# Intermountain Basins Playa Ecological System

## Ecological Integrity Assessment

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# A. INTRODUCTION

## *A.1 Classification Summary*

**CES304.786 InterMountain Basins Playa**

**Spatial Scale & Pattern**: Small Patch **Classification Confidence**: medium
**Required Classifiers:** Natural/Semi-natural, Non-vegetated (<10% vasc.), Upland, Wetland
**Diagnostic Classifiers:** Lowland [Lowland], Playa, Temperate [Temperate Xeric], Alkaline Soil, Saline Substrate Chemistry, Aridic, Depressional, Alkaline Water, Saline Water Chemistry, Caliche Layer, Impermeable Layer, Intermittent Flooding

**Non-Diagnostic Classifiers:** Shrubland (Shrub-dominated), Herbaceous, Dwarf-Shrub, Forb, Graminoid, Clay Subsoil Texture

**HGM:** Depressional and Mineral Flats

**Concept Summary:** This ecological system is composed of barren and sparsely vegetated playas (generally<10% plant cover) found in the intermountain western US. Salt crusts are common throughout, with small saltgrass stands in depressions and sparse shrubs around the margins. These systems are intermittently flooded. Typically, the water is prevented from percolating through the soil by an impermeable soil sub-horizon and is left to evaporate. Some playas are affected by high groundwater tables. Soil salinity varies greatly with soil moisture and greatly affects species composition. Characteristic species may include iodine bush (*Allenrolfea occidentalis*),greasewood Great Basin wildrye (*Leymus cinereus*), saltgrass (*Distichlis spicata*), and/or saltbush (*Atriplex* spp.).

**USFS Divisions (Bailey):** 304
**TNC Ecoregions:** 10:C, 11:C, 19:C, 6:C
**Subnations/Nations:** CA:c, CO:c, ID:c, NV:c, OR:c, UT:c, WA:p, WY:c

## *A.2 Ecological System Description*

Intermountain Basin playas occur in the large basins between major mountain ranges throughout the Intermountain West. In the Great Basin, playas can also be found in large basins formerly occupied by pluvial lakes (Young et al. 1986). This document will mostly focus on those playas which occur in Colorado, thus application of this Scorecard in other areas of the intermountain west may need to be adapted to local conditions. Playas and similar saline wetlands in the Southern Rockies occur in the intermountain basins, where the hydrogeomorphic template for their formation is abundant on the landscape.

Many definitions of playas describe them as closed basin systems whose hydrological input is limited to precipitation and surface runoff. For example, in the Closed Basin of the San Luis Valley, Colorado, playa systems form in terminal stream reaches that originate in the nearby mountain ranges (Cooper and Severn 1992). However, many of the playas found in Intermountain Basins differ by being subjected to groundwater discharge or capillary movement of water from seasonally high water tables (Riley 2001, Lines 1979). For example, in the Closed Basin in the San Luis Valley, similar playa systems form due to complex interactions of surface and ground water (Riley 2001) and playas systems in the Great Basin are often associated with local aquifers (Lines 1979). Regardless of their hydrological source, Intermountain Basin playas share similar soil chemistry as well as floristics with many stereotypical, precipitation-fed playas as those found in the Southern High Plains of Texas and New Mexico (Riley 2001).

- ## A.2.1. Environment

*Climate*

A continental climate dominates the Southern Rocky Mountains producing warm, dry summers and cold winters and an overall semi-arid climate. Most precipitation occurs as snowfall (as much as 80% at high elevations) during the winter months and thus is the most important source of water for wetlands and riparian areas in the Southern Rocky Mountains (Laubhan 2004; Windell et. al 1986; Cooper 1990). However, late-summer convective thunderstorms produce slight peaks in runoff in late summer (Baker 1987; Rink and Kiladis 1986). Evaporation generally exceeds precipitation, especially at lower elevations and in the intermountain basins; however, increasing precipitation and lower temperatures at higher elevations tends to reverse this trend, although aspect, topography, and intense solar radiation can moderate these effects on the evaporation/precipitation ratio (Laubhan 2004). The ratio between evaporation and precipitation has a strong influence on the hydrology of wetlands throughout the region.

Climate has a large role in maintenance of playas since the interplay of evapotranspiration and precipitation can dictate water level fluctuation as well as soil chemistry (i.e., evaporative salts in the soil). In general, playas are tied to the precipitation and runoff characteristics of their contributing basins. During high precipitation years, many of playas might hold standing water for 3 to 4 months whereas in dry years the playas may not retain standing water at all (Cooper et al. 2000).

*Geomorphology*

The Southern Rocky Mountains are composed of various igneous, metamorphic, and sedimentary rocks (Mutel and Emerick 1984; Windell et al. 1986). The mountain valleys are relatively young topographical forms created by the erosional effects of flowing water and glacier movement (Windell et al. 1986). Intermountain basins were formed from tectonic and volcanic events which occurred during mountain-forming processes (Windell et al. 1986). The valleys of these basins are now filled with deep alluvial deposits derived from erosional processes in the nearby mountain ranges (Windell et al. 1986). Glaciation has had a large influence on landforms at high elevations through large-scale erosional and depositional processes.

*Hydrology*

The interaction of climate and geomorphology has a strong influence on local hydrological processes in a wetland. For example, snowmelt at high elevations contributes a large proportion of water to most wetland types through its influence on groundwater and surface water dynamics (Laubhan 2004). In mountain valleys, snowmelt and geomorphology are major factors controlling the extent, depth, and duration of saturation resulting from high groundwater levels and also exert controls most aspects of the frequency, timing, duration, and depth of flooding along riparian areas (Laubhan 2004). Wetlands in intermountain basins are also affected by snowmelt via its association with the contributing surface water to the valley aquifers.

Groundwater levels are dependent on the underlying bedrock, watershed topography, soil characteristics, and season (Rink and Kiladis 1986). In areas of thin soils, little surface water is retained as groundwater; however, in areas of deep alluvial material surface water collects in alluvial aquifers which support numerous wetlands (Rink and Kiladis 1986). Groundwater discharge also occurs in areas where subsurface flow is forced to the surface due to underlying impermeable bedrock or soils or a break in topography.

Surface water flow is a function of snowmelt, watershed and valley topography and area, late-summer rainfall, and the extent of upstream riparian wetlands (Rink and Kiladis 1986). Upstream wetlands release water throughout the growing season and are an important contribution to streamflow during later-summer and/or drought periods.

The intermountain basins receive surface water from streams originating in the surrounding mountains. These streams can terminate in depressions or basins that have no drainage outlet, impermeable soils, and high evaporation rates. Water loss from playas occurs primarily through evaporation since vegetation cover is often sparse, no drainage outlet exists, and little water is lost to groundwater recharge and often results in a high concentration of salts in the upper soil profile (Laubhan 2004; Cooper et al. 2000). Many playas fill from snowmelt-fed streams in late spring and most are dry by late summer. Heavy monsoon precipitation can cause some playas to refill in late summer, but summer rains are generally of secondary importance. Some playas may only wet up during high precipitation years (Cooper 1996). The soils in playas are alkali clays with low rates of water infiltration allowing rapid evaporation at the water surface and accumulation of salts. They support a flora adapted to seasonal soil saturation and saline conditions.

However, some playas are more affected by high water tables and have little surface flooding (Cooper et al. 2000, Riley 2001). Many intermountain basins have abundant groundwater aquifers which are recharged by subsurface and/or surface flow from the adjacent mountains (Laubhan 2004). When these aquifers approach the soil surface, the capillary fringe can bring salts to the upper soil profile and result in playa formation. For example, many of the playas in the San Luis Valley, Colorado depend upon a complex interaction of surface and groundwater sources that undergo characteristic seasonal and inter-annual fluctuations. In some playas, the water table may be within 1 m, especially in early summer, but never reaches the soil surface (Cooper 1996). However, capillary action moves water from the water table up through the soil profile to the surface. Salts contained in the soil and groundwater are carried to the soil surface by this capillary movement of groundwater (Cooper and Severn 1992). When this capillary water reaches the soil surface, it is subjected to high evaporation rates leaving increased concentrations of dissolved salts in the upper soil horizons and on the soil surface as a salt "crust" (Cooper and Severn 1992). The concentration of salts can be up to 500 times the amount found in freshwater wetlands (Cooper and Severn 1992). In other playas, the water table may be close to the surface in the early portion of the growing season but by mid-summer tends to drop leaving salt crusts on the soil surface due to the amount of solutes contained in the soil and groundwater (Cooper 1993).

### ▪ A.2.2. Vegetation & Ecosystem

*Vegetation*

Playa vegetation is strongly affected by water and soil salinity, thus playas have developed unique floristic patterns based on the level of salinity in the soil. Species diversity tends to decline with an increase soil salinity resulting in low floristic diversity in playas (Riley 2001, Cooper 1986). In a saline meadow in Utah, Brotherson (1987) found that forb cover was most common in driest areas, cover of sedges and rushes were prevalent in wet areas, and grass cover was equal along the moisture and salinity gradient. Cooper and Severn (1992) observed that the entire range of soil moisture and salinity levels, and associated plant communities occurred over an elevation gradient of only 5 to 8 feet in the San Luis Valley. Water table levels or duration of inundation along with the corresponding affects on soil chemistry (e.g., accumulation of salts) supports the development of different vegetation zones in playas. Regularly flooded playas support well developed aquatic and shoreline emergent vegetation, such as pondweeds (*Potamogeton* spp.), horned pondweed, spikerush, hardstem bulrush, and three-square bulrush. Salt flats are found where capillary action results in an abundance of salt crusts on the soil and often support seasonal stands of salt tolerant annuals which complete their life cycles after surface water evaporates and the late summer rains begin. Species such as seablite (*Suaeda calceoliformis*), seaside heliotropium (*Heliotropium curassavicum*), and red glasswort (*Salicornia rubra* or *S. utahensis*) can be found on these salt flats, but they are often void of vegetation. Nevade bulrush, saltgrass, three-square bulrush, alkaligrass (*Puccinellia airoides*), alkali cordgrass (*Spartina gracilis*), arrowgrass (*Triglochin* ssp.), and Baltic rush are found in areas of seasonally high water tables and saline soils. Salt grass typically occurs in mesic soils but can tolerate various salinity levels (Riley 2001). Adjacent alkali flats and dunes are dominated by greasewood (*Sarcobatus vermiculatus*) and rabbitbrush (*Chrysothamnus* spp.), respectively. Greasewood is tolerant of moderate to highly saline conditions and is able to extract water from 3-5 m below the soil surface (Riley 2001). However, greasewood can also be found in areas with a high water table. Rabbitbrush is found in less saline, upland soils. Iodine bush (*Allenrolfea occidentalis*) is a common component of playas in the Great Basin (Young et al. 1986; Lines 1979). Other species commonly found in playa systems include alkali sacaton (*Sporobolus airoides*), saltbush (*Atriplex* spp.), scratchgrass muhly (*Muhlenbergia asperifolia*), redwool plaintain (*Plantago eriopoda*), and sea milkwort (*Glaux maritima*). Mud flats may also be present in areas where soil salts are less abundant.

Playas support many rare and unique species. The playas of the San Luis Valley support the most numerous, largest, and healthiest populations of slender spiderflower (*Cleome multicaulis*) in the world. Historically, this species occurred in rare, suitable habitats in south-central Colorado and from southeastern Arizona east to western Texas and south to northern Mexico, with 1 disjunct population in central Wyoming. However, the species is in apparent decline. The Arizona populations have not been confirmed since the 1940's and species has not been seen in New Mexico in recent times (the collections from Las Cruces, New Mexico date from 1851). Although there are now over 25 documented occurrences in Colorado alone, the species appears highly threatened, especially by water projects, and it occurs in few protected areas. The fact that it is an annual, along with its habitat specificity, may make it more vulnerable to chance extinction in a string of bad years or due to other stochastic events. Slender spiderflower has a limited distribution due to its requirement of moist alkaline soil along with periodic soil disturbance, such as pocket gopher (*Thomomys talpoides*) diggings. These habitat requirements limit the slender spiderflower to the edges of alkaline wet meadows and playas.

A playa in South Park, Colorado supports the only population of salt watercress (*Thellungiella salsuginea*) in Colorado. The species is widespread in Asia but only a few populations exist in North America (Colorado Native Plant Society 1997). The plant is found on salt flats near Antero Reservoir in South Park.

*Biogeochemistry*

In the arid west, salinity is only second to water as being the most critical factor affecting plant growth and vegetation distribution in playas is closely tied to salinity gradients (Laubhan 2004). In the past, saline, alkali, saline-alkali, and saline-sodic were terms often used to describe soils affected by soluble salts, high pH, and exchangeable soils (Soil Science Society of America 2005). Saline soils are those containing sufficient amounts of soluble salts (e.g., conductivity is > 4.0 mS/cm) able to adversely affect plant growth (Soil Science Society of America 2005; Sposito 1989). Saline soils have an exchangeable sodium percentage less than 15 and a pH is less then 8.5 (USDA 1954). Saline soils often have white crusts on the surface and their chemical characteristics are based on the amount and type of salts present (USDA 1954). In saline soils, sodium rarely comprises more than half of the soluble cations and thus is not adsorbed to a significant extent (USDA 1954). Calcium and magnesium concentrations can vary while potassium is present in minor amounts (USDA 1954). Low soluble salts may also be present in saline soils such as calcium sulfate (gypsum) and calcium and magnesium carbonates (lime) (USDA 1954). Alkali soils have a pH of 8.5 or higher and an exchangeable sodium percentage greater than 15. Thus, alkali soils have a high pH and sufficient amounts of exchangeable sodium to interfere with the growth of most plants (Soil Science Society of America 2005). Sodic soils are nonsaline soils yet have significant amounts of exchangeable sodium which can affect plant growth as well as soil structure (Soil Science Society of America 2005). Saline-alkali soils (also called saline-sodic soils) are those with high salinity (e.g., conductivity >4 dS $m^{-1}$) as well as containing sufficient exchangeable sodium and soluble salts to interfere with the growth of most plants and containing appreciable quantities of soluble salts (Soil Science Society of America 2005). Today, most soil scientists refer to either: (1) saline or (2) sodic soils to describe these conditions (Soil Science Society of America 2005).

In arid and semi-arid regions, where evaporation exceeds precipitation, soluble salts are not leached from the soil profile and thus cause these soils to become saline or sodic (Windell et al. 1986). This phenomenon is especially apparent in the intermountain basin throughout the West, such as the San Luis Valley in Colorado, Big Horn Basin in Wyoming, and the intermountain basins of southwestern Montana (Windell et al. 1986). These basins have relatively flat topography and fine-textured soils underlain by deep deposit of alluvial sediment (Windell et al. 1986). These alluvial sediments often support aquifers and thus high water tables in many areas. In places where the water table is close enough to the soil surface to be affected by the capillary fringe, salts can accumulate in the upper soils horizons and on the soil surface (Windell et al. 1986). However, there can be large spatial variability in the water table depth and subsequent levels of soil salinity in a single wetland. In the San Luis Valley, Colorado, the entire range of salinity levels (highly saline to non-saline) can be observed over an elevation change as little as 5 to 8 feet (Cooper and Severn 1992). In addition, seasonal changes in soil salinity can be observed due to seasonal rainfall. For example, Cooper and Severn (1992) note that late summer monsoonal rains in the San Luis Valley, Colorado can temporarily leach salts down through the soil profile and that the germination and growth of many annual and perennial halophytic plants coincide with these annual precipitation events. Thus, although salinity is an important ecological determinant in playas, the spatial and temporal variability of soil salinity at any one playa can be quite large.

Playa soils are saline and/or sodic due to the amount of chlorides and sulfates of calcium, magnesium, sodium, and potassium in the soil profile (Riley 2001). The pH of the soils is related to the type of salts found in the soil. High soil pH has a strong negative influence on the availability of nutrients as well as potentially being toxic of many plants. For example, iron, manganese, zinc, and calcium availability are often reduced in high pH soils and the abundance of $HCO_3^-$ OH- ions can be toxic to many plants (Riley 2001, Brady 1990).

*Productivity*

Primary productivity of playas is relatively low compared to other wetlands types and varies according the amount of salts in the soil as well as duration of standing water (Cooper and Severn 1992). Production is highest when soil salinity levels are low. Soil salinity appears to be highest when the water table does not reach within 1 foot of the soil surface whereas higher water tables tend to remove salts from the soil resulting in higher primary productivity (Cooper and Severn 1992).

Succession in playas occurs slowly or may not even occur at all due to a limited pool of species capable of surviving the saline conditions (Riley 2001). Long-term changes in water levels have the most profound effect on changes in plant communities (Riley 2001).

*Animals*

Saltgrass is the host plant for a rare skipper, the San Luis sandhill skipper (*Polites sabuleti ministigma*). The San Luis sandhill skipper is a geographically isolated subspecies of a wider spread species limited to the San Luis Valley and Arkansas River canyon in southern Colorado (Scott 1982). This species prefers the lower lying, moister habitats such as playas, along pond and stream shoreline, and near springs where its host plant, salt grass is encountered (Rondeau and Sanderson 1998).

The variability in water levels and salinity and the subsequent vegetation types support a variety of aquatic and terrestrial invertebrates. These invertebrates provide an abundant food supply for numerous species of waterbirds such as avocets (*Recurvirostra americana*), black-necked stilts (*Himantopus mexicanus*), snowy plover (*Charadius alexandrinus*), and Wilson's Phalarope (*Phalaropus tricolor*). Playas and other wetlands around the Great Salt Lake in Utah as well as other large wetland complexes found in the Great Basin provide some of the most important migratory habitat for waterbirds in the interior west (Gammonley 2004)). Wetlands in the San Luis Valley, including playas, support the highest concentration of breeding waterbirds in Colorado (USFWS 2002). Playas are most important for shorebirds, where exposed salt and mud flat offer an abundant supply of invertebrates and potential nesting habitat.

### ▪ A.2.3. Dynamics

Playa development is driven by the duration and frequency of flooding and level of local groundwater tables. The effects of this hydrological regime result in unique soil chemistry and resulting floristic patterns. Thus, playas are intimately tied to runoff patterns and the water table (Cooper 1996).

Some general patterns of ecosystem development can be observed in playas. Typically, playas exhibit distinct bands or zones of vegetation which vary according to the degree of inundation, soil moisture, and soil salinity (Cooper and Severn 1992). Conceptually, from wettest to driest, this includes the following vegetation types (1) horned pondweed (*Zanichellia palustris*) and hardstem bulrush (*Schoenoplectus acutus*) are found where at least 3 to 4 months of flooding occur. Cattail (*Typha latifolia*) is often absent in these areas due the level of salinity; (2) emergent species such as common spikerush (*Eleocharis palustris*) and three square bulrush (*Schoenoplectus pungens*) occur in areas inundated for short durations (e.g., 1 to 3 months), (3) shallow emergent species such as Nevada bulrush (*Amphiscirpus nevadensis*) and mountain rush (*Juncus balticus* var. *montanus*) are found in areas of high water tables and saline soils, (4) salt flats are found where capillary action results in an abundance of salt crusts on the soil. Very few plants grow on these flats, but red glasswort (*Salicornia rubra*) and alkali bulrush (*Schoenoplectus maritimus*) can often be found in this zone, (4) saline wet meadow species such as saltgrass (*Distichlis spicata*), three-square bulrush (*Schoenoplectus pungens*), and Baltic rush are found in seasonally saturated soils, and finally (5) adjacent drier meadows less affected by soil salts (Cooper and Severn 1992). Mud flats may also be present in areas where soil salts are less abundant. Of course, not all of these types are always present since shoreline gradient and hydrological regime can essentially exclude some of these zones.

### A.2.4. Landscape

It is evident from the hydro-geomorphic setting of playas that their integrity is partly determined by processes operating in the surrounding landscape and more specifically in the contributing watershed. The quality and quantity of ground and surface water input is almost entirely determined by the condition of the surrounding landscape. Various types of land use can alter surface runoff, recharge of local aquifers, and introduce excess nutrients, pollutants, or sediments.

It is clear that playas are intimately connected to uplands in their upstream watersheds as well as adjacent areas. However, the reverse is also true: playas provide connectivity between upland systems.

Assessments of playas have considered the landscape properties of the local watershed to be a critical factor in assessing condition (Keate 2005, Cooper and Severn 1992, and Rondeau 2001).

### A.2.5. Size

The size of a wetland, whether very small or very large, is a natural characteristic defined by a site's topography, soils, and hydrological processes. The natural range of sizes found on the landscape varies for each wetland type. As long as a wetland has not been reduced in size by human impacts or isn't surrounded by areas that have experienced human disturbances, then size isn't very important to the assessment of ecological integrity. However, if human disturbances have decreased the size of the wetland or if the surrounding landscape is impacted and has the potential to affect the wetland, larger sized wetlands are able to buffer against these impacts better than smaller sized wetlands due to the fact they generally possess a higher diversity of abiotic and biotic processes allowing them to recover and remain more resilient. Under such circumstances, size may be an important factor in assessing ecological integrity.

Size is often very important when the conservation or functional value of a wetland is considered. For example, larger wetlands tend to have more diversity, often support larger populations of component species, are more likely to support sparsely distributed species, and may provide more suitable wildlife habitat as well as more ecological services derived from natural ecological processes (e.g. sediment/nutrient retention, floodwater storage, etc.) than smaller wetlands. Thus, when conservation or functional values are of concern, size is almost always an important component to the assessment.

Of course, in the context of regulatory wetland mitigation, size is always important whether mitigation transactions are based on function or integrity "units" and thus should be used to weight such transactions.

The size of playas can vary greatly depending on their topographic location, underlying soil texture, and driving hydrological processes. Some are very small (< 2 acres) while others can be very large (> 20 acres).

## *A.3 ECOLOGICAL INTEGRITY*

### ▪ A.3.1. Threats

*Hydrological Alteration:* Playas depend upon a complex interaction of surface and groundwater sources which undergo characteristic seasonal and inter-annual fluctuations. Reservoirs, water diversions, groundwater withdrawal, ditches, roads, and human land uses in the contributing watershed which perturb the timing or magnitude of surface- and/or ground- water flows, are likely to affect playas detrimentally. Even minor changes in the water table depth or duration of inundation can have profound effects on soil salinity, and consequently, wetland vegetation (Cooper and Severn 1992). Wetland dependent fauna, such as waterbirds, amphibians, or vertebrates may be affected by even brief changes in wetland hydrology.

*Land Use*
Most impacts from land use to playas will result from alterations to surface or subsurface hydrology. Of course, anthropogenic disturbance to playa soils and adjacent ecosystems might also provide favorable vectors for the establishment of invasive and/or exotic species.

*Nutrient enrichment*
It is not known what affect nutrient enrichment would have on playas since the high pH of playa soils often overrides effects of the concentration of major nutrients on plant distributions. However, it might be expected that an increase in some nutrients might favor invasive and/or exotic species tolerant of saline conditions.

*Exotics*
Non-native species can displace native species, alter hydrology, alter structure, and affect food web dynamics by changing the quantity, type, and accessibility to food for fauna (Zedler and Kercher 2004). Numerous invasive and/or exotic species are known to occur in playas. Common reed (*Phragmites australis*), a native invasive species, can establish and dominate some less-saline playas. Whitetop (*Cardaria* spp.), a non-native species, can be very problematic in playas, although it can be found in non-saline wetlands as well. Non-native annuals such as goosefoot (*Chenopodium glaucum* and *C. rubra*) can be found on salt flats. Canada thistle (*Cirsium arvense*) may also be found in less saline areas. Russian thistle (*Salsola* spp.), ironweed (*Bassia hyssopifolia*), and kochia (*Kochia scoparia*) are also common exotic species in playas.

*Fragmentation:* Human land uses both within the wetland as well as in adjacent and upland areas can fragment the landscape and thereby reduce connectivity between wetland and upland areas. This can adversely affect the movement of surface/groundwater, nutrients, and dispersal of plants and animals. Roads, bridges, and development can also fragment both wetland and upland areas. Intensive grazing and recreation can also create barriers to ecological processes.

### A.3.2. Justification of Metrics

As reviewed above, the literature suggests that the following attributes are important measures of the ecological integrity of Intermountain Basins Playas:

- Landscape Context: Land use within the contributing watershed has important effects on the connectivity and sustainability of many ecological processes critical to this system.
- Biotic condition: Species composition and diversity, presence of conservative plants, and invasion of exotics are important measures of biological integrity.
- Abiotic Condition: Hydrological integrity is the most important variable to measure, however land use within the wetland can have detrimental impacts on other important abiotic processes such as nutrient cycling.
- Size: Absolute size is important for consideration of conservation values as well as ecosystem resilience. Relative size is also very important as it provides information regarding historical loss or degradation of wetland size.

### A.3.3. Ecological Integrity Metrics

A synopsis of the ecological metrics and ratings is presented in Table 2. The three tiers refer to levels of intensity of sampling required to document a metric. Tier 1 metrics are able to be assessed using remote sensing imagery, such as satellite or aerial photos. Tier 2 typically require some kind of ground sampling, but may require only qualitative or semi-quantitative data. Tier 3 metrics typically require a more intensive plot sampling or other intensive sampling approach. A given measure could be assessed at multiple tiers, though some metrics are not doable at Tier 1 (i.e., they require a ground visit).

*Core and Supplementary Metrics*
The Scorecard (see Tables 1 & 2) contains two types of metrics: Core and Supplementary. Separating the metrics into these two categories allows the user to adjust the Scorecard to available resources, such as time and funding, as well as providing a mechanism to tailor the Scorecard to specific information needs of the user.

**Core metrics** are shaded gray in Tables 1 & 2 and represent the minimal metrics that should be applied to assess ecological integrity. Sometimes, a Tier 3 Core metric might be used to replace Tier 2 Core Metrics. For example, if a Vegetation Index of Biotic Integrity is used, then it would not be necessary to use similar Tier 2 Core metrics such as Percentage of Native Graminoids, Percentage of Native Plants, etc.

**Supplementary metric**s are those which should be applied if available resources allow a more in depth assessment or if these metrics add desired information to the assessment. Supplementary metrics are those which are not shaded in Tables 1 & 2.

Table 1. Overall Set of Metrics for the Intermountain Basin Playa System. Tier: 1 = Remote Sensing, 2 = Rapid, 3 =Intensive. (Alpha-numeric codes in parentheses is reference to the metric ID and corresponds to the section in which the metric is described)

| **Category** | **Essential Ecological Attribute** | **Indicators & Metrics** | **Tier** | **Field Value** | **Rating (A,B,C,D)** |
|---|---|---|---|---|---|
| LANDSCAPE CONTEXT | Landscape Context | Adjacent Land Use (B.1.1) | 1 | | |
| | | Buffer Width (B.1.2) | 1 | | |
| | | Percentage of unfragmented landscape within 1 km. (B.1.3) | 1 | | |
| BIOTIC CONDITION | Community Composition | Percent of Cover of Native Plant Species (B.2.1) | 2 | | |
| | | Invasive Species – Plants (B.2.2) | 2 | | |
| | | Floristic Quality Index (Mean C) (B.2.3) | 3 | | |
| | Patch Diversity | Biotic Patch Richness (B.2.4) | 2 | | |
| | | Interspersion of Biotic Patches (B.2.5) | 2 | | |
| ABIOTIC CONDITION | Energy/ Material Flow | Land Use Within the Wetland (B.3.1) | 2 | | |
| | | Sediment Loading Index (B.3.2) | 1 | | |
| | Hydrological Regime | Water Table Depth (B.3.3) | 2 | | |
| | | Water Table Depth (B.3.4) | 3 | | |

| Category | Essential Ecological Attribute | Indicators & Metrics | Tier | Field Value | Rating (A,B,C,D) |
|---|---|---|---|---|---|
| | | Surface Water Runoff Index (B.3.5) | 1 | | |
| | | Hydrological Alterations (B.3.6) | 2 | | |
| | Chemical/ Physical Processes | Nutrient/ Pollutant Loading Index (B.3.7) | 1 | | |
| | | Nitrogen Enrichment (C:N) (B.3.8) | 3 | | |
| | | Phosphorous Enrichment (C:P) (B.3.9) | 3 | | |
| | | Soil Organic Carbon (B.3.10) | 3 | | |
| | | Soil Bulk Density (B.3.11) | 3 | | |
| SIZE | Size | Absolute Size (B.4.1) | 1 | | |
| | | Relative Size (B.4.2) | 1 | | |

Table 2. Metric Ranking Criteria. Tier: 1 = Remote Sensing, 2 = Rapid, 3 =Intensive. (Alpha-numeric codes in parentheses is reference to the metric ID and corresponds to the section in which the metric is described). Confidence column indicates that reasonable logic and/or data support the index.

| **Category** | **Essential Ecological Attribute** | **Indicators /Metrics** | **Tier** | **Definition** | **Confidence** | *Metric Ranking Criteria* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Excellent (A)** | **Good (B)** | **Fair (C)** | **Poor (D)** |
| LANDSCAPE CONTEXT | Landscape Context | Adjacent Land Use (B.1.1) | 1 | Addresses the intensity of human dominated land uses within 100 m of the wetland. | Medium | Average Land Use Score = 1.0-0.95 | Average Land Use Score = 0.80-0.95 | Average Land Use Score = 0.4-0.80 | Average Land Use Score = < 0.4 |
| | | Buffer Width (B.1.2) | 1 | Wetland buffers are vegetated, natural (non-anthropogenic) areas that surround a wetland. | Medium/High | Wide > 100 m | Medium. 50 m to <100 m | Narrow. 25 m to 50 m | Very Narrow. < 25 m |
| | | Percentage of unfragmented landscape within 1 km. (B.1.3) | 1 | An unfragmented landscape has no barriers to the movement and connectivity of species, water, nutrients, etc. between natural ecological systems. | Medium | Embedded in 90-100% unfragmented, roadless natural landscape; internal fragmentation absent | Embedded in 60-90% unfragmented natural landscape; internal fragmentation minimal | Embedded in 20-60%% unfragmented natural landscape; Internal fragmentation moderate | Embedded in < 20% unfragmented natural landscape. Internal fragmentation high |
| BIOTIC CONDITION | Community Composition | Percent of Cover of Native Plant Species (B.2.1) | 2 | Percent of the plant species which are native to the Southern Rocky Mountains. | High | 100% cover of native plant species | 85-< 100% cover of native plant species | 50-85% cover of native plant species | <50% cover of native plant species |

| Category | Essential Ecological Attribute | Indicators /Metrics | Tier | Definition | Confidence | *Metric Ranking Criteria* Excellent (A) | Good (B) | Fair (C) | Poor (D) |
|---|---|---|---|---|---|---|---|---|---|
| | | Invasive Species – Plants (B.2.2) | 2 | Percent of playa which is dominated by invasive, aggressive plants. | High | No whitetop (*Cardaria* spp.) or Canada thistle (*Cirsium arvense*) present | Whitetop or Canada thistle present but sporadic | Whitetop and Canada thistle are abundant | Whitetop dominant and Canada thistle abundant |
| | | Floristic Quality Index (Mean C) (B.2.3) | 3 | The mean conservatism of all the native species growing in the wetland. | High | Mean C > 4.5 | Mean C = 3.5-4.5 | Mean C = 3.0 – 3.5 | Mean C < 3.0 |
| | Patch Diversity | Biotic/Abiotic Patch Richness (B.2.4) | 2 | The number of biotic/abiotic patches or habitat types present in the wetland. | Medium | > 75-100% of the possible patch types are evident in the wetland | > 50-75% of the possible patch types are evident in the wetland | 25-50% of the possible patch types are evident in the wetland | < 25% of the possible patch types are evident in the wetland |
| | | Interspersion of Biotic Patches (B.2.5) | 2 | The spatial arrangement of biotic/abiotic patch types within the wetland, especially the degree to which patch types intermingle with each other (e.g. the amount of edge between patches). | Medium | Horizontal structure consists of a very complex array of nested and/or interspersed, irregular biotic/abiotic patches, with no single dominant patch type | Horizontal structure consists of a moderately complex array of nested or interspersed biotic/abiotic patches, with no single dominant patch type | Horizontal structure consists of a simple array of nested or interspersed biotic/abiotic patches, | Horizontal structure consists of one dominant patch type and thus has relatively no interspersion |
| ABIOTIC CONDITION | Energy/ Material Flow | Land Use Within the Wetland (B.3.1) | 2 | Addresses the intensity of human dominated land uses within the wetland. | Medium | Average Land Use Score = 1.0-0.95 | Average Land Use Score = 0.80-0.95 | Average Land Use Score = 0.4-0.80 | Average Land Use Score = < 0.4 |

| Category | Essential Ecological Attribute | Indicators /Metrics | Tier | Definition | Confidence | *Metric Ranking Criteria* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Excellent (A)** | **Good (B)** | **Fair (C)** | **Poor (D)** |
| | | Sediment Loading Index (B.3.2) | 1 | A measure of the varying degrees to which different land uses contribute excess sediment via surface water runoff and overland flow into a wetland. | Medium | Average Score = 0.9 – 1.0 | Average Score = 0.8 – 0.89 | Average Score = 0.75 – 0.79 | Average Score = < 0.7 |
| | Hydrological Regime | Water Table Depth (B.3.3) | 2 | Estimates water table depth using hydric soil indicators from a single site visit. | Medium/High | Seasonal high water table and/or soils saturated for long durations; Hydric Soils present; Water table is within 0.5 m of soil surface.<br><br>Surface soil horizons are gleyed or have a chroma value of 2 or less in mottled soils, or 1 less in unmottled soils; Depth to mottles is within 40 cm | Seasonal high water table and/or soils saturated for long durations; Hydric Soils present; Water table is within 0.5 m of soil surface.<br><br>Surface soil horizons are gleyed or have a chroma value of 2 or less in mottled soils, or 1 less in unmottled soils; Depth to mottles is within 40 cm | No redoximorphic features present < 40 cm. Soil chromo > 2<br><br>Hydric Soils NOT present<br><br>Indicators of remnant hydric conditions may be present (e.g., distinct boundaries between mottles and matrix) | No redoximorphic features present < 40 cm. Soil chromo > 2<br><br>Hydric Soils NOT present<br><br>Indicators of remnant hydric conditions may be present (e.g., distinct boundaries between mottles and matrix) |

| Category | Essential Ecological Attribute | Indicators /Metrics | Tier | Definition | Confidence | *Metric Ranking Criteria* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Excellent (A)** | **Good (B)** | **Fair (C)** | **Poor (D)** |
| | | Water Table Depth (B.3.4) | 3 | Determines average water table depth based on measurements from shallow groundwater wells. | High | Water table depth in June-early July is consistent with baseline levels. The water table is within 1 m of the soil surface for at least a portion of the growing season. Standing water is not deeper than 2 m and does not persist for more than 4 months. | Water table depth in June-early July is consistent with baseline levels. The water table is within 1 m of the soil surface for at least a portion of the growing season. Standing water is not deeper than 2 m and does not persist for more than 4 months. | Water table depth in June-early July is inconsistent with baseline levels. The water table is below 1 m of the soil surface for the entire growing season. Standing water is deeper than 2 m and persists for more than 4 months. | Water table depth in June-early July is inconsistent with baseline levels. The water table is below 1 m of the soil surface for the entire growing season. Standing water is deeper than 2 m and persists for more than 4 months. |
| | | Surface Water Runoff Index (B.3.5) | 1 | A measure of the varying degrees to which different land uses alters surface water runoff and overland flow into a wetland. | Medium | Average Score = 0.9 – 1.0 | Average Score = 0.8 – 0.89 | Average Score = 0.75 – 0.79 | Average Score = < 0.7 |
| | | Hydrological Alterations (B.3.6) | 2 | The degree to which onsite or adjacent land uses and human activities have altered hydrological processes. | Medium | No alterations. No dikes, diversions, ditches, flow additions, or fill present in wetland that restricts or redirects flow | Low intensity alteration such as roads at/near grade, small diversion or ditches (< 1 ft. deep) or small amount of flow additions | Moderate intensity alteration such as 2-lane road, low dikes, roads w/culverts adequate for stream flow, medium diversion or ditches (1-3 ft. deep) or moderate flow additions. | High intensity alteration such as 4-lane Hwy., large dikes, diversions, or ditches (>3 ft. deep) capable to lowering water table, large amount of fill, or artificial groundwater pumping or high amounts of flow additions |

| Category | Essential Ecological Attribute | Indicators /Metrics | Tier | Definition | Confidence | *Metric Ranking Criteria* Excellent (A) | Good (B) | Fair (C) | Poor (D) |
|---|---|---|---|---|---|---|---|---|---|
| | Chemical/ Physical Processes | Nutrient/ Pollutant Loading Index (B.3.7) | 1 | A measure of the varying degrees to which different land uses contributed excess nutrients and pollutants via surface water runoff and overland flow into a wetland. | Medium | Average Score = 0.9 – 1.0 | Average Score = 0.8 – 0.89 | Average Score = 0.75 – 0.79 | Average Score = < 0.7 |
| | | Nitrogen Enrichment (C:N) (B.3.8) | 3 | The carbon to nitrogen (C:N) ratio in the aboveground biomass or leaves of plants. . | Medium/High | Leaf tissue C:N is equivalent to natural range of variability | Leaf tissue C:N is slightly less and outside of natural range of variability | Leaf tissue C:N is significantly lower than natural range of variability | Leaf tissue C:N is significantly lower than natural range of variability |
| | | Phosphorous Enrichment (C:P) (B.3.9) | 3 | The carbon to phosphorous (C:P) ratio in the aboveground biomass or leaves of plants. | Medium/High | Leaf tissue C:P is equivalent to natural range of variability | Leaf tissue C:P is slightly less and outside of natural range of variability | Leaf tissue C:P is significantly lower than natural range of variability | Leaf tissue C:P is significantly lower than natural range of variability |
| | | Soil Organic Carbon (B.3.10) | 3 | Measures the amount of soil organic carbon present in the soil. | Medium/High | Soil C is equivalent to natural range of variability | Soil C is nearly equivalent to natural range of variability | Soil C is significantly lower than natural range of variability | Soil C is significantly lower than natural range of variability |
| | | Soil Bulk Density (B.3.11) | 3 | A measure of the compaction of the soil horizons. | Medium/High | Bulk density value for wetland is at least 0.2 (g/cm3) less than Root Restricting Bulk Density value for the soil texture found in the wetland. | Bulk density value for wetland is at least 0.2 (g/cm3) less than Root Restricting Bulk Density value for the soil texture found in the wetland. (same as Very Good) | Bulk density for wetland is between 0.2 to 0.1 (g/cm3) less than Root Restricting Bulk Density value for the soil texture found in the wetland. | Bulk density for wetland is = or > than Root Restricting Bulk Density value for the soil texture found in the wetland. |

| Category | Essential Ecological Attribute | Indicators /Metrics | Tier | Definition | Confidence | *Metric Ranking Criteria* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Excellent (A)** | **Good (B)** | **Fair (C)** | **Poor (D)** |
| SIZE | Size | Absolute Size (B.4.1) | 1 | The current size of the wetland | High | > 20 acres | 10 to 20 acres | 2 to 10 acres | < 2 acre |
| | | Relative Size (B.4.2) | 1 | The current size of the wetland divided by the total potential size of the wetland multiplied by 100. | High | Wetland area = onsite Abiotic Potential | Wetland area < Abiotic Potential; Relative Size = 90 – 100% ; (< 10% of wetland has been reduced, destroyed or severely disturbed due to roads, impoundments, development, human-induced drainage, etc. | Wetland area < Abiotic Potential; Relative Size = 75 – 90%; 10-25% of wetland has been reduced, destroyed or severely disturbed due to roads, impoundments, development, human-induced drainage, etc | Wetland area < Abiotic Potential; Relative Size = < 75%; > 25% of wetland has been reduced, destroyed or severely disturbed due to roads, impoundments, development, human-induced drainage, etc |

### *A.4 Scorecard Protocols*

For each metric, a rating is developed and scored as A – (Excellent) to D – (Poor). The background, methods, and rationale for each metric are provided in section B. Each metric is rated, then various metrics are rolled together into one of four categories: Landscape Context, Biotic Condition, Abiotic Condition, and Size. A point-based approach is used to roll-up the various metrics into Category Scores.

Points are assigned for each rating level (A, B, C, D) within a metric. The default set of points are A = 5.0, B = 4.0, C = 3.0, D = 1.0. Sometimes, within a category, one measure is judged to be more important than the other(s). For such cases, each metric will be weighted according to its perceived importance. Points for the various measures are then added up and divided by the total number of metrics. The resulting score is used to assign an A-D rating for the category. After adjusting for importance, the Category scores could then be averaged to arrive at an Overall Ecological Integrity Score.

Supplementary metrics are not included in the Rating Protocol. However, they could be incorporated if the user desired.

- #### A.4.1. Landscape Context Rating Protocol

Rate the Landscape Context metrics according to their associated protocols (see Table 2 and details in Section B). Use the scoring table below (Table 3) to roll up the metrics into an overall Landscape Context rating.

Rationale for Scoring: Adjacent land use and buffer width are judged to be more important than the amount of fragmentation within 1 km of the wetland since a wetland with no other natural communities bordering it is very unlikely to have a strong biological connection to other natural lands at a further distance.

Thus, the following weights apply to the Landscape Context metrics:

Table 3. Landscape Context Rating Calculation.

| **Measure** | **Definition** | **Tier** | **A** | **B** | **C** | **D** | **Weight** | **Score** (weight x rating) |
|---|---|---|---|---|---|---|---|---|
| Adjacent Land Use (B.1.1) | Addresses the intensity of human dominated land uses within 100 m of the wetland. | 1 | 5 | 4 | 3 | 1 | 0.40 | |
| Buffer Width (B.1.2) | Wetland buffers are vegetated, natural (non-anthropogenic) areas that surround a wetland. | 1 | 5 | 4 | 3 | 1 | 0.40 | |
| Percentage of unfragmented landscape within 1 km. (B.1.3) | An unfragmented landscape has no barriers to the movement and connectivity of species, water, nutrients, etc. between natural ecological systems. | 1 | 5 | 4 | 3 | 1 | 0.20 | |

| Measure | Definition | Tier | A | B | C | D | Weight | Score (weight x rating) |
|---|---|---|---|---|---|---|---|---|
| **Landscape Context Rating** | A = 4.5 - 5.0<br>B = 3.5 – 4.4<br>C = 2.5 – 3.4<br>D = 1.0 – 2.4 | | | | | | | **Total =** (sum of N scores |

- ### A.4.2. Biotic Condition Rating Protocol

Rate the Biotic Condition metrics according to their associated protocols (see Table 2 and details in Section B). Use the scoring table below (Table 4) to roll up the metrics into an overall Biotic Condition rating.

Rationale for Scoring: The Floristic Quality Index (FQI) metric is judged to be more important than cover of native species and invasive species metric. The latter two provide very useful information, but the FQI provides a more reliable indicator of biotic condition.

Scoring for Biotic Condition is a bit more complex. For example, the Floristic Quality Index (FQI) may or may not be assessed, depending on resources (since it is a Tier 3 metric). If it is included then the weights without parentheses apply to the Biotic Condition metrics. If FQI is not included then the weight in parentheses is used for the Tier 2 metrics.

Table 4. Biotic Condition Rating Calculation.

| Measure | Definition | Tier | A | B | C | D | Weight* | Score (weight x rating) |
|---|---|---|---|---|---|---|---|---|
| Percent of Cover of Native Plant Species (B.2.1) | Percent of the plant species which are native to the Southern Rocky Mountains. | 2 | 5 | 4 | 3 | 1 | 0.30 (0.55) | |
| Invasive Species – Plants (B.2.2) | Percent of playa which is dominated by invasive, aggressive plants. | 2 | 5 | 4 | 3 | 1 | 0.20 (0.45) | |
| Floristic Quality Index (Mean C) (B.2.3) | The mean conservatism of all the native species growing in the wetland. | 3 | 5 | 4 | 3 | 1 | 0.50 (N/A) | |
| **Biotic Condition Rating** | A = 4.5 - 5.0<br>B = 3.5 – 4.4<br>C = 2.5 – 3.4<br>D = 1.0 – 2.4 | | | | | | | **Total =** (sum of N scores |

* The weight in parentheses is used when metric B.2.3 is not used.

### A.4.3 Abiotic Condition Rating Protocol

Rate the Abiotic Condition metrics according to their associated protocols (see Table 2 and details in Section B). Use the scoring table below (Table 5) to roll up the metrics into an overall Abiotic Condition rating.

Rationale for Scoring: Quantitative water table data are judged to more reliable than the other metrics for indicating Abiotic Condition (shaded metric in Table 5). However, if such data are lacking then stressor related metrics (Land Use & Hydrological Alterations) are perceived to provide more dependable information concerning Abiotic Condition.

Scoring for Abiotic Condition is a based on two scenarios: (1) one with a Tier 2 Water Table metric or (2) one with a Tier 3 Water Table metric. Both of these metrics are shaded in Table 4 to indicate that only one should be used in the Scorecard. The weights for the former scenario are shown without parentheses whereas weights for the latter are in parentheses.

Table 5. Abiotic Condition Rating Calculation.

| Measure | Definition | Tier | A | B | C | D | Weight* | Score (weight x rating) |
|---|---|---|---|---|---|---|---|---|
| Land Use Within the Wetland (B.3.1) | Addresses the intensity of human dominated land uses within the wetland. | 2 | 5 | 4 | 3 | 1 | 0.25 (0.25) | |
| Water Table Depth (B.3.3) | Estimates water table depth using hydric soil indicators from a single site visit. | 2 | 5 | 5 | 0 | 0 | 0.20 (N/A) | |
| Water Table Depth (B.3.4) | Determines average water table depth based on measurements from shallow groundwater wells. | 3 | 5 | 5 | 0 | 0 | N/A (0.45) | |
| Hydrological Alterations (B.3.6) | The degree to which onsite or adjacent land uses and human activities have altered hydrological processes. | 2 | 5 | 4 | 3 | 1 | 0.55 (0.30) | |
| **Abiotic Condition Rating** | A = 4.5 - 5.0<br>B = 3.5 – 4.4<br>C = 2.5 – 3.4<br>D = 1.0 – 2.4 | | | | | | | **Total =** (sum of N scores |

* The weight in parentheses is used when the measure for B.3.4 is substituted for the measure in B.3.3. B.3.4 is a more accurate and reliable measure than B.3.3.

### A.4.4 Size Rating Protocol

Rate the two measures according to the metrics protocols (see Table 2 and details in Section B). Use the scoring table below (Table 6) to roll up the metrics into an overall Size rating.

Rationale for Scoring: Since the importance of size is contingent on human disturbance both within and adjacent to the wetland, two scenarios are used to calculate size:

(1) When Landscape Context Rating = “A”:
Size Rating = Relative Size metric rating (weights w/o parentheses)

(2) When Landscape Context Rating = “B, C, or D”.
Size Rating = (weights in parentheses)

Table 6. Size Rating Calculation.

| Measure | Definition | Tier | A | B | C | D | Weight* | Score (weight x rating) |
|---|---|---|---|---|---|---|---|---|
| Absolute Size (B.4.1) | The current size of the wetland | 1 | 5 | 4 | 3 | 1 | 0.0 (0.70) | |
| Relative Size (B.4.2) | The current size of the wetland divided by the total potential size of the wetland multiplied by 100. | 1 | 5 | 4 | 3 | 1 | 1.0 (0.30) | |
| **Size Rating** | A = 4.5 - 5.0<br>B = 3.5 – 4.4<br>C = 2.5 – 3.4<br>D = 1.0 – 2.4 | | | | | | | **Total =** (sum of N scores |

* The weight in parentheses is used when Landscape Context Rating = B, C, or D.

## ▪ A.4.5 Overall Ecological Integrity Rating Protocol

If an Overall Ecological Integrity Score is desired for a site, then a weighted-point system should be used with the following rules:

1. If Landscape Context = *A* then the Overall Ecological Integrity Rank = **[Abiotic Condition Score *(0.35)] + [Biotic Condition Score *(0.25)] + [Landscape Context Score * (0.25)] + [Size Score * (0.15)]** **Note:** For this calculation ONLY consider Relative Size for Size Score

2. If Landscape Context is *B*, *C*, or *D* AND Size = *A* then the Overall Ecological Integrity Rank = **[Abiotic Condition Score *(0.35)] + [Biotic Condition Score *(0.25)] + [Size Score * (0.25)] + [Landscape Context Score * (0.15)]**

3. If Landscape Context is *B*, *C*, or *D* AND Size = *B* then the Overall Ecological Integrity Rank = **[Abiotic Condition Score *(0.35)] + [Biotic Condition Score *(0.25)] + [Landscape Context Score * (0.20)] + [Size Score * (0.20)]**

4. If Landscape Context is *B*, *C*, or *D* AND Size = *C* or *D* then the Overall Ecological Integrity Rank = **[Abiotic Condition Score *(0.35)] + [Biotic Condition Score *(0.25)] + [Landscape Context Score * (0.25)] + [Size Score * (0.15)]** **Note:** For this calculation use both Absolute and Relative Size for Size Score.

The Overall Ecological Rating is then assigned using the following criteria:

A = 4.5 - 5.0
B = 3.5 – 4.4
C = 2.5 – 3.4
D = 1.0 – 2.4

# B. PROTOCOL DOCUMENTATION FOR METRICS

## *B.1 Landscape Context Metrics*

- ### B.1.1. Adjacent Land Use

**Definition:** This metric addresses the intensity of human dominated land uses within 100 m of the wetland.

**Background:** This metric is one aspect of the landscape context of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** The intensity of human activity in the landscape has a proportionate impact on the ecological processes of natural systems. Each land use type occurring in the 100 m buffer is assigned a coefficient ranging from 0.0 to 1.0 indicating its relative impact to the wetland (Hauer et al. 2002).

**Measurement Protocol:** This metric is measured by documenting surrounding land use(s) within 100 m of the wetland. This should be completed in the field then verified in the office using aerial photographs or GIS. However, with access to current aerial photography and/or GIS data a rough calculation of Land Use can be made in the office. Ideally, both field data as well as remote sensing tools are used to identify an accurate % of each land use within 100 m of the wetland edge.

To calculate a Total Land Use Score estimate the % of the adjacent area within 100 m under each Land Use type and then plug the corresponding coefficient (Table 3) with some manipulation to account for regional application) into the following equation:

*Sub-land use score* = ∑ LU x PC⁄100

where**:** LU = Land Use Score for Land Use Type; PC = % of adjacent area in Land Use Type.

Do this for each land use within 100 m of the wetland edge, then sum the Sub-Land Use Score(s) to arrive at a Total Land Score. For example, if 30% of the adjacent area was under moderate grazing (0.3 * 0.6 = 0.18), 10% composed of unpaved roads (0.1 * 0.1 = 0.01), and 40% was a natural area (e.g. no human land use) (1.0 * 0.4 = 0.4), the Total Land Use Score would = 0.59 (0.18 + 0.01 + 0.40).

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Measure (Metric) Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Average Land Use Score = 1.0-0.95 | Average Land Use Score = 0.80-0.95 | Average Land Use Score = 0.4-0.80 | Average Land Use Score = < 0.4 |

**Data**:

Table 7. Current Land Use and Corresponding Land Use Coefficients (based on Table 21 in Hauer et al. (2002))

| Current Land Use | Coefficient |
|---|---|
| Paved roads/parking lots/domestic or commercially developed buildings/gravel pit operation | 0.0 |
| Unpaved Roads (e.g., driveway, tractor trail) / Mining | 0.1 |
| Agriculture (tilled crop production) | 0.2 |
| Heavy grazing by livestock / intense recreation (ATV use/camping/popular fishing spot, etc.) | 0.3 |
| Logging or tree removal with 50-75% of trees >50 cm dbh removed | 0.4 |
| Hayed | 0.5 |
| Moderate grazing | 0.6 |
| Moderate recreation (high-use trail) | 0.7 |
| Selective logging or tree removal with <50% of trees >50 cm dbh removed | 0.8 |
| Light grazing / light recreation (low-use trail) | 0.9 |
| Fallow with no history of grazing or other human use in past 10 yrs | 0.95 |
| Natural area / land managed for native vegetation | 1.0 |

**Scaling Rationale:** Land uses have differing degrees of potential impact. Some land uses have minimal impact, such as simply altering the integrity of native vegetation (e.g., recreation and grazing), while other activities (e.g., hay production and agriculture) may replace native vegetation with nonnative or cultural vegetation yet still provide potential cover for species movement. Intensive land uses (i.e., urban development, roads, mining, etc.) may completely destroy vegetation and drastically alter hydrological processes. The coefficients were assigned according to best scientific judgment regarding each land use's potential impact (Hauer et al. 2002).

**Confidence that reasonable logic and/or data support the index:** Medium.

- ### B.1.2. Buffer Width

**Definition:** Wetland buffers are vegetated, natural (non-anthropogenic) areas that surround a wetland. This includes forests, grasslands, shrublands, lakes, ponds, streams, or another wetland.

**Background:** This metric is one aspect of the landscape context of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** The intensity of human activity in the landscape often has a proportionate impact on the ecological processes of natural systems. Buffers reduce potential impacts to wetlands by alleviating the effects of adjacent human activities (Castelle et al. 1992). For example, buffers can moderate stormwater runoff, reduce loading of sediments, nutrients, and pollutants into a wetland as well as provide habitat for wetland-associated species for use in feeding, roosting, breeding and cover (Castelle et al. 1992).

**Measurement Protocol:** This metric is measured by estimating the width of the buffer surrounding the wetland. Buffer boundaries extend from the wetland edge to intensive human land uses which result non-natural areas. Some land uses such as light grazing and recreation may occur in the buffer, but other more intense land uses should be considered the buffer boundary. Irrigated meadows may be considered a buffer if the area appears to function as a buffer between the wetland and nearby, more intensive land uses such as agricultural row cropping, fenced or unfenced pastures, paved areas, housing developments, golf courses, mowed or highly managed parkland, mining or construction sites, etc. (Mack 2001).

Measurement should be completed in the field then verified in the office using aerial photographs or GIS. Measure or estimate buffer width on four or more sides of the wetland then take the average of those readings (Mack 2001). This may be difficult for large wetlands or those with complex boundaries. For such cases, the overall buffer width should be estimated using best scientific judgment.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Wide > 100 m | Medium. 50 m to <100 m | Narrow. 25 m to 50 m | Very Narrow. < 25m |

**Data**: N/A

**Scaling Rationale:** Increases in buffer width improve the effectiveness of the buffer in moderating excess inputs of sediments, nutrients, and other pollutants from surface water runoff and provides more potential habitat for wetland dependent species (Castelle et al. 1992). The categorical ratings are based on data from Castelle et al. (1992), Keate (2005), Mack (2001), and best scientific judgment regarding buffer widths and their effectiveness in the Southern Rocky Mountains.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

- **B.1.3. Percentage of Unfragmented Landscape Within One Kilometer**

**Definition:** An unfragmented landscape is one in which human activity has not destroyed or severely altered the landscape. In other words, an unfragmented landscape has no barriers to the movement and connectivity of species, water, nutrients, etc. between natural ecological systems. Fragmentation results from human activities such as timber clearcuts, roads, residential and commercial development, agriculture, mining, utility lines, railroads, etc.

**Background:** This metric is one aspect of the landscape context of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** The intensity of human activity in the landscape often has a proportionate impact on the ecological processes of natural systems. The percentage of fragmentation (e.g., anthropogenic patches) provides an estimate of connectivity among natural ecological systems. Although related to metric B.1.1 and B.1.2, this metric differs by addressing the spatial interspersion of human land use as well as considering a much larger area.

**Measurement Protocol:** This metric is measured by estimating the amount of unfragmented area in a one km buffer surrounding the wetland and dividing that by the total area. This can be completed in the office using aerial photographs or GIS.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Measure (Metric) Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Embedded in 90-100% unfragmented, roadless natural landscape; internal fragmentation absent | Embedded in 60-90% unfragmented natural landscape; internal fragmentation minimal | Embedded in 20-60%% unfragmented natural landscape; Internal fragmentation moderate | Embedded in < 20% unfragmented natural landscape. Internal fragmentation high |

**Data**: N/A

**Scaling Rationale:** Less fragmentation increases connectivity between natural ecological systems and thus allow for natural exchange of species, nutrients, and water. The categorical ratings are based on Rondeau (2001).

**Confidence that reasonable logic and/or data support the index:** Medium.

### *B.2 Biotic Condition Metrics*

- **B.2.1. Percent of Cover of Native Plant Species**

**Definition:** Percent of the plant species which are native to the Southern Rocky Mountains.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Native species dominate Southern Rocky Mountain wetlands which have excellent ecological integrity. This metric is a measure of the degree to which native plant communities have been altered by human disturbance. With increasing human disturbance, non-native species invade and can dominate the wetland.

**Measurement Protocol:** A qualitative, ocular estimate of cover is used to calculate and score the metric. The entire occurrence of the playa system should be walked and a qualitative ocular estimate of the total cover of native species growing in the wetland should be made. Alternatively, if time and resources allow a more quantitative determination of species presence and cover such methods (i.e. Peet et al. 1998) are encouraged to be used. The metric is calculated by dividing the total cover of native species by the total cover of all species and multiplying by 100.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| 100% cover of native plant species | 85-< 100% cover of native plant species | 50-85% cover of native plant species | <50% cover of native plant species |

**Data**: N/A

**Scaling Rationale:** The criteria are based on extrapolated thresholds from ecological site descriptions from Utah, Wyoming, and Montana (NRCS 2005), data and descriptions in Cooper (1990), Windell et al. (1996), CNHP (2005), and best scientific judgment. These are tentative hypotheses as they have not been validated with quantitative data. The Colorado Natural Heritage Program is currently developing a Vegetation Index of Biotic Integrity. Data from this project will likely provide the necessary information to confirm, validate, and improve the criteria.

**Confidence that reasonable logic and/or data support the index:** High

### ▪ B.2.2. Invasive Species - Plants

**Definition:** Percent of playa which is dominated by invasive, aggressive plants.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Non-native species or native increasers can displace other native species, alter hydrology, alter structure, and affect food web dynamics by changing the quantity, type, and accessibility to food for fauna (Zedler and Kercher 2004). Wetlands dominated by non-native, invasive species typically support fewer native animals (Zedler and Kercher 2004). Playas are susceptible to invasion by numerous invasive and/or exotic species are known to occur in playas. Common reed (*Phragmites australis*), a native invasive species, can establish and dominate some less-saline playas. Whitetop (*Cardaria* spp.), a non-native species, can be very problematic in playas, although it can be found in non-saline wetlands as well. Non-native annuals such as goosefoot (*Chenopodium glaucum* and *C. rubra*) can be found on salt flats. Canada thistle (*Cirsium arvense*) may also be found in less saline areas. Russian thistle (*Salsola* spp.), ironweed (*Bassia hyssopifolia*), and kochia (*Kochia scoparia*) are also common exotic species in playas.

**Measurement Protocol:** A qualitative, ocular estimate of cover is used to calculate and score the metric. The entire occurrence of the playa system should be walked and a qualitative ocular estimate of the total cover of invasive species growing in the wetland should be made. Alternatively, if time and resources allow a more quantitative determination of species presence and cover such methods (i.e. Peet et al. 1998) are encouraged to be used. The metric is calculated by dividing the total cover of invasive species by the total cover of all species and multiplying by 100.

**Metric Rating:** Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Metric Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| No whitetop (*Cardaria* spp.) or Canada thistle (*Cirsium arvense*) present | Whitetop or Canada thistle present but sporadic | Whitetop and Canada thistle are abundant | Whitetop dominant and Canada thistle abundant |

**Data**: N/A

**Scaling Rationale:** The criteria are based on and best scientific judgment. These are tentative hypotheses as they have not been validated with quantitative data.

**Confidence that reasonable logic and/or data support the index:** High

- ### B.2.3. Floristic Quality Index (Mean C)

**Definition:** The mean conservatism of all the native species growing in the wetland.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Plants grow in habitats in which they are adapted to, including biotic and abiotic fluctuations associated with that habitat (Wilhelm and Masters 1995). However, when disturbances to that habitat exceed the natural range of variation (e.g., many human-induced disturbances), only those plants with wide ecological tolerance will survive and conservative species (e.g., those species with strong fidelity to habitat integrity) will decline or disappear according to the degree of human disturbance (Wilhelm and Master 1995; Wilhelm personal communication, 2005).

The Floristic Quality Index (FQI), originally developed for the Chicago region (Swink and Wilhelm 1979, 1994) is a plant community index designed to assess the degree of "naturalness" of an area based on the presence of species whose ecological tolerance are limited (U.S. EPA 2002). FQI methods have been developed and successfully tested in Illinois (Swink and Wilhelm 1979), Missouri (Ladd 1993), Ohio (Andreas and Lichvar 1995), southern Ontario (Oldham et al. 1995), Michigan (Herman et al. 1996), Indiana (Coffee Creek Watershed Conservancy, 2001), and North Dakota (Northern Great Plains Floristic Quality Assessment Panel, 2001).

The Colorado Floristic Quality Assessment Panel is currently assigning coefficients of conservatism to the Colorado flora. Initial testing of the Colorado FQI should begin in 2006 and available for use shortly thereafter. However, calibration of the FQI will likely occur over many years of use and thus this metric will need to be updated accordingly.

**Measurement Protocol:** Species presence/absence data need to be collected from the wetland. Although, quantitative measurements are preferred, depending on time and financial constraints, this metric can be measured with qualitative or quantitative data. The two methods are described as follows: (1) Site Survey (semi-quantitative): walk the entire occurrence of the wetland system and make notes of each species encountered. A thorough search of each macro- and micro-habitat is required. (2) Quantitative Plot Data: The plot method described by Peet et al. (1998) is recommended for collecting quantitative data for this metric. This method uses a 20 x 50 m plot which is typically established in a 2 x 5 arrangement of 10 x 10 m modules. However, the array of modules can be rearranged or reduced to meet site conditions (e.g. 1 x 5 for linear areas or 2 x 2 for small, circular sites). The method is suitable for most types of vegetation, provides information on species composition across spatial scales, is flexible in intensity and effort, and compatible with data from other sampling methods (Mack 2004; Peet et al. 1998).

The metric is calculated by referencing only native species C value from the Colorado FQI Database (*in development*; *expected to be completed in 2006*), summing the C values, and dividing by the total number of native species (Mean C).

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Measure (Metric) Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| > 4.5 | 3.5-4.5 | 3.0 – 3.5 | < 3.0 |

**Data**: Colorado FQI Database (*in development*; *expected to be completed in 2006*)

**Scaling Rationale:** In the Midwest, field studies using FQI have determined that a site with a Mean C of 3.0 or less is unlikely to achieve higher C values thus this value was used as the Restoration Threshold (between Fair and Poor). In other words, those sites have been disturbed to the degree that conservative species are no longer able to survive and or compete with the less conservative species as a result of the changes to the soil and or hydrological processes on site (Wilhelm and Masters 1995). Sites with a Mean C of 3.5 or higher are considered to have at least marginal quality or integrity thus this value was used as the Minimum Integrity Threshold (between Good and Fair) (Wilhelm and Masters 1995). The threshold between Excellent and Good was assigned based on best scientific judgment upon reviewing the FQI literature. Although it is not know if these same thresholds are true for the Southern Rocky Mountains, they have been used to construct the scaling for this metric. As the FQI is applied in this region, the thresholds may change.

**Confidence that reasonable logic and/or data support the index:** High

- **B.2.4. Biotic/Abiotic Patch Richness**

**Definition:** The number of biotic/abiotic patches or habitat types present in the wetland. The metric is not a measure of the spatial arrangement of each patch.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Ecological diversity of a site is correlated with biotic/abiotic patch richness (Collins et al. 2004). Unimpacted sites have an expected range of biotic/abiotic patches. Human-induced alterations can decrease patch richness.

**Measurement Protocol:** This metric is measured by determining the number of biotic/abiotic patches present at a site and dividing by the total number of possible patches for the specific wetland (see Table 8). This percentage is then used to rate the metric in the scorecard.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| > 75-100% of the possible patch types are evident in the AA | > 50-75% of the possible patch types are evident in the AA | 25-50% of the possible patch types are evident in the AA | < 25% of the possible patch types are evident in the AA |

**Data**:

Table 8. Biotic/Abiotic Patch Types in Playas

| **Patch Type** |
|---|
| Open water |
| Mud flats |
| Salt flats |
| Deep emergent plants |
| Shallow emergent plants |
| Saline wet meadows |
| Greasewood present |
| Adjacent or onsite seeps/springs |
| Hummocks or mounds |
| Submerged/floating vegetation |
| Contributing stream |

**TOTAL = 11**

**Scaling Rationale:** The scaling criteria are based on Collins et al. (2004), however best scientific judgment was used to modify patch types to correspond with Southern Rocky Mountainwetlands.

**Confidence that reasonable logic and/or data support the index:** Medium

- **B.2.5. Interspersion of Biotic/Abiotic Patches**

**Definition:** Interspersion is the spatial arrangement of biotic/abiotic patch types within the wetland, especially the degree to which patch types intermingle with each other (e.g. the amount of edge between patches).

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Spatial complexity of biotic/abiotic patches is indicative of intact ecological processes (Collins et al. 2004). Unimpacted sites have an expected spatial pattern of biotic/abiotic patches. Human-induced alterations can decrease this complexity and homogenize patch distribution.

**Measurement Protocol:** This metric is measured by determining the degree of interspersion of biotic/abiotic patches present in the wetland. This can be completed in the field for most wetlands, however aerial photography may be beneficial for larger sites (Collin et al. 2004). The metric is rated by matching site interspersion with the categorical ratings in the scorecard.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Horizontal structure consists of a very complex array of nested and/or interspersed, irregular biotic/abiotic patches, with no single dominant patch type | Horizontal structure consists of a moderately complex array of nested or interspersed biotic/abiotic patches, with no single dominant patch type | Horizontal structure consists of a simple array of nested or interspersed biotic/abiotic patches, | Horizontal structure consists of one dominant patch type and thus has relatively no interspersion |

**Data**: See B.2.4 for list and definitions of Biotic Patches.

**Scaling Rationale:** The scaling criteria are based on Collin et al. (2004), however best scientific judgment was used to modify criteria to correspond with Southern Rocky Mountain wetlands.

**Confidence that reasonable logic and/or data support the index:** Medium

### *B.3 Abiotic Condition Metrics*

- **B.3.1. Land Use Within the Wetland**

**Definition:** This metric addresses the intensity of human dominated land uses within the wetland.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** The intensity of human activity in the wetland often has a proportionate impact on the ecological processes occurring onsite. Each land use type is assigned a coefficient ranging from 0.0 to 1.0 indicating its relative impact to the wetland (Hauer et al. 2002).

**Measurement Protocol:** This metric is measured by documenting land use(s) within the wetland. This should be completed in the field then verified in the office using aerial photographs or GIS. However, with access to current aerial photography and/or GIS data a rough calculation of Land Use can be made in the office. Ideally, both field data as well as remote sensing tools are used to identify an accurate % of each land use within 100 m of the wetland edge.

To calculate a Total Land Use Score estimate the % of the wetland area under each Land Use type and then plug the corresponding coefficient (Table 9) with some manipulation to account for regional application) into the following equation:

*Sub-land use score* = $\sum$ LU x PC/100

where**:** LU = Land Use Score for Land Use Type; PC = % of adjacent area in Land Use Type.

Do this for each land use within 100 m of the wetland, then sum the Sub-Land Use Score(s) to arrive at a Total Land Score. For example, if 30% of the wetland was under moderate grazing (0.3 * 0.6 = 0.18), 10% composed of unpaved roads (0.1 * 0.1 = 0.01), and 40% was a natural area (e.g. no human land use) (1.0 * 0.4 = 0.4), the Total Land Use Score would = 0.59 (0.18 + 0.01 + 0.40).

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Average Land Use Score = 1.0-0.95 | Average Land Use Score = 0.80-0.95 | Average Land Use Score = 0.4-0.80 | Average Land Use Score = < 0.4 |

**Data**:

Table 9. Current Land Use and Corresponding Land Use Coefficients (based on Table 21 in Hauer ete al. (2002))

| **Current Land Use** | **Coefficient** |
|---|---|
| Paved roads/parking lots/domestic or commercially developed buildings/gravel pit operation | 0.0 |
| Unpaved Roads (e.g., driveway, tractor trail) / Mining | 0.1 |
| Agriculture (tilled crop production) | 0.2 |
| Heavy grazing by livestock / intense recreation (ATV use/camping/popular fishing spot, etc.) | 0.3 |
| Logging or tree removal with 50-75% of trees >50 cm dbh removed | 0.4 |
| Hayed | 0.5 |
| Moderate grazing | 0.6 |
| Moderate recreation (high-use trail) | 0.7 |
| Selective logging or tree removal with <50% of trees >50 cm dbh removed | 0.8 |
| Light grazing / light recreation (low-use trail) | 0.9 |
| Fallow with no history of grazing or other human use in past 10 yrs | 0.95 |
| Natural area / land managed for native vegetation | 1.0 |

**Scaling Rationale:** The coefficients were assigned according to best scientific judgment regarding each land use's potential impact (Hauer et al. 2002). Land uses have differing degrees of potential impact. Some land uses have minimal impact, such as simply altering the integrity of native vegetation (e.g., recreation and grazing), while other activities (e.g., hay production and agriculture) may replace native vegetation with nonnative or cultural vegetation yet still provide potential cover for species movement. Intensive land uses (i.e., urban development, roads, mining, etc.) may completely destroy vegetation and drastically alter hydrological processes.

**Confidence that reasonable logic and/or data support the index:** Medium.

- ### B.3.2. Sediment Loading Index

**Definition:** The sediment loading index is a measure of the varying degrees to which different land uses contribute excess sediment via surface water runoff and overland flow into a wetland.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** The type and amount of each land use in the wetland and contributing watershed affects the amount of sediment that enters into a wetland. Excess sediment can change nutrient cycling, bury vegetation, suppress regeneration of plants, and carry pollutants into the wetland.

In a functional assessment of slope and depressional wetlands associated with the Great Salt Lake, Keate (2005) developed a HGM assessment model primarily based on land use as a surrogate for human impacts on wetland functions. Coefficients from Nnadi (1997) were used to represent the sediment, nutrient loading, runoff, and wildlife impacts associated with various land uses. The functions considered included hydrologic, geochemical and habitat characteristics. The same coefficients used in the Keate (2005) method are used for this metric.

**Measurement Protocol:** Identify and estimate the percentage of each land use within the wetland and the contributing watershed (within 100 m of the wetland). This is best completed in the field, however with access to current aerial photography a rough calculation of Land Use can be made in the office. Ideally, both field data as well as remote sensing tools are used to identify an accurate % of each land use. Once the percentage of each land use is identified, multiply it by the corresponding Sediment Loading coefficient found for each land use in Appendix B, then sum for the Sediment Loading Index Score.

For example, if 50% of the wetland and contributing watershed (within 100 m of the wetland) was multi-family residential, 20% had a dirt/local roads, and 30% natural vegetation the calculation would be (0.5 * 0.61) + (0.2 * 0.97) + (0.3* 1.0) = 0.79 (Sediment Loading Index Score). Referring to the scorecard, this would give the metric a "Fair" rating.

The contributing watershed can be calculated or digitized using Digital Elevation Models in a GIS. Surface water divides are determined using topography and although groundwater divides do not always coincide with these same hydrological divides, groundwater movement is assumed to do so, unless other data for the site is available.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Average Score = 0.9 – 1.0 | Average Score = 0.8 – 0.89 | Average Score = 0.75 – 0.79 | Average Score = < 0.7 |

**Data**: Appendix B.

**Scaling Rationale:** The scaling is based on best scientific judgment. Scores below 0.7 are assumed to have crossed a threshold in which loading impacts are considered to not be restoreable (based on the land uses that have coefficients below 0.7). Additional research may suggest changes to the scaling criteria.

**Confidence that reasonable logic and/or data support the index:** Low/medium.

- ### B.3.3. Water Table Depth

**Definition:** This metric estimates water table depth using hydric soil indicators from a single site visit.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Hydric soils exhibit morphological characteristics which result from extended (more than a few days) periods of saturation and/or inundation (USDA 2002). These indicators are often used to indicate soil saturation and water table depth for wetland assessment procedures (Environmental Laboratory 1987; USDA 2002).

If metric B.3.4 cannot be used due to time/financial constraints, this metric provides an alternative, rapid, qualitative estimate of water table depth.

**Measurement Protocol:** This metric is measured by digging multiple soil pits in the wetland, ensuring that soil pit locations represent the edge as well as interior of the wetland. If quantitative vegetation data are being collected, soil pits should be located within these plots to allow correlations with vegetation data. For example, if using the 20 x 50 m plots described by Peet et al. (1998), soil pits would be located within each of the intensive modules. Allow at least 30 minutes to pass before measuring the water level in the soil pits. The distance between the soil surface and water level equals depth to water table.

Each horizon should be described and hydric soil indicators should be noted as to their depth, abundance, size, and contrasts (soil color). Soil and mottle colors (chroma/value) should be estimated from a Munsell Soil Chart. The USDA (2002) document, Field Indicators of Hydric Soils (see below) should be consulted for additional information about hydric soil indicators.

Consideration of annual precipitation (or more specifically, annual snowpack) and its deviation from long-term averages from the closest weather station are needed to assess the reliability of this metric. Also, special attention should be placed on identifying any redoximorphic features which may be indicative of remnant hydrological conditions.

**Metric Rating:** Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Metric Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Seasonal high water table and/or soils saturated for long durations; Hydric Soils present; Water table is within 0.5 m of soil surface.<br><br>Surface soil horizons are gleyed or have a chroma value of 2 or less in mottled soils, or 1 less in unmottled soils; Depth to mottles is within 40 cm | Seasonal high water table and/or soils saturated for long durations; Hydric Soils present; Water table is within 0.5 m of soil surface.<br><br>Surface soil horizons are gleyed or have a chroma value of 2 or less in mottled soils, or 1 less in unmottled soils; Depth to mottles is within 40 cm | No redoximorphic features present < 40 cm. Soil chromo > 2<br><br>Hydric Soils NOT present<br><br>Indicators of remnant hydric conditions may be present (e.g., distinct boundaries between mottles and matrix) | No redoximorphic features present < 40 cm. Soil chromo > 2<br><br>Hydric Soils NOT present<br><br>Indicators of remnant hydric conditions may be present (e.g., distinct boundaries between mottles and matrix) |

**Data**: See

**Scaling Rationale:** The metric criteria are based on U.S. Army Corps of Engineers (1987), USDA (2002), and best scientific judgment.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

- ### B.3.4. Water Table Depth

**Definition:** This metric estimates median water table depth based on measurement from shallow groundwater wells.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Seasonally high water tables are critical for the maintenance of ecological integrity in wet meadows.

This metric uses weekly measurements of the water table through June, July, and August to indicate the hydrological integrity.

**Measurement Protocol:** If quantitative vegetation data are being collected, monitoring wells should be located within these plots to allow correlations with vegetation data. For example, if using the 20 x 50 m plots described by Peet et al. (1998), wells would be located within each of the intensive modules.

Monitoring wells are set vertically in the ground to intercept the groundwater passively. Shallow monitoring wells should be installed according the protocol identified in the technical note, *Installing Monitoring Wells/Piezometers in Wetlands* (U.S. Army Corps of Engineers 2000). To summarize, 3.8 cm PVC pipe is perforated from just below the ground surface to the bottom of the pipe. Using a soil auger, a hole is dug to at least 40 cm. Sand is placed in the bottom of the well, the pipe is placed in the hole which is then backfilled with the excavated soil. Bentonite clay is then used to seal the opening of the hole and to ensure surface water does not infiltrated freely into the hole. Water levels inside the pipe result from the integrated water pressures along the entire length of perforations.

Water levels can be read with a steel measuring tape marked with a water-soluble marker. The only equipment needed is the tape, marker, and a rag to wipe the tape dry after each reading. The height of the well above the ground surface should be noted every time the instrument is read because pipes are known to move (U.S. Army Corps of Engineers). Another simple measuring tool is that described in Henszey (1991). This instrument is attached to a meter tape, lowered into the well, and beeps when it contacts water at which point a measurement is taken from the tape and subtracted from the height of the well above the soil surface to give the depth of the water table.

Water levels should be checked weekly during the summer months. Automatic recording devices record water levels with down-well transducers or capacitance-based sensors are efficient for season-long monitoring but these cost much more than manually read instruments (U.S. Army Corps of Engineers 2000). However, automatic recorders may be less expensive than total travel costs and salaries. In addition, the credibility of monitoring data is enhanced by automatic wells (U.S. Army Corps of Engineers 2000). Automatic water-level recorders should be periodically checked and recalibrated as necessary (U.S. Army Corps of Engineers 2000).

Consideration of annual precipitation (or more specifically, annual snowpack) and its deviation from long-term averages from the closest weather station are needed to assess the reliability of this metric. During years of average precipitation (e.g. average snowpack) this metric is a reliable rapid metric of the integrity of groundwater levels in the fen. Long-term monitoring of ground water in the wetland coupled with an analysis of climatic variation during that time-frame will provide the most reliable information.

Median water table levels should be calculated for each month and hydrographs should be constructed to visually inspect trends.

**Metric Rating:** Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Metric Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Water table depth in June-early July is consistent with baseline levels. The water table is within 1 m of the soil surface for at least a portion of the growing season. Standing water is not deeper than 2 m and does not persist for more than 4 months. | Water table depth in June-early July is consistent with baseline levels. The water table is within 1 m of the soil surface for at least a portion of the growing season. Standing water is not deeper than 2 m and does not persist for more than 4 months. | Water table depth in June-early July is inconsistent with baseline levels. The water table is below 1 m of the soil surface for the entire growing season. Standing water is deeper than 2 m and persists for more than 4 months. | Water table depth in June-early July is inconsistent with baseline levels. The water table is below 1 m of the soil surface for the entire growing season. Standing water is deeper than 2 m and persists for more than 4 months. |

**Data**: Cooper and Severn (1992) and Cooper et al. (2000).

**Scaling Rationale:** The metric criteria are based on Cooper and Severn (1992), Cooper et al. (2000), and best scientific judgment.

**Confidence that reasonable logic and/or data support the index:** High.

### ▪ B.3.5. Surface Water Runoff Index

**Definition:** The surface water runoff index is a measure of the varying degrees to which different land uses alters surface water runoff and overland flow into a wetland.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** The type and amount of each land use in the wetland and contributing watershed affects the timing, duration, and frequency of surface water runoff and overland flow into a wetland. These flows alter the hydrological regime of the wetland and can result in degradation of biotic integrity, change nutrient cycling, and potentially affect physical integrity.

In a functional assessment of slope and depressional wetlands associated with the Great Salt Lake, Keate (2005) developed a HGM assessment model primarily based on land use as a surrogate for human impacts on wetland functions. Coefficients from Nnadi (1997) were used to represent the sediment, nutrient loading, runoff, and wildlife impacts associated with various land uses. The functions considered included hydrologic, geochemical and habitat characteristics. The same coefficients used in the Keate (2005) method are used for this metric.

**Measurement Protocol:** Identify and estimate the percentage of each land use within the wetland and the contributing watershed (within 100 m of the wetland). This is best completed in the field, however with access to current aerial photography a rough calculation of Land Use can be made in the office. Ideally, both field data as well as remote sensing tools are used to identify an accurate % of each land use. Once the percentage of each land use is identified, multiply it by the corresponding Surface Water Runoff coefficient found for each land use in Appendix B, then sum for the Surface Water Index Score.

For example, if 50% of the wetland and contributing watershed (within 100 m of the wetland) was under heaving grazing, 10% had a dirt road, and 40% natural vegetation the calculation would be (0.5 * 0.76) + (0.1 * 0.71) + (0.4* 1.0) = 0.85 (Surface Water Index Score). Referring to the scorecard, this would give the metric a “Fair” rating.

The contributing watershed can be calculated or digitized using Digital Elevation Models in a GIS. Surface water divides are determined using topography and although groundwater divides do not always coincide with these same hydrological divides, groundwater movement is assumed to do so, unless other data for the site is available

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Average Score = 0.9 – 1.0 | Average Score = 0.8 – 0.89 | Average Score = 0.75 – 0.79 | Average Score = < 0.7 |

**Data**: Appendix B.

**Scaling Rationale:** The scaling is based on best scientific judgment. Scores below 0.7 are assumed to have crossed a threshold in which runoff impacts are considered to not be restoreable (based on the land uses that have coefficients below 0.7). Additional research may suggest changes to the scaling criteria.

**Confidence that reasonable logic and/or data support the index:** Medium.

### ▪ B.3.6. Hydrological Alterations

**Definition:** The degree to which onsite or adjacent land uses and human activities have altered hydrological processes.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Land uses within or near a wetland can reduce soil permeability, affect surface water inflows, impede subsurface flow, and lower water tables.

**Measurement Protocol:** This metric is measured by evaluating land use(s) and human activity within or near the wetland which appear to be altering the hydrological regime of the site. Data collected in the field as well as from aerial photograph and GIS should be used. The ratings in the scorecard reflect various degrees of hydrological alteration.

**Metric Rating:** Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Metric Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| No alterations. No dikes, diversions, ditches, flow additions, or fill present in wetland that restricts or redirects flow | Low intensity alteration such as roads at/near grade, small diversion or ditches (< 1 ft. deep) or small amount of flow additions | Moderate intensity alteration such as 2-lane road, low dikes, roads w/culverts adequate for stream flow, medium diversion or ditches (1-3 ft. deep) or moderate flow additions. | High intensity alteration such as 4-lane Hwy., large dikes, diversions, or ditches (>3 ft. deep) capable to lowering water table, large amount of fill, or artificial groundwater pumping or high amounts of flow additions |

**Data**: N/A

**Scaling Rationale:** The criteria are based on Keate (2005) and best scientific judgment.

**Confidence that reasonable logic and/or data support the index:** Medium.

### ▪ B.3.7. Nutrient/Pollutant Loading Index

**Definition:** The nutrient/pollutant loading index is a measure of the varying degrees to which different land uses contributed excess nutrients and pollutants via surface water runoff and overland flow into a wetland.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** The type and amount of each land use in the wetland and contributing watershed affects the amounts and types of nutrients and pollutants that enter into a wetland. Excess nutrients can result in degradation of biotic integrity, change nutrient cycling, and potentially affect peat integrity.

In a functional assessment of slope and depressional wetlands associated with the Great Salt Lake, Keate (2005) developed a HGM assessment model primarily based on land use as a surrogate for human impacts on wetland functions. Coefficients from Nnadi (1997) were used to represent the sediment, nutrient loading, runoff, and wildlife impacts associated with various land uses. The functions considered included hydrologic, geochemical and habitat characteristics. The same coefficients used in the Keate (2005) method are used for this metric.

**Measurement Protocol:** Identify and estimate the percentage of each land use within the wetland and the contributing watershed (within 100 m of the wetland). This is best completed in the field, however with access to current aerial photography a rough calculation of Land Use can be made in the office. Ideally, both field data as well as remote sensing tools are used to identify an accurate % of each land use. Once the percentage of each land use is identified, multiply it by the corresponding Nutrient/Pollutant Loading coefficient found for each land use in Appendix B, then sum for the Nutrient/Pollutant Loading Index Score.

For example, if 50% of the wetland and contributing watershed (within 100 m of the wetland) was under heaving grazing, 10% had a dirt road, and 40% natural vegetation the calculation would be (0.5 * 0.87) + (0.1 * 0.92) + (0.4* 1.0) = 0.93 (Surface Water Index Score). Referring to the scorecard, this would give the metric a “Good” rating.

The contributing watershed can be calculated or digitized using Digital Elevation Models in a GIS. Surface water divides are determined using topography and although groundwater divides do not always coincide with these same hydrological divides, groundwater movement is assumed to do so, unless other data for the site is available

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Average Score = 0.9 – 1.0 | Average Score = 0.8 – 0.89 | Average Score = 0.75 – 0.79 | Average Score = < 0.7 |

**Data**: Appendix B.

**Scaling Rationale:** The scaling is based on best scientific judgment. Scores below 0.7 are assumed to have crossed a threshold in which loading impacts are considered to not be restoreable (based on the land uses that have coefficients below 0.7). Additional research may suggest changes to the scaling criteria.

**Confidence that reasonable logic and/or data support the index:** Low/medium.

- **B.3.8. Nutrient Enrichment (C:N)**

**Definition:** The carbon to nitrogen (C:N) ratio in the aboveground biomass or leaves of plants is used to determine whether there is excess N in the system (compared to reference standard). Increasing leaf N decreases the C:N ratio and indicates nitrogen enrichment.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Nitrogen enrichment causes vegetation to increase uptake and storage of nitrogen in plant tissue and generally results in increased productivity (Craft et al. 1995, Bridgham et al. 1996 *in* U.S. EPA 2002). These changes affect ecosystem processes including decomposition (Valiela et al. 1982, Davis 1991, Rybczyk et al. 1996 *in* U.S. EPA 2002) and accumulation of soil organic matter (Craft and Richardson 1993, 1998, Morris and Bradley 1999 *in* U.S. EPA 2002). Floristic composition may change as aggressive, competitive species take advantage of increased nutrients and displace less competitive species. All of these changes degrade the ecological integrity of the wetland by altering energy flow, nutrient cycling, and potential habitat for fauna assemblages (U.S. EPA 2002).

**Measurement Protocol:** Herbaceous plants are preferentially sampled because they respond to nutrient enrichment quicker than woody species (U.S. EPA 2002). Two or three dominant species should be selected for sampling. Samples should be collected from plants of a similar age and clipped from nodes a similar distance below the terminal bud (U.S. EPA 2002). The plants should be growing in similar habitats. If habitat is heterogeneous, then it is best to sample from each dominant habitat type. Multiple samples should be collected from several individual plants (5-10) to capture variability within the population. It is important to make collections from the same species at each site so that variation in leaf tissue nutrient concentrations is minimized (U.S. EPA 2002). See U.S. EPA (2002) for additional information.

Nitrogen is typically measured by dry combustion using a CHN analyzer. Each clipped sample should be placed in their own individual paper bag and sent to a laboratory for analysis of soil organic carbon (e.g., CHN Analyzer). Do not put the sample in a plastic bag as this could induce decomposition of the sample.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Measure (Metric) Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Leaf tissue C:N is equivalent to natural range of variability | Leaf tissue C:N is slightly less and outside of natural range of variability | Leaf tissue C:N is significantly lower than natural range of variability | Leaf tissue C:N is significantly lower than natural range of variability |

**Data**: N/A

**Scaling Rationale:** Reference C:N ratios need to be established in undisturbed wetlands. Thereafter, the scaling is based on best scientific judgment and an assumed linear relationship of the amount of deviation from the reference standard to level of nutrient enrichment. If data are collected from wetlands across a disturbance gradient, quantitative criteria could be established.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

- **B.3.9. Nutrient Enrichment (C:P)**

**Definition:** The carbon to phosphorous (C:P) ratio in the aboveground biomass or leaves of plants is used to determine whether there is excess P in the system (compared to reference standard). Increasing leaf P decreases the C:P ratio and indicates phosphorous enrichment.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Phosphorous enrichment causes vegetation to increase uptake and storage of phosphorous in plant tissue and generally results in increased productivity (Craft et al. 1995, Bridgham et al. 1996 *in* U.S. EPA 2002). These changes affect ecosystem processes including decomposition (Valiela et al. 1982, Davis 1991, Rybczyk et al. 1996 *in* U.S. EPA 2002) and accumulation of soil organic matter (Craft and Richardson 1993, 1998, Morris and Bradley 1999 *in* U.S. EPA 2002). Floristic composition may change as aggressive, competitive species take advantage of increased nutrients and displace less competitive species. All of these changes degrade the ecological integrity of the wetland by altering energy flow, nutrient cycling, and potential habitat for fauna assemblages (U.S. EPA 2002).

**Measurement Protocol:** Herbaceous plants are preferentially sampled because they respond to nutrient enrichment quicker than woody species (U.S. EPA 2002). Two or three dominant species should be selected for sampling. Samples should be collected from plants of a similar age and clipped from nodes a similar distance below the terminal bud (U.S. EPA 2002). The plants should be growing in similar habitats. If habitat is heterogeneous, then it is best to sample from each dominant habitat type. Multiple samples should be collected from several individual plants (5-10) to capture variability within the population. It is important to make collections from the same species at each site so that variation in leaf tissue nutrient concentrations is minimized (U.S. EPA 2002). See U.S. EPA (2002) for additional information.

Phosphorous is typically measured by spectrophotometry in acid ($H_2SO_4$-$H_2O_2$) digests. Each clipped sample should be placed in their own individual paper bag and sent to a laboratory for analysis of soil organic carbon (e.g., CHN Analyzer). Do not put the sample in a plastic bag as this could induce decomposition of the sample.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Leaf tissue C:P is equivalent to natural range of variability | Leaf tissue C:P is slightly less and outside of natural range of variability | Leaf tissue C:P is significantly lower than natural range of variability | Leaf tissue C:P is significantly lower than natural range of variability |

**Data**: N/A

**Scaling Rationale:** Reference C:P ratios need to be established in undisturbed wetlands. Thereafter, the scaling is based on best scientific judgment and an assumed linear relationship of the amount of deviation from the reference standard to level of nutrient enrichment. If data are collected from wetlands across a disturbance gradient, quantitative criteria could be established.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

### ▪ B.3.10. Soil Organic Carbon

**Definition:** This metric measures the amount of soil organic carbon present in the soil.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Soil organic matter or carbon generally refers to the organic fraction of the soil, including plant and animal residues at various stages of decomposition, as well as substances synthesized by the soil organisms (Neue 1984). Organic matter plays an extremely important role in the soil environment, including increases water holding capacity, encouraging soil structure, has a high cation exchange capacity, and supplies essential nutrients (Brady 1990).

Soil organic carbon is strong metric of soil quality due to its sensitivity to environmental disturbance (NRC 2000 *in* Fennessy et al. 2004). Given that soil organic carbon contributes to critical hydrologic, biogeochemical, and physical processes, a reduction in soil organic carbon from reference conditions serves as a strong indicator of loss of soil quality.

**Measurement Protocol:** Multiple soil pits should be dug in the wetland to a depth of at least 40 cm. If quantitative vegetation data are being collected, soil pits should be located within these plots to allow correlations with vegetation data. For example, if using the 20 x 50 m plots described by Peet et al. (1998), soil pits would be located within each of the intensive modules. At least five replicate soil samples should be taken within the top 10 cm of the soil surface in each pit. The replicates are mixed together as "one" sample from the site. Each soil sample should be placed in their own individual plastic bag, packed on ice, and sent to a laboratory for analysis of soil organic carbon (e.g., CHN Analyzer).

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| **Measure (Metric) Rating** | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Soil C is equivalent to natural range of variability | Soil C is nearly equivalent to natural range of variability | Soil C is significantly lower than natural range of variability | Soil C is significantly lower than natural range of variability |

**Data**: N/A

**Scaling Rationale:** Reference soil organic carbon levels need to be established in undisturbed wetlands. Thereafter, the scaling is based on best scientific judgment and an assumed linear relationship of the amount of deviation from the reference standard to level of disturbance. If data are collected from wetlands across a disturbance gradient, quantitative criteria could be established. Alternatively, if "baseline" soil organic carbon levels are known (from "pre-impact" conditions or from adjacent unaltered sites) then this metric can be used to determine change of soil organic carbon with time.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

- ### B.3.11. Soil Bulk Density

**Definition:** Soil bulk density is a ratio of the mass/volume of the soil. This metric is a measure of the compaction of the soil horizons.

**Background:** This metric is one aspect of the condition of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Bulk density is a measure of the weight of the soil divided by its volume and provides an indication of the level of compaction. Compaction can result from any activity which compresses soil particles thereby increasing the weight to volume ratio. This can reduce the soil's water holding capacity, infiltration rate, water movement through the soil, and limit plant growth by physically restricting root growth (NRCS 2001). Bulk density of organic soils are typically much less than those of mineral soils, however as decomposition increases and/or organic soils are compacted from human activity, bulk density of organic soils will increase. This has corresponding negative impacts on ecological processes such as water movement through the peat body, decomposition, and nutrient cycling.

**Measurement Protocol:** Multiple soil pits should be dug in the wetland to a depth of at least 40 cm. If quantitative vegetation data are being collected, soil pits should be located within these plots to allow correlations with vegetation data. For example, if using the 20 x 50 m plots described by Peet et al. (1998), soil pits would be located and samples collected within each of the intensive modules.

The samples are collected by taking a core sample within the top 15 cm of the soil. A cylinder of known volume should be used to collect samples. A PVC pipe of known dimensions will suffice. The cylinder is simply inserted into the soil profile, extracted, then shaved to eliminate any soil which is not contained within the cylinder. The soil remaining in the cylinder can then be placed into a plastic bag and then sent to a laboratory for analysis. Bulk density and soil texture (e.g., particle distribution) should be analyzed. Alternatively, texture can be determined in the field using the "field hand method", however lab analysis is preferable.

Once texture and bulk density are determined, use the information below to determine whether the soil's bulk density is less than, equal to, or greater then the minimum root-restricting bulk density values listed for the corresponding texture of the soil and assign the metric rating accordingly in the scorecard.

There are no root restricting values given for organic soils, thus if the wetland is dominated by organic soil, reference bulk density measurements need to be established in undisturbed areas.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Measure (Metric) Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Bulk density value for wetland is at least 0.2 (g/cm3) less than Root Restricting Bulk Density value for the soil texture found in the wetland. | Bulk density value for wetland is at least 0.2 (g/cm3) less than Root Restricting Bulk Density value for the soil texture found in the wetland. (same as Very Good) | Bulk density for wetland is between 0.2 to 0.1 (g/cm3) less than Root Restricting Bulk Density value for the soil texture found in the wetland. | Bulk density for wetland is = or > than Root Restricting Bulk Density value for the soil texture found in the wetland. |

**Data**: The data below are derived from a Natural Resource Conservation Service, Soil Quality Information Sheet — Compaction which can be found online at: http://soils.usda.gov/sqi/publications/sqis.html

Theses texture classes have the following Root Restricting Bulk Density values (g/cm3):

1. Coarse, medium, and fine sand AND loamy sand other than loamy very fine sand = 1.8 g/cm3
2. Very fine sand, loamy very find sand = 1.77 g/cm3
3. Sandy loam = 1.75 g/cm3
4. Loam, sandy clay loam = 1.7 g/cm3
5. Clay loam = 1.65 g/cm3
6. Sandy clay = 1.6 g/cm3
7. Silt, silt loam = 1.55 g/cm3
8. Silty clay loam = 1.5 g/cm3
9. Silty clay = 1.45 g/cm3
10. Clay = 1.4 g/cm3

**Scaling Rationale:** The scaling is based on best scientific judgment and an assumed linear relationship of the amount of deviation from the reference standard to level of disturbance. However, no distinction was made between Excellent and Good as there is no information to suggest that threshold. Alternatively if "baseline" bulk density levels are known (from "pre-impact" conditions or from adjacent unaltered areas) then this metric can be used to determine change of bulk density with time.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

## *B.4 Size Metrics*

### ▪ B.4.1. Absolute Size

**Definition:** Absolute size is the current size of the wetland.

**Background:** This metric is one aspect of the size of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Absolute size is pertinent to ecological integrity if the surrounding landscape is impacted by human-induced disturbances. When the surrounding landscape is impacted and has the potential to affect the wetland, larger sized wetlands are able to buffer against these impacts better than smaller sized wetlands due to the fact they generally possess a higher diversity of abiotic and biotic processes allowing them to recover and remain more resilient. However, when the landscape is unimpacted (i.e. has an "Excellent" rating), then absolute size has little impact on ecological integrity since there are no adjacent impacts to buffer. Of course, larger wetlands tend to have more diversity (MacArthur and Wilson 1967); however, this is a metric more pertinent to functional or conservation value than ecological integrity. Thus, absolute size is included as a metric but is only considered in the overall ecological integrity rank if the landscape is impacted. Regardless, absolute size provides important information to conservation planners and land managers.

**Measurement Protocol:** Absolute size can be measured easily in GIS using aerial photographs, orthophoto quads, National Wetland Inventory maps, etc. Absolute size can also be estimated in the field using 7.5 minute topographic quads, National Wetland Inventory maps, or a global positioning system. Wetland boundaries aren't delineated using jurisdictional methods (U.S. Army Corps of Engineers 1987) rather by the guidelines identified for delineating the boundaries of the wetland ecological system type.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Metric Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| > 8 hectares | 4 to 8 hectares | 1 to 4 hectares | < 1 hectare |

**Data**: N/A

**Scaling Rationale:** Scaling criteria are based on Rondeau (2001) and best scientific judgment.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

### B.4.2. Relative Size

**Definition:** Relative size is the current size of the wetland divided by the total potential size of the wetland multiplied by 100.

**Background:** This metric is one aspect of the size of specific occurrences of wetland ecological systems.

**Rationale for Selection of the Variable:** Relative size is an indication of the amount of the wetland lost due to human-induced disturbances. It provides information allowing the user to calibrate the Absolute Size metric to the abiotic potential of the wetland onsite. For example, if a wetland has an Absolute Size of 2 hectares but the Relative Size is 50% (1 hectare), this indicates that half of the original wetland has been lost or severely degraded. Unlike Absolute Size, the Relative Size metric is always considered in the ecological integrity rank.

**Measurement Protocol:** Relative size can be measured in GIS using aerial photographs, orthophoto quads, National Wetland Inventory maps, etc. However, field calibration of size is required since it can be difficult to discern the abiotic potential of the wetland from remote sensing data. However, the reverse may also be true since old or historic aerial photographs may indicate a larger wetland than observed in the field. Relative size can also be estimated in the field using 7.5 minute topographic quads, National Wetland Inventory maps, or a global positioning system. Wetland boundaries aren't delineated using jurisdictional methods (U.S. Army Corps of Engineers 1987) rather by the guidelines identified for delineating the boundaries of the wetland ecological system type.

**Metric Rating**: Assign the metric an Excellent, Good, Fair, or Poor rating on the scorecard.

| Measure (Metric) Rating | | | |
|---|---|---|---|
| **Excellent** | **Good** | **Fair** | **Poor** |
| Wetland area = onsite Abiotic Potential | Wetland area < Abiotic Potential; < 10% of wetland has been reduced (destroyed or severely disturbed e.g change in hydrology) due to roads, impoundments, development, human-induced drainage, etc. | Wetland area < Abiotic Potential; 10-25% of wetland has been reduced (destroyed or severely disturbed e.g change in hydrology) due to roads, impoundments, development, human-induced drainage, etc. | Wetland area < Abiotic Potential; > 25% of wetland has been reduced (destroyed or severely disturbed e.g change in hydrology) due to roads, impoundments, development, human-induced drainage, etc. |

**Data**: N/A

**Scaling Rationale:** Scaling criteria are based on Rondeau (2001) and best scientific judgment.

**Confidence that reasonable logic and/or data support the index:** Medium/High.

# C. REFERENCES

Andreas, B.K. and R.W. Lichvar. 1995. Floristic index for establishing assessment standards: A case study for northern Ohio. Technical Report WRP-DE-8, U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MS.

Baker, W.L. 1987. Recent Changes in the Riparian Vegetation of the Montane and Subalpine Zones of Western Colorado, U.S.A. PhD Dissertation. University of Wisconsin. Madison, WI.

Brady, N.C. 1990. The Nature and Properties of Soils. MacMillian Publishing, New York, NY.

Botherson, J.D. 1987. Plant community zonation in response to soil gradients in a saline meadow near Utah Lake, Utah County, Utah. Great Basin Naturalist Vol. 47(2) 322-333.

Bridgham SD, Pastor J, Jannsens JA, Chapin C, Malterer TJ. 1996. Multiple limiting gradients in peatlands: a call for a new paradigm. Wetlands 16:45-65.

Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, T. Erickson, S.S. Cooke. 1992. Wetland Buffers: Use and Effectiveness. Adolfson Associates, Inc., Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Pub. No. 92-10.

Coffee Creek Watershed Conservancy. 2001. 2001 Monitoring reports. http://www.coffeecreekwc.org/ccwc/ccwcmission/monitoring_reports.htm Coffee Creek Watershed Conservancy, Chesterton, IN.

Colorado Native Plant Society. 1997. Rare Plants of Colorado. Second Edition. Falcon Press. Helena, MT.

Collins, J.N., E. Stein, and M. Sutula. 2004. California Rapid Assessment Method for Wetlands V.2.0, User's Manual and Scoring Forms (Draft). Online at: http://www.wrmp.org/cram.html

Colorado Natural Heritage Program. 2005. Wetland and Riparian Plot Database. These data can be found at VegBank: http://vegbank.org/vegbank/index.jsp

Cooper, D.J. and C. Severn. 1992. Wetlands of the San Luis Valley, Colorado: An Ecological Study and Analysis of the Hydrologic Regime, Soil Chemistry, Vegetation and the Potential Effects of a Water Table Drawdown. Unpublished report prepared for Colorado Division of Wildlife, U.S. Fish and Wildlife Service, and the Rio Grande Water Conservation District.

Cooper, D.J. 1990. Ecology of Wetlands in Big Meadows, Rocky Mountain National Park, Colorado. U.S. Fish and Wildlife Service, Biological Report 90(15).

Cooper, D.J. 1993. Ecological Studies of Wetlands in South Park, Colorado: Classification, Functional Analysis, Rare Species Inventory, and the Effects of Removing Irrigation. Unpublished report prepared for the U.S. Environmental Protection Agency, Region VIII.

Cooper, D.J. 1996. Wetlands of the San Luis Valley, Colorado. *In*: Geologic Excursions to the Rocky Mountains and Beyond: Field Trip Guidebook for the 1996 Annual Meeting, Geological Society of America (Editors: R. A. Thompson, M. R. Hudson, & and C. L. Pillmore) Colorado Geological Survey, Department of Natural Resources, Denver, CO.

Cooper, D.J. and C. Severn. 1992. Wetlands of the San Luis Valley, Colorado: An Ecological Study and Analysis of the Hydrologic Regime, Soil Chemistry, Vegetation and the Potