% of wetland area. Slope and riverine wetlands were more common in the Cache-Malad stratum, each making up 16% of wetland area. Six wetland classes, discussed in more detail below under "Wetland Classification," were described in the study area (table 6). Playas and mudflats were the most common in the Great Salt Lake stratum, occurring in 27% and 41% of wetland area, respectively, and no woody wetlands were recorded in the Great Salt Lake stratum. In the Cache-Malad stratum, almost 44% of wetlands were meadows, with 16% emergent marsh, and 12.5% each playa and woody wetland. Three sites in the Cache-Malad stratum were classified as submergent marsh, though two were sparsely vegetated shallow water. Overall, the least common wetland class in the study area was woody wetlands, estimated to occupy only 1.6% of all wetland area.

Table 6. Hydrogeomorphic classes and wetland types in the study area, including estimated percent of wetland area in each class and standard error in parentheses.

Class	Study Area	Great Salt Lake	Cache-Malad
Hydrogeomorphic Class			
Depressional	35.5 (6.9)	31.8 (8.1)	59.4 (7.5)
Depressional Impoundment	16.2 (6.2)	18.2 (7.2)	3.1 (2.8)
Depressional Impoundment Fringe	19.7 (5.5)	22.7 (5.5)	0
Impoundment Release	19.7 (6.7)	22.7 (7.7)	0
Lacustrine Fringe	0.4 (0.4)	0	3.1 (2.8)
Mineral Soils Flats	0.4 (0.4)	0	3.1 (2.7)
Slope	6.0 (3.0)	4.5 (3.7)	15.6 (5.1)
Riverine	2.1 (0.7)	0	15.6 (5.1)
Wetland Type			
Submergent Marsh	13.1 (5.2)	13.6 (6.5)	9.4 (4.6)
Emergent marsh	10.0 (4.7)	9.1 (5.7)	15.6 (5.6)
Meadow	13.7 (4.1)	9.1 (4.1)	43.8 (5.3)
Mudflat	36.3 (7.3)	40.9 (8.4)	6.3 (3.2)
Playa	25.3 (7.3)	27.3 (8.7)	12.5 (3.9)
Woody Wetlands	1.6 (0.7)	0	12.5 (5.0)

Wetland Condition

Stressors

Potential water quality and hydroperiod stressors were identified prior to surveys based on GIS analysis of surrounding land cover and probable water sources. Agricultural runoff and point source discharges were the two most common water quality stressors in the study area, estimated to impact over 80% and 68% of wetland area, respectively, and usually considered moderate severity (table 7). Both were more common in the Great Salt Lake stratum than in the Cache-Malad stratum. Runoff from development (including paved roads) was only common in the Cache-Malad stratum and typically considered low severity. Hydroperiod stressors were also common at the landscape scale. Ditching, control structures, and berms are all estimated to affect more than 66% of wetland area in the study area, with all three much more common and typically considered more severe in the Great Salt Lake stratum. Irrigation return flows and runoff from impervious surfaces were common in the Cache-Malad stratum and typically considered low or moderate severity.

Stressors within the wetland buffer (100-m area surrounding AAs) were much more common in the Cache-Malad stratum compared to the Great Salt Lake stratum (table 7). The most widespread stressors in the buffer of wetlands in the Great Salt Lake stratum were non-native plant species, found at 68% of wetland sites, followed by minor off-road vehicle disturbance and dikes, dams, and control structures, each found at 18% of sites. In the Cache-Malad stratum, four categories of stressors were found in 25% or more of wetland buffers, including non-native plant cover, livestock grazing, modified

Table 7. Landscape stressors in the study area and estimated percentage of wetland area affected by each stressor and standard error in parentheses. Values represent the percent of wetland area affected by the stressors at the landscape and buffer scale, not the percent of total buffer area with a particular stressor. Stressors estimated to occur in 50% or more of wetland area bold and underlined and those estimated to occur in between 25% and 50% of wetland area are in bold.

Indicator	Study Area	Great Salt Lake	Cache-Malad
Landscape Water Quality Stressor			
Agricultural land	**83.2 (5.0)**	**86.4 (6.1)**	**62.5 (6.6)**
Development (including paved roads)	9.7 (3.3)	4.5 (3.7)	**43.8 (6.8)**
Quarries and sediment from miscellaneous sources	17 (5.6)	18.2 (6.7)	9.4 (4.7)
Point source dischargers	**68.5 (6.4)**	**72.7 (7.3)**	**40.6 (5.8)**
Landscape Hydroperiod Stressor			
Control structure	**73.5 (5.2)**	**81.8 (6.8)**	18.8 (5.4)
Berm controlling inflow/outflow	**74.7 (5.3)**	**81.8 (6.8)**	**28.1 (7.2)**
Ditching	**66.8 (5.4)**	**72.7 (5.7))**	**28.1 (6.8)**
Irrigation return flows	19.7 (4.9)	13.6 (6.3)	**59.4 (5.7)**
Impervious surface	2.1 (0.6)	0	15.6 (4.2)
Land Use Stressors in 100-m Buffer			
Cropland	1.6 (0.7)	0	12.5 (4.9)
Haying	2.9 (0.9)	0	21.9 (6.1)
Development	2.1 (0.8)	0 0	15.6 (5.5)
Roads	6.4 (3.5)	4.5 (3.8)	18.8 (5.5)
Livestock grazing	24.4 (5.3)	18.2 (5)	**65.6 (7.1)**
Hydrologic Stressors in 100-m Buffer			
Modified channels and ditching	17.2 (5.2)	13.6 (5.5)	**40.6 (7.2)**
Human-made basin or pond	0.4 (0.4)	0	3.1 (2.7)
Dikes, dams, and water control structures (including roads)	19.5 (5.6)	18.2 (6.6)	**28.1 (6.1)**
Water Quality Stressors in 100-m Buffer			
Excessive filamentous algae	1.6 (0.7)	0	12.5 (5.3)
Stormwater discharge	0.4 (0.4)	0	3.1 (2.7)
Other Stressors in 100-m Buffer			
Off-road vehicles disturbance	18.7 (6.1)	18.2 (6.7)	21.9 (6.6)
Non-native plant species cover	**68.0 (4.7)**	**63.6 (3.7)**	**96.9 (2.8)**

channels and ditching, and dikes, dams, and water control structures. Stressors that were frequently considered high severity when present include haying crops, ditching, and non-native plant cover in the Cache-Malad stratum and ditching and dikes in the Great Salt Lake stratum.

Only four categories of stressors were recorded directly within AAs in the Great Salt Lake stratum and each were found in 9.1% or more of surveyed wetlands (table 8). These stressors included channel modification, substrate disturbance from livestock, other substrate disturbance, and livestock browse. Livestock disturbances were much more common in the Cache-Malad stratum; about one-third of sites had substrate disturbance or browse from livestock or both, though impacts were rarely recorded as high severity. Other stressors found at greater than 18% of surveyed wetlands in the Cache-Malad stratum include excessive filamentous algae and non-livestock substrate disturbance.

Wetland Condition

Fifteen sites had overall wetland condition scores greater than 4.5, including one of the subjectively selected reference sites. Most of these high-scoring sites were in the Great Salt Lake stratum and many were playas or submergent marshes with low species diversity. In fact, 11 of the 15 sites with six or fewer species were amongst the highest scoring sites. The only top-scoring sites with more than six species included the subjectively selected site at Salt Creek Waterfowl Management Area, a privately-owned slope wetland in Box Elder county, and two playas in Box Elder County. The four lowest scoring sites (all with scores <3) included a stand of *Phragmites australis* at Bear River Migratory Bird Refuge and three wetlands completely surrounded by agricultural areas in the Cache-Malad stratum.

Wetlands in the Great Salt Lake stratum were generally rated as being in better condition than those in the Cache-Malad stratum (tables 9 and 10; figure 3). They had higher mean scores for two of the landscape metrics—overall buffer ($p < 0.001$) and percent intact landscape ($p < 0.001$)—and for the soil disturbance ($p < 0.001$) and wetland edge connectivity ($p = 0.027$) metrics. The mean overall score and scores for the landscape and physical categories were also higher in the Great Salt Lake stratum. Analysis of the cumulative density function of overall score also showed that distributions of scores differed by strata ($p = 0.03$, figure 3). Aspects of condition that were frequently rated poorly in both strata included horizontal interspersion, hydroperiod, timing of inundation, water quality, and relative native cover. Only wetland edge connectivity frequently was scored as A in both strata.

Table 8. Assessment area stressors in the study area and estimated percentage of wetland area affected by each stressor and standard error in parentheses. Values represent the percent of wetlands area that would have these stressors within the AA, not the total percent cover of the stressor across all wetland area. Stressors estimated to occur in between 25% and 50% of wetland area are in bold.

Stressor	Study Area	Great Salt Lake	Cache-Malad
Channel modification	9.1 (4.5)	9.1 (4.8)	9.4 (4.5)
Stormwater directly into AA	0.4 (0.3)	0	3.1 (2.6)
Substrate disturbance from livestock	8.1 (3.1)	4.5 (3.7)	**31.3 (7.2)**
Non-livestock substrate disturbance (e.g., compaction, dredging)	10.4 (4.8)	9.1 (5.7)	18.8 (5.8)
Livestock browse	12.4 (4.5)	9.1 (4.8)	**34.4 (7.1)**
Excessive filamentous algae	2.9 (0.9)	0	21.9 (6.6)
Vegetation mowing	0.8 (0.5)	0	6.3 (3.8)

Table 9. Condition metric results for the Cache-Malad stratum showing the estimated percent of wetland area in each rank and standard error in parentheses. Metrics are sorted by the lowest to highest mean score, calculated by converting ranks to values as detailed in the text. Empty cells indicate ranks not scored for particular metrics.

Metric	Mean Score	A	A-	B	C	C-	D	N/A
Buffer Condition: Vegetation	2.5	13.8 (5.2)		20.7 (6.5)	24.1 (6.9)		46.9 (7.0)	
Relative Native Cover[1]	2.8	28.1 (6.3)			18.8 (6.6)	25.0 (7.0)	28.1 (6.3)	
Water Quality	2.8	6.3 (3.7)		18.8 (5.9)	46.9 (7.5)		28.1 (6.5)	
Horizontal Interspersion[2]	2.8	12.5 (5.4)		28.1 (7.1)	21.9 (6.6)		37.5 (7.8)	
Hydroperiod	3.0	3.1 (2.6)		37.5 (6.9)	2.05 (6.4)	28.1 (6.1)	6.3 (3.7)	
Timing of Inundation	3.3	18.8 (5.7)		37.5 (5.9)	15.6 (5.6)	12.5 (4.9)	15.6 (5.3)	
Percent Intact Landscape	3.7	34.4 (7.3)		21.9 (6.7)	31.3 (6.4)		12.5 (5.3)	
Buffer Condition: Soil	3.8	34.5 (7.1)		44.8 (7.9)	17.2 (6.4)		12.5 (5.3)	
Absolute Noxious Cover	4.0	46.9 (6.9)		28.1 (6.3)	12.5 (5.4)		12.5 (5)	
Soil Disturbance	4.0	37.5 (7.3)		40.6 (8)	15.6 (5.5)		6.3 (3.8)	
Turbidity and Pollutants	4.1	25 (7.1)		15.6 (5.8)	3.1 (2.8)		6.3 (3.8)	50.0 (7.6)
Algae Growth	4.1	25 (6.5)		12.5 (5.2)	18.8 (5.8)		0	43.8 (7.7)
Connectivity: Whole Wetland	4.2	40.6 (7.0)		34.4 (6.7)	25.0 (5.5)		0	
Buffer Width	4.3	59.4 (7.2)	6.3 (3.8)	25.0 (6.3)	0		9.4 (4.6)	
Litter Accumulation[1]	4.4	75.0 (6.8)			21.9 (6.3)		3.1 (2.7)	
Percent Buffer	4.5	78.1 (6.2)	0	12.5 (5.0)	0		9.4 (4.6)	
Woody Species Regeneration	4.7	15.6 (5.5)		0	3.1 (2.8)		0	81.3 (5.8)
Connectivity: Edge	4.7	75.0 (5.9)		21.9 (5.7)	3.1 (2.7)		0	
Woody Debris[1]	5.0	21.9 (5.5)			0		0	78.1 (5.5)

[1]Scored as AB rather than A or B separately.

[2]Includes all sites in stratum even though metric not used for scoring for emergent marsh, submergent marsh, playa, and mudflat wetland types.

Wetland Function

We used the depressional field forms to evaluate function for most wetlands in both strata, though one site in the Great Salt Lake stratum was classified as slope and one, five, and six sites in the Cache-Malad stratum were classified as lakeshore fringe, slope, and riverine, respectively. More than half the wetlands in the Cache-Malad stratum received water quality function scores between 7 and 9, whereas only 18% of sites in the Great Salt Lake stratum scored in that range and more than half scored 5 or less (table 11). Sites in the Cache-Malad stratum were frequently rated as having higher landscape potential and societal value for water quality improvement than those in the Great Salt Lake stratum, whereas the strata were more similar in the distribution of ratings for wetland potential (table 12). In particular, more sites in the Cache-Malad stratum were surrounded by land use that could generate pollutants, received stormwater discharge, and were located in contributing basins with incorporated areas or agricultural land, leading to higher landscape potential scores, and more sites were located in

Table 10. Condition metric results for the Great Salt Lake stratum showing the estimated percent of wetland area in each rank and standard error in parentheses. Metrics are sorted by the lowest to highest mean score, calculated by converting ranks to values as detailed in the text. Empty cells indicate ranks not scored for particular metrics.

Metric	Mean Score	A	A-	B	C	C-	D	N/A
Horizontal Interspersion[1]	2.0	0		13.6 (6.6)	31.8 (9.5)		54.5 (10.0)	
Hydroperiod	2.9	9.1 (4.8)		9.1 (4.9)	45.5 (10.0)	31.8 (8.5)	4.5 (4.1)	
Woody Debris[2]	3.0	0			4.5 (3.9)		0	95.5 (3.9)
Water Quality	3.3	22.7 (5.8)		22.7 (6.6)	36.4 (5.9)		18.2 (6.8)	
Timing of Inundation	3.4	9.1 (4.8)		22.7 (7.4)	63.6 (9)	4.5 (3.8)	0	
Relative Native Cover[2, 3]	3.4	57.1 (7.9)			0	14.3 (7.0)	28.6 (8.5)	4.5 (3.8)
Absolute Noxious Cover	3.7	50.0 (8.6)		18.2 (7.7)	9.1 (5.4)		22.7 (7.8)	
Buffer Condition: Vegetation	4.0	50.0 (6.8)		22.7 (7.7)	13.6 (6.1)		13.6 (6.5)	
Woody Species Regeneration	4.0	0		4.5 (3.7)	0		0	95.5 (3.7)
Litter Accumulation[2]	4.3	72.7 (8.7)			18.2 (7.6)		9.1 (5.5)	
Connectivity: Whole Wetland	4.4	45.5 (8.9)		45.5 (9.7)	9.1 (5.6)		0	
Turbidity and Pollutants	4.4	18.2 (7.3)		9.1 (5.5)	4.5 (3.8)		0	68.2 (8.5)
Algae Growth	4.5	31.8 (8.5)		27.3 (8.3)	0		0	40.9 (9.4)
Buffer Condition: Soil	4.7	72.7 (7.2)		27.3 (7.2)	0		0	
Percent Intact Landscape	4.7	77.3 (7.9)		18.2 (7.7)	4.5 (3.8)		0	
Soil Disturbance	4.9	90.9 (4.1)		9.1 (4.1)	0		0	
Buffer Width	5.0	95.5 (3.8)	0	4.5 (3.8)	0		0	
Connectivity: Edge	5.0	95.5 (3.8)		4.5 (3.8)	0		0	
Percent Buffer	5.0	100	0	0	0		0	

[1]Includes all sites in stratum even though metric not used for scoring for emergent marsh, submergent marsh, playa, and mudflat wetland types.

[2]Rank scored as AB rather than A or B separately.

[3]One site was not rated because it was unvegetated.

basins with TMDLs or discharged to impaired waterbodies, leading to higher societal value scores. Riverine wetlands tended to have higher scores for landscape potential to improve water quality and riverine and lake fringe wetlands tended to have higher scores for societal value than other wetlands.

Sites in the Cache-Malad stratum had more area with higher overall scores for hydrologic functions than those in the Great Salt Lake stratum (table 11). The Great Salt Lake stratum had no sites rated as high for site potential or landscape potential to support hydrologic functions; more than three-quarters of sites were rated as medium in each category (table 12). The Cache-Malad stratum had more sites rated as high for both components, but also had almost half of the sites rated as low for site potential for hydrologic functions. Wetlands in the Great Salt Lake stratum frequently had more depth of storage than those in the Cache-Malad stratum due to impoundments, leading to fewer sites with low hydrologic function ratings, and wetlands in the Cache-Malad stratum more frequently received stormwater discharge, were surrounded by land use generating pollutants, or were riverine wetlands

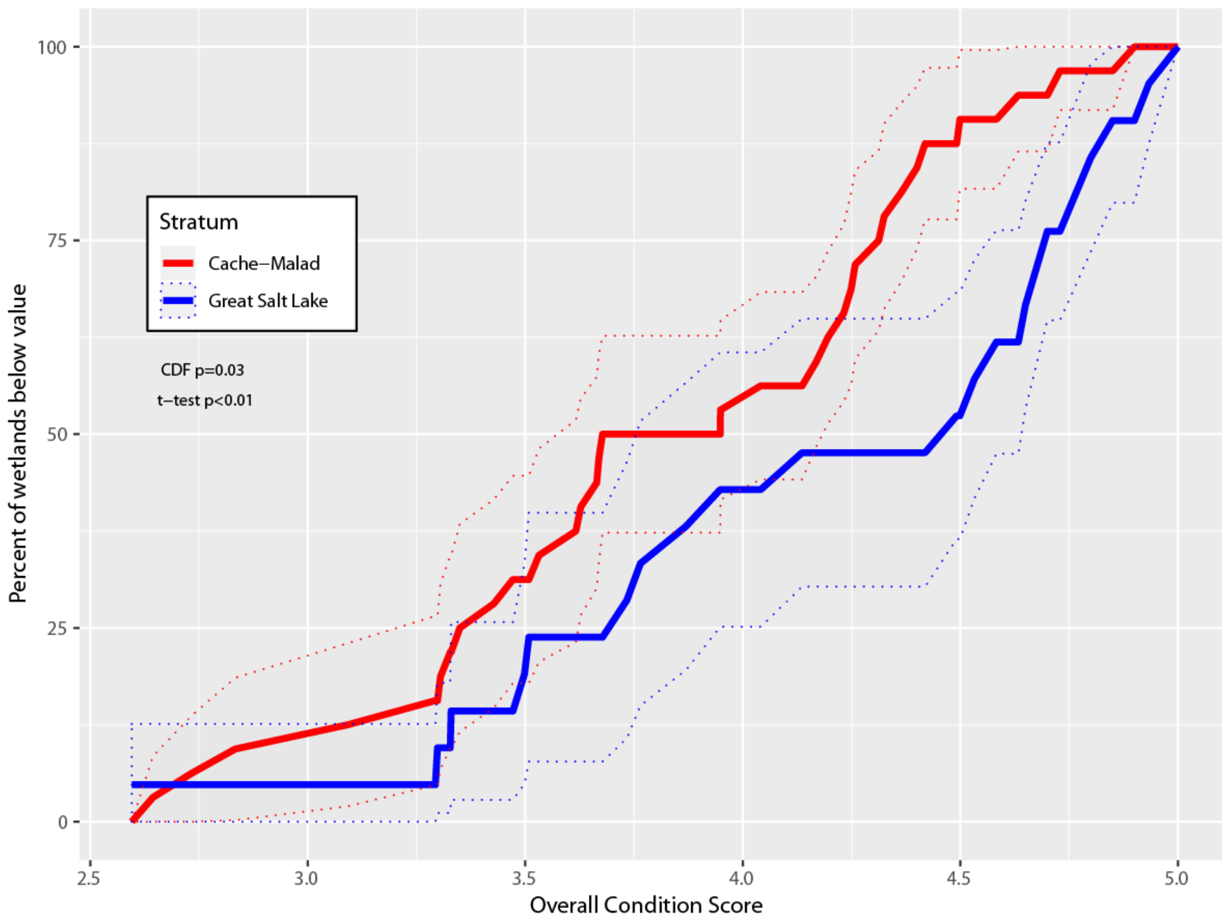

Figure 3. Cumulative density functions of overall condition scores showing the estimated percentage of wetland area that has an overall URAP score at or below the indicated values for the two strata. Solid lines represent estimates and dotted lines represent 95% confidence interval.

Table 11. Overall scores for water quality improvement and hydrologic functions, including estimated percent of wetland area with each score and standard error in parentheses. Dashes indicate values that were not applicable for a function.

Overall Score	Water Quality Improvement			Hydrologic Function		
	Study Area	Cache-Malad	Great Salt Lake	Study area	Cache-Malad	Great Salt Lake
2	-	-	-	9.5 (4.4)	12.5 (4.4)	9.1 (5.4)
3	12.3 (4.7)	3.1 (2.7)	13.6 (5.7)	24.3 (6.6)	34.4 (7.6)	22.9 (7.5)
4	17.0 (5.4)	9.4 (4.2)	18.2 (6.4)	62.5 (6.3)	25.0 (7.0)	68.2 (7.8)
5	21.4 (6.4)	12.5 (4.8)	22.7 (6.9)	3.3 (1.0)	25.0 (6.9)	0
6	26.6 (7.2)	21.9 (6.3)	27.3 (8.8)	0.41 (0.35)	3.1 (2.6)	0
7	14.7 (5.0)	21.9 (6.1)	13.6 (5.7)	-	-	-
8	7.2 (3.2)	25.0 (6.8)	4.5 (3.8)	-	-	-
9	0.82 (0.5)	6.3 (3.7)	0	-	-	-

Table 12. Categorical scores for water quality improvement and hydrologic functions, including estimated percent of wetland area performing each component at low, medium, and high levels.

Metric Category	Low	Medium	High
Cache-Malad			
Water Quality Improvement			
Site potential to improve water quality	18.8 (5.6)	46.9 (7.6)	34.4 (7.3)
Landscape potential to support water quality function	12.5 (5.1)	62.5 (7.8)	25.0 (6.9)
Societal value	31.3 (5.5)	15.6 (4.7)	53.1 (5.6)
Hydrologic Function			
Site potential to reduce flooding and erosion	46.9 (8.1)	40.6 (8.2)	12.5 (5.0)
Landscape potential to support hydrologic function	12.5 (4.4)	68.8 (6.4)	18.8 (6.2)
Great Salt Lake			
Water Quality Improvement			
Site potential to improve water quality	27.3 (8.1)	40.9 (8.5)	31.8 (8.8)
Landscape potential to support water quality function	59.1 (7.4)	40.9 (7.4)	0
Societal value	27.3 (6.3)	68.2 (7.2)	4.5 (3.8)
Hydrologic Function			
Site potential to reduce flooding and erosion	22.7 (7.8)	77.3 (7.8)	0
Landscape potential to support hydrologic function	18.2 (6.6)	81.8 (6.6)	0

with upgradient dams or incorporated areas, leading to higher landscape potential scores. In the Cache-Malad stratum, riverine wetlands were the only wetlands that scored high and all slope wetlands and the one lake fringe wetland all scored as low for site potential for hydrologic function. Slope wetlands tended to score low for the landscape potential component of hydrologic function as well.

Sensitive Ecological Features

Wildlife Species

Surveyors noted wildlife species observed during surveys, including signs such as tracks and droppings. Surveyors took photographs to document any amphibians observed during surveys. Identification of other wildlife was at 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 study area and should not be considered a complete list because wildlife observations were not a focus of the survey method. Birds, mammals, amphibians, reptiles, fishes, and invertebrates were documented in both the Great Salt Lake and Cache-Malad strata (table 13). No state or federally sensitive wildlife species were documented. Evidence of wildlife from at least two taxonomic groups (e.g., bird, amphibian, etc.) were documented in each wetland type.

Sensitive Plant Species

We recorded five plant species considered sensitive within the state of Utah, including one species of greatest conservation need (SGCN), three potential species of greatest conservation need (PSGCN), and one species with status under review (M. Wheeler, Rare Plant Conservation Coordinator for the State of Utah, written communication, February 9, 2018). At least one collection was made for each species, and vouchers will be submitted to the Intermountain Herbarium at Utah State University

Table 13. Wildlife observations during wetland surveys.

Strata	Birds	Mammals	Amphibians and Reptiles	Fish	Invertebrate
Great Salt Lake	hawk, songbird, swallow, duck, piscivorous bird, stilt	cow, coyote, deer, mouse, muskrat, racoon	northern leopard frog, garter snake	unknown fish	dragonfly/dam selfly, snail
Cache-Malad	songbird, swallow, duck, shorebird	beaver, cow, deer, mouse, racoon	northern leopard frog, garter snake	carp, other fish	dragonfly/dam selfly, snail

In Logan, Utah. Seven of the 11 sites with sensitive plant species were managed by Pacificorp or state or federally managed.

We recorded *Leersia oryzoides* (rice cutgrass) at one site. This plant has SGCN status and is listed as state imperiled in Utah by NatureService (undated). *L. oryzoides* is a native obligate wetland grass found throughout southern Canada and the United States. Surveyors recorded the species with less than 1% cover in Cache County in a riparian wetland on an island within the Bear River in a localized depression with shallow standing water.

We recorded *Spirodela polyrrhiza* (common duckmeat) at three sites in Cache County. This plant has PSGCN status and is listed as critically imperiled in Utah by NatureService (undated). *S. polyrrhiza* is a native obligate floating monocot found throughout Canada and the United States. Surveyors recorded the species as having less than 1% cover at all three sites. *S. polyrrhiza* was found at the same site as the *L. oryzoides*, making that site the only one with two sensitive plant species.

We recorded *Juncus articulatus* (jointleaf rush) at one site. This plant has PSGCN status but is not currently ranked by NatureService (undated). *J. articulatus* is a native obligate rush found in both Canada and the United States. Surveyors recorded the species as having less than 1% cover at a spring-fed slope wetland in Cache County.

We recorded *Teucrium canadense* var. *occidentale* (western germander) at one site. This plant has PSGCN status and is listed as critically imperiled in Utah by NatureService (undated). It is a native forb found in most of the contiguous United States and Canada. *T. canadense* is rated as a facultative wetland species though the variety *occidentale* does not have a wetland indictor rating. Surveyors recorded the species as having less than 1% cover in a wooded riparian wetland along the Cub River in Cache County.

We recorded *Puccinellia simplex* (California alkaligrass) at five sites. This plant has an unknown status on the Utah sensitive species list but is listed as critically imperiled in Utah by NatureService (undated). *P. simplex* is a native annual grass with a facultative wetland indicator rating known to occur only in California and Utah. Surveyors recorded the species as having less than 1% cover at four playa sites around Great Salt Lake and at one isolated playa site on private property in the Malad Valley near Portage, Utah, with 2% cover.

Wetland Vegetation

We recorded 940 encounters with 212 unique plant species at random and reference sites, including 72 species found at only one site. Non-native species composed 38% of these species. There were fewer species recorded in the Great Salt Lake stratum than in the Cache-Malad stratum, 76 versus 205, though the proportion of non-native species was about the same in each stratum. We were not able to identify to species 74 of the plants we encountered, of which 55 were tentatively identified to genus only and the remainder were identified to lifeform. *Atriplex* was the most frequent genus not identified to species, at 22 sites; mature fruit is often required for positive identification and members of this genus typically fruit late in the growing season. Other genera occasionally not identified to species include *Typha*, *Chenopodium*, *Bassia* (smotherweed), *Rumex* (dock), *Tamarix*, and *Eleocharis*, each identified to genus at between three and nine sites. All *Typha* in the study area are native and have a C-value of 3 and all *Tamarix* were considered introduced and noxious, so we included unidentified members of each genus in the floristic data analysis. We also assumed unidentified *Isoetes* (quillwort), *Carex*, and *Eleocharis* were native and unidentified *Bassia* was introduced. Seven unidentified plant records had greater than 2% cover at a site.

Plant Community Composition Metrics

Mean C values across the study area ranged from 0.5 to 4.5. Half the sites in the Great Salt Lake stratum had mean C values of 3 or higher versus less than 15% of the sites in the Cache-Malad stratum, and sites in the Great Salt Lake stratum had both higher average mean C and a significantly different cumulative density function than sites in the Cache-Malad stratum (figure 4). Cumulative density functions also differed between strata for relative native cover though mean values did not; the Great Salt Lake stratum had more sites with low values and more sites with high values for this metric. Mean relative native cover was about 71% for the study area. Means and distributions did not differ across strata for the absolute noxious cover metric. Both strata had at least one site with 100% relative native cover, no noxious weeds, and no non-native species.

Noxious Weed Plant Species

Fourteen noxious weed species were documented in the study area, of which all were in the Cache-Malad stratum and only five in the Great Salt Lake stratum (table 14). In the Great Salt Lake stratum, *Phragmites australis* was the most widespread and abundant noxious weed species, found at almost half of the surveyed sites and estimated to occupy 12.7% of wetland area. Though not identified to subspecies, we assumed all *P. australis* to be the invasive *australis* subspecies based on the rarity of the native subspecies in Utah (Kulmatiski and others, 2010). *Lepidium latifolium* (broadleaved pepperweed) was also common, at 22.7% of wetlands in the Great Salt Lake stratum. In the Cache-Malad stratum, *Cirsium arvense* (Canada thistle) was found at 11 sites, *L. latifolium* at 6 sites, *Conium maculatum* (poison hemlock) and *Elymus repens* (quackgrass) at 5 sites each, and other noxious weed species at 4 or fewer sites. Besides *P. australis* and *E. repens*, all recorded noxious weeds occurred with 8% or less cover at each site and only *Convolvulus arvensis* (field bindweed), *L. latifolium, Galega officinalis* (professor-weed), and *Tamarix* were recorded with more than 2% cover at any sites. Most of the noxious weed species found in this study are Class 3, widely spread species where management should focus on containing new populations. However, we recorded one Class 1B species, *G. officinalis*, at four wetland sites in Cache County. Class 1B species occur in limited populations within Utah and are a high priority for eradication to prevent further spread in the state.

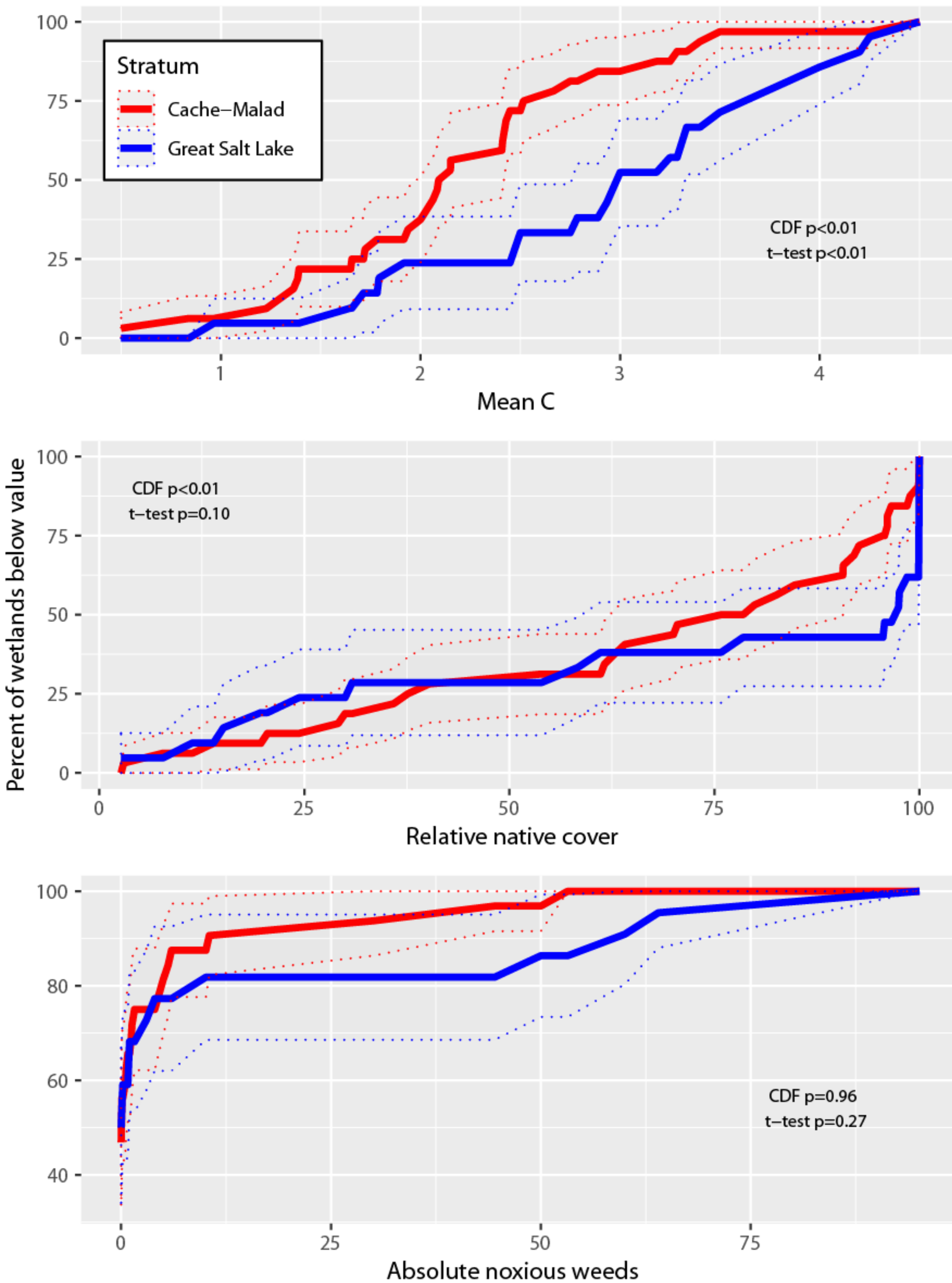

Figure 4. Cumulative density functions of plant composition metrics showing the estimated percentage of wetland area having plant community composition metric value at or below the indicated values. Solid lines represent estimates and dotted lines represent 95% confidence interval.

Table 14. Noxious weed species detected in the study area, including estimates of percent cover in each stratum and standard error in parentheses. The number of sites where each species was detected follows the cover estimates.

Scientific Name (Common Name)	Noxious Weed Listing	Wetland Indicator	Study Area	Great Salt Lake (n=22)	Cache-Malad (n=32)
Cardaria draba (white top)	Class 3	None listed	0.008 (0.13)	0	0.06 (0.3) n=1
Cirsium arvense (Canada thistle)	Class 3	FACU	0.04 (0.1)	0.02 (0.1) n=1	0.2 (0.3) n=11
Conium maculatum (poison hemlock)	Class 3	FACW	0.04 (0.2)	0.02 (0.1) n=1	0.1 (0.3) n=5
Convolvulus arvensis (field bindweed)	Class 3	None listed	0.04 (0.5)	0	0.3 (1.4) n=4
Cynoglossum officinale (gypsyflower)	Class 3	FACU	0.005 (0.05)	0	0.04 (0.1) n=4
Elaeagnus angustifolia (Russian olive)	Class 4	FAC	0.01 (0.13)	0	0.08 (0.4) n=2
Elymus repens (quackgrass)	Class 3	FAC	0.3 (3.0)	0	2.2 (7.9) n=5
Galega officinalis (professor-weed)	Class 1B	None listed	0.03 (0.3)	0	0.2 (0.8) n=4
Isatis tinctoria (Dyer's woad)	Class 2	None listed	0.0008 (0.009)	0	0.006 (0.02) n=2
Lepidium latifolium (broadleaved pepperweed)	Class 3	FAC	0.2 (0.6)	0.1 (0.4) n=6	0.3 (1.4) n=6
Lythrum salicaria (purple loosestrife)	Class 2	OBL	0.002 (0.03)	0	0.02 (0.09) n=1
Onopordum acanthium (Scotch cottonthistle)	Class 3	None listed	0.0004 (0.006)	0	0.003 (0.02) n=1
Phragmites australis[1] (common reed)	Class 3	FACW	11.3 (25.0)	12.7 (26.3) n=9	1.7 (8.7) n=4
Tamarix spp.[2] (tamarisk)	Class 3	FAC	0.2 (0.6)	0.2 (0.7) n=2	0.02 (0.09) n=3

[1]All observations recorded without subspecies are assumed to be non-native.

[2]Utah lists only *Tamarix ramosissimum* (saltcedar) as noxious, but all species of *Tamarisk* were considered noxious for this study.

Wetland Classification

Development of Wetland Types

Two Ecological Systems, Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland and Inter-Mountain Basins Playa, were reasonably distinct from other groups of sites in plant community composition ordinations (figure 5) and had strong similarities within groups based both on plant composition and structural attributes. The two other common Ecological Systems, Inter-Mountain Basins Alkaline Closed Depression and North American Arid West Emergent Marsh, had high variability

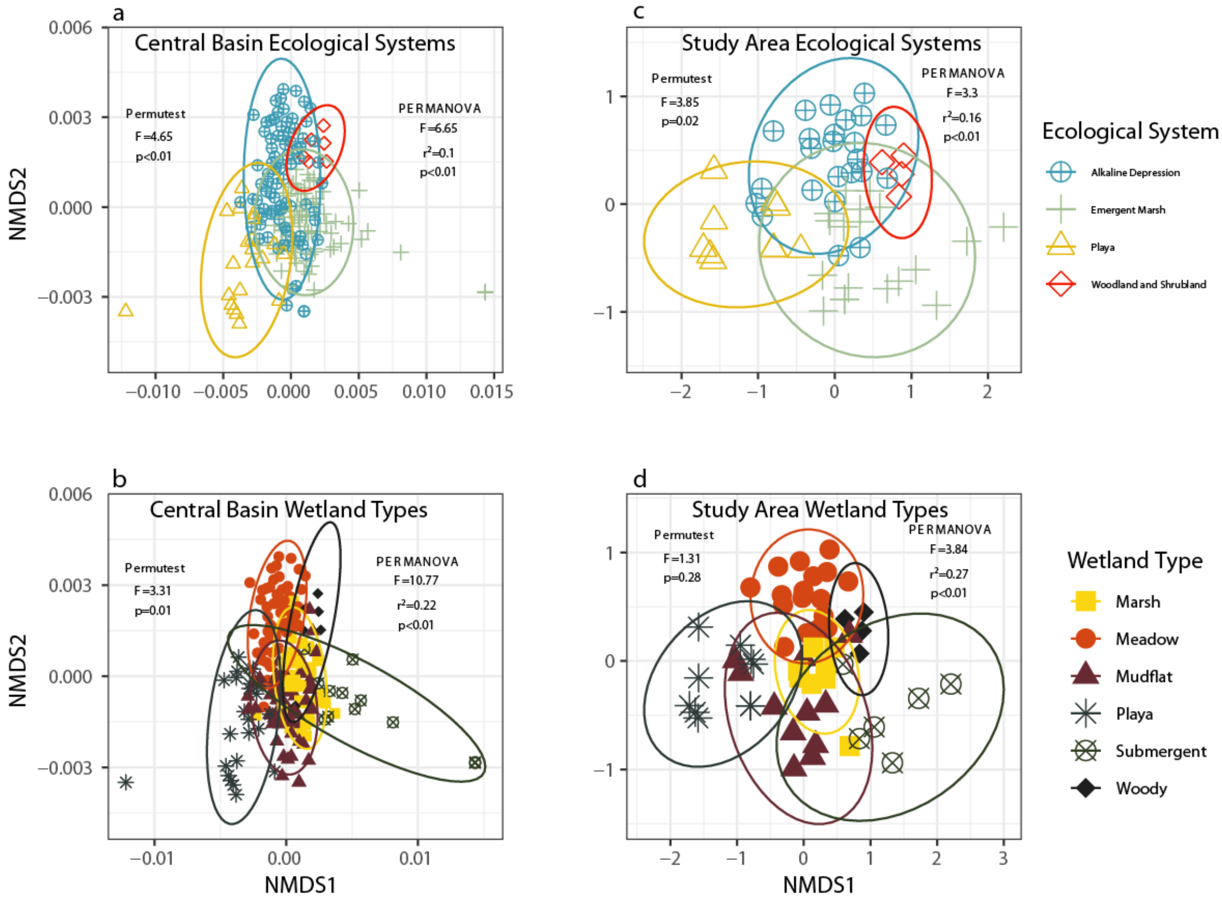

Figure 5. Ordination of survey sites based on vegetation cover data for all Central Basin (a, b) and study area (c, d) sites, color-coded by Ecological System (a, c) and wetland type (b, d). Circles represent 95% confidence interval for each class. Results of permutest and PERMANOVA tests included for each classification. Ecological Systems and some wetland types are shortened in legend. For Ecological Systems, Alkaline Depression = Inter-Mountain Basins Alkaline Closed Depression; Emergent Marsh = North American Arid West Emergent Marsh; Playa = Inter-Mountain Basins Playa; and Woodland and Shrubland = Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland. For wetland types, Marsh = emergent marsh; Submergent = submergent marsh, and Woody = woody wetlands.

within each system and strong overlap between one another. We reclassified sites with very low cover of emergent species from the North American Arid West Emergent Marsh Ecological System to create a submergent type. Then, based on review of site data, we classified the remaining North American Arid West Emergent Marsh sites as either emergent marsh or mudflat; the latter wetland type was distinguished by having a more seasonal and dynamic water regime than the former. The Inter-Mountain Basins Alkaline Closed Depression were primarily classified as meadows or mudflats, though some were also classified as playa. We ended up with six systems—woody wetlands, playa, mudflat, marsh, submergent (including shallow water), and meadow. At least 17 sites were classified as each wetland type, except woody wetlands, where we only had 6 sites.

The new wetland types improved clustering in ordination plots and explained more of the variation in distances (r^2), though overlap between wetland types is still clearly present (figure 5a and 5b). Overlap occurs in part because some sites were mosaics of wetland types rather than one distinct type, though all sites were assigned to a single dominant wetland type. PERMANOVA results were significant for sites in the Central Basin for both Ecological Systems and wetland type, but did not meet the assumption of similar dispersion, so we did not conduct additional pairwise testing. The use of wetland types reconciled a number of outliers in the Central Basin ordination, most notably in the emergent marsh Ecological System (figure 5a and 5b). Nearly half of the sites classified as submergent marsh were outliers in the emergent marsh Ecological System. These sites shared some species with emergent marshes, such as *Stuckenia pectinata* (sago pondweed), but differed in that submergent species were much more dominant and the sites lacked other typical emergent marsh vegetation such as cattails.

Wetland Types in the Study Area

The use of wetland types also explained more of the variation in distances versus Ecological Systems when looking at only sites in the study area (figure 5c and 5d). PERMANOVA results were significant for both Ecological Systems and wetland types, though only the latter met the assumption of equal dispersion (permutest $F = 1.31$, $p = 0.28$). Pairwise PERMANOVA tests showed significant differences between all wetland types except submergent marsh and woody wetlands (table 15). Playa and submergent marsh wetland types clustered on opposite ends of the first NMDS axis, with emergent marsh sites in the middle (figure 5d). Meadow and mudflat sites clustered on opposite ends of the second NMDS axis, with a considerable amount of overlap between mudflats and marshes. Several

Table 15. Results of pairwise PERMANOVA tests of plant community ordinations using wetland types and Bonferroni corrected p-values. Pair in italics is the only pair with adjusted p-value > 0.05.

Pairs	Sums of Squares	F Statistic	R^2	Adjusted p-value
meadow vs mudflat	1.821	4.84	0.152	0.0015
meadow vs submergent	1.226	3.122	0.129	0.0015
meadow vs playa	1.841	4.874	0.163	0.0015
meadow vs marsh	1.539	4.428	0.161	0.0015
meadow vs woody	1.042	2.735	0.126	0.009
mudflat vs submergent	1.23	3.238	0.168	0.0135
mudflat vs playa	1.582	4.353	0.179	0.0015
mudflat vs marsh	1.156	3.575	0.166	0.024
mudflat vs woody wetland	1.046	2.889	0.171	0.045
submergent vs playa	1.202	3.138	0.183	0.003
submergent vs marsh	1.273	3.906	0.246	0.012
submergent vs woody	*0.872*	*2.206*	*0.216*	*0.075*
playa vs marsh	1.852	5.808	0.266	0.0015
playa vs woody	1.142	3.149	0.208	0.0375
marsh vs woody	1.046	3.601	0.265	0.03

species were associated with particular wetland types. *Eleocharis rostellata* (beaked spikerush), *Carex nebrasecensis* (Nebraska sedge), *Triglochin maritima* (seaside arrowgrass), *Juncus arcticus* (mountainrush), and several non-native grasses and forbs were correlated with meadows, *Salicornia rubra* (red swampfire) was associated with playa sites, *Bolboschoenus maritimus* (cosmopolitan bulrush) with mudflats, and *Zannichellia palustris* (horned pondweed) and *Stuckenia pectinata* with submergent marsh sites. Descriptive statistics about each wetland type in the study area are in table 16.

Playa: Playas are wetlands with saline soils that are frequently either sparsely vegetated, dominated by annual species, or dominated by saline-tolerant woody perennials such as *Allenrolfea occidentalis* (iodinebush). Ten sites were classified as playa in the study area and most were classified as depressional, though one site was classified as mineral soil flats, two were classified as depressional impoundment fringe, and one as impoundment release. The depressional impoundment fringe wetlands were located in impoundments that rarely flood and the impoundment release wetland appeared to rarely be inundated by the nearby impoundment release channel. None of the surveyed playas had surface water at the time of survey, though half had saturated soils between 25 and 60 cm below the soil surface, suggesting that groundwater may play a role in their hydrology. Playa soils generally had high soil EC values with half of the sites out of range of our high EC meter (>14,000 µS) when using a 1:5 soil to water mixture. At sites where soil EC values were able to be measured, values ranged from 1950 to 18,240 µS.

Playas typically had low plant cover, though one playa had 58% cover with high cover by *Hordeum marinum ssp. gussoneanum* (Mediterranean barley), also the only species found with more than 10% cover at a site. Playas were among the least diverse wetlands, with only 29 unique plant species recorded across all sites and a mean of six species per site. The most frequently encountered species were *Salicornia rubra* and *Allenrolfea occidentalis*; both had low mean cover where they were found, 3.6% and 4.7%, respectively. *Puccinellia simplex* (California alkaligrass), a native annual grass whose distribution in Utah is poorly understood, was encountered at four sites, usually with less than 1% cover. *Bassia hyssopifolia* (fivehorn smotherweed) and *Bromus tectorum* (cheatgrass) were the most frequently encountered non-native species.

Emergent marsh: Emergent marshes are wetlands dominated by emergent forbs and graminoids and frequently inundated with water 15 cm or more in depth, though water depths may vary throughout the year. Eight sites were classified as emergent marshes in the study area, four per stratum. Marshes were classified as a variety of HGM classes, including depressional, depressional impoundment, impoundment release, lacustrine fringe, and riverine. At the time they were surveyed, two emergent marshes had no surface water, three had less than 10% water cover, one had 30% water cover, and two were completely inundated; water when present was typically less than 20 cm deep. While vegetation and landscape position were used to classify sites as marshes, a dry year and managed hydrology likely caused the lack of water at many of these sites. Surface water EC values in emergent marshes ranged from 1033 to 3502 µS, and pH ranged from 6.86 to 9.26.

Emergent marsh sites were typically dominated by *Typha* spp., *Schoenoplectus acutus* (hardstem bulrush), *Schoenoplectus americanus* (chairmaker's bulrush), *Phragmites australis*, or a combination thereof. *Typha* spp. was found at all sites and had a mean cover of 21%; *S. acutus* was found at six sites and had a mean cover of 18%; and *P. australis* and *S. americanus* were at five sites and had mean cover

Table 16. Summary of ecological attributes by wetland type for sites within the study area. 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. Values are derived from unweighted data.

Attribute	Playa	Emergent Marsh	Submergent Marsh	Mudflat	Woody Wetland	Meadow
Number of Sites	12	9	5	9	4	17
Elevation Range (m)	1282-1331	1285-1346	1282-1345	1282-1349	1294-1348	1285-1359
Number of Sites per Strata	Cache-Malad (4), Great Salt Lake (8)	Cache-Malad (6), Great Salt Lake (3)	Cache-Malad (2), Great Salt Lake (3)	Cache-Malad (2), Great Salt Lake (7)	Cache-Malad (4)	Cache-Malad (15), Great Salt Lake (2)
% Shallow Water (<20 cm)	0 (0-0)	27.7 (0-100)	20.0 (0-100)	11.1 (0-100)	2.8 (0-6)	9.5 (0-70)
% Deep Water (≥20 cm)	0 (0-0)	6.7 (0-50)	80.0 (0-100)	0 (0-0)	4.0 (0-16)	0.3 (0-2)
% Total Water	0 (0-0)	34.3 (0-100)	100 (100)	11.0 (0-100)	6.8 (0-20)	9.8 (0-72)
pH[1] H_20	n=0	7.7 (6.9-9.3, n=7)	8.8 (7.9-9.9, n=5)	7.6 (n=1)	8.1 (7.8-8.5, n=4)	7.5 (7.1-8.0, n=10)
Electroconductivity (uS)[1] H_20	n=0	1734 (945-3502, n=7)	2487 (395-4530, n=5)	3969 (n=1)	1061 (698-1637, n=4)	1277 (555-5800, n=10)
Number of Unique Species	29	91	11	61	94	138
Species Richness	6.0 (0-13)	20.8 (3-49)	3.4 (2-7)	12.0 (4-27)	43.0 (34-53)	22.6 (5-33)
Herbaceous Emergent Richness[2]	5.0 (0-12)	19.6 (2-44)	1.2 (0-4)	11.2 (4-26)	35.5 (25-44)	21.9 (5-33)
Herbaceous Aquatic[3]	0 (0)	0.9 (0-2)	2.0 (2)	0.2 (0-1)	1.0 (0-2)	0.4 (0-2)
Shrub Richness	0.9 (0-4)	0 (0)	0 (0)	0 (0)	4.0 (2-5)	0 (0)
Tree Richness	0 (0)	0.33 (0-3)	0.2 (0-1)	0.2 (0-1)	2.5 (2-3)	0.1 (0-1)
Absolute Herbaceous Emergent % Cover[2]	16.8 (0-58.4)	68.5 (30-92)	0.1 (0-0.4)	57.4 (4.2-98.1)	47.8 (23.4-69.1)	97.3 (73.8-144.6)
Absolute Herbaceous Aquatic % Cover[3]	0 (0)	4.8 (0-35)	56.0 (0.2-100)	0.4 (0-2)	7.2 (0-28)	0.2 (0-1)
Absolute Shrub % Cover	2.2 (0-20.5)	0 (0)	0 (0)	0 (0)	16.8 (6.6-32.0)	0 (0)
Absolute Tree % Cover	0(0)	0.1 (0-1.1)	0.1 (0-0.5)	0.4 (0-3.0)	40.4 (2.6-78.0)	0.1 (0-0.5)
Relative % Native Cover[4]	90.2 (11.4-100)	86.3 (39.8-100)	94.0 (70-100)	48.2 (26.6-98.5)	51.8 (13.9-90.7)	56.0 (29.7-100)
Mean C[5]	3.2 (1.9-4.5)	2.2 (1.5-2.7)	3.1 (2-4.5)	2.4 (1.3-4)	1.8 (1.4-2.2)	2.0 (0.5-3.4)
Cover-weighted Mean C	3.4 (0.6-4.8)	2.7 (1.3-3.3)	3.7 (2.1-7.0)	1.6 (0.1-3.7)	1.9 (0.6-3.6)	2.2 (0.9-4.8)
Absolute % Noxious Cover	0 (0-0.2)	7.8 (0-53.2)	0 (0-0.1)	30.8 (0-95.1)	2.3 (0.8-5.6)	5.8 (0-44.5)
Relative % Cover of Wetland Species[6]	71.8 (6.7-100)	87.2 (55.9-100)	94.0 (70-100)	87.3 (58.3-100)	48.6 (14.6-66.8)	59.3 (2.34-98.8)

[1]The mean and range of mean water quality parameter values at each site. Number of sites having water quality data shown in parentheses.
[2]Herbaceous emergent species include grass, graminoid, sedge, rush, vine, forb, and aquatic emergent.
[3]Herbaceous aquatic species include aquatic floating, and aquatic submergent.
[4]At sites where ≥80% of plant species by cover had known nativity.
[5]At sites where ≥80% of the plant species had known C-values.
[6]Cover of facultative wetland and obligate species divided by all cover, only shown for sites where ≥80% of the herbaceous cover had known wetland indicator values

of 13% for each species. *Distichlis spicata* (saltgrass) was also very common, but typically had 2% or less cover. Most emergent marshes had more than 70% total vegetation cover; only one site had less than 50% cover. Most sites were dominated by native plant species and had more than 91% relative cover of obligate or facultative wetland species cover.

Submergent marsh (including shallow water): Submergent marshes are wetlands dominated by submergent or floating aquatic vegetation, typically having 10% or less cover of emergent species, though we also included very sparsely vegetated shallow water wetlands as part of this class.

Submergent marshes are distinct from emergent marshes due to the general lack of emergent vegetation canopy cover, dominance of submergent aquatic vegetation, and deeper, more consistent water levels. Six sites were classified as submergent marshes, four in the Great Salt Lake stratum and two in the Cache-Malad stratum. Four sites had surface water less than 35 cm in depth and were largely vegetated with submerged vegetation and two sites had standing water 48 cm or more deep and 2% or less cover of vegetation. All sites were classified as depressional or depressional impoundments, including two natural depressions in the Great Salt Lake stratum, two sites within managed impoundments at the Bear River Migratory Bird Refuge, one site in Cutler Reservoir, and one site in a natural oxbow which received water from a small stream.

Submergent marshes were, along with playas, the least diverse sites, typically having seven or fewer species. They were usually dominated by only one or two species, which were often *Stuckenia pectinata*, *Zannichellia palustris*, or *Ruppia cirrhosa* (spiral ditchgrass). *Lemna minor* (common duckweed) was also found with minimal cover at most sites. Submergent marshes had very little cover of non-native species, which typically were only present along site edges.

Mudflat: Mudflats are wetlands dominated by emergent forbs and graminoids and characterized by cycles of inundation and drying from adjacent lakes or artificial impoundments. Mudflat sites are often located in shoreline landscapes (historical or current) with somewhat regular and complete changes in hydrology, cycling between completely inundated and completely dry based on adjacent lake or impoundment levels. However, this pattern may be disrupted or no longer present in some areas around Great Salt Lake where historic lake levels have not occurred for decades. Frequency and duration of inundation vary widely depending on water availability and management. A mudflat that is inundated for a longer period of time may become an emergent marsh and a submergent marsh that dries out may become a mudflat.

Eleven sites in the study area were classified as mudflats; all but two were in the Great Salt Lake stratum. These sites were mostly associated with managed impoundments and nearly all received water from sources such as managed ditches and impoundments. The two Cache-Malad stratum sites were floodplain depressional wetlands that receive water from overbank flooding from nearby rivers in high flow years. Mudflats in the Cache-Malad stratum and the two mudflats closest to major canals in the Great Salt Lake stratum were the only sites with soil EC values less than 700 µS; the remaining sites had EC values between 2335 and 14,650 µS. Only one site had surface water at the time of survey and most sites had soil saturation within 60 cm of the surface.

Mudflats typically had low diversity and four of the five mudflats having more than nine species were the sites with the lowest soil EC values. Mudflats were often dominated by *Phragmites australis*, with *Bolboschoenus maritimus* and *Distichlis spicata* also common but much less dominant. *P. australis* was found at six sites with 45% mean cover, *B. maritimus* at eight sites with 10% mean cover, and *D. spicata* at seven sites with 12% mean cover. Mean cover of noxious weeds was much greater in mudflats (25%) than for any other wetland type, mostly due to cover of *P. australis*. Total vegetation cover varied considerably across sites; five sites had between 17% and 43% cover and six sites had between 66% and 98% cover.

Woody wetlands: Woody wetlands are wetlands dominated by woody species, typically having 20% or more woody species cover. These sites were dominated by shrubs or trees, or a combination thereof. All of the woody wetlands were within the Cache-Malad stratum, were classified as riverine, and occurred in relatively narrow riparian corridors or on islands within river channels. Sites had very little water cover at the time of visit, though one site had a much larger and permanently filled depression. All sites received water from overbank flooding, with minor inputs from subsurface flow or irrigation tail water run-off. Soils had relatively low EC, with values between 98 and 306 µS, and water at the sites ranged between 698 and 1637 µS for EC and between 7.8 and 8.5 for pH. None of the sites were influenced by beaver activity.

Woody wetlands were dominated by woody species including *Salix fragilis* (crack willow), *Salix exigua* (narrowleaf willow), *Crataegus rivularis* (river hawthorn), *Cornus sericea* (redosier dogwood), and *Acer negundo* (boxelder), though only *S*. *exigua* occurred at more than two sites. Woody wetlands were the most diverse wetlands, having a mean of 43 species per site. The introduced grass *Phalaris arundinacea* (reed canarygrass) was found in the understory at all sites having a mean cover of 15%. Several noxious weeds were present at all sites, each with less than 1% cover, including *Cirsium arvense*, *Conium maculatum*, and *Cynoglossum officinale* (gypsyflower).

Meadow: Meadows are wetlands dominated by emergent forbs and graminoids that are frequently supported by high groundwater or shallow inundation of a few centimeters. Seventeen sites in the study area were classified as meadows, including eleven classified as depressional and six classified as slope. More than half of these sites received water from irrigation via ditches or return flows or from pipes directly feeding the wetland. Others received water from groundwater sources, impoundment release, or overbank flooding from channels. Nine sites were dry at the time of the survey; six had 15% or less cover and two had 60% or more cover of water less than 20 cm deep. Soil EC values were frequently lower than in other wetland types and always 1000 µS or less. Surface water EC values at the eight sites with some surface water were also typically low (555–1108 µS) though one site that contained a small pond fed by agricultural runoff had EC of 5800 µS. Values for pH ranged from 7.14 to 8.04.

Many of the meadows were dominated by *Carex nebrascensis*, native rushes *Eleocharis rostellata* and *Juncus arcticus*, and introduced grasses and forbs including *Alopecurus arundinaceus* (creeping meadow foxtail), *Schedonorus arundinaceus* (tall fescue), *Thinopyrum ponticum* (tall wheatgrass), and *Trifolium fragiferum* (strawberry clover). *Tamarix* spp. was the only woody species encountered and was found at two sites with less than 1% cover.

Reference Sites

We identified 10 sites as least disturbed and 17 sites as most disturbed for the mudflat wetland type. Stressor values within the AA were lower than we expected so we adjusted the screen to categorize sites as least disturbed if they had AA stress values of <0.063 for each AA stress category, rather than our initial screen of ≤1 and buffer stress index values <2 rather than ≤2. The relative native cover screen remained at ≥80%. The final screens used to classify sites as most disturbed were buffer stress ≥3, relative native cover <50%, and ≥0.063 for any one of the vegetation, hydroperiod, or physical substrate AA stress indices.

All ten least disturbed sites were within the vicinity of Great Salt Lake, including eight near Bear River Bay, one near Willard Spur, and one on the southeastern shore of Great Salt Lake near Farmington Bay. Only one of the least disturbed sites was a non-probability (i.e., handpicked) site. All ten sites had cover of the facultative native grass *Distichlis spicata* and seven had cover of the obligate wetland species *Bolboschoenus maritimus*, with mean cover of 36.8% and 17.7%, respectively. The most disturbed sites were generally closer to large population centers in Ogden and Salt Lake City, including one in relatively rural Cache Valley, two along the shores of Utah Lake, three within Salt Lake Valley, and ten near Great Salt Lake. *Phragmites australis* was present at all but one of the most disturbed sites and had a mean cover of 56%.

Least disturbed sites had higher cover-weighted mean C and relative native cover and lower absolute noxious cover, absolute wetland cover, relative wetland cover, and cover-weighted height than most disturbed sites, with Bonferroni adjusted p-values of 0.01 or less for all metrics (figure 6). *Phragmites australis* accounted for roughly half of the plant cover at most of the most disturbed sites and was absent or accounted for 1% or less cover at all but one of the least disturbed sites. The dominance of *P. australis* in disturbed areas also accounts for the differences in cover-weighted height and absolute wetland cover between least and most disturbed sites since the species is taller than other common mudflat species and is a facultative wetland species.

Landscape Profile

In the Great Salt Lake stratum, unconsolidated shore, emergent meadow, and lake shallow water are the most prevalent aquatic features, each making up 22% or more of the total aquatic feature

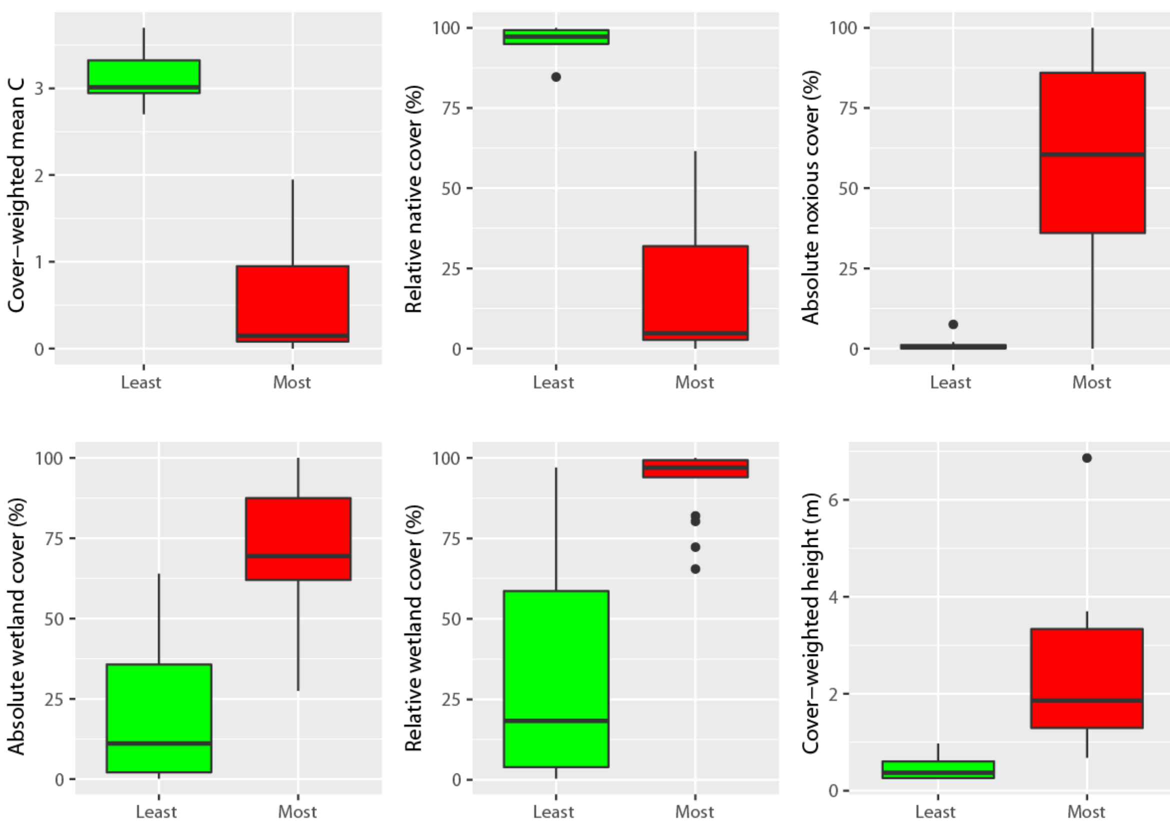

Figure 6. Boxplots of the six best performing vegetation metrics comparing least disturbed and most disturbed mudflats. All six metrics had adjusted $p \leq 0.01$.

area (table 17). Lake deepwater and woody wetlands are all very uncommon, each having less than 30 ha in the stratum. Most aquatic features were categorized as having moderate local stress, though three-quarters of unconsolidated shore and almost half the emergent meadow was categorized as low local stress. Only ponds had more than 5% of features categorized as having high local stress.

Just under half the mapped aquatic features in the Cache-Malad stratum are emergent meadow; riverine and lake shallow water were the second and third most common features, respectively. Forested and scrub shrub wetlands, ponds, and lake shallow water are the least common aquatic features and, excepting lake shallow water, are also subject to the highest levels of local stress, with more than 40% of area in the high stress class. Overall, about 9% of aquatic features in the stratum were in the low, 63% in the moderate, and 29% in the high stress category.

Just over half of the aquatic resource area in the Great Salt Lake stratum is federally owned, and the remainder is roughly equally split between private and state ownership (table 18). The majority of privately owned land in the stratum is managed as a private duck hunting reserve or mitigation bank. In contrast, more than 90% of the aquatic resource area in the Cache-Malad stratum is privately owned. The majority of state ownership in both strata are as state sovereign land or waterfowl management

Table 17. Area of mapped aquatic features by strata and percent of area in low, moderate, and high local stress classes.

Aquatic Feature Class	Area (ha)	Local Stress Class		
		Low	Moderate	High
Great Salt Lake				
Riverine	672	7.0%	91.2%	1.8%
Lake deepwater	16	0.0%	100.0%	0.0%
Lake edge	9999	0.3%	99.6%	0.1%
Pond	584	5.6%	86.9%	7.4%
Unconsolidated shore	16,817	77.8%	22.0%	0.2%
Emergent marsh	3218	15.3%	83.2%	1.5%
Emergent meadow	14,030	47.4%	51.1%	1.5%
Scrub shrub	29	12.2%	87.7%	0.1%
Forested	<0.1	0.0%	100.0%	0.0%
Cache-Malad				
Riverine	2652	18.2%	16.7%	36.8%
Lake deepwater	467	0.0%	97.9%	2.2%
Lake edge	1549	7.5%	82.5%	10.0%
Pond	642	1.5%	56.4%	42.1%
Unconsolidated shore	978	10.0%	82.9%	7.1%
Emergent marsh	1312	14.6%	68.0%	17.4%
Emergent meadow	6686	5.6%	59.7%	34.7%
Scrub shrub	419	1.1%	57.8%	41.1%
Forested	214	0.3%	46.9%	52.8%

Table 18. Aquatic feature ownership by strata, including the percent of wetland area in each ownership category and overall percent private, state, and federal ownership. Values for waterfowl management areas (WMA) and the Bear River Migratory Bird Refuge only show the percent of aquatic resource area owned by the lead entity (Utah Division of Wildlife Resources and U.S. Fish and Wildlife Service, respectively), not inholdings managed as part of the WMA or Refuge.

Ownership Class	Great Salt Lake	Cache-Malad
Private	**24.6%**	**90.8%**
Duck hunting reserve	14.0%	1.6%
Mitigation bank	2.1%	0.0%
Other private land	8.5%	89.2%
State	**24.1%**	**6.5%**
Sovereign land	15.0%	3.1%
Waterfowl management area	8.9%	2.0%
Other state land	0.2%	1.4%
Federal	**51.3%**	**2.7%**
Bear River Migratory Bird Refuge	47.0%	1.7%
Bureau of Land Management	4.3%	0.3%
Other federal land	0.0%	0.7%
Tribal	**0.0%**	**0.8%**

areas; only a small percent of aquatic resources is managed by other state agencies. Most of the federal ownership in the Great Salt Lake stratum is via the Bear River Migratory Bird Refuge with a smaller portion managed by the Bureau of Land Management. Federal ownership is very limited in the Cache-Malad stratum, having only small areas managed by the Bear River Migratory Bird Refuge, Bureau of Land Management, U.S. Forest Service, and Bureau of Reclamation.

At least 94% of aquatic resource area in each stratum overlapped the WRLU data (table 19). In the Great Salt Lake stratum, the majority of aquatic resource area was mapped as riparian and aquatic by the WRLU data; pasture and agriculture were mapped as 3.3% and 1.9% of area, respectively. Less than 4% of aquatic resource area was mapped as irrigated or subirrigated in the stratum. In contrast, in the Cache-Malad stratum, about 20% of the aquatic resource area was mapped as grass and hay or as pasture, 9% as agriculture, and 4% as urban. Irrigated and subirrigated areas each accounted for 20% of the aquatic resource in the Cache-Malad stratum.

DISCUSSION

Target Population and Limitations on Inference

Generalizations about wetland condition and other study findings only pertain to the target population. We used a broad definition of wetland for our target population, including unvegetated and sparsely vegetated mudflats and areas with aquatic bed and shallow water. Furthermore, not all sites had evidence of all three wetland indicators, meaning that they might not all meet the regulatory definition of wetland (though further field effort would be needed to determine this). Our study design only allows us to make inference to mapped wetlands. NWI data are outdated for much of the study

Table 19. Percent overlap between aquatic features and land use and irrigation classes. Agriculture includes orchards, crop fields, fallow land and dryland farming.

Land Use and Irrigation Classes	Great Salt Lake	Cache-Malad
Land Use Class		
Agriculture	1.9%	8.9%
Hay and turf	0.6%	17.9%
Pasture	3.3%	20.1%
Urban	0.2%	4.0%
Sewage lagoon	0.1%	1.6%
Riparian and aquatic	93.3%	41.8%
Not mapped	0.8%	5.6%
Irrigation Class		
% Irrigated	0.3%	20.8%
% Subirrigated	3.5%	20.6%

area, though most of the selected sites were either part of the target population or were other aquatic features such as deep water or wastewater ponds; very little of the mapped area appeared to be non-aquatic. Although we can estimate the amount of mapped wetland area that is not in fact target wetland, we cannot estimate the amount of unmapped 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 characteristics to mapped wetlands or small in proportion to the size of the mapped target population, then target population estimates will still be robust. Survey results could also 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 were not able to obtain access to one-fifth of the selected survey sites in the Cache-Malad stratum, though we surveyed a similar proportion of privately-owned wetlands as was in our original sample selection

Wetland Condition

The three main threats to wetlands in the study area are non-native plant species (including noxious weeds), water quality stressors, and hydrologic alteration. These same threats are also widespread in other Central Basin wetlands between the east shore of Great Salt Lake and the Wasatch Range (Menuz and others, 2016; Menuz and Sempler, 2018). Many other aspects of wetland condition in the study area appeared to be good. Wetlands were typically completely surrounded by buffer land cover, and buffer width was usually at least 75 m wide. Sites infrequently had evidence of turbidity, pollutants or excessive algae, and litter accumulation was typically good. The few woody wetlands in the study area generally had healthy regeneration of woody species and neither excessive nor scant woody debris, though half were dominated by non-native woody species.

Wetland condition varied between strata. Wetlands in the Great Salt Lake stratum had higher overall condition scores, less landscape alteration and soil disturbance, and higher mean C values. These differences are largely related to differences in land use between strata. More than 75% of the land cover in the Cache-Malad stratum is developed or agricultural versus less than 5% in the Great Salt Lake stratum, and wetlands in the Great Salt Lake stratum are mostly managed for duck hunting or birdlife in general rather than as pasture or agriculture. Some of the difference between strata may be due to differences in condition across wetland types. More than 40% of wetlands in the Great Salt Lake stratum are estimated to be playa or submergent marsh versus about 22% in the Cache-Malad stratum, and these wetland types were frequently among the top-scoring wetlands. Playas and submergent marshes were frequently found in landscape settings devoid of development and agriculture, such as on unvegetated lakebed, in large flooded or dry impoundments near Great Salt Lake or within Cutler Reservoir. These systems also frequently had low species diversity and few non-native species, likely due to the strong environmental constraints imposed by very high soil salinity in most playas and moderately deep flooding in submergent marshes which prevent most other species from establishing. The biggest threats to playas and submergent marshes in the study area may be their potential to be converted to upland or another wetland type—playas may convert to mudflats if they are flushed with water, and submergent marshes within impoundments will only persist when there is enough water available to support them.

Non-Native Plant Species

Altered plant communities are one of the most common disturbances to wetlands in the study area. In the Great Salt Lake stratum, the most widespread and abundant introduced species was *Phragmites australis*, which is a Class 3 noxious weed; this species was particularly common in mudflats and emergent marshes. The rapid expansion of *P. australis* in the region has been well documented (Kulmatiski and others, 2010), and the species is already the focus of concern and extensive control efforts by land managers around Great Salt Lake due to its ecological and social impacts (Rohal and others, 2018). Though elimination of the species is unlikely due to the large area it occupies, control efforts have opened up habitat that was previously overrun with *P. australis*, and researchers are actively exploring the best methods for control and restoration (Rohal and others, 2017). Other non-native species in the stratum were generally uncommon, not very abundant where found, or both.

A variety of species accounted for the high non-native plant cover found in the Cache-Malad stratum. Though noxious weeds are certainly an issue for wetlands in the Cache-Malad stratum, no single species was of particular concern like in the Great Salt Lake stratum. Only two noxious weed species were sometimes dominant or co-dominant at sites, *Phragmites australis* at one site along the Bear River near Cutler Reservoir and *Elymus repens* at two sites along the Little Bear River. *Phalaris arundinacea*, though sometimes considered a native species (but see Kettenring and others, 2019) and planted for erosion control or pasture, is also a species of concern. *P. 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). The species was found at eight sites, mostly along the Bear River and its tributaries, including at two sites with at least 25% cover. Two of the four surveyed woody wetlands, both along the Bear River, were dominated by the non-native tree *Salix fragilis*, a willow species commonly naturalized along irrigation watercourses and natural waterways. Some widespread and frequently abundant non-native species in the Cache-Malad stratum, such as *Alopecurus arundinaceus*, *Schedonorus arundinaceus*, and *Trifolium fragiferum*, are frequently intentionally planted for livestock forage and haying (Jensen and others, 2001) and thus may have either been directly planted in wetlands or escaped from nearby fields.

We recommend three actions to improve plant community composition of wetlands in the study area. First, landowners and land managers should continue control efforts for noxious weed species, focusing on species that are most likely to negatively impact wetlands, such as *Phragmites australis*, and on emerging threats such as *Galega officinalis* that are present in small populations and thus can potentially be prevented from becoming widespread. 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) and the *Intermountain Planting Guide* (Jensen and others, 2001) has recommendations for native pasture species. Third, meadows and woody wetlands with intact plant communities should be prioritized for protection because they are infrequent on the landscape. Mudflats also rarely had intact plant communities; however, intact mudflats may be difficult to preserve because of their dynamic nature which may lead to substantial changes in vegetation communities over short periods of time.

Water Quality

Most wetlands in the study area are subject to potentially high levels of water quality stress. In the Great Salt Lake stratum, most wetlands receive water from canals off the Bear River, which receives substantial agricultural runoff and direct point source discharge and is impaired everywhere in the study area. In the Cache-Malad stratum, water quality stress has multiple sources, including livestock manure and substrate disturbance directly in wetlands, runoff from adjacent lands, and inputs from impaired streams and lakes. Buffers were typically adequate to remove most sediment, nitrogen, phosphorus, and pesticides before reaching wetlands (McElfish and others, 2008, Zhang and others, 2010), though almost one-quarter of wetland area in the Cache-Malad stratum is not completely surrounded by buffer land cover, and buffers cannot protect against stressors input directly into wetlands.

A combination of strategies may be necessary to protect and improve wetland water quality in the study area. First, water quality of impaired source water can be improved through development and implementation of TMDL plans or other approaches. Fortunately, the Lower and Middle Bear River are among the implementation priorities for addressing water quality issues set forth by the Utah Division of Water Quality (2016b). Second, landowners 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 runoff. Private landowners can receive technical and financial assistance from agencies such as the U.S. Natural Resources Conservation Service, the Utah Department of Agriculture and Food, and the Utah Department of Natural Resource's Watershed Restoration Initiative to support best management practices. Last, research should be conducted to examine the extent to which perceived water quality stressors lead to differences in water quality parameters and the extent to which water quality parameters relate to other measures of wetland condition, such as plant community composition.

Wetland Hydropattern

All but a few wetlands, all of which were playas, were estimated to have some degree of hydropattern alteration, and most sites were in fair to poor condition for at least one of the two hydropattern metrics (hydroperiod and timing of inundation). Most wetlands in the Great Salt Lake stratum are either located within impoundments tightly managed to meet bird habitat goals or receive a substantial amount of water release from these impoundments, though specific management goals likely differ between the different management entities in the region (federal, state, private hunting clubs). These managed wetlands will never have a natural hydropattern, but management can ideally be optimized to support natural functioning within the constraints of management goals and water availability. In the Cache-Malad stratum, common sources of hydrologic alteration to wetlands include direct flood irrigation to create pasture, irrigation return flows from adjacent land, and damming and water diversions along rivers. Reducing irrigation on the landscape may allow some wetlands to return to a more natural hydropattern, but could cause the loss of many wetlands, particularly those whose natural water inputs have been impacted by water diversion (Sueltenfuss and others, 2013; Berkowitz and Evans, 2014).

Wetland Function

We directly investigated water quality improvement and hydrologic function in the study area, and wildlife use and recreational use can be inferred from our results. We documented wildlife use in both strata and in all wetland types, even though surveyors did not conduct targeted species surveys. Wetland recreational use in the study area includes hunting, bird watching, and boating. More than half of the aquatic resources in the study area are privately or publicly managed, at least in part, for duck hunting, and much of the wetlands in the study area are accessible for boating, such as on Cutler Reservoir, and bird watching.

Wetlands in the Cache-Malad stratum generally rated higher than those in the Great Salt Lake stratum for the water quality improvement function, particularly in the landscape potential and societal value categories. These differences may be more related to nuances of the protocol and how users interpreted metrics rather than true differences between sites. Wetlands in the Cache-Malad stratum are in closer proximity to stressors such as agriculture, livestock grazing, and development than those in the Great Salt Lake stratum whereas many of the depressional impoundments in the Great Salt Lake stratum receive water directly from canals off the impaired Bear River. For landscape potential, the protocol evaluates sources of water quality stress that may reach sites with an emphasis on nearby stressors, particularly for depressional wetlands. If a depressional wetland does not have a septic system or altered land cover (e.g., agriculture, pasture, or development) within about 76 m of the site, then it cannot score higher than medium for landscape potential for water quality stress. Furthermore, surveyors could have assigned depressional wetlands a rating of medium based on more distant stressors but may not have always taken those stressors into account because those stressors were not directly asked about in the metrics. The societal value component is almost entirely focused on whether wetlands discharge to or are within basins with waterbodies that are impaired or have TMDLs. However, waterbodies in the Great Salt Lake stratum and Great Salt Lake itself have not been assessed for impairment status because the Utah Division of Water Quality is still determining appropriate assessment methods for these areas. Only 13.6% of surveyed wetlands in the Great Salt Lake stratum, versus 68.8% of those in the Cache-Malad stratum, were located in areas that were assessed by the Utah Division of Water Quality, making it difficult for wetlands in the stratum to receive high scores for the societal value metric. On other aspects of societal value not evaluated by the protocol, such as recreational or wildlife values, wetlands in the Great Salt Lake stratum would likely have scored much higher.

The distribution of hydrologic function ratings also appeared to differ by stratum, with most sites rated as medium for site potential and landscape potential in the Great Salt Lake stratum and a greater diversity of ratings in the Cache-Malad stratum. However, on closer examination, much of the difference in ratings stems from differences in wetland HGM classes. For site potential to perform hydrologic functions, riverine wetlands were always rated as medium or high, slope as low, and depressional as low or medium. Depressional wetlands tended towards ratings of medium in the Great Salt Lake stratum and were more evenly split in the Cache-Malad stratum, probably due to the greater depth of storage in impoundments, which were common in the Great Salt Lake stratum. For landscape potential to perform hydrologic functions, slope wetlands were almost always low, depressional almost always medium, and riverine always medium or high.

Although wetlands in the study area clearly perform important water quality and hydrologic functions, we cannot translate the functional scores into more precise estimates of the economic or ecological benefits of these functions. Furthermore, we have questions about the validity of the method, in particular whether it makes sense to rate so many wetlands in the Great Salt Lake stratum as having low landscape potential and societal value for water quality improvement. We are using a protocol adapted from another state where it serves a different purpose; we recommend continuing to evaluate the appropriateness of the protocol in other settings in Utah and consider modifications in the future.

Wetland Classification

The new wetland type classification scheme developed by this study shows promise for separating out ecologically distinct wetland types. In particular, the classification scheme separated wetlands classified as the very broadly defined alkaline depression Ecological System into three types—meadows, marshes, and mudflats—and classified outliers in the emergent marsh Ecological System as submergent wetlands. Types tended to cluster together in the ordination plots and, more importantly, shared hydrologic and structural similarities. Furthermore, we found justification for the importance of separating wetlands into these types based on differences in condition across types. For example, submergent marshes tended to have higher overall condition scores and higher mean C values than emergent marshes. We would not want to set a reference standard for all marshes based only on the high-scoring submergent marshes because those scores may not be realistic for emergent marshes.

The classification scheme should be further tested and evaluated before it is finalized. Though we had data from almost 200 sites, large parts of the Central Basin were not included in the analysis, particularly areas to the west and south of Great Salt Lake. We also only had samples from six woody wetlands. This wetland type is relatively rare in the ecoregion so targeted sampling would likely be necessary to obtain a larger sample. Additional data would also be useful for evaluating and refining some of the wetland types. For example, further analysis may support separating out fresh meadow from saline meadow or woody playas from herbaceous playas. Mudflats are particularly difficult to characterize; they have substantial overlap in species composition with emergent marshes and some overlap with playas as well. One issue in distinguishing mudflats from other types may be the transitional nature of the mudflat. A series of wet years or changes in management may inundate a mudflat for longer periods of time, decreasing soil salinity and increasing cover of emergent marsh vegetation such as *Typha* spp. Conversely, a series of dry years or changes in management may dry out a mudflat, increase soil salinity, and convert a mudflat to a playa. An additional issue with mudflat wetlands is that many sites dominated by *Phragmites australis* were assigned to the mudflat class. However, *P. australis* is an ecosystem engineer that modifies its habitat through excessive accumulation of litter and altered hydrology, so it is often difficult to determine the natural analog for wetlands that are near monocultures of the species. Further investigation of the mudflat wetland type is warranted.

Reference Sites

We searched for reference sites within the mudflat wetland type in the Central Basin by screening for sites that had low and high levels of disturbance and a largely intact native plant community. The biggest distinguisher between least and most disturbed mudflats was the presence and dominance of *Phragmites australis*, which also accounted for much of the difference in vegetation metrics between low- and high-quality sites. Most of the vegetation metrics differed as expected, with higher cover-weighted mean C, higher relative native cover, and lower absolute noxious cover at the least disturbed sites versus the most disturbed sites. However, most disturbed wetlands also had more absolute and relative wetland cover. This is likely due in part to the much greater abundance of the facultative wetland species *P. australis* at most disturbed sites, though most disturbed sites also occasionally had high cover of facultative wetland or obligate wetland species such as *Rumex stenophyllus* (narrowleaf dock), *Eleocharis palustris* (common spikerush), *Schoenoplectus acutus*, and *Phalaris arundinacea,* and least disturbed sites frequently had higher cover of the facultative *Distichlis spicata*. This difference in species composition and wetland affinity between sites could imply that most disturbed sites were generally wetter than least disturbed sites. As discussed above, further evaluation of the mudflat wetland type is needed to determine whether the mudflat type characterizes a distinct set of wetlands and how to best classify dense stands of *P. australis*.

We had to tighten the thresholds of stress indices to select the target number of least disturbed wetland sites. In other words, more sites than expected had low levels of site and buffer stress, the opposite of what was found for Central Basin wetlands in a similar study in the Jordan Watershed, where thresholds had to be loosened (Menuz and Sempler, 2018). Very low levels of disturbance were recorded within sites for both the least and most disturbed sites and moderately low levels within buffers. However, stress indices only focused on within-site and adjacent stressors, not more distant water quality and hydropattern stressors that are prevalent within the sample population. Future work should consider broadening the evaluation of stressors to include hydrology stressors outside of the immediate vicinity of sites and then re-running selection of least and most disturbed sites.

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REFERENCES

Anderson, M.J., 2001, A new method for non-parametric multivariate analysis of variance: Austral Ecology, v. 26, p. 32-46.

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

Audubon, undated, Important bird areas: Online, https://www.audubon.org/important-bird-areas, accessed May 20, 2019.

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

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

Burden, C.B., and others, 2017, Groundwater conditions in Utah, spring of 2017: 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. 58, 118 p.

Cache County, undated, Historical drainage district viewer: Online, http://cacheut.maps.arcgis.com/apps/webappviewer/index.html?id=10e8f5b09a7247659258b6139f7e4c93, accessed October 8, 2019.

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 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.

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., Schafale, M., Foti, T., Josse, C., and Christy, J., 2008, Ecological performance standards for wetland mitigation—an approach based on ecological integrity assessments: Arlington, NatureServe, 38 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.

Hruby, T., 2014, Washington State wetland rating system for eastern Washington—2014 update: Olympia, 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, Rocky Mountain Research Station, 282 p.

Jensen, K., Horton, H., Reed, R., and Whitesides, R., 2001, Intermountain planting guide: Logan, 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.

Kariya, K.A., Roark, D.M., and Hanson, K.M., 1994, Hydrology of Cache Valley, Cache County, Utah, and adjacent parts of Idaho, with emphasis on simulation of ground-water flow: prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Resources and Division of Water Rights, Resources Technical Publication No. 108, 120 p.

Kem C. Gardner Policy Institute, undated, Population projects: Online, https://gardner.utah.edu/demographics/population-projections, accessed May 20, 2019.

Kettenring, K.M., Menuz, D., and Mock, K.E., 2019, The nativity and distribution of the cryptic invader *Phalaris arundinacea* (reed canarygrass) in riparian areas of the Columbia and Missouri River Basins: Wetlands, v. 39, no. 1, p. 55–66.

Kincaid, T., and Olsen A., 2019, spsurvey: Spatial Survey Design and Analysis, R package version 4.0.0.

Kulmatiski, A., Beard, K. H., Meyerson, L. A., Gibson, J. R., and Mock, K. E., 2010, Nonnative Phragmites australis invasion into Utah wetlands: Western North American Naturalist, v. 70, no. 4, p. 541–553.

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., 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.

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.

McCoy-Sulentic, M. and Menuz, D., 2019, Validation of a rapid wetland assessment protocol—evaluation of survey and temporal and observer variability in vegetation data: Utah Geological Survey Report of Investigation 277, 22 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., online, https://geodata.geology.utah.gov/pages/home.php.

Menuz, D., 2017, Developing core indicators for assessing wetlands in Utah: Utah Geological Survey unpublished contract deliverable for U.S. Environmental Protection Agency's Regional Enhancing State and Tribal Programs Funding X7-96820201, 32 p.

Menuz, D., and McCoy-Sulentic, M., 2019, Validation of a rapid wetland assessment protocol—testing inter-observer and intra-seasonal variability: Utah Geological Survey Report of Investigation 278, 43 p.

Menuz, D., Sempler, R., and Jones, J., 2014, Great Salt Lake wetland condition assessment: Utah Geological Survey contract deliverable for the U.S. Environmental Protection Agency, 54 p.

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

Menuz, D., and Sempler, R., 2018, Jordan River watershed wetland assessment and landscape analysis: Utah Geological Survey contract deliverable for the U.S. Environmental Protection Agency, 82 p.

Minnesota Pollution Control Agency (MPCA), 2014, Rapid floristic quality assessment manual wq-bwm2-02b: Minnesota Pollution Control Agency, St. Paul, p. 1–44.

Multi-Resolution Land Characteristics Consortium, 2019, NLCD 2017 land cover: Online, https://www.mrlc.gov/data, accessed May 15, 2019.

NatureServe, undated, NatureServe Explorer: Online, http://explorer.NatureService.org/index.htm, accessed March 2019.

Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H., Szoecs, E., Wagner, H., 2018, vegan—Community Ecology Package: R package version 2.5-3, online, http://CRAN.R-project.org/package=vegan.

Palmquist, E.C., Ralston, B.E., Sarr, D., Merritt, D.M., Shafroth, P.B., and Scott, J.A., 2017, Functional traits and ecological affinities of riparian plants along the Colorado River in Grand Canyon: Western North American Naturalist, v. 77, no. 1 p. 22–31.

R Core Development Team, 2019, 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.

Rohal, C.B., Hambrecht, K., Cranney, C., and Kettering, K.M., 2017, How to restore *Phragmites*-invaded wetlands: Logan, Utah Agricultural Experiment Station Research Report 224, 22 p.

Rohal, C.B., Kettenring, K.M., Sims, K., Hazelton, E., and Ma, Z., 2018, Surveying managers to inform a regionally relevant invasive *Phragmites australis* control research program: Journal of Environmental Management, v. 206, p. 807–806.

SITLA, BLM, and Partners, undated, Land ownership: Online, https://gis.utah.gov/data/cadastre/land-ownership, accessed September 2019.

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.

Stolp, B.J., Brooks, L.E., and Solder, J.E., 2017, Hydrology and numerical simulation of groundwater flow and streamflow depletion by well withdrawals in the Malad-Lower Bear River area, Box Elder County, Utah: U.S. Geological Survey Scientific Investigation Report 2017-5011, 113 p.

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.

SWCA Environmental Consultants, 2010, Middle Bear River and Cutler Reservoir total maximum daily load (TMLD): Salt Lake City, prepared for the Utah Division of Water Quality, 236 p.

Toole, T., 2011, Chapter 2.4 Bear River watershed management unit assessment, *in* 2008 final Utah 305(b) report—part 2 integrated report: Utah Division of Water Quality, 14 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, 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, 2013, Level III and IV ecoregions of the continental United States: Online, https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states.

U.S. Environmental Protection Agency, 2016, National Wetland Condition Assessment: 2011 Technical Report, EPA-843-R-15-006, 245 p.

U.S. Fish and Wildlife Service, 2018, National wetlands inventory website: Online, http://www.fws.gov/wetlands/data/State-Downloads.html, accessed May 2018.

U.S. Fish and Wildlife Service, 2019, National wetlands inventory website: Online, http://www.fws.gov/wetlands/data/State-Downloads.html, accessed June 2019.

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

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

Utah Division of Water Resources, 2004, Bear River basin—planning for the future: Salt Lake City, with input from the State Water Plan Coordinating Committee, 88 p.

Utah Division of Water Resources, 2017, Water related land use: Online, gis.utah.gov/data/planning/water-related-land, accessed August 2019.

Utah Division of Water Rights, 1999, Interim Cache Valley ground-water management plan: Salt Lake City, 6 p.

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

Utah State University Water Quality Extension, 2012, Improving Utah's water quality—middle Bear River Watershed: NR/WQ/2011-2, online https://www.utahcleanwater.org/uploads/4/7/2/2/47227279/middle_bear_river_watershed_fs.pdf, 2p.

Utah State University Water Quality Extension, 2014, Improving Utah's water quality—lower Bear River Watershed: NR/WQ/2014-01pr, online, https://www.utahcleanwater.org/uploads/4/7/2/2/47227279/lower_bear_river_watershed_fs.pdf, 2p.

Utah Wildlife Action Plan Joint Team, 2015, Utah wildlife action plan—a plan for managing native wildlife species and their habitats to help prevent listing under the Endangered Species Act: Utah Division of Wildlife Resources publication number 15-14, 374 p.

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

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

Wurtsbaugh, W., Miller, C., Null, S., Wilcok, P., Hahnenberger, M., and Howe, F., 2016, Impacts of water development on Great Salt Lake and the Wasatch Front: Online, https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1891&context=wats_facpub, 9 p.

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

Utah Rapid Assessment Procedure User's Manual

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

User's Manual, Version 3.0—DRAFT

Diane Menuz, Jennifer Jones, Miles McCoy-Sulentic, and Ryhan Sempler
Utah Geological Survey
Salt Lake City, UT 84114

Utah Rapid Assessment Procedure: Method for Evaluating Ecological Integrity in Utah Wetlands
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Diane Menuz, Jennifer Jones, Miles McCoy-Sulentic, and Ryhan Sempler
Utah Geological Survey
Salt Lake City, UT 84114

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Introduction and Background

The Utah Geological Survey (UGS) began developing the Utah Rapid Assessment Procedure (URAP) in 2014 as a tool to rapidly assess the condition of Utah's wetland resources. URAP is intended to provide basic inventory information on the status, condition, and potential function of Utah's wetlands and has been implemented in several regions in the state (Menuz and others, 2016a; Menuz and others, 2016b; Menuz and Sempler, 2018). The UGS added metrics to assess habitat for sensitive amphibian species to the protocol in 2015 and 2016 (Menuz and Sempler, 2018) and developed draft methods for wildlife habitat and water quality improvement functionality in 2017 (Menuz, 2017), though water quality function is currently being evaluating using the Washington State Wetland Rating System (Hruby 2014).

Condition and function assessments can be used to identify priority sites for restoration projects (those with lower condition scores or higher function scores) or conservation actions (those with higher condition and function scores). With repeat sampling, URAP can be used to evaluate the success of restoration projects or the effects of new stressors on wetland condition and function. When applied to a random selection of wetlands, URAP can be used to make generalizations about the health and function 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 wetland 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.

Environmental Protection Agency Assessment 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 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 per site. 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 typically include the collection detailed plant community data from a timed meander survey, which can be considered quasi-Level III data (see McCoy-Sulentic and Menuz, 2019, for a comparison of different wetland vegetation survey methods) and may also include the collection of water quality samples. 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 the condition, function, or both of wetlands. Condition assessments 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. 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. The condition and function components of URAP work together to provide a more complete understanding of the state of Utah's wetlands.

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 Utah.

Wetland classification is used in different ways with URAP. 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). The interspersion metric is only considered for certain Ecological Systems. Keys to the three classification systems being used for Utah, Cowardin; Ecological Systems; and HGM, are provided in appendix A.

URAP 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 in 2010 and 2013, including the Utah Wetlands Ambient Assessment Method (Hoven and Paul, 2010), the Colorado's Ecological Integrity Assessment (Lemly and Gilligan, 2013), and USA-RAM, an assessment protocol used in the EPA's 2011 National Wetland Condition Assessment. 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. The resulting protocol was field testing the Weber Watershed in 2014 and additional adjustments were made to the metrics as needed (Menuz and others, 2016a).

The UGS added metrics to assess habitat for sensitive amphibian species to the protocol in 2015 and 2016 (Menuz and Sempler, 2018) and developed draft methods for wildlife habitat and water quality improvement functionality in 2017 (Menuz, 2017). The latter two components were developed as simple checklists of indicators rather than more complex metrics due to feedback from a working group meeting; stakeholders thought more complex approaches would be too difficult to validate and simple approaches would be more repeatable across observers (Menuz, 2017). The UGS conducted a field validation study in 2017 to further evaluate the repeatability of results across different observers and at different times of the year (Menuz and McCoy-Sulentic, 2019). Major changes as a result of this testing included a major rewrite of the wildlife indicator checklist and use of the Washington State Wetland Rating System in lieu of the water quality indicator checklist. Some individual condition and amphibian habitat metrics were also changed, and additional supporting information to help raters was developed.

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.

Presurvey Activities

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. 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. 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, landscape maps showing the site surrounded by 100, 500, and 1000-m buffers, and a map of the likely contributing basin to the site.

Wetland Determination

Surveyors must first determine whether a site is within the target population for the project. For UGS projects, the target population frequently includes all wetlands, as defined by U.S. Fish and Wildlife Service (USFWS), that are less than 1 m deep. The USFWS definition states that 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).

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 is 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 1). 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

Table 1. 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

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.

Assessment Area Establishment

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.

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 UGS assessments are usually any area that meets the definition used by the 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).

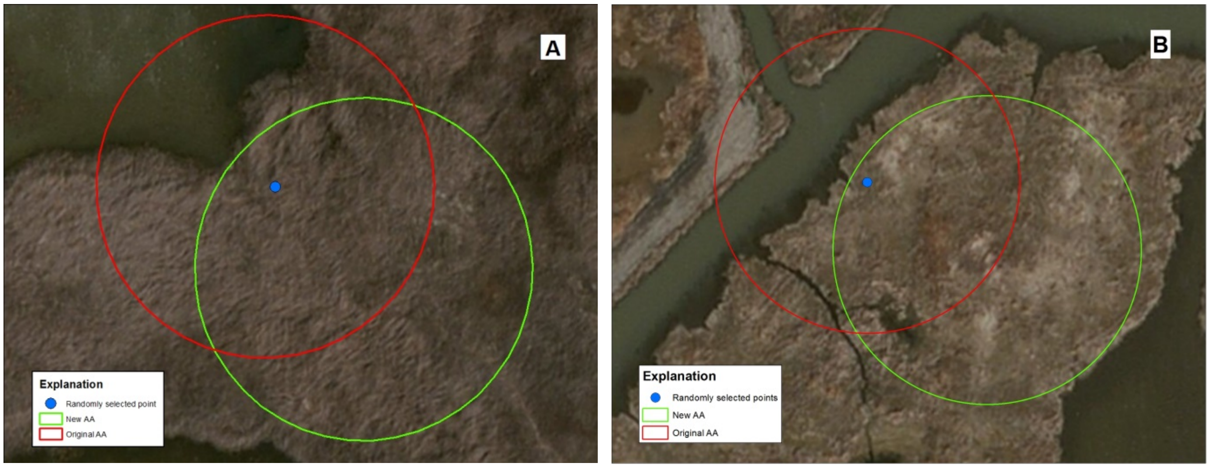


Figure 1. Examples of moving the original AA to a more appropriate survey location. On left (A), AA created by original sample point (red circle) has inclusions of water on its edge. If this water is more than 1 m deep, AA location should be shifted (green circle) so that inclusions are not directly 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.

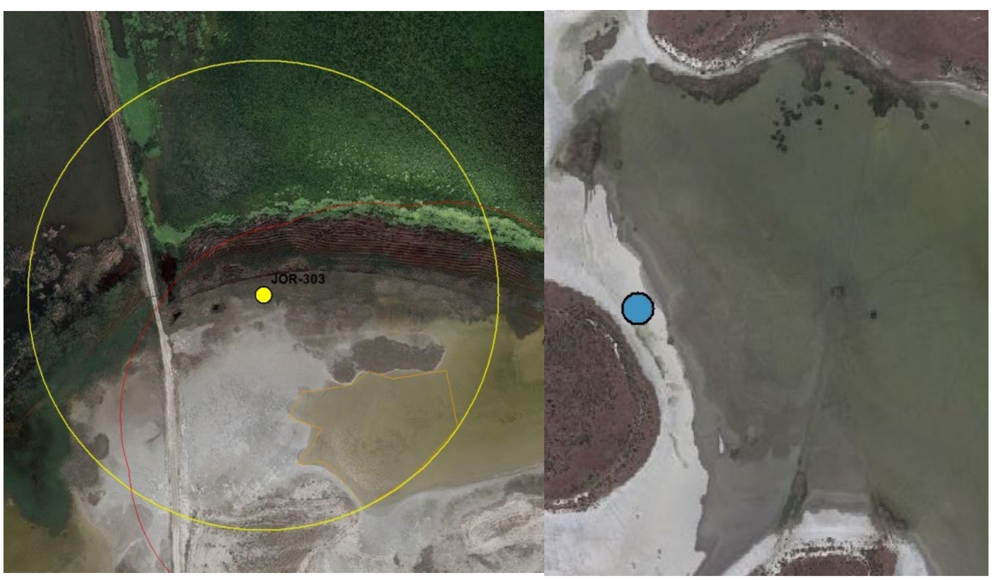


Figure 3. AA placement on the edge of open water. On the left, AA was moved from the area surrounding the point because the AA overlapped both a hard edge (the dike) as well as a sharp change in elevation between the open water to the north and the dry mudflats to the left. On the right, the site could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

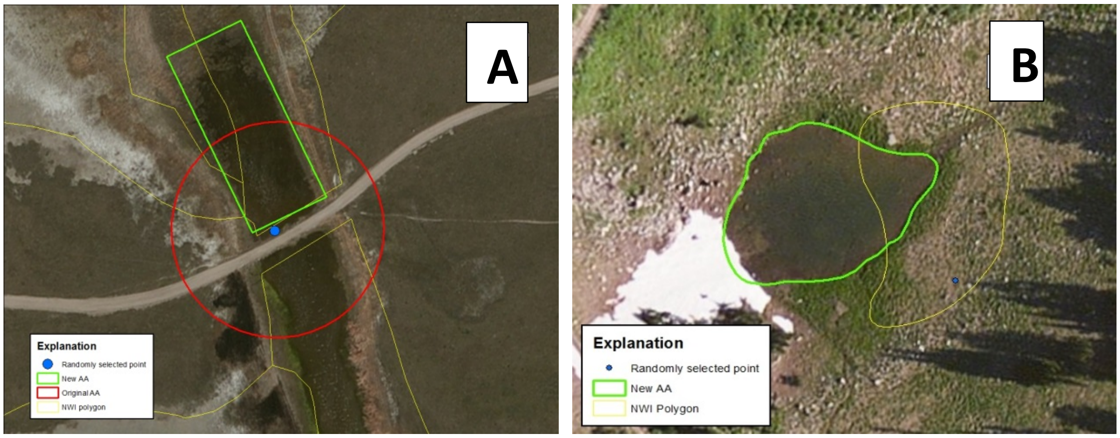


Figure 4. Reshaped survey sites. Site on left (A) was redrawn as a rectangular AA, though a circular AA potentially may also fit. At the site on right (B), the randomly selected point originally fell on the edge of the NWI polygon (yellow circle). A freeform AA was drawn in red around the probable wetland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

General Site Evaluation

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 UGS will typically collect all spatial and photographic data using a tablet. For circular AAs, spatial data and photographs will be recorded at points to the north, east, south, and west along the AA boundary, with spatial data also recorded at the site center. For rectangular AAs, spatial data will be recorded at each of the four corners of the AA and spatial and photographic data will be recorded approximately midway along each of the sides of the rectangle. For freeform AAs, surveyors will record linear spatial data as they walk along the site boundary and also collect point spatial data and photographs at four locations approximately evenly spaced along the AA edge.

Additional photographs and waypoint information will be collected at the location of the soil profile and water quality samples. Surveyors may also want to record photographs of unusual features, features that document rating for some metrics, and an overview of the site (e.g., looking down on entire site from a high point) or document noteworthy features.

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 for 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.

Livestock grazing: Evaluate whether site has history of being grazed, based on freshness of dung and tracks, presence of livestock, fencing, and browse on vegetation. Use the reference card in appendix A to determine whether tracks are from cattle or native species, if uncertain.

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. We will record a list of all plant species found within the AA during a progressive timed meander. Markers placed at the AA boundary will be used to guide the meander search for species at the AA scale. To conduct a progressive timed meander, first determine the number of plant communities present within the AA. Allow 30 minutes for the first community and add 20 minutes for each additional community. Note the time that each species was encountered. If < 3 new species are encountered during the last 10 minutes, stop meander. If ≥ 3 new species are found during the last ten minutes, continue for additional 10 minutes. Continue until < 3 new species are found in 10 minutes. Determine percent cover of each species in the AA at the end of the meander. 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. 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.

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 with a note indicating the associated site. 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 each of the most common plant zones 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 2 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 2. Features that may be present within soil pits.

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

Soil salinity data will be collected next to each soil pit. Data will be collected from a 15-cm soil sample extracted using an auger adjacent to the soil pit. Photograph and record the location using the Collector app. Complete data collection for soil profile and then gather the top 15-cm of the soil core and place into plastic container or bucket. Make sure to include any surface crust that may be present and remove as much root material and rocks as you can. Homogenize the soil in the Tupperware or bucket by hand. Measure ¼ cup of soil, ensuring that the soils are loosely placed into the cup and not compacted. If soils are wet and difficult to handle, you may form a loose puck to place into the cup. Empty ¼ cup of soil into a blender cup or other larger container with a sealable lid and add 1 ¼ (~300ml) cup of distilled water. Place lid on container and shake mixture vigorously 25 times. Let the mixture settle at least 10 minutes then insert the meter into the mixture and record the electroconductivity (EC) when the value has stabilized.

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 electroconductivity (EC). Use a handheld multiparameter meter to measure pH, 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 as stained or clear. 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.

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 and Buffer Transects

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.

Surveyor will walk 100-m transects in each of the cardinal directions whenever possible to collect data on the presence and intensity of some stressors. If surveyors cannot walk the full 100-m transect due to issues with land ownership or obstructions such as deep water, they will either estimate the values for the transect or walk a transect in one of the ordinal directions. The 100-m stressor checklist collects data on features present within 100-m of the AA. Surveyors will use a combination of aerial imagery and buffer transect information to determine stressors present in the buffer, supplemented with additional field observations within he buffer as needed. 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 3 for a brief description and examples of the different stressor categories the checklist assesses.

Surveyors will assess stressors within the AA after walking through the AA. For each stressor, surveyors will only consider how the stressor affects the particular category (vegetation, physical habitat, and hydrology) being evaluated. 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.

Condition Assessment

Background and Scoring

The URAP condition assessment is composed of 19 metrics divided into five categories, including landscape context, hydrologic condition, physical structure, vegetation structure, and plant species composition. (table 4). Four of the metrics are evaluated independently and then combined to create an overall buffer metric score. Metrics are generally scored by evaluating which of four potential states

Table 3. 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).
Nutrients/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).

Table 4. 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 using the formula:
overallBuffer=(percentBuffer*bufferWidth)0.5*([bufferConditionSoil+bufferConditionVeg]/2)0.5

[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

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 ranks from A to D; table 5 shows a conceptualization of the differences among the ranks in terms of degree of degradation, example conditions, and management priorities. Some metrics have more than four states to account for a greater diversity of recognized states, and the best condition state at some sites is assigned a value of AB because of the difficulty in distinguishing between A and B states. These metrics include A- (4.5 points), AB (5 points), and C- (2 points) states.

URAP condition scores are calculated by first converting all rank values to numeric values based on the following: A or AB—5, A—4.5, B—4, C—3, C-—2, D—1. The mean metric score is then calculated 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 4. Means are taken across a variable number of metrics per site since not all metrics are evaluated at every site. Overall condition scores are obtained by taking the mean value across all categorical scores. Current use of URAP does not support converting categorical and overall condition scores back to ranks

Plant Species Composition Metrics

Relative Cover Native Species

Definition and background: This metric measures 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

Table 5. Description of condition categories, ranked from A through D (Lemly and others, 2011).

Rank	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.

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 6). 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.

Table 6. 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

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 plant community data from meander survey or field ocular estimates (table 7). See reference cards for list of noxious weed species in Utah.

Table 7. 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.

Landscape Context Metrics

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 8 thresholds used to evaluate the percent intact landscape metric. 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 9).

Table 8. 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.

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 9 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 10). 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.

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).

Table 9. 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 10. 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.

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 11). 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 11. 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.

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 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 12 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 12. 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 impact.
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.

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 13 that best describes the condition of the buffer vegetation.

Table 13. 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 vegetation. 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.

Hydroperiod (Frequency and Duration of Inundation and Drawdown)

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. 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.

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

Table 14. Metric rating for hydroperiod.

Rank	State
A	Hydroperiod 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 deviates slightly from natural conditions. Minor modifications at site or in contributing area affect inflow and outflow of water. Some examples include slightly increased flashiness from impervious surfaces, decrease in inundation due to dams on tributaries, small inputs of tailwater irrigation, small alterations to size of channels or berms, or secondary flooding at the end of the growing season. Changes to hydroperiod may only be noticeable in extreme years or may lead to minor changes in flood duration or frequency.
C	Hydroperiod 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-	Hydroperiod 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 (e.g.- managed impoundment), 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	Hydroperiod is extremely different from natural conditions. 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 in this category experience extreme changes in hydroperiod such as groundwater pumping causing a spring to run dry, dikes blocking all flow except in extreme flood years, or detention basins that undergo short fill and release cycles.

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 15. Metric rating for timing of inundation.

Rank	State
A	Site has no to very little deviation from natural inundation 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. Majority of inflow timing during growing season is natural or shift in inundation timing of hours up to several days. Some examples include accelerated timing of input from straightened channels, small/distant impervious surfaces, delayed timing from regulation on tributaries, small additions from irrigation seepage or tailwater, or moderate additions for sites receiving water from irrigation channels or impoundment releases.
C	Site has a moderate shift in inundation timing. Shift in timing of several days up to three weeks, or unusual moderate inputs of water in the middle of the growing season, or large additions near the end of the growing season. Some examples include accelerated timing from moderate/large impervious surfaces in contributing area, delayed timing from water regulation in close proximity to site, moderate inputs of irrigation water via seepage or tailwater runoff in additional to naturally timed influxes of water or large levees of inundation in the fall in artificial impoundments that are otherwise managed in a more seasonally appropriate manner.
C-	Sites have a large shift in inundation timing. Shift in timing of three weeks up to two months or inundation timing is somewhat natural 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. Timing characterized by near absence of naturally timed inputs with site receiving majority of water from irrigation return-flows, wastewater effluent, or other industrial outfall source or site managed with very little regard for natural timing of water inputs.
D	Sites have an extreme shift in inundation timing. Shift in 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. Some examples include springs that have gone completely dry due to groundwater extraction, or former floodplain wetlands that only receive water when up-stream impoundments are released.

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.

Table 16. 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.

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. Similar 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: Evaluate areas with standing water, as well as areas that obviously recently had standing water, such as drying pond edges or areas with dried algal mats (table 17). Lack of dried algal mats in the absence of surface water should not be taken as evidence of an A or B rating for this metric. Take photo if rated below B. Ignore macroalgae (*Chara* spp.) in the evaluation.

Table 17. Metric rating for algae growth.

Rank	State
NA	No surface water at site and no evidence of dried algal mats in recently inundated areas.
A	Water is clear with minimal algal growth. Dried algal mats, if present, minimal.
B	Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness. Dried algal mats, if present, minimal.
C	Algal growth occurs in moderate to large patches throughout the AA. Water may have a moderate greenish tint or sheen. Site may have evidence of moderate to large patches of dried algae mats in recently inundated areas.

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).

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.

Table 18. Metric rating for water quality.

Rank	State
A	**There are no water quality stressors likely to impact site.**

	All Sites: 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). *For Sites receiving most water from channels:* 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.** *All Sites:* Within the AA, some minor dung and soil disturbance from livestock (if grazing impacts very light, may be an A); up-gradient stressors within 500 m of site are minor, 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:* The 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.*** *All Sites:* Within the AA, moderate dung and soil disturbance from livestock 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 slope leading to the site and the land cover between the stressor and the site; vegetated very low slope may be B and unvegetated very steep slope may be D). *For sites receiving most water from channels:* The entire contributing area has ~20-60% development or cropland, though these land uses are less prevalent within 2 km of site, or has a moderate number of oil and gas wells, mines, or point source dischargers that are distant from site or only a few that are closer streams and lakes that contribute to the site are not listed on the 303d or are listed, but water quality is likely to be attenuated or improved before reaching the wetland by passing through reservoirs or emergent vegetation.
D	**Site likely to receive substantial water quality stressors.** *All Sites:* Stressors may include: high levels of dung and soil disturbance from livestock within AA or, up-gradient stressors such as irrigation return flow water, fertilizer and pesticide application, and erosion from fires, construction, off-road vehicles, and dirt roads *discharging directly into sites.* May be considered C if run-off from the features is likely to occur infrequently, if slope is shallow, or if only a small area of the AA receives these 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). *For sites receiving most water from channels:* The entire contributing area has>60% development or cropland, a high number of oil and gas wells, mines, or point source dischargers; or streams and lakes that directly contribute to the site are listed as impaired on the 303d list.

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 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.
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 (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 m^2 (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 m^2 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.

Table 21. Metric rating for horizontal interspersion.

Rank	State
A	High degree of horizontal interspersion. AA is characterized by a complex array of nested or interspersed zones. AA has both a high number of zones and a high degree of interspersion of those zones.
B	Moderate degree of horizontal interspersion.
C	Low degree of horizontal interspersion.
D	Minimal horizontal interspersion. AA characterized by one dominant zone with little to no other zones.

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.

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 and none are expected for the wetland type. 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. A wide size-class diversity of downed woody debris and standing snags is present and common where expected. 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.

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. Sites with very low woody species cover (~ < 2.5%) are typically rated as either NA (woody species naturally uncommon/absent) or a rating below A to indicate issues with regeneration. Sites where woody species are expected but sparse or absent absent due to disturbances can be rated as D.

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. Regeneration moderately impacted for some reason (describe).
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.

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.

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 A). 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.

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.

Amphibian Habitat Metrics

Background and Scoring

Amphibian metrics were developed to provide a rapid method for evaluating habitat for two state sensitive amphibians, the Columbia spotted frog and boreal toad. Metrics were developed in consultation with the Ecological Integrity Tables for each species, a summary of key indicators for the species with ratings associated with each indicator (Oliver, 2006 and 2007). The Tables were screened for habitat-based indicators; data from the tables were supplemented with literature review.

Amphibian metrics are converted to a mean score for each species and than evaluated to determine whether sites meet or exceed thresholds that determine whether sites may be suitable habitat, first converting ranks to point values based on the following: A—5, B—4, C—3, D—1. For boreal toad, we first obtain 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. For boreal toad, we take the mean value of the four boreal toad-specific metrics plus the presence of north shore and slope and water depth metrics. Metrics for the boreal toad have been extensively tested at sites with known breeding populations to determine their suitability for evaluating boreal toad breeding habitat (Menuz, 2016; Menuz, 2017a). Sites with mean metric values ≥3.8 are most likely to be suitable for boreal toad breeding. For Columbia spotted frog, we take the mean value of three of the Columbia spotted frog-specific metrics (ignoring the waterbody substrate metric) plus the presence of north shore and slope and water depth metrics. More limited testing has been conducted with the Columbia spotted frog metrics with data from eight known breeding sites and four sites within the breeding range of the species. All but one site had scored ≥4.4; the lowest scoring site received a score of 3.6. We preliminary will consider mean metric scores ≥3.6 to be potentially suitable for Columbia spotted frog breeding.

Boreal Toad Metrics

Breeding Waterbody

Definition and background: Suitable breeding waterbodies for boreal toad are typically pooled or slow-moving waters that are large enough not to dry up before tadpoles mature and deep enough not to freeze at night during the summer, such as lakes, ponds, and large pools (Oliver, 2007). Lotic waters are typically too cold and swift for breeding, though low-gradient backwaters and oxbows may be used. Surface water must be present for the duration of the time from egg mass to tadpole development, which may take approximately 75 days (McGee and Keinath, 2004), though the exact duration will vary depending on the rate of development.

Measurement protocol: Determine what types of waterbodies are present within the AA (table 25). Also consider waterbodies immediately adjacent to the AA if the waterbody shore is within the AA or comprises the AA boundary. Rank the site for the highest-quality feature present so, for example, a site would receive a rating of A if it has both beaver ponds and a flowing stream. Sites without any indication of surface water or that are only flooded for very short periods of time, including sites that are periodically flood irrigated and allowed to dry out, should be rated as D.

Table 25. Metric ratings for boreal toad breeding waterbodies.

Rank	State
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: flowing rivers and streams OR lentic but very small or uniformly shallow: temporary pools, small puddles.
D	No surface water typically present at site (e.g., less than a few weeks of surface water per growing season) or surface water present intermittently throughout summer (e.g., field flood irrigated and then completely dried out periodically all summer) (skip the next three metrics)

Shallow Water Temperature

Definition and background: Boreal toad typically lay their eggs on the shallow edges of larger waterbodies or in shallower ponds that can warm rapidly in the sun (Oliver, 2007). Very cold temperatures can be deadly to eggs and warmer temperatures allow for faster development of eggs into tadpoles, providing more time for tadpoles to develop into metamorphs that can survive outside water before water freezes or dries up.

Measurement protocol: Measure water temperature using a handheld meter in the highest quality breeding waterbody present at the site (e.g., in a beaver pond and not a flowing stream) in areas most suitable for breeding, particularly shallow unshaded areas along the north shore of the waterbody if available. Take measurements towards the warmest part of the day if possible to capture the potential peak temperatures. Estimate the likely peak water temperature, assuming an increase in a couple of degrees if measurements are made early in the morning or on an overcast day (table 26).

Table 26. Metric ratings for boreal toad shallow water temperature.

Rank	State
A	28–34 °C
B	16–27 °C or 35 °C
C	11–15 °C or 36 °C
D	≤10 °C or ≥37 °C

Hibernation Features

Definition and background: Boreal toad spend winter outside of the water in hibernacula, which can include animal burrows, rockslide or debris piles, beaver lodges, rocky chambers near streams, and cavities under boulders or tree roots (McGee and Keinath, 2004; Oliver, 2007). They can move several kilometers from breeding waterbodies to hibernacula, though for the sake of this metric we will only search within AAs and their buffers. Boreal toad will cross roads and other unnatural features to move to hibernacula, though these disturbances can increase their mortality.

Measurement protocol: Walk a 100-m transect line in the buffer on the north, east, south, and west sides of the AA to search for potential hibernation features, including woody debris piles, animal burrows, and loose soil, and determine the connectivity of the features to the AA (table 27).. Also estimate the availability of hibernation features in the remainder of the buffer and search the AA itself for features. Circle all of the types of features observed and then select the metric state that best fits the description of the availability of hibernation features in the AA and a 100-m buffer surrounding the AA.

Table 27. Metric ratings for boreal toad hibernation features.

Rank	State

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 or no surface water typically 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	

Understory-Forming Vegetation

Definition and background: Boreal toad make extensive use of terrestrial habitats after breeding where understory-forming vegetation may be important to prevent evaporative water loss while allowing them to move freely in the understory. Boreal toad are associated with at least moderate shrub cover in terrestrial habitat (McGee and Keinath, 2004; Oliver, 2007). However, Menuz (2006) speculated that tall forbs such as *Rudbeckia occidentalis* (western coneflower) and *Solidago altissima* (Canada goldenrod) may play a similar role as shrubs in preventing evaporative loss after finding that three of seven breeding sites in northern Utah had little to no shrub cover. The same study found that sites with ≥60% shrub cover also did not have boreal toad, potentially because of lack of appropriate basking habitat.

Measurement protocol: Evaluate this metric within the AA and in the valley bottom or floodplain terraces in the 100-m buffer (i.e., do not evaluate on steep slopes in the buffer, table 28). Determine the aerial extent of each vegetation type (shrub and tall forb) within terrestrial portions of the valley bottom. Cover estimates are for the area occupied by each vegetation type, not the shade cover that occurs when the sun is directly overhead.

Table 28. Metric ratings for boreal toad understory-forming vegetation.

Shrub	**Tall Forbs**	**State**
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.

Columbia Spotted Frog Metrics

Breeding Waterbodies

Definition and background: Columbia spotted frog need to breed in waterbodies with minimal flow that are large enough not to dry up in summer and deep enough not to freeze solid at night during the summer. In Utah, they typically breed in beaver ponds, river oxbows, stock ponds, and spring complexes. Surface water must be present for the duration of the time from egg mass to tadpole development.

Measurement protocol: Determine what types of waterbodies are present within the AA (table 29). Rank the site for the highest-quality feature present so, for example, a site would receive a rating of A if it has both beaver ponds and a flowing stream. Sites without any indication of surface water or that are only flooded for very short periods of time, including sites that are periodically flood irrigated and allowed to dry out, should be rated as D.

Table 29. Metric ratings for Columbia spotted frog breeding waterbodies.

Rank	State
A	Waterbodies suitable for breeding present. Waterbodies large enough not to dry up in summer and deep enough not to freeze solid at night during the breeding season 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 (likely to freeze or dry up).
C	Lotic systems (rivers or streams) OR lentic but very small or uniformly shallow (e.g., temporary pools, small puddles).
D	No surface water typically present at site or site with water regime of A or drier (score waterbody metrics as D).

Waterbody Substrate

Definition and background: Columbia spotted frog area thought to typically breed in waterbodies with finer substrates, such as deep organic muds and silts (Oliver, 2006).

Measurement protocol: Evaluate this metric in waterbodies that rank highest for the Columbia spotted frog breeding waterbody metric. Sink your hand or a ruler into the bottom of the waterbody to determine the substrate material and whether it is hard-packed or loose and then select the appropriate rank (table 30).

Table 30. Metric ratings for Columbia spotted frog waterbody substrate.

Rank	State
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 OR substrate is hard-packed mud or silt.
D	Cobble, boulder, or bedrock predominant substrate with deep mud/silt absent.

Waterbody Vegetation

Definition and background: Emergent, floating, and submergent vegetation in breeding waterbodies can provide structure to attach egg masses to and cover to protect tadpoles from aquatic predators, but excessive emergent vegetation can shade out the water. Interspersion of about 50% emergent and 50% open water (or water with floating or submergent vegetation) may be ideal for Columbia spotted frog (Oliver, 2006).

Measurement protocol: Evaluate this metric in waterbodies that rank highest for the Columbia spotted frog breeding waterbody metric. Estimate cover only for the portion of the waterbodies that are < 1m deep (table 31).

Table 31. Metric ratings for Columbia spotted frog waterbody vegetation.

Rank	State
A	At least 20% of waterbody shallows have some type of emergent, floating, or submerged 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).
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).
D	No or <1% vegetation in waterbody shallows or emergent vegetation densely covers entire waterbody.

Overwintering Waterbodies

Definition and background: Columbia spotted frog hibernate in non-freezing well-oxygenated water, such as groundwater-fed systems, deep pools (≥1 m), and perennially flowing water. At least a slight flow of water can be important to maintain oxygenation (Oliver, 2006). Overwintering sites are typically within 100 m of breeding sites. Features such as overhanging banks, holes, log debris, and lose soil can help provide shelter and protection from freezing.

Measurement protocol: Evaluate all perennial waterbodies within the AA and surrounding 100-m buffer and then select the state that fits the best (table 32).

Table 32. Metric ratings for Columbia spotted frog overwintering waterbodies.

Rank	State
A	Waterbodies very suitable for hibernation present. 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	Moderately suitable waterbodies for hibernation present. Waterbodies include the above types, but hibernation features may be less common or waterbodies may occasionally freeze to bottom.
C	Marginally suitable waterbodies for hibernation present. Water may not be particularly well oxygenated or may freeze most years or hibernation features may be rare or absent.
D	No potential overwintering habitat near AA (e.g. there is no water present or all water is likely to freeze or dry

	up).

Metrics for Both Species

Presence of North Shore

Definition and background: The north shore of waterbodies is often a favorable location for amphibians to lay egg masses because these areas receive the most sunlight (Oliver, 2006; Oliver, 2007). Warmer water can lead to faster development from egg to tadpole, which can be important in areas where the growing season is short. East-west aligned waterbodies will have the most north shore present, such as an east-west flowing river or an oval-shaped pond with the long axis in the east-west direction. Sinuous streams and round or squarish waterbodies may also have ample north shore present. North shore is considered a habitat feature for both boreal toad and Columbia spotted frog.

Measurement protocol: This metric will be evaluated for the highest rated waterbodies identified in the boreal toad and Columbia spotted frog breeding waterbody metrics. Use the site map, and a compass if necessary, to determine the orientation of the waterbodies at the site and use the north shore diagram to select the best rank for this metric (table 33).

Table 33. Metric ratings for presence of north shore.

Rank	State
A	Ample north shore present (shore on north side of waterbody).
B	Moderate amount of north shore present.
C	Minor amount of north slope present.
D	Little or no north shore present OR waterbody densely covered in emergent/woody vegetation with no openings.

Slope and Water Depth Near Shore

Definition and background: Boreal toad and Columbia spotted frog typically lay their eggs in shallow water (<10 cm for boreal toad, <20 cm for Columbia spotted frog) where solar radiation can warm the water to appropriate temperatures for tadpole development (Oliver, 2006; Oliver, 2007). Waterbodies with gentle slopes can provide a large area with shallow water even in the case of water fluctuation since a portion of the slope will be around 10 to 20 cm deep at some level of water.

Measurement protocol: This metric will be evaluated for the highest rated waterbodies identified in the boreal toad and Columbia spotted frog breeding waterbody metrics. Select the rank that best describes the presence of shallow water on gentle slopes on the waterbody edge (table 34).

Table 34. Metric ratings for slope and water depth.

Rank	State
A	Mostly gentle slopes and/or large area, esp. along north shores, with gentle slopes; water <10 cm common. Changes in water levels typically lead to much greater horizontal rather than vertical change.
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.

C	Gentle slopes present, but uncommon. Few areas with water <10 cm deep.
D	All shorelines with steep slopes OR water <10 cm not present.

Amphibian Stressor Metrics

Livestock Disturbance

Definition and background: Livestock grazing during the breeding season can cause direct mortality to amphibians from trampling (McGee and Keinath, 2004; Oliver, 2006; Oliver, 2007). High levels of vegetation removal from livestock grazing can also increase mortality from desiccation due to lack of cover (McGee and Keinath, 2004), though some studies suggest that moderate levels of grazing may help maintain areas of open water and recreate missing natural disturbance regimes (Watson and others, 2003). This metric was adapted from the Ecological Integrity Table for Columbia spotted frog (Oliver, 2006), but is relevant to boreal toad as well.

Measurement protocol: Examine the AA and surrounding buffer for signs of livestock grazing, including cow patties, tracks and pugging, and browse (table 35).. Signs of high intensity grazing include large areas of bare soil, deep pugging, and very grazed down willows and herbaceous plants. Estimate timing of grazing based on freshness of any dung, tracks, and browse.

Table 35. Metric ratings for livestock disturbance.

Rank	State
A	No evidence of livestock grazing in AA or buffer
B	Low intensity grazing in buffer; no grazing in AA.
C	High intensity buffer grazing or winter AA grazing, or low intensity AA summer grazing.
D	High intensity grazing in AA in summer

Impervious Surface

Definition and background: Impervious surfaces can alter hydrology of nearby waterbodies by increasing run-off and flashiness of flows and can affect water quality through siltation and run-off of contaminants such as oil and grease (Oliver, 2006). This metric is most relevant to Columbia spotted frog because they are much more likely than boreal toad to breed in areas near impervious surface. For the sake of this metric, concrete, asphalt, and gravel surfaces will all be considered impervious.

Measurement protocol: Evaluate the distance from the edge of the AA to the nearest impervious surface, such as paved or gravel roads, parking lots, sidewalks, and roofs (table 36).

Table 36. Metric ratings for distance to impervious surface.

Rank	State
A	>300 m
B	200-300
C	100-200
D	<100 m

Mining

Definition and background: High concentrations of metals such as zinc, cadmium, and copper can cause delayed growth and mortality in amphibians, including the boreal toad (Jones and others, 1998). These metals sometimes accumulate in areas with past mining legacies, including many of the high elevation areas where boreal toad breed.

Measurement protocol: Evaluate both the AA and surrounding 100-m buffer to look for any indications of mining, including mine tailings or mine shafts. Use site maps to assist in the evaluation. If there is evidence of current or historic mining in the AA or buffer, select Yes and otherwise select No.

Wildlife Indicator Checklist

Background

The wildlife indicator checklist is designed to provide a quick method for evaluating whether a site has potential to provide habitat for wildlife species within specific taxonomic groups and for wildlife in general. The wildlife indicator checklist was initially developed in 2016 using a combination of best professional judgement from wildlife experts and literature review (Menuz, 2017b). The UGS compiled a list of potential wildlife indicators from existing assessment protocols and asked wildlife specialists to rate each indicator for its importance to taxa of interest (e.g., wading birds, amphibians). The list of indicators was refined at a working group meeting, through meetings with wildlife specialists, and through literature review. The draft wildlife indicator checklist was robustly field-tested in 2017 to test for consistency within and across survey teams and substantial modifications were made as the result of this testing. The wildlife indicator checklist is still in the process of review and final scoring methods have not yet been developed.

General Measurement Protocol

Record data for the wildlife indicator checklist near the end of the survey after walking through and obsevering most of the site. Most indicators are rated as True or False, with some also having a not applicable (N/A) option. A True statement indicates the presence of a feature or a less disturbed state and a False statement indicates the opposite. Use site maps to help with indicators related to surrounding land use. Mark features as present if they are present in a quantity that makes it reasonable to locate within 20 minutes of survey. For example, do not mark “site includes bulrush species” as True if there are just one or two individuals, but it is okay if they are present in a very small patch (<1% cover). Below is more specific guidance for some of the categories of indicators.

Species Observations

Species observational data are collected for background information only. Surveyors are not expected to be skilled in wildlife identification, and wildlife surveys will be rapid and opportunistic rather than detailed. Furthermore, surveys will occur at a single visit rather than the repeated surveys required to estimate detection and occupancy rates. Surveyors will only record species to the level of taxonomic certainty that they are comfortable with (e.g., red-tailed hawk vs. hawk vs. raptor vs. bird) and lack of presence should not be presumed to indicate an absence of a species. Data will be used to compile a (non-exhaustive) list of wildlife species observed in different regions or wetland types within a project area and to assess the link between habitat features and wildlife functional groups. Particular species of interest may also be shared with partner agencies, for example, sightings of amphibians may be uploaded to the iNaturalist Herps of Utah page and sightings of sensitive wildlife species will be shared with biologists at the Utah Division of Wildlife Resources.

Measurement protocol: While walking up to a new site, pay attention to any wildlife species that may be using the wetland because some species may be driven from their cover and out of the site by your approach. Throughout the survey, pay attention to any wildlife or wildlife signs that you see, including footprints, scat, beaver dams, and nests. Take photographs when possible to aid in identification back in the office and be as detailed as possible in the observation notes. Do not record species that are merely flying over or are adjacent to the site and do not record species if you cannot place it into a taxonomic group (e.g., "heard rustling, may be mouse or frog" should not be recorded).

Habitat Types

Most wildlife species require more than one habitat to fully support them, including habitat for breeding, feeding, and cover. Most avian species and some other wildlife move between habitat patches to meet their needs, making an isolated wetland less valuable than a wetland embedded within a complex of other natural wetland and upland land cover. The habitat type indicators evaluate the diversity of habitat within sites as well as whether those types are present within 1 km of sites. Habitat type must be present in the indicated depth range in majority of spring (April, May, June) or Fall (July, August, September).

Measurement protocol: The presence of habitat types will be determined after walking an adequate portion of the AA and examining aerial imagery on site maps or handheld tablet computer. Within the AA, each habitat type must occupy at least 5% of the assessment area and no more than 10 patches can be combined to meet the size threshold. (10 m^2 in a standard 40-m radius AA). Within 1 km of AA, each habitat patch must occupy at least 1000 m^2. Two challenges of this evaluation are determining whether regions meet the hydrologic requirements and evaluating the 1 km area without being able to field verify the imagery. To address the first challenge, surveyors will information from the office evaluation, soil profile, and vegetation communities to determine which habitat types are likely present. For example, a site with no surface water during a fall visit likely has the "shallow emergent water" indicator if *Schoenoplectus americanus* is a dominant species. Surveyors can use National Wetlands Inventory data to evaluate likely wetland types present in the 1 km buffer, though this data is often out of date and multiple habitat types may be represented by a single Cowardin code. The field form lists Cowardin codes that may indicate presence of particular habitat types.

Aquatic Mollusk Collection and Habitat Metrics

Background

The UGS has begun collaborating with the Utah Department of Wildlife Resources (DWR) to include mollusk-specific components to wetland surveys to help fill data gaps identified in the Wildlife Action Plan by addressing an inadequate understanding of distribution and range, inadequate inventory and assessment methods, and inadequate survey methods for many aquatic mollusk species and the habitats where they may be found. The UGS is working closely with the DWR to develop the protocol and increase the UGS's capacity to monitor for aquatic mollusks.

As the UGS is in the process of developing expertise in mollusk identification, the specific components included are focused on specimen collection and preservation and documentation of locality. Observers are not expected to be experts in mollusk identification but are expected to take detailed notes on the morphological characteristics of each species found, a best guess at taxonomy using available resources, and to properly preserve the specimen for future identification and genetic testing.

Measurement and collection protocol

To search for aquatic mollusk species, survey each aquatic habitat type present at a site, for a total of no more than 30 minutes. It is assumed that additional incidental observations will be made by both observers while conducting other components of URAP that may supplement and guide the mollusk-specific survey. Be sure to examine vegetation by hand, occasionally turning over leaves and sweeping around the base of plants in dense vegetation. Use a kitchen sieve to gather substrate in a few places, sieve out soil and other material, and dump into a small Tupperware to examine the contents for mollusks or shells.

Many of the habitat metrics for this component are taken from site information already gathered for general site information, though additional information to be recorded includes spring type and discharge if applicable, a description of the habitat and substrate where each mollusk species is observed, and additional documentation of disturbances. To maintain consistent data format with other DWR surveys, record overall and specific site disturbances and water control structures in addition to the site and buffer stressors. Record a physical description of each mollusk species found at a site including information such as the aperture dimensions and location (left or right opening), color, overall dimensions, and number of coils. For each species found, include a description of the area it was found including vegetation, substrate, and water depth. Also describe the distribution, abundance, and area occupied by each species. Record the time you begin and end the survey to note the total time spent for the survey effort. Record the spatial coordinates of any mollusks collections and take a photo of the area it was collected from. Consider drawing the area occupied by each species on the site map.

If mollusk collections are made, collect an appropriate number of individuals as to not adversely impact the population. For example, if a species is extremely abundant try to take around 25 individuals; if a species is not abundant ($<10/m^2$), consider collecting only empty shells, taking pictures or collecting only 1-3 live individuals. Keep aquatic snails in a properly labeled 1-liter container nearly filled to the top (about 1 inch of head space) with water from where the snails were collected. Keep the sample cool in a cooler with ice. Do not keep the snails in the jar of water for more than 12 hours. Be sure to label the container with the site name and the corresponding species number if more than one species was collected at a site. This will maintain record keeping when making labels for preserved specimens. Preservation should be done at the end of the day they were collected when you return to camp or to the office.

Preservation protocol

Aquatic snails

For very small snails, such as spring snails (Pyrgulopsis), drop directly into 95% ethanol.

For larger specimens, try to pop the operculum off the snail to ensure tissues will be preserved. Use the hot water method for preserving larger specimens via the following steps:

1. Place live snails in container deep enough for them to be submerged in the container when it is filled with water (but don't fill with water yet).
2. Allow time for snails to come out of their shells and start flailing around
3. While snails are coming out of their shells, heat water to a rolling boil.
4. Let snails sit in water for 15-25 seconds. Then pour off water.
5. Place snails in a container with 95% ethanol.
6. Wrap the base of the container's cap with electrical tape to help prevent evaporation of ethanol.

   NOTE: Metal mesh strainers can be useful in this process. Put a strainer in the bottom of your container, let the snails come out in the strainer, and then fill the cup/bowl with water covering the snails. After 15-25 seconds you can just pick up the strainer and have the snails. This allows you to not worry about pouring out very hot water and not pouring out snails.

Terrestrial snails

Put snails in jar completely filled with water, wait until snails are nonresponsive (about 12 hours), then add snail directly to 95% ethanol.

Labeling specimen collections

For labeling voucher specimens, include how the specimen was preserved (e.g., use of formalin, hot water, % ethanol) so that others will know if the specimen can be used for DNA. Indicate the level of certainty in the identification of the specimen. If labels are printed on Resistall or Rite in the Rain paper, labels may be included in the jar along with the ethanol. Wrap a second label around the container and attach with rubber bands or tape. List the full name for the collector(s). The voucher number will be the site ID with a hyphen and then the unique mollusk number (e.g., CB-001-1).

Label example:

Taxon: _________________% certainty_____ Date: ___________
Collectors: ___________________ Voucher #:________________
State: Utah County: ________ Land ownership: ________________
UTME _________________ UTMN _________________ NAD83

Habitat description: ____
Circle one: live dead/shell both Preservation: ___________________

Water Quality and Hydrologic Function Metrics

Background

The UGS is currently using a protocol developed in Washington State to evaluate wetland water quality and hydrologic (flood and erosion reduction) functions (Hruby, 2014). The Washington State Wetland Rating System assesses wetlands by HGM class, including depressional, slope, riverine, or lake fringe wetlands. Wetlands are evaluated and scored separately for their capacity to perform, landscape potential to perform, and societal value of each function. Each of the three components (capacity, landscape potential, and societal value) is composed of one or more metrics and each metric is composed of two or more statements with point values associated with each statement. Sites are then rated as low, medium, or high for capacity, landscape potential, and societal value based on the total number of points they were assigned across all metrics in the category. Scoring for sites is detailed in the Washington State Wetland Rating System manual.

There are several challenges with using a protocol designed for another state for the URAP assessment. First, the Washington State Wetland Rating System is designed for assessing whole-wetlands rather than plots within wetlands. Surveyors will sometimes need to evaluate a wetland beyond the boundary of the AA to adequately address metrics. For example, when evaluating the characteristics of surface water outflow in depressional wetlands, surveyors should use determine whether the wetland has an outlet, not merely whether there is an outlet within the AA. For other metrics, such as clay or organic soils, surveyors should only evaluate conditions within the AA itself. Surveyors will need to be clear on which metrics need to be evaluated within an AA versus in the whole wetland. Second, some metrics in the Washington State Wetland Rating System require either research or a high degree of familiarity with existing flood control and watershed plans, as well as flooding history in basins. Surveyors using URAP will not typically have time or expertise to evaluate some of these metrics and therefore certain metrics will not be scored. In particular, the societal value section of the hydrologic function component will not be scored. Third, the Washington State Wetland Rating System was obviously designed and tested for use in Washington only. It may include some attributes that are not relevant to Utah and may exclude other attributes that are important to Utah. Furthermore, Washington State Wetland Rating System has separate protocols for eastern and western Washington. UGS is currently using the eastern Washington version, but there may be some cases where the western Washington version is more appropriate. The UGS will continue to evaluate the appropriateness of use of the protocol as they collect more data.

Use Notes

Surveyors should use the Washington State Wetland Rating System for Eastern Washington (Hruby, 2014) for guidance on rating each component. The manual includes important information for rating each metric. Surveyors should also use the key in the manual for determining which HGM class to consider the site for the sake of the functional assessment. Surveyors should not look for information about a site's societal value in watershed, local, and flood control plans, but can answer questions on societal value of water quality function based on whether there is a TMDL for the basin where a site is located. Surveyors will ignore mention of UGA (Urban Growth Area) and evaluate associated metrics based solely on presence of incorporated areas.

Data from the office evaluation will be important for rating many components of the assessment, including determining whether a region or basin is on the 303(d) list and whether a TMDL has been developed for the site or basin. Information on known harmful algal blooms can be found on the Utah Division of Water Quality's website at https://deq.utah.gov/legacy/divisions/water-quality/health-advisory/harmful-algal-blooms/bloom-events/index.htm. Areas with documented blooms between 2016 and 2018 include Big Lake (Monroe Mountain), Deer Creek Reservoir, East Canyon (Taylor Hollow site), Echo Reservoir, Farmington Bay, Hoop Lake, Jordan River and associated canals, Jordanelle Reservoir, Lower and Upper Box Creek Reservoir (Monroe Mountain), Manning Meadow Reservoir (Monroe Mountain), Mantua Reservoir, Matt Warner Reservoir, Mill Meadow Reservoir (Fish Lake Mountains), Montes Creek Reservoir (near Roosevelt), Ogden's 21st Street Pond, Otter Creek Reservoir, Panguitch Lake, Payson Lakes, Pineview Reservoir, Rockport Reservoir, Salina Reservoir, Scofield Reservoir, Strawberry Reservoir, Upper Kents Lake, and Utah Lake.

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.

Hruby, T., 2014, Washington State wetland rating system for eastern Washington−2014 update: Olympia, Washington, Washington Department of Ecology publication #14-06-030, 126 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.

Jones, M.S., Goettl, J.P., Scherff-Norris, K.L., Brinkman, S., Livo, L.J., and Goebel, A.M., 1998, Colorado Division of Wildlife boreal toad research program report−1995-1997: 171 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.

McCoy-Sulentic, M., and Menuz, D., 2019, Validation of a rapid wetland assessment protocol for Utah−Evaluation of survey methods and temporal and observer variability in vegetation data: Salt Lake City, Utah Geological Survey Report of Investigation 277, 22 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.

McGee, M, and Keinath, D., 2004, Species assessment for boreal toad (*Bufo boreas boreas*) in Wyoming: Laramie, Wyoming, Wyoming Natural Diversity Database, prepared for the Bureau of Land Management, 86 p.

Menuz, D., 2016, 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, 33 p.

Menuz, D., Sempler, R., and Jones, J., 2016a, Weber River watershed wetland condition assessment: Salt Lake City, Utah Geological Survey, 106 p.

Menuz, D., Sempler, R., and Jones, J., 2016b, Assessment of wetland condition and wetland mapping in the Upper Blacks Fork and Smiths Fork, Uinta Mountains, Utah: Salt Lake City, Utah Geological Survey Report of Investigation 274, 31 p.

Menuz, D.M., 2017a, 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.

Menuz, D.M., 2017b, Developing core indicators for assessing wetlands in Utah: Utah Geological Survey, Salt Lake City, 32 p.

Menuz, D., and Sempler, R., 2018, Jordan River Watershed wetland assessment and landscape analysis: Salt Lake City, Utah Geological Survey, 82 p.

Menuz, D. and McCoy-Sulentic, M., 2019, Validation of a rapid wetland assessment protocol for Utah−Testing inter-observer and intra-season variability: Salt Lake City, Utah Geological Survey Report of Investigation 278, 43 p.

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

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

Oliver, G.V., 2007, Western toad (*Anaxyrus boreas*) Ecological Integrity Table: Utah Division of Wildlife Resources Natural Heritage Program, 14 p.

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.

Watson, J.W., McAllister, K.R., Pierce, D.J., 2003, Home ranges, movements, and habitat selection of Oregon spotted frogs (Rana pretiosa): Journal of Herpetology, v. 37, no. 2, p. 292-300.

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

CONTENTS

Checklist of Field Equipment

Items for Overnight or Remote Travel

- First aid and car emergency kit
- Satellite phone / emergency beacon
- Plant press with newspaper
- Ethanol
- Stove for boiling water/preserving mollusks

Paper Items

- File Folder
    - Site maps / office evaluation
    - Forms (main forms, soil & water, metrics, and ground cover/veg)
    - Emergency contact numbers
    - Permits
- URAP User's Manual
- WA State Wetland Rating System manual
- Army Corps Regional Supplement

General Group Gear

- Tablets with apps and charger (2)
- Action Packer
    - GPS
    - Measuring tape (50 m)
    - Plastic bags for plant samples
    - Hand sanitizer / bug spray / socks
    - Extra mollusk containers
    - Extra rulers and weeders
    - Munsell or other soil color chart
    - Water quality meters (high and low)
    - Plant & mollusk identification guides
- Pencil Case
    - Mollusks containers (2)
    - Extra AA batteries
    - Pencils, sharpie, lead
    - Compass
    - Flagging tape
    - Hand lens
    - Gloves

Core Center

- Sharpshooter or auger
- Waders and knee boots
- Large water jug
- Cooler with ice
- Large tarp for keeping gear dry
- Three containers for water quality lab samples per site
- Disinfectant bucket
    - Scrub brush for cleaning shoes
    - Sprayer with sparquat
    - Gloves
- Gear bucket
    - Pin flags
    - Pocket knife
    - Handheld ruler (2)
    - Soil tarp
    - Pocket knife
    - Distilled water
    - Tupperware for mixing soil
    - Blender cup (2)
    - Plastic measuring cup (1/4 cup)
    - Plastic measuring cup (300 ml)
    - Transparency tube
    - Mesh sieve
    - Weeder to dig plant specimen

Individual Field Gear

- Gear assigned to individuals
    - Laminated reference guides
    - Pencils
    - Clipboard
- Personal gear
    - Large backpack
    - Water bottles
    - Food for field
    - Insect repellent, head net
    - Sun screen
    - Cell phone (for emergencies)

Field Order of Operations and To Do Checklist

1) Locate plot center. Make mental note of any wildlife observed while walking into AA.
2) Determine whether site can be sampled (wetland present and at least 0.1 ha).
3) Determine placement of AA.
4) Flag out boundary and collect coordinates on AA boundary and photos using tablet
5) Determine the number of vegetation zones within AA and which need to be sampled with soil pits (those with ≥30% cover within AA).
6) Water quality/soils surveyor
   a. Select location to dig soil pit in first vegetation zone.
   b. Collect soil salinity sample adjacent to selected pit site and measure initial EC after about 5 minutes of settling time.
   c. Dig soil pit and describe soil profile. Record time when pit is complete so that total settling time of pit can later be determined. Flag pit. Take photo and GPS location of soil pit using tablet.
   d. Measure soil salinity sample. Rinse meters.
   e. Repeat steps a-d for each additional vegetation zone with >30% cover in AA and repeat steps b and d at for each vegetation zone with >10% cover in AA.
   f. Determine location(s) to collect waterbody data. Collect descriptive and handheld parameter data in up to three waterbodies at the site, sampling a variety of waterbody types if different types exist in the AA. Take photo and GPS location of soil pit.
   g. Collect water quality laboratory sample in waterbody most likely to have the largest influence on the site's overall hydrology.
   h. Pay attention to and record any mollusks encountered while collecting soil and water quality data. Conduct focused mollusk survey when other data collection is complete.
7) Botanist
   a. Conduct timed meander of AA. Record litter and water depth measurements during this process and come up with ground cover estimates and site sketch.
   b. Pay attention to and record any mollusks encountered during survey.
8) Walk 100 m buffer transects (whoever is done first)

WALK AROUND BUFFER AND AA AS NEEDED TO COMPLETE TASKS 9 TO 11. If one surveyor is done before the other, they may start the data collection for the components that are straight-forward, but will wait for their field partner to complete the remainder. For example, a surveyor may record *Not present* for most of the buffer stressors and then discuss with field partner the severity of a road and non-native cover stressors to finalize the stressor checklist.

9) Fill out stressor, structural features, and plant zone information.
10) Fill out wildlife and water quality functional metrics.
11) Fill out tablet field data.
12) Go through checklist before Leaving the Field (next page)

Checklist Before Leaving the Field

□ Ensure field forms are complete and submit tablet data.

□ 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, tapes, and ropes.

□ Make sure all spatial data and photos are record. Take photos of:

- Algae, litter, woody debris, and woody species regeneration
- Photos to illustrate unusual features or features that cannot be identified
- Any photos that may be illustrative for future training purposes

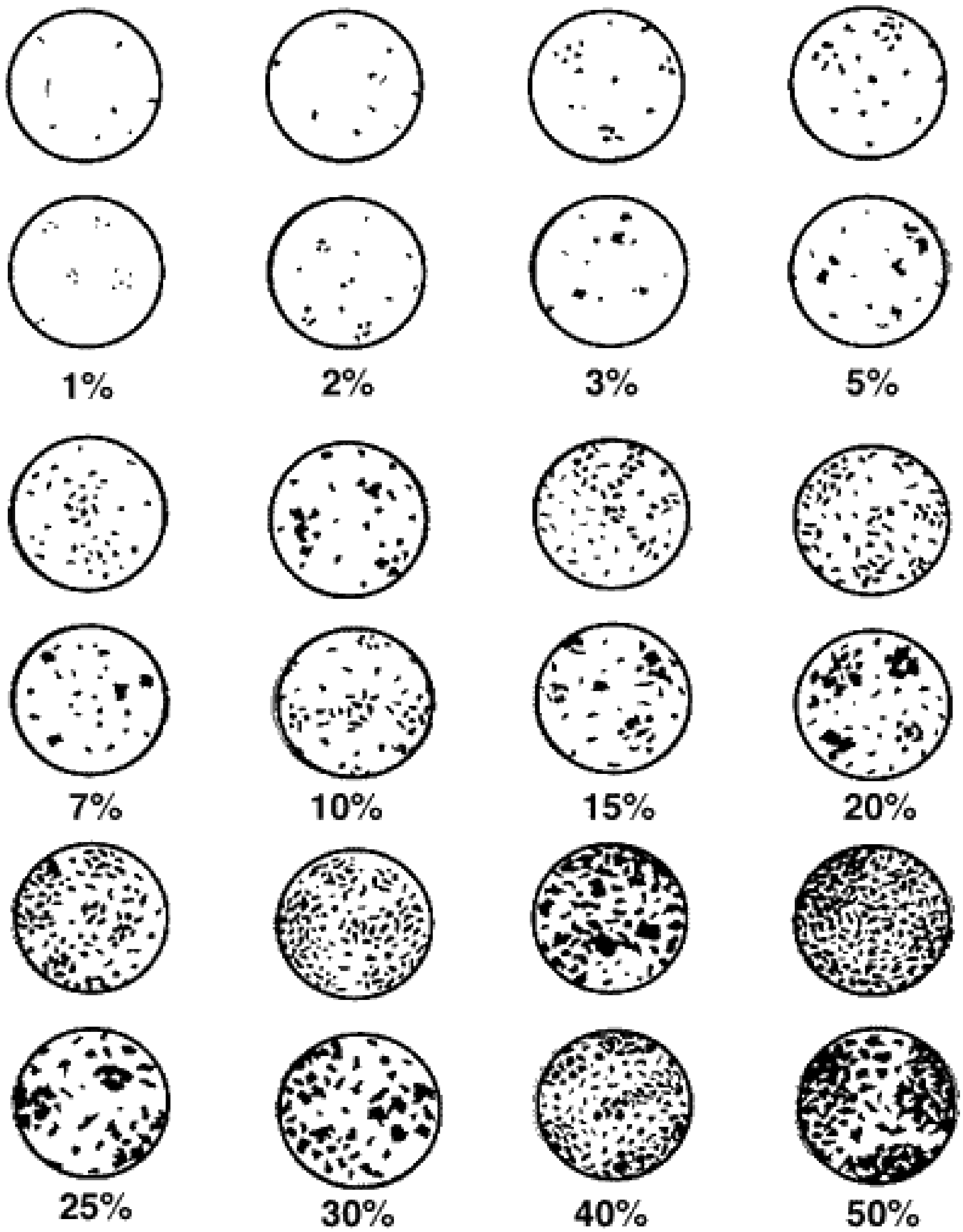
□ Collect all unknown plant species

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

□ Check to make to leave will field gear that you brought, especially

1. Tablet
2. Water quality meters
3. 50-m tape
4. Handheld tapes
5. Compasses
6. Soil auger

Plant Cover Reference Cards[1]



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

Noxious Weed List

Species in bold have been observed during UGS' program surveys. List and observed species information up-to-date as of June 2019.

Family	Scientific Name	Common Name	Growth Habit	Arid West	WMVC	Noxious Class
Apiaceae	**Cicuta douglasii**	**western water hemlock**	**forb**	**OBL**	**OBL**	**Duchesne**
Apiaceae	**Conium maculatum**	**poison hemlock**	**forb**	**FACW**	**FAC**	**3**
Asteraceae	Acroptilon repens	hardheads	forb			**3**
Asteraceae	**Arctium minus**	**lesser burdock**	**forb**	**FACU**	**UPL**	**Morgan, Summit**
Asteraceae	**Carduus nutans**	**nodding plumeless thistle**	**forb**	**FACU**	**UPL**	**3**
Asteraceae	Centaurea calcitrapa	red star-thistle	forb			1B
Asteraceae	Centaurea diffusa	diffuse knapweed	forb			2
Asteraceae	Centaurea melitensis	Maltese star-thistle	forb			1A
Asteraceae	Centaurea solstitialis	yellow star-thistle	forb			2
Asteraceae	Centaurea stoebe	spotted knapweed	forb			2
Asteraceae	Centaurea stoebe ssp. micranthos	spotted knapweed	forb			2
Asteraceae	Centaurea virgata	squarrose knapweed	forb			2
Asteraceae	Centaurea virgata ssp. squarrosa	squarrose knapweed	forb			2
Asteraceae	Chondrilla juncea	rush skeletonweed	forb			2
Asteraceae	**Cirsium arvense**	**Canada thistle**	**forb**	**FACU**	**FAC**	**3**
Asteraceae	**Cirsium vulgare**	**bull thistle**	**forb**	**FACU**	**FACU**	**Beaver, Iron, Wayne**
Asteraceae	**Ericameria nauseosa**	**rubber rabbitbrush**	**shrub**			**Garfield**
Asteraceae	Lactuca tatarica	blue lettuce	forb	FAC	FAC	Juab
Asteraceae	Lactuca tatarica var. pulchella	blue lettuce	forb			Juab
Asteraceae	**Leucanthemum vulgare**	**oxeye daisy**	**forb**	**UPL**	**FACU**	1B
Asteraceae	**Onopordum acanthium**	**Scotch cottonthistle**	**forb**			**3**
Asteraceae	Scorzonera laciniata	cutleaf vipergrass				1B
Boraginaceae	**Cynoglossum officinale**	**gypsyflower**	**forb**	**FACU**	**FACU**	**3**
Boraginaceae	Echium vulgare	common viper's bugloss	forb			1B
Brassicaceae	Alliaria petiolata	garlic mustard	forb	FACU	FACU	1B
Brassicaceae	Brassica elongata	elongated mustard	forb			1B
Brassicaceae	Brassica tournefortii	Asian mustard	forb			1B
Brassicaceae	Cardaria	whitetop				**3**
Brassicaceae	Cardaria chalepensis	lenspod whitetop	shrub			**3**
Brassicaceae	**Cardaria draba**	**whitetop**	**forb**			**3**
Brassicaceae	Cardaria pubescens	hairy whitetop	forb	UPL	FACU	**3**
Brassicaceae	Hesperis matronalis	dames rocket	forb	FACU	FACU	4
Brassicaceae	**Isatis tinctoria**	**Dyer's woad**	**forb**			2
Brassicaceae	**Lepidium latifolium**	**broadleaved pepperweed**	**forb**	**FAC**	**FAC**	**3**
Chenopodiaceae	Halogeton glomeratus	saltlover	forb			Washington

Clusiaceae	Hypericum perforatum	common St. Johnswort	forb	FACU	FACU	1B
Convolvulaceae	Convolvulus	bindweed				**3**
Convolvulaceae	**Convolvulus arvensis**	**field bindweed**	**forb**			**3**
Convolvulaceae	Convolvulus equitans	Texas bindweed		FACU	FACU	**3**
Cyperaceae	Cyperus esculentus	yellow nutsedge	sedge	FACW	FAC	Davis
Elaeagnaceae	**Elaeagnus angustifolia**	**Russian olive**	**tree**	**FAC**	**FAC**	4
Euphorbiaceae	Euphorbia esula	leafy spurge	forb			2
Euphorbiaceae	Euphorbia esula var. esula	leafy spurge	forb			2
Euphorbiaceae	Euphorbia myrsinites	myrtle spurge	forb			4
Fabaceae	Alhagi maurorum	camelthorn	shrub	FAC	FAC	1B
Fabaceae	Cytisus scoparius	Scotch broom	shrub			4
Fabaceae	Cytisus scoparius var. scoparius	Scotch broom	shrub			4
Fabaceae	**Galega officinalis**	**professor-weed**	**forb**			1B
Lamiaceae	Salvia aethiopis	Mediterranean sage	forb			1A
Lythraceae	**Lythrum salicaria**	**purple loosestrife**	**forb**	**OBL**	**OBL**	2
Poaceae	Aegilops cylindrica	jointed goatgrass	grass			**3**
Poaceae	Arundo donax	giant reed	grass	FACW	FACW	1B
Poaceae	Cynodon dactylon	Bermudagrass	grass	FACU	FACU	3 (not WA)
Poaceae	**Elymus repens**	**quackgrass**	**grass**	**FAC**	**FAC**	**3**
Poaceae	Imperata cylindrica	cogongrass	grass		FACU	4
Poaceae	**Phragmites australis**	**common reed**	**grass**	**FACW**	**FACW**	**3**
Poaceae	**Phragmites australis ssp. australis**		**grass**	**FACW**	**FACW**	**3**
Poaceae	Sorghum almum	Columbus grass	grass			**3**
Poaceae	Sorghum halepense	Johnsongrass	grass	FACU	FACU	**3**
Poaceae	Taeniatherum caput-medusae	medusahead	grass			2
Poaceae	Ventenata dubia	North Africa grass	grass			1A
Polygonaceae	Polygonum cuspidatum	Japanese knotweed		FACU	FACU	1B
Scrophulariaceae	Linaria dalmatica	Dalmatian toadflax	forb			2
Scrophulariaceae	Linaria dalmatica ssp. dalmatica	Dalmatian toadflax	forb			2
Scrophulariaceae	Linaria vulgaris	butter and eggs	forb			2
Solanaceae	Hyoscyamus niger	black henbane	forb			2
Solanaceae	Solanum elaeagnifolium	silverleaf nightshade				Washington
Solanaceae	Solanum rostratum	buffalobur nightshade	forb			Davis, San Juan
Tamaricaceae	**Tamarix**	**tamarisk**	**tree**			**3**
Tamaricaceae	Tamarix aphylla	Athel tamarisk		FAC	FACW	**3**
Tamaricaceae	**Tamarix chinensis**	**five-stamen tamarisk**	**tree**	**FAC**	**FAC**	**3**
Tamaricaceae	Tamarix parviflora	smallflower tamarisk		FAC	FACW	**3**
Tamaricaceae	Tamarix ramosissima	saltcedar				**3**
Zygophyllaceae	Tribulus terrestris	puncturevine	forb			**3**

Key to Ecological Systems

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 (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 (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 (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 (Great Basin Woodland)**

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 (Interdunal Swale)**

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 (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 (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 (Alkaline 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 (Emergent Marsh)**

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**

[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.

Seasonally Saturated (B): The substrate is saturated at or near the surface for extended periods during the growing season, but unsaturated conditions prevail by the end of the season in most years. Surface water is typically absent, but may occur for a few days after heavy rain and upland runoff.

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.

Continuously Saturated (D): The substrate is saturated at or near the surface throughout the year in all, or most, years. Widespread surface inundation is rare, but water may be present in shallow depressions that intersect the groundwater table, particularly on a floating peat mat.

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:

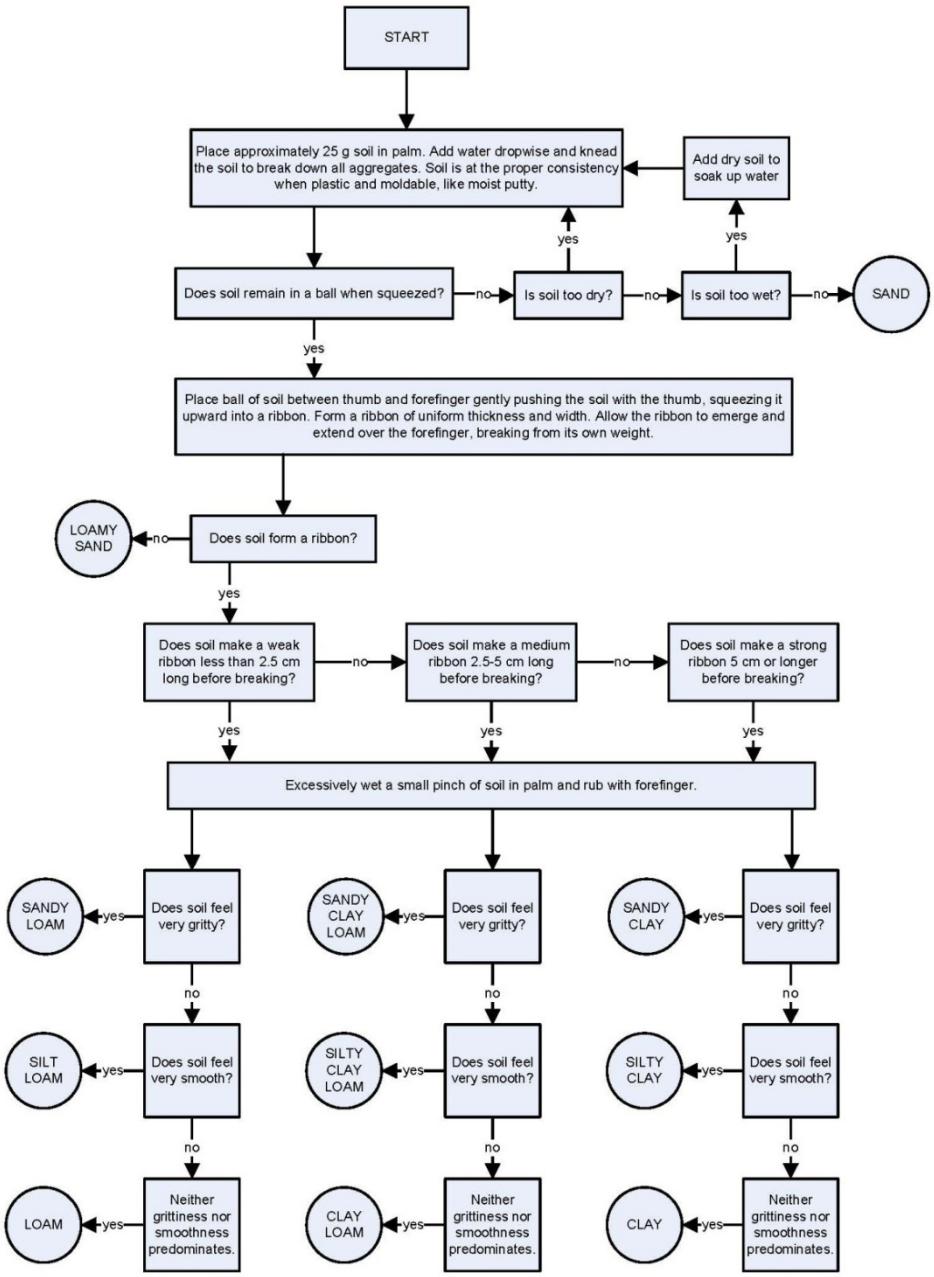
1. Determine strata (vegetation layers) present in the area. Strata include trees (DBH ≥7.6 cm), saplings and shrubs (DBH < 7.6 cm), herbaceous plants, and woody vines.
2. Estimate the percent of the assessment area covered by each strata. For example, all tree species combined (including trunks and 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.

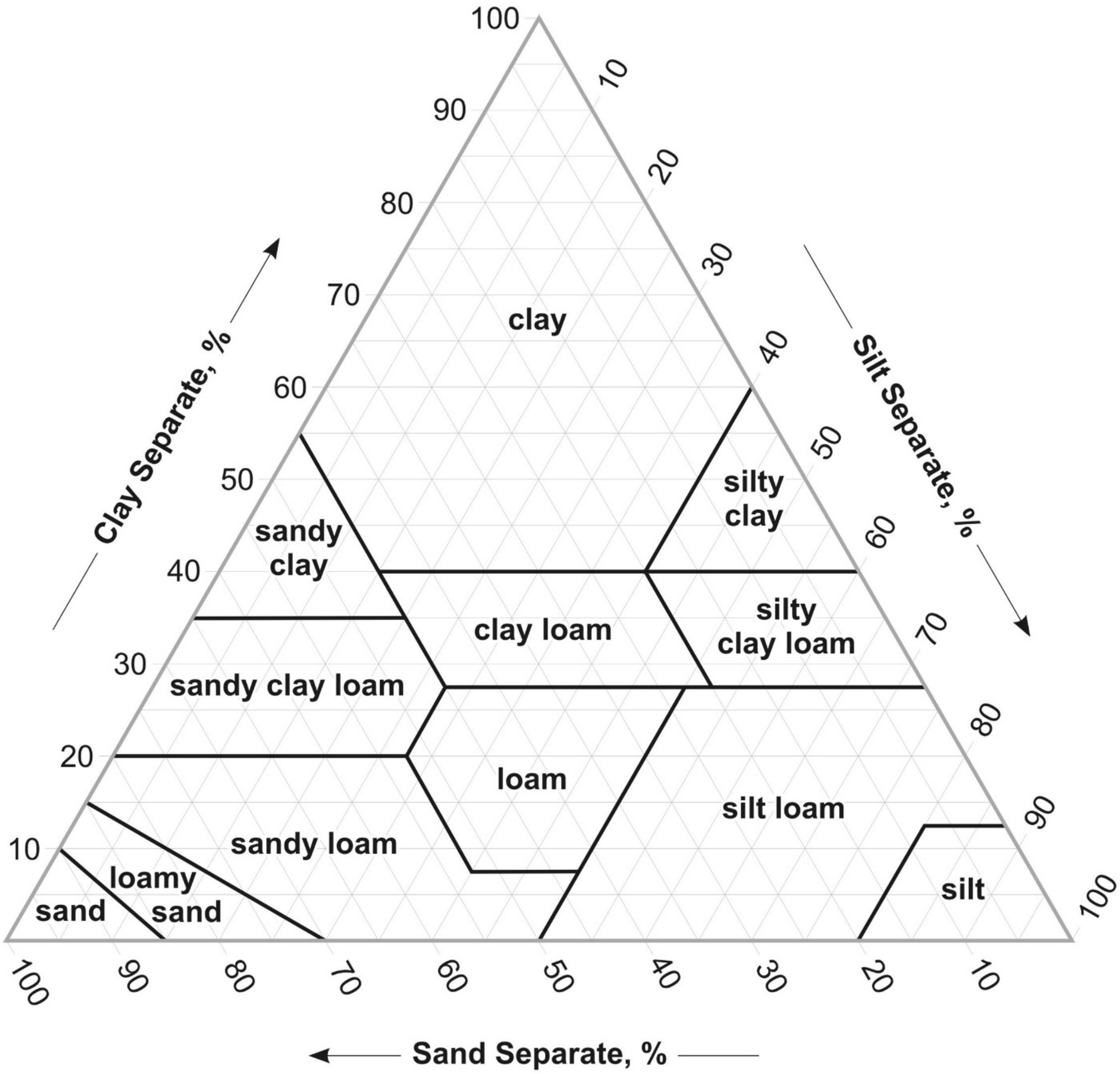
Indicator	Description	Type
Group A – Observation of Surface Water or Saturated Soils		
A1 – Surface water		**P**
A2 – High water table	Within 30 cm of the soil surface	**P**
A3 – Saturation	Within 30 cm of soil surface (i.e., glistening or water shakes off soil), with water table or restrictive soil 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



[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?**

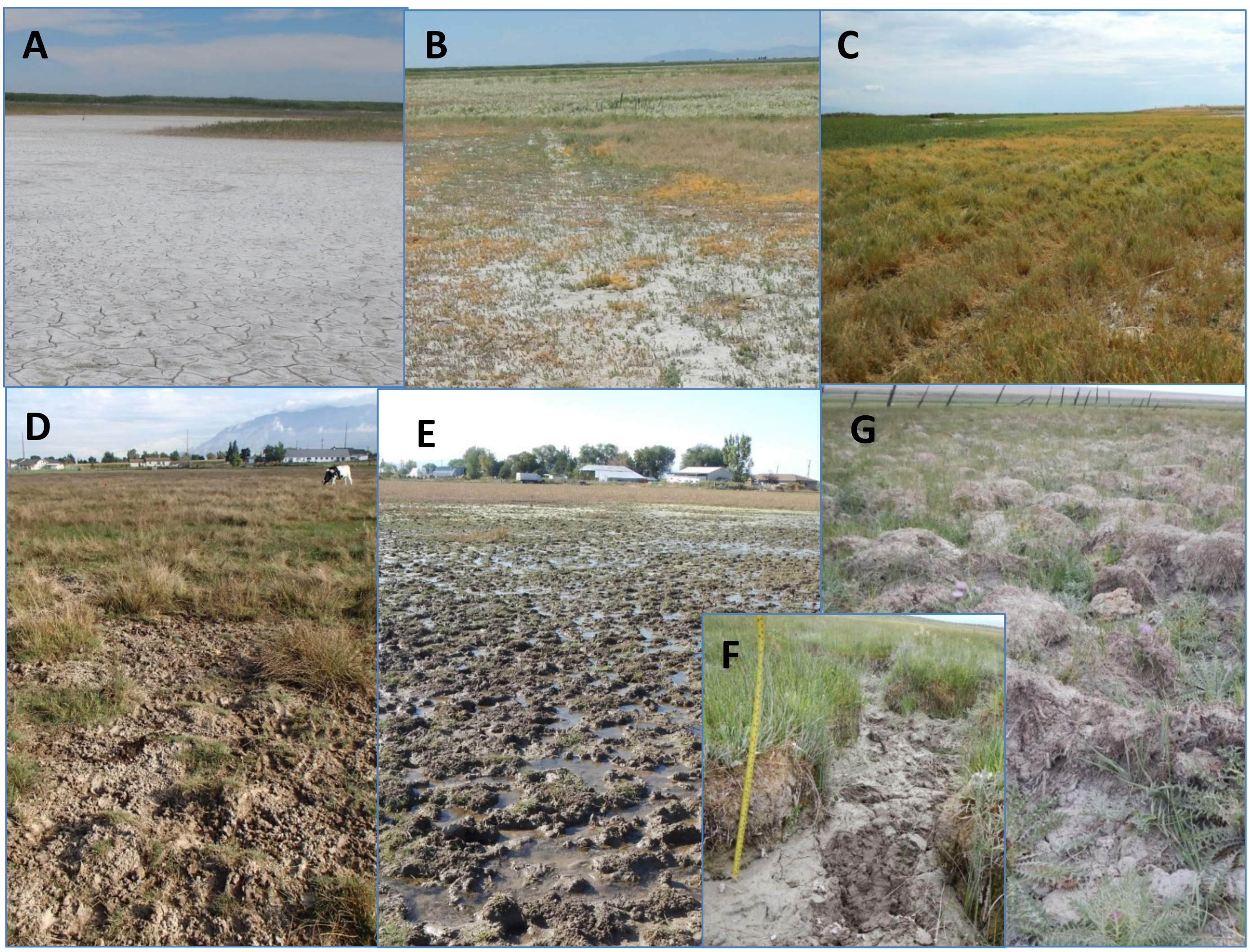
Explanation of figures:

A is a site with naturally bare soil and no signs of soil disturbance, 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.

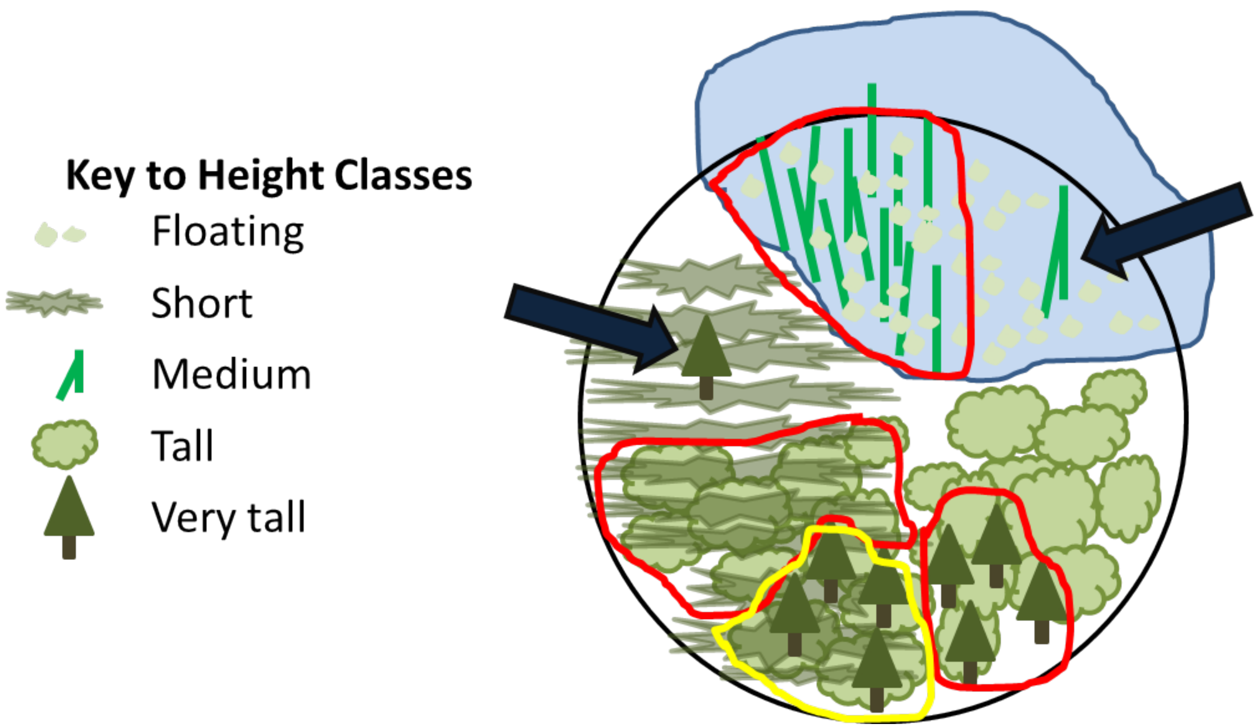
C shows tracks through vegetation. If vegetation is merely toppled over due to tracks, site may be scored as A. If vegetation is stunted or not growing due to compaction, site would likely score as B. May need to also take into account depth of any soil damage.

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.



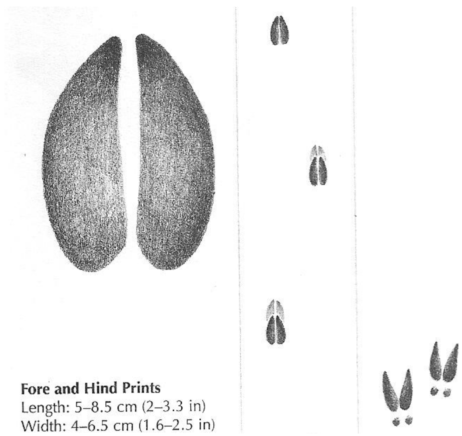
Reference Card for Overlap Estimates

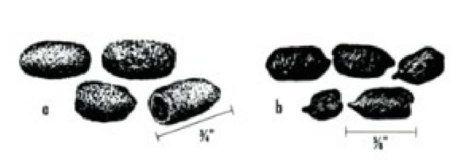
The diagram below shows a potential assessment area (bounded by black lines) with the distribution of different height classes of vegetation. The assessment area should be divided into regions with different overlap statuses before making overlap estimates. In the example below, areas with overlap of two heights are circled in red and three heights area 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.



Wild and Domestic Ungulate Tracks

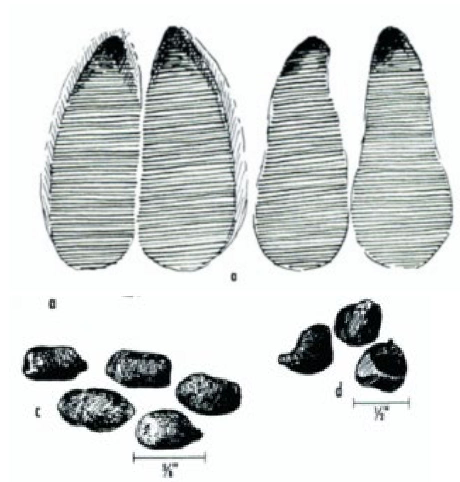
Mule Deer





2-3.3 in. L
1.6-2.5 in. W
Overall heart-shaped track.
Scat: More uniform and rounded than sheep.

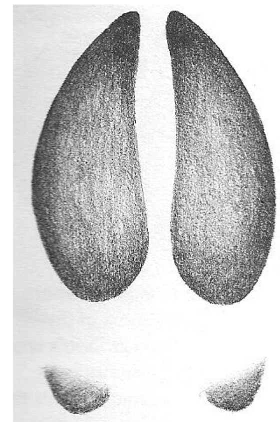
Domestic Sheep



2.5-3 in. L

Most similar in size to deer, but with front tips close to the centerline of each hoof half rather than heart-shaped. Overall blocky shaped track (if box was drawn around track, tips of hooves will extend closer to box edges than those of a deer). **Scat: More irregular and acorn-shaped than deer.**

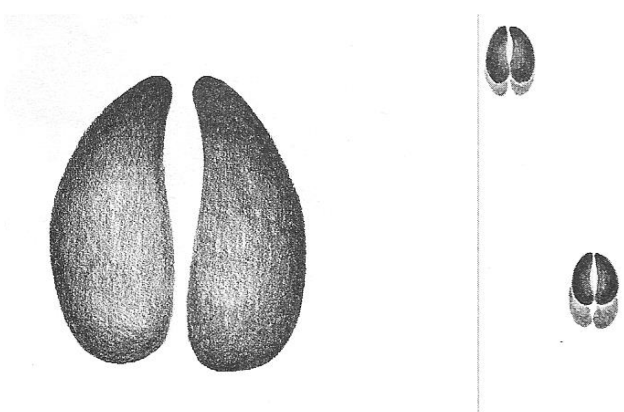
Moose



4-7 in. L
11 in. L (with dewclaws)
3.5-6 in. W

Prints generally larger than other ungulates and less rounded than elk, overall wider straddle. Juvenile moose tracks can be confused with elk. Scat: pellet form in piles, larger pellets and pile size than elk.

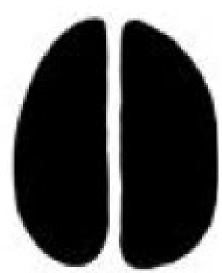
Elk



3.5-5 in. L
2.5-4.5 in. W

Usually neat, rounded print. Adult elk stride: 16-34 in. Scat: pellet form in piles, larger than deer or goat droppings.

Domestic Cow



4-5 in. L
3.25-4.5 in. W

Tracks most similar in size to elk or small moose, but more rounded and cows have with distinct globular scat rather than pellets. However calf track can be confused with adult elk. Stride is usually smaller in calf than in elk of comparable size. Calf stride: 20.5-22.5 in. Scat: large globular form.

Other tips:
-Pronghorn antelope tracks (possibly confused with deer) have concave sides along the length of the hoof as opposed to the convex sides of a deer.
-A bighorn sheep tracks is wedge-shaped when compared to the heart-shaped track of a deer or more box-shaped track of a sheep.

APPENDIX B

Utah Rapid Assessment Procedure Field Forms

2018 UTAH RAPID ASSESSMENT PROTOCOL FIELD SURVEY FORM

LOCATION AND GENERAL SITE INFORMATION

Unique Site ID: _____________________ **Site Name**:____

Date (mm/dd/yyyy): ___________________________**Surveyor IDs**: _____________________________________

AA Dimensions:
__ 40-m radius circle
__ Rectangle, width___, length___
__ Freeform (collect GPS track of edge)

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 BR-101-SOIL1, but can be listed below 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

Basin and Range Ecological System (pick only one) Fidelity: High Med Low
___ Emergent Marsh ___ Great Basin Wood/Shrub ___ Greasewood Flat ___ Playa ___ Alkaline Depression
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	**Stream Flow Duration**
______ Confined Valley Setting (valley width < 2x bankfull width)	______ Perennial
______ Unconfined Valley Setting (valley width ≥ 2x bankfull width)	______ Intermittent
AA Proximity to Channel	______ Ephemeral
AA includes: ___ channel and one bank ___ channel and two banks	**Stream Depth at Time of Survey (if evaluated):**
___ no channel and one bank ___ no channel and no bank	**Channel is :** Dry In Pools Only Flowing
For sites with no channel, record distance from AA edge to channel center: ______ m	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:

URAP WETLAND CONDITION METRICS

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.

Comments:

Buffer Width (Evaluate up to 100 m from AA edge

Transect	Length (m)	Rank	State
N		A	Mean width >95 m
NE		A-	Mean width >75 and ≤95 m
E		B	Mean width >50 and ≤75 m
SE		C	Mean width >25 and ≤50 m
S		D	Mean width <25 or no buffer exists
SW		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)	
W			
NW			
Mean			

Comments:

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 impact.
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.

Comments:

Buffer Condition-Vegetation (Evaluate in *buffer land cover only* within 100-m of AA edge; collect dominant plant species if nativity 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.

Comments:

Percent Intact Landscape- buffer land cover within 500-m and directly connected to site

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.

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.
Comments:	

HYDROLOGIC CONDITION	
Major Water Sources (only check those that are substantial contributors to sites, put a star by dominant water source)	
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/high groundwater from spring or seep	___ irrigation via tail water run-off (irrigation return flows)
___ alluvial aquifer (elevated water table, us. near river/stream)	___ discharge from impoundment release
___ natural surface flow	___ urban run-off/culverts
___ direct precipitation	___ pipes directly feeding wetlands
___ direct snowmelt	___ other (list)_________________________________

Timing of Inundation	
Rank	**State**
A	Site has no to very little deviation from natural inundation 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. Majority of inflow timing during growing season is natural or shift in inundation timing of hours up to several days. Some examples include accelerated timing of input from straightened channels, small/distant impervious surfaces, delayed timing from regulation on tributaries, small additions from irrigation seepage or tailwater, or moderate additions for sites receiving water from irrigation channels or impoundment releases.
C	Site has a moderate shift in inundation timing. Shift in timing of several days up to three weeks, or unusual moderate inputs of water in the middle of the growing season, or large additions near the end of the growing season. Some examples include accelerated timing from moderate/large impervious surfaces in contributing area, delayed timing from water regulation in close proximity to site, moderate inputs of irrigation water via seepage or tailwater runoff in additional to naturally timed influxes of water or large levees of inundation in the fall in artificial impoundments that are otherwise managed in a more seasonally appropriate manner.
C-	Sites have a large shift in inundation timing. Shift in timing of three weeks up to two months or inundation timing is somewhat natural 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. Timing characterized by near absence of naturally timed inputs with site receiving majority of water from irrigation return-flows, wastewater effluent, or other industrial outfall source or site managed with very little regard for natural timing of water inputs.
D	Sites have an extreme shift in inundation timing. Shift in 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. Some examples include springs that have gone completely dry due to groundwater extraction, or former floodplain wetlands that only receive water when up-stream impoundments are released.
Comments:	

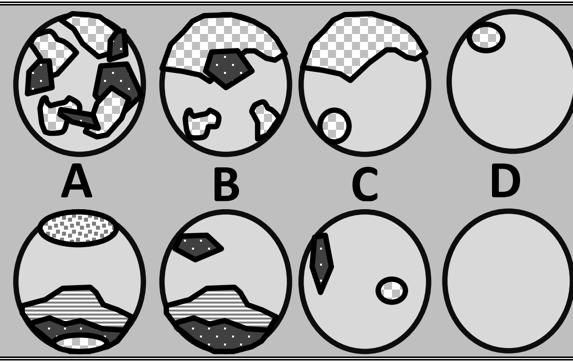
Hydroperiod (Evaluate state in relation to natural hydroperiod- i.e. a week change in duration is much longer for a playa than for a marsh)	
Rank	**State**
A	The hydroperiod, including frequency and duration of inundation and drawdown, within the AA is natural. There are no major hydrologic stressors 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 experience 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)
Comments:	

Turbidity and Pollutants (evaluate visual signs of degradation not considering algae)	
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
Comments:	

Algae Growth. Evaluate areas with standing water, as well as areas that obviously recently had standing water, such as drying pond edges or areas with dried algal mats. Lack of dried algal mats in the absence of surface water should not be taken as evidence of an *A* or *B* rating for this metric. Take photo if rated below B. Ignore macroalgae (*Chara* spp.) in the evaluation.			
Rank	**State- Surface Water**		
NA	No surface water at site and no evidence of dried algal mats in recently inundated areas.		
A	Water is clear with minimal algal growth. Dried algal mats, if present, minimal.		
B	Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness. Dried algal mats, if present, minimal.		
C	Algal growth occurs in moderate to large patches throughout the AA. Water may have a moderate greenish tint or sheen. Site may have evidence of moderate to large patches of dried algae mats in recently inundated areas.		
D	Algal mats are extensive, blocking light to the bottom. Water may have a strong greenish tint and the bottom is difficult to see. Site may have evidence of extensive dried algal mats in recently inundated areas.		
Comments:			

Connectivity (Evaluate both for the area immediately adjacent to the AA edge and the whole-wetland. Whole-wetland is considered as full extent of wetland area beyond the AA edge. If wetland area is very large (i.e.-large impoundment or fringe) make a note and only consider area within 500m of AA edge. 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.
Y N	Only 500 m area was considered when evaluating the "whole wetland"	
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.** *All Sites:* 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). *For Sites receiving most water from channels:* 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.** *All Sites:* Within the AA, some minor dung and soil disturbance from livestock (if grazing impacts very light, may be an A); up-gradient stressors within 500 m of site are minor, 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:* The 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.*** *All Sites:* Within the AA, moderate dung and soil disturbance from livestock 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 slope leading to the site and the land cover between the stressor and the site; vegetated very low slope may be B and unvegetated very steep slope may be D). *For sites receiving most water from channels:* The entire contributing area has ~20-60% development or cropland, though these land uses are less prevalent within 2 km of site, or has a moderate number of oil and gas wells, mines, or point source dischargers that are distant from site or only a few that are closer streams and lakes that contribute to the site are not listed on the 303d or are listed, but water quality is likely to be attenuated or improved before reaching the wetland by passing through reservoirs or emergent vegetation.
D	**Site likely to receive substantial water quality stressors.** *All Sites:* Stressors may include: high levels of dung and soil disturbance from livestock within AA or, up-gradient stressors such as irrigation return flow water, fertilizer and pesticide application, and erosion from fires, construction, off-road vehicles, and dirt roads *discharging directly into sites.* May be considered C if run-off from the features is likely to occur infrequently, if slope is shallow, or if only a small area of the AA receives these 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). *For sites receiving most water from channels:* The entire contributing area has>60% development or cropland, a high number of oil and gas wells, mines, or point source dischargers; or streams and lakes that directly contribute to the site are listed as impaired on the 303d list.
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.**	

Rank	State
A	High degree of horizontal interspersion. AA is characterized by a complex array of nested or interspersed zones. AA has both a high number of zones and a high degree of interspersion of those zones.
B	Moderate degree of horizontal interspersion.
C	Low degree of horizontal interspersion
D	Minimal horizontal interspersion. AA characterized by one dominant zone with little to no other zones.
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.
Comments:	

Woody Debris

NA	There are no obvious inputs of woody debris and none are expected for the wetland type. 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. A wide size-class diversity of downed woody debris and standing snags is present and common where expected. 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.
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.
Comments	

Woody Species Regeneration Age Classes
Information for guidance only; 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.

Class	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

VEGETATION COMPOSITION

Relative Cover of Native Plant 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
Comments:	

Absolute Cover of Noxious Weeds (see current noxious species list)	
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.
Comments:	

Amphibian Habitat Metrics- Columbia Spotted Frog

	Columbia Spotted Frog Breeding Waterbodies *Within AA*
A	Waterbodies large enough not to dry up in summer and deep enough not to freeze solid at night during the breeding season 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 (likely to freeze or dry up).
C	Lotic systems (rivers or streams) OR lentic but very small or uniformly shallow (e.g., temporary pools, small puddles).
D	No surface water typically present at site (skip the next two metrics).

	Waterbody substrate (Check manually, considering only waterbody scored in metric above)
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 OR substrate is hard-packed mud or silt.
D	Cobble, boulder, or bedrock predominant substrate with deep mud/silt absent.

	Vegetation growing in waterbody shallows (areas <1 m deep) in waterbodies scored in metric above
A	At least 20% of waterbody shallows have some type of emergent, floating, or submerged 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).
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).
D	No or <1% vegetation in waterbody shallows or emergent vegetation densely covers entire waterbody.

	Presence of North Shore (Long Axis of Waterbody). Use compass to orient sitemap to North.
A	Ample north shore present (shore on north side of waterbody).
B	Moderate amount of north shore present.
C	Minor amount of north slope present.
D	Little or no north shore present.

	Slope and Water Depth Near Shore (including part of shore in AA and main waterbody outside AA)
A	Mostly gentle slopes and/or large area, esp. along north shores, with gentle slopes; water <10 cm common. Changes in water levels typically lead to much greater horizontal rather than a vertical change.
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.
C	Gentle slopes present, but uncommon. Few areas with water <10 cm deep.
D	All shorelines with steep slopes OR water <10 cm not present.

	Waterbodies *within 100 m of AA* for overwintering habitat (needs non-freezing water and oxygenation)
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 freeze some years; 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		**Distance to impervious surface from AA (pavement, gravel)**
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

		Mining
Y	N	Evidence of current/historic mining in AA or buffer (mine tailings, mine shafts, etc.)?

Columbia spotted frog metric notes:

URAP Stressors and Topographic Complexity Field Form

Site ID:___________________ **Date:________________________**

BUFFER DISTURBANCES: **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 estimated disturbances. Search an area about 1 m to either side of transect. Record sources of bare patches, if present, in comments.**

Transect Direction (N, E, etc.)	% Walked or Able to be Estimated	# of Cow Patties	Livestock trails	Livestock prints / pugging >22 cm deep	Unnatural bare soil patches at least 1 m^2 (comment on source)
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed
		0 1-10 >10-100 >100	Present Not observed	Present Not observed	Present Not observed

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**	Severity: Hydroperiod	Severity: Water Contaminates Nutrients / toxins	Severity: Sedimentation	Severity: Vegetation Stress
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			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				

URAP Stressors and Topographic Complexity Field Form

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				
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-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		
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:		
Comments:		

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
	Salt flat/alkali flat	Dry open area of fine-grained sediment and accumulated salts. Often wet in the winter months or with heavy precipitation.			
	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.			
	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.			
	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.			
	Plant hummocks (naturally formed)	A mound composed of plant material resulting in a raised pedestal of persistent roots or rhizomes.			
	Sediment mounds	Depositional features formed from repeated flood flows depositing sediment on the floodplain, similar to hummocks but lacking plant cover.			
	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
	River/stream	Areas of flowing water associated with a sizeable channel			W D
	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
	Oxbow/backwater channel	Areas holding stagnant or slow moving water that have been partially or completely disassociated from the primary river channel.			W D
	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
	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.			

URAP Stressors and Topographic Complexity Field Form

Structural Patch		Description	% Cover	Patch Size (m^2)	Wet or Dry?
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.			

Comments

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

Comments and list features creating microtopography:

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"; cover should add up to 100%

Type: E for emergent, S for Scrub-scrub, F for forested, AB for aquatic bed/floating, and O for other

If Other, 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); B (seasonal sat.); D (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:____

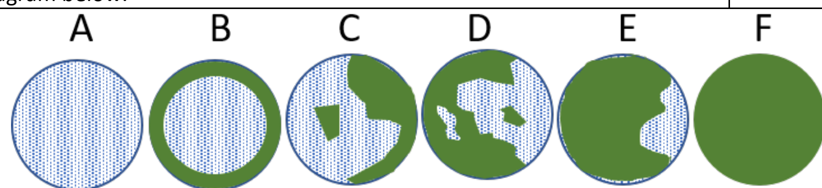
P6: Type: E S F AB O Regime: _____ Dominant Species:_________________________________ Height:______ cm % AA:____

Site ID:	Survey Date:	
Species Observations: Score based on observations of *wildlife* and *wildlife signs* (e.g. footprints, scat, beaver dams, etc.) within the assessment area. Do not record species that are merely flying over or are adjacent to the site. Record the common names of species to the highest level of detail known (e.g., red-tailed hawk vs. hawk vs. raptor vs. bird).		
Present?	**Functional Group**	**Observation Notes and Common Name**
Bird Groups		
Y N	Piscivorous birds (e.g., gull, tern, grebe, cormorant, pelican)	
Y N	Diving ducks (e.g., redhead, goldeneye, ruddy duck)	
Y N	Dabbling ducks (e.g., mallard, pintail, cinnamon teal)	
Y N	Ducks, unknown group	
Y N	Wading birds (e.g., egret, heron, ibis)	
Y N	Secretive marsh birds (e.g., moorhen, coot, sora, rail, bittern)	
Y N	Shorebirds (plover, sandpiper, stilt, avocet)	
Y N	Other bird species	
Other Wildlife		
Y N	Reptiles (snake, lizard, turtle)	
Y N	Amphibians (frog, toad, salamander, including tadpoles)	
Y N	Fish	
Y N	Dragonflies/damselflies	
Y N	Beaver or evidence of beaver activity (dams, gnawed logs)	
Y N	Non-beaver mammals (deer, raccoon, coyote, etc.)	
Y N	Mollusks (if snail, record whether left or right-handed)	
Y N	***Were mollusk-specific surveys conducted?***	
Y N	Other wildlife	

Wetland Characteristics. Evaluate statements based on conditions within the AA unless stated otherwise.		
	LANDSCAPE CONTEXT	
LC2	Barriers (such as above-grade culverts, levees) impeding aquatic connectivity are nonexistent or easily passed by most aquatic animals (e.g., fish, tadpoles). Evaluate connectivity between AA and surrounding waterbodies, at a distance up to 100-m from the AA. N/A = no or insubstantial surface water.	True False N/A
LC3	30-m buffer of relatively intact vegetation and soils extends along at least 90% of the site perimeter (no roads [low-use vegetated tracks okay], minimal unnatural bare soil, etc.)	True False
LC4	Site is surrounded by buffer land cover for 300 m in all directions. See list of buffer land covers.	True False
LC5	At least 2/3rds of area within 1 km of site is *directly connected* via buffer land to site and does not have high intensity development (e.g., urban/industrial areas, paved roads), high-intensity agriculture (excluding haying/pasture), or high-intensity recreation (e.g., golf courses, ball fields).	True False
	SITE DISTURBANCE	
SD1	Site not grazed or only lightly grazed by livestock or wild horses. Look for signs of pugging, browsing, and manure.	True False
SD2	Site does not appear routinely disturbed by activities such as mowing, mechanical plant removal, vehicle travel, dredging, excavation, filling of sediment, etc.	True False
SD3	No evidence of regular recreational use at site (based on trash, social trails, ATV tracks, fire rings, etc.).	True False
	WATER QUALITY AND HYDROLOGY	
WQ1	Water quality at site appears good. Site does not have excessive (>20% cover) filamentous algae or evidence of turbidity, unnatural oil sheens, or other pollutants. N/A = no or insubstantial surface water; minimal dried algae.	True False N/A
WQ2	There are no apparent hydrologic manipulations within site that are likely to artificially reduce water levels (drainage, spring boxes, etc.) or severely alter water timing.	True False
WQ3	Site has perennial stream or canal within boundary or directly touching site edge.	True False
WQ4	Wetland includes springs that flow most of the year.	True False
WQ5	Shores of seasonally or permanently inundated waterbodies (streams, pools, ponds, lakes) are predominantly gradual so that small changes in the amount of water lead to large increases or decreases in inundated area. See images associated with amphibian metrics. N/A = no waterbodies (make T/F if waterbodies present but dry)	True False N/A
WQ6	Site has areas of seasonally flooded or permanent open water (unvegetated, submergent, or floating species only) with structural features above the high water mark such as tufted litter, logs, or rocks. N/A = no or insubstantial surface water.	True False N/A
WQ7	Submerged aquatic vegetation is present.	True False

HABITAT TYPES PRESENT *AT SITE* (OR ADJACENT/WITHIN 1 KM IF SPECIFIED BY INDICATOR)			
	Habitat type must be present in the indicated depth range in majority of spring (April, May, June) or Fall (July, August, September). Within AA, habitat must occupy at least 5% of the assessment area and no more than 10 patches can be combined to meet the size threshold. ($10\ m^2$ in a standard 40-m radius AA). Within 1 km of AA, each habitat patch must occupy at least $1000\ m^2$. Cowardin classification codes that *may* indicate presence of a class are listed under each habitat type, though the same code could indicate more than one habitat type.	**In AA?**	**Within 1 km of AA?**
HT1	**Deep open water**. Slow or not flowing open water with depth >35 to 100+ cm. Can have submergents or floating species, but no emergent species (i.e. cattails, sedges, rushes). Map codes: UB or AB class, F, G, or H water regimes.	True False	True False
HT2	**Shallow open water** . Slow or not flowing open water with depth >10 to 35 cm, usually with submergent vegetation but no emergents. Map codes: UB or AB class, F, G, or H water regimes.	True False	True False
HT3	**Deep emergent water.** Emergent vegetation in water depth of >25 to 60 cm. Map codes: PEMF or PEMG.	True False	True False
HT4	**Shallow emergent water.** Emergent vegetation in water depth 5 to 25 cm). Map codes: PEMF or PEMG.	True False	True False
HT5	**Tall emergent water**. Emergent vegetation at least 0.75 to 2 m tall in water depth of 5 to 25 cm. Map codes: PEMF or PEMG. May be same as shallow emergent water. Map codes: PEMF or PEMG.	True False	True False
	Interspersed emergent vegetation: Areas with interspersion between emergent vegetation in standing water and open water, with approximately 20 to 50% emergent species and the remaining water. Water depth between 5 and 60 cm. See diagram below.	True False	True False

C and D are considered interspersed emergent vegetation. A and F only have one habitat type, B has no interspersion of the vegetation, and E has too much emergent with no interspersion.



HT6	**Partially vegetated mudflat.** Area seasonally flooded and then exposed with 0 and 5 cm water depth. Mudflats may have species such as saltgrass, pickleweed, or seepweed, but will not be densely vegetated with build-up litter. Map codes: US class, A or C water regime.	True False	True False
HT7	**Wet meadow.** Fresh, saline, or alkaline wet meadows that are saturated or with intermittent shallow surface flooding. Typical meadow species include sedges, rushes, and a mixture of grass species. Map codes: PEM with A, B, C, D, or E water regimes.	True False	True False
HT8	**Natural upland** within 5 meters from edge of AA and connected by buffer land cover to AA (mark under *In AA*) or within 1 km of AA. Natural uplands include all upland buffer land.	True False	True False

STRUCTURAL FEATURES		
SF1	Undercut banks are present at site along intermittent or perennial watercourses (streams, ponds, lakes). N/A = no watercourses)	True False N/A
SF2	Roosting structures, such as trees, shrubs, and standing snags, are available within site or immediately adjacent (within 5 m from edge and connected by buffer land cover).	True False
SF3	Animal burrows are readily apparent at site.	True False
SF4	Features such as logs, tufted litter, and rocks that provide structural complexity are present in areas of AA that are dry most of the growing season and typically have <5 cm standing water when wet. N/A = no dry areas present	True False N/A

VEGETATION		
VE1	Site has a diversity of plant species. Site not a near “mono”culture of one or two predominant herbaceous or graminoid species (comprising about 80% of the total herbaceous/graminoid cover) with other species rare. N/A = site largely unvegetated).	True False N/A
VE2	Noxious weeds are uncommon or absent (only one or a few individuals).	True False
VE3	Site includes bulrush species such as *Schoenoplectus acutus*, *S. americanus*, or *S. maritimus*.	True False
VE4	Trees (woody species with DHB >7.5 cm).are growing in AA or immediately adjacent (within 5 m from edge and connected by buffer land cover).	True False
VE5	Wetland shrubs are growing within site (woody species with DBH<7.5 cm).	True False
VE6	Woody vegetation recruitment healthy. Mixture of age classes (i.e., seedling, sapling, adult) present. Vegetation not limited to decadent/dying individuals. Examples of decadent vegetation include mushroom-shaped shrubs and very short woody plants with thick bases (from repeatedly being grazed or mowed down). N/A = <5% woody species cover *and* no evidence that woody species would be more common without anthropogenic stressors.	True False N/A

DEPRESSIONAL WETLANDS **Water Quality Functions** - Indicators that the site functions to improve water quality	Points (only 1 score per box)
D 1.0. Does the site have the potential to improve water quality?	
D 1.1. Characteristics of surface water outflows from the wetland: Wetland has no surface water outlet — points = 5 Wetland has an intermittently flowing outlet — points = 3 Wetland has a highly constricted permanently flowing outlet — points = 3 Wetland has a permanently flowing, unconstricted, surface outlet — points = 1	
D 1.2. The soil 2 in below the surface (or duff layer) is true clay or true organic *(use NRCS definitions of soils)* YES = 3 NO = 0	
D 1.3. Characteristics of persistent vegetation (Emergent, Scrub-shrub, and/or Forested Cowardin classes) Wetland has persistent, ungrazed, vegetation for > $^2/_3$ of area — points = 5 Wetland has persistent, ungrazed, vegetation from $^1/_3$ to $^2/_3$ of area — points = 3 Wetland has persistent, ungrazed vegetation from $^1/_{10}$ to < $^1/_3$ of area — points = 1 Wetland has persistent, ungrazed vegetation < $^1/_{10}$ of area — points = 0	
D 1.4. Characteristics of seasonal ponding or inundation: *This is the area of ponding that fluctuates every year. Do not count the area that is permanently ponded.* Area seasonally ponded is > ½ total area of wetland — points = 3 Area seasonally ponded is ¼ - ½ total area of wetland — points = 1 Area seasonally ponded is < ¼ total area of wetland — points = 0	
Total for D 1 — Add the points in the boxes above	

Rating of Site Potential If score is:____**12- 16 = H** ____**6- 11 = M** ____ **0- 5 = L** *Record the rating on the first page*

D 2.0. Does the landscape have the potential to support the water quality function of the site?	
D 2.1. Does the wetland receive stormwater discharges? Yes = 1 No = 0	
D 2.2. Is > 10% of the area within 150 ft of the wetland in land uses that generate pollutants? Yes = 1 No = 0	
D 2.3. Are there septic systems within 250 ft of the wetland? Yes = 1 No = 0	
D 2.4. Are there other sources of pollutants coming into the wetland that are not listed in questions D 2.1- D 2.3? Source____________ Yes = 1 No = 0	
Total for D 2 — Add the points in the boxes above	

Rating of Landscape Potential If score is:____**3 or 4 = H** ____**1 or 2 = M** ____**0 = L** *Record the rating on the first page*

D 3.0. Is the water quality improvement provided by the site valuable to society?	
D 3.1. Does the wetland discharge directly (i.e., within 1 mi) to a stream, river, or lake that is on the 303(d) list? Yes = 1 No = 0	
D 3.2. Is the wetland in a basin or sub-basin where water quality is an issue in some aquatic resource [303(d) list, eutrophic lakes, problems with nuisance and toxic algae]? Yes = 1 No = 0	
D 3.3. Has the site been identified in a watershed or local plan as important for maintaining water quality (*answer YES if there is a TMDL for the drainage or basin in which the wetland is found*)? Yes = 2 No = 0	
Total for D 3 — Add the points in the boxes above	

Rating of Value If score is:____**2-4 = H** ____**1 = M** ____**0 = L** *Record the rating on the first page*

Wetland name or number____________

DEPRESSIONAL WETLANDS **Hydrologic Functions** - Indicators that the site functions to reduce flooding and erosion.	Points (only 1 score per box)
D 4.0. Does the site have the potential to reduce flooding and erosion?	
D 4.1. <u>Characteristics of surface water outflows from the wetland</u>: Wetland has no surface water outlet — points = 8 Wetland has an intermittently flowing outlet — points = 4 Wetland has a highly constricted permanently flowing outlet — points = 4 Wetland has a permanently flowing unconstricted surface outlet — points = 0 *(If outlet is a ditch and not permanently flowing treat wetland as "intermittently flowing")*	
D 4.2. <u>Depth of storage during wet periods</u>: *Estimate the height of ponding above the bottom of the outlet. For wetlands with no outlet, measure from the surface of permanent water or deepest part (if dry).* Seasonal ponding: > 3 ft above the lowest point in wetland or the surface of permanent ponding — points = 8 Seasonal ponding: 2 ft - < 3 ft above the lowest point in wetland or the surface of permanent ponding — points = 6 The wetland is a headwater wetland — points = 4 Seasonal ponding: 1 ft - < 2 ft — points = 4 Seasonal ponding: 6 in - < 1 ft — points = 2 Seasonal ponding: < 6 in or wetland has only saturated soils — points = 0	
Total for D 4 — Add the points in the boxes above	

<u>Rating of Site Potential</u> If score is:____**12-16 = H** ____**6-11 = M** ____**0-5 = L** *Record the rating on the first page*

D 5.0. Does the landscape have the potential to support the hydrologic functions of the site?	
D 5.1. Does the wetland receive stormwater discharges? — Yes = 1 No = 0	
D 5.2. Is > 10% of the area within 150 ft of the wetland in a land use that generates runoff? — Yes = 1 No = 0	
D 5.3. Is more than 25% of the contributing basin of the wetland covered with intensive human land uses? — Yes = 1 No = 0	
Total for D 5 — Add the points in the boxes above	

<u>Rating of Landscape Potential</u> If score is:____**3 = H** ____**1 or 2 = M** ____**0 = L** *Record the rating on the first page*

D 6.0. Are the hydrologic functions provided by the site valuable to society?	
D 6.1. <u>The wetland is in a landscape that has flooding problems</u>. Choose the description that best matches conditions around the wetland being rated. *Do not add points. Choose the highest score if more than one condition is met.* The wetland captures surface water that would otherwise flow down-gradient into areas where flooding has damaged human or natural resources (e.g., houses or salmon redds), AND Flooding occurs in sub-basin that is immediately down-gradient of wetland — points = 2 Surface flooding problems are in a sub-basin farther down-gradient — points = 1 The existing or potential outflow from the wetland is so constrained by human or natural conditions that the water stored by the wetland cannot reach areas that flood. *Explain why* ________________________________ — points = 0 There are no problems with flooding downstream of the wetland — points = 0	
D 6.2. Has the site has been identified as important for flood storage or flood conveyance in a regional flood control plan? — Yes = 2 No = 0	
Total for D 6 — Add the points in the boxes above	

<u>Rating of Value</u> If score is:____**2-4 = H** ____**1 = M** ____**0 = L** *Record the rating on the first page*

RIVERINE WETLANDS **Water Quality Functions** - Indicators that the site functions to improve water quality		Points (only 1 score per box)
R 1.0. Does the site have the potential to improve water quality?		
R 1.1. Area of surface depressions within the Riverine wetland that can trap sediments during a flooding event: Depressions cover >$^1/_3$ area of wetland Depressions cover > $^1/_{10}$ area of wetland Depressions present but cover < $^1/_{10}$ area of wetland No depressions present	 points = 6 points = 3 points = 1 points = 0	
R 1.2. Structure of plants in the wetland (areas with >90% cover at person height; **not** Cowardin classes): Forest or shrub > $^2/_3$ the area of the wetland Forest or shrub $^1/_3$ – $^2/_3$ area of the wetland Ungrazed, herbaceous plants > $^2/_3$ area of wetland Ungrazed herbaceous plants $^1/_3$ – $^2/_3$ area of wetland Forest, shrub, and ungrazed herbaceous < $^1/_3$ area of wetland	 points = 10 points = 5 points = 5 points = 2 points = 0	
Total for R 1	Add the points in the boxes above	

Rating of Site Potential If score is:___**12-16 = H** ___**6-11 = M** ___**0-5 = L** *Record the rating on the first page*

R 2.0. Does the landscape have the potential to support the water quality function of the site?		
R 2.1. Is the wetland within an incorporated city or within its UGA?	Yes = 2 No = 0	
R 2.2. Does the contributing basin include a UGA or incorporated area?	Yes = 1 No = 0	
R 2.3. Does at least 10% of the contributing basin contain tilled fields, pastures, or forests that have been clearcut within the last 5 years?	Yes = 1 No = 0	
R 2.4. Is > 10% of the area within 150 ft of wetland in land uses that generate pollutants	Yes = 1 No = 0	
R 2.5. Are there other sources of pollutants coming into the wetland that are not listed in questions R 2.1-R 2.4? Source_______________________	Yes = 1 No = 0	
Total for R 2	Add the points in the boxes above	

Rating of Landscape Potential If score is:___**3-6 = H** ___**1 or 2 = M** ___**0 = L** *Record the rating on the first page*

R 3.0. Is the water quality improvement provided by the site valuable to society?		
R 3.1. Is the wetland along a stream or river that is on the 303(d) list or on a tributary that drains to one within 1 mi?	Yes = 1 No = 0	
R 3.2. Does the river or stream have TMDL limits for nutrients, toxics, or pathogens?	Yes = 1 No = 0	
R 3.3. Has the site been identified in a watershed or local plan as important for maintaining water quality? A*nswer YES if there is a TMDL for the drainage in which wetland is found*.	Yes = 2 No = 0	
Total for R 3	Add the points in the boxes above	

Rating of Value If score is:___**2-4 = H** ___**1 = M** ___**0 = L** *Record the rating on the first page*

RIVERINE WETLANDS **Hydrologic Functions** - Indicators that site functions to reduce flooding and stream erosion	Points (only 1 score per box)
R 4.0. Does the site have the potential to reduce flooding and erosion?	
R 4.1. Characteristics of the overbank storage the wetland provides: *Estimate the average width of the wetland perpendicular to the direction of the flow and the width of the stream or river channel (distance between banks). Calculate the ratio: (average width of wetland)/(average width of stream between banks).* If the ratio is more than 2 points = 10 If the ratio is 1-2 points = 8 If the ratio is ½-<1 points = 4 If the ratio is ¼-< ½ points = 2 If the ratio is < ¼ points = 1	
R 4.2. Characteristics of plants that slow down water velocities during floods: *Treat large woody debris as forest or shrub. Choose the points appropriate for the best description (polygons need to have > 90% cover at person height. These are NOT Cowardin classes).* Forest or shrub for more than $^2/_3$ the area of the wetland points = 6 Forest or shrub for >$^1/_3$ area OR emergent plants > $^2/_3$ area points = 4 Forest or shrub for > $^1/_{10}$ area OR emergent plants > $^1/_3$ area points = 2 Plants do not meet above criteria points = 0	
Total for R 5 Add the points in the boxes above	

Rating of Site Potential If score is:____**12-16 = H** ____**6-11 = M** ____**0-5 = L** *Record the rating on the first page*

R 5.0. Does the landscape have the potential to support the hydrologic functions of the site?	
R 5.1. Is the stream or river adjacent to the wetland downcut? Yes = 0 No = 1	
R 5.2. Does the up-gradient watershed include a UGA or incorporated area? Yes = 1 No = 0	
R 5.3. Is the up-gradient stream or river controlled by dams? Yes = 0 No = 1	
Total for R 5 Add the points in the boxes above	

Rating of Landscape Potential If score is:____**3 = H** ____**1 or 2 = M** ____**0 = L** *Record the rating on the first page*

R 6.0. Are the hydrologic functions provided by the site valuable to society?	
R 6.1. Distance to the nearest areas downstream that have flooding problems? *Choose the description that best fits the site.* The sub-basin immediately down-gradient of site has surface flooding problems that result in damage to human or natural resources points = 2 Surface flooding problems are in a basin farther down-gradient points = 1 No flooding problems anywhere downstream points = 0	
R 6.2. Has the site been identified as important for flood storage or flood conveyance in a regional flood control plan? Yes = 2 No = 0	
Total for R 6 Add the points in the boxes above	

Rating of Value If score is:____**2-4 = H** ____**1 = M** ____**0 = L** *Record the rating on the first page*

LAKE FRINGE WETLANDS **Water Quality Functions** - Indicators that the site functions to improve water quality.		Points (only 1 score per box)
L 1.0. Does the site have the potential to improve water quality?		
L 1.1. Average width of plants along the lakeshore *(use polygons of Cowardin classes)*: Plants are more than 33 ft (10 m) wide Plants are more than 16 ft (5 m) and < 33 ft (10 m) wide Plants are more than 6 ft (2 m) and < 16 ft (5 m) wide Plants are less than 6 ft wide	 points = 6 points = 3 points = 1 points = 0	
L 1.2. Characteristics of the plants in the wetland: Choose the appropriate description that results in the highest points, and do not include any open water in your estimate of coverage. The herbaceous plants can be either the dominant form or as an understory in a shrub or forest community. *These are not Cowardin classes. Area of cover is total cover in the wetland, but it can be in patches. Herbaceous does not include aquatic bed*. Cover of herbaceous plants is > 90% of the vegetated area Cover of herbaceous plants is > $^2/_3$ of the vegetated area Cover of herbaceous plants is > $^1/_3$ of the vegetated area Other plants that are not aquatic bed > $^2/_3$ wetland Other plants that are not aquatic bed in > $^1/_3$ vegetated area Aquatic bed plants and open water cover > $^2/_3$ of the wetland	 points = 6 points = 4 points = 3 points = 3 points = 1 points = 0	
Total for L 1	Add the points in the boxes above	

Rating of Site Potential If score is:___**8-12 = H** ___**4-7 = M** ___**0-3 = L** *Record the rating on the first page*

L 2.0. Does the landscape have the potential to support the water quality function of the site?		
L 2.1. Is the lake used by power boats?	Yes = 1 No = 0	
L 2.2. Is > 10% of the area within 150 ft of wetland on the upland side in land uses that generate pollutants?	Yes = 1 No = 0	
L 2.3. Does the lake have problems with algal blooms or excessive plants such as milfoil?	Yes = 1 No = 0	
Total for L 2	Add the points in the boxes above	

Rating of Landscape Potential If score is:___**2 or 3 = H** ___**1 = M** ___**0 = L** *Record the rating on the first page*

L 3.0. Is the water quality improvement provided by the site valuable to society?		
L 3.1. Is the lake on the 303(d) list of degraded aquatic resources?	Yes = 1 No = 0	
L 3.2. Is the lake in a sub-basin where water quality is an issue (at least one aquatic resource in the basin is on the 303(d) list)?	Yes = 1 No = 0	
L 3.3. Has the site been identified in a watershed or local plan as important for maintaining water quality? *Answer YES if there is a TMDL for the lake or basin in which wetland is found.*	Yes = 2 No = 0	
Total for L 3	Add the points in the boxes above	

Rating of Value If score is:___**2-4 = H** ___**1 = M** ___**0 = L** *Record the rating on the first page*

Wetland name or number____________

LAKE FRINGE WETLANDS **Hydrologic Functions** - Indicators that the wetland unit functions to reduce shoreline erosion	Points (only 1 score per box)
L 4.0. Does the site have the potential to reduce shoreline erosion?	
L 4.1. Distance along shore and average width of Cowardin classes along the lakeshore (**do not** include Aquatic Bed): *Choose the highest scoring description that matches conditions in the wetland.* > ¾ of distance is Scrub-shrub or Forested at least 33 ft (10 m) wide — points = 6 > ¾ of distance is Scrub-shrub or Forested at least 6 ft (2 m) wide — points = 4 > ¼ distance is Scrub-shrub or Forested at least 33 ft (10 m) wide — points = 4 Plants are at least 6 ft (2 m) wide (do not include Aquatic Bed) — points = 2 Plants are less than 6 ft (2 m) wide (do not include Aquatic Bed) — points = 0	

Rating of Site Potential If score is: ___**6 = M** ___**0-5 = L** *Record the rating on the first page*

L 5.0. Does the landscape have the potential to support hydrologic functions of the site?	
L 5.1. Is the lake used by power boats with more than 10 hp? Yes = 1 No = 0	
L 5.2. Is the fetch on the lake side of the wetland at least 1 mile in distance? Yes = 1 No = 0	
Total for L 5 — Add the points in the boxes above	

Rating of Landscape Potential If score is:___**2 = H** ___**1 = M** ___**0 = L** *Record the rating on the first page*

L 6.0. Are the hydrologic functions provided by the site valuable to society?	
L 6.1. Are there resources, both human and natural, along the shore that can be impacted by erosion? If more than one resource is present, choose the one with the highest score. There are human structures or old growth/mature forests within 25 ft of OHWM of the shore in the wetland — points = 2 There are nature trails or other paths and recreational activities within 25 ft of OHWM — points = 1 Other resources that could be impacted by erosion — points = 1 There are no resources that can be impacted by erosion along the shores of the wetland — points = 0	

Rating of Value If score is:___**2 = H** ___**1 = M** ___**0 = L** *Record the rating on the first page*

NOTES and FIELD OBSERVATIONS:

SLOPE WETLANDS **Water Quality Functions** - Indicators that the site functions to improve water quality	Points (only 1 score per box)
S 1.0. Does the site have the potential to improve water quality?	
S 1.1. Characteristics of average slope of wetland: *(a 1% slope has a 1 ft vertical drop in elevation for every 100 ft of horizontal distance)* Slope is 1% or less points = 3 Slope is > 1% - 2% points = 2 Slope is > 2% - 5% points = 1 Slope is greater than 5% points = 0	
S 1.2. The soil 2 in below the surface (or duff layer) is true clay or tureorganic *(use NRCS definitions)*: Yes = 3 No = 0	
S 1.3. Characteristics of the plants in the wetland that trap sediments and pollutants: Choose the points appropriate for the description that best fits the plants in the wetland. *Dense means you have trouble seeing the soil surface (>75% cover), and uncut means not grazed or mowed and plants are higher than 6 in.* Dense, uncut, herbaceous plants > 90% of the wetland area points = 6 Dense, uncut, herbaceous plants > ½ of area points = 3 Dense, woody, plants > ½ of area points = 2 Dense, uncut, herbaceous plants > ¼ of area points = 1 Does not meet any of the criteria above for plants points = 0	
Total for S 1 Add the points in the boxes above	

Rating of Site Potential If score is:____**12 = H** ____**6-11 = M** ____**0-5 = L** *Record the rating on the first page*

S 2.0. Does the landscape have the potential to support the water quality function at the site?	
S 2.1. Is > 10% of the area within 150 ft on the uphill side of the wetland in land uses that generate pollutants? Yes = 1 No = 0	
S 2.2. Are there other sources of pollutants coming into the wetland that are not listed in question S 2.1? Other sources ______________________________ Yes = 1 No = 0	
Total for S 2 Add the points in the boxes above	

Rating of Landscape Potential If score is:____**1-2 = M** ____**0 = L** *Record the rating on the first page*

S 3.0. Is the water quality improvement provided by the site valuable to society?	
S 3.1. Does the wetland discharge directly to a stream, river, or lake that is on the 303(d) list (*within 1 mi*)? Yes = 1 No = 0	
S 3.2. Is the wetland in a basin or sub-basin where water quality is an issue? *At least one aquatic resource in the basin is on the 303(d) list.* Yes = 1 No = 0	
S 3.3. Has the site been identified in a watershed or local plan as important for maintaining water quality (*answer YES if there is a TMDL for the drainage or basin in which wetland is found*)? Yes = 2 No = 0	
Total for S 3 Add the points in the boxes above	

Rating of Value If score is:____**2-4 = H** ____**1 = M** ____**0 = L** *Record the rating on the first page*

SLOPE WETLANDS **Hydrologic Functions** - Indicators that the site functions to reduce flooding and erosion	Points (only 1 score per box)
S 4.0. Does the site have the potential to reduce flooding and erosion?	
S 4.1. Characteristics of plants that reduce the velocity of surface flows during storms: Choose the points appropriate for the description that best fits conditions in the wetland. *Stems of plants should be thick enough (usually > $^1/_8$ in), or dense enough, to remain erect during surface flows*. Dense, uncut, **rigid** plants cover > 90% of the area of the wetland points = 1 All other conditions points = 0	

Rating of Site Potential If score is:____**1 = M** ____**0 = L** *Record the rating on the first page*

S 5.0. Does the landscape have the potential to support the hydrologic functions of the site?	
S 5.1. Is more than 25% of the area within 150 ft upslope of wetland in land uses that generate excess surface runoff? Yes = 1 No = 0	

Rating of Landscape Potential If score is:____**1 = M** ____**0 = L** *Record the rating on the first page*

S 6.0. Are the hydrologic functions provided by the site valuable to society?	
S 6.1. Distance to the nearest areas downstream that have flooding problems: The sub-basin immediately down-gradient of site has surface flooding problems that result in damage to human or natural resources (e.g., houses or salmon redds) points = 2 Surface flooding problems are in a sub-basin farther down-gradient points = 1 No flooding problems anywhere downstream points = 0	
S 6.2. Has the site been identified as important for flood storage and flood conveyance in a regional flood control plan? Yes = 2 No = 0	
Total for S 6 Add the points in the boxes above	

Rating of Value If score is:____**2-4 = H** ____**1 = M** ____**0 = L** *Record the rating on the first page*

NOTES and FIELD OBSERVATIONS:

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 (including under water, vegetation or litter)					
Cover lichens (including under water, vegetation, litter, and on trees)					
Cover algae(including under water, vegetation or litter)					
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)

Comments:

V3.0 June 18, 2018

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 m^2 = 1% of standard 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.

Determine the number of plant communities in the AA. The initial search time will be 30 minutes for the first community plus 20 minutes for each additional community. If 3 or more new species are encountered in the last 10 minutes of the survey, add 10 additional minutes to the survey time. Continue until < 3 new species are found in 10 minutes.

Scientific Name/Pseudonym	Time	Coll #	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										

V3.0 June 18, 2018

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	Time	Coll #	H	P	% AA	% 1	% 2	% 3	% 4

URAP Soil Form

Site ID:_____________ **PHOTOGRAPH SOIL PIT AND LAB WATER QUALITY LOCATION**

Veg Patch #:______ Unique ID (SOIL#):______________________ 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

Organic 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)	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):

URAP Waterbody Form

SITE ID_____________ **Date:**______________________

WQ Start Time: _________ (24-hr time) **End Time:** _________ (24-hr time) **Wind:** Calm Light Strong

72 hour rainfall estimate : none light/drizzle heavy/storm **Air temperature**:____°C

Current Weather: Mostly Clear (0-10% cloud) Partly Cloudy (10-50%) Mostly Cloud (50-99%) Overcast (100%) Rain Snow

WB1, inc. notes

WB TYPE: (circle one) permanent lake/pond temporary pool/pond springhead pool springhead channel stream ditch active beaver pond inactive beaver pond wet meadow with standing water impoundment fringe GSL impoundment impoundment release (no channel) other:_______________________________________

Not channel-like: wetted area[1]: <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m² **Channel-like, average width:** _____ cm

Waterbody with Depth…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (add to 100)

PRIMARY SUBSTRATE: Silt/mud Sand/gravel Cobble Boulder/Bedrock Other:

% WATER WITH EMERGENT VEG. 0 1-25 >25-50 >50	% SURFACE ALGAE 0 1-25 >25-50 >50
% WATER WITH SUBMERGENT VEG. 0 1-25 >25-50 >50	% CHARA 0 1-25 >25-50 >50

TURBIDITY: Mostly turbid Mixture of turbid/clear Mostly clear

WB2, inc. notes

WB TYPE: (circle one) permanent lake/pond temporary pool/pond springhead pool springhead channel stream ditch active beaver pond inactive beaver pond wet meadow with standing water impoundment fringe GSL impoundment impoundment release (no channel) other:_______________________________________

Not channel-like: wetted area[1]: <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m² **Channel-like, average width:** _____ cm

Waterbody with Depth…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (add to 100)

PRIMARY SUBSTRATE: Silt/mud Sand/gravel Cobble Boulder/Bedrock Other:

% WATER WITH EMERGENT VEG. 0 1-25 >25-50 >50	% SURFACE ALGAE 0 1-25 >25-50 >50
% WATER WITH SUBMERGENT VEG. 0 1-25 >25-50 >50	% CHARA 0 1-25 >25-50 >50

TURBIDITY: Mostly turbid Mixture of turbid/clear Mostly clear

WB3, inc. notes

WB TYPE: (circle one) permanent lake/pond temporary pool/pond springhead pool springhead channel stream ditch active beaver pond inactive beaver pond wet meadow with standing water impoundment fringe GSL impoundment impoundment release (no channel) other:_______________________________________

Not channel-like: wetted area[1]: <10m² 10-<100m² 100-<1000m² 1000-5000m² >5000m² **Channel-like, average width:** _____ cm

Waterbody with Depth…. <0.2 m _____% 0.2- 1 m _____% 1-2 m_____% >2 m _____% (add to 100)

PRIMARY SUBSTRATE: Silt/mud Sand/gravel Cobble Boulder/Bedrock Other:

% WATER WITH EMERGENT VEG. 0 1-25 >25-50 >50	% SURFACE ALGAE 0 1-25 >25-50 >50
% WATER WITH SUBMERGENT VEG. 0 1-25 >25-50 >50	% CHARA 0 1-25 >25-50 >50

TURBIDITY: Mostly turbid Mixture of turbid/clear Mostly clear

Water Chemistry Data

WB #/ GPS ID	*Lab MLID*	*Shore (N, NE E, etc.)*	*Stand. or Flow.*	*Depth of water (cm)*	*pH*	*EC*	*EC units or Out of Range*	*Temp (°C)*	*Color*	*Turbidity Tube*	*Shaded >1/3 day?*
			S F				*uS mS OOR*		Clear Stained	*> or =* (circle one): _____ cm	Yes No
			S F						Clear Stained	*> or =* (circle one): _____ cm	Yes No
			S F						Clear Stained	*> or =* (circle one): _____ cm	Yes No

[1]Regular Full Size Ford F-150 (excluding mirrors) is about 12.5 m², Baseball diamond is about 750m², football field is about 5300 m²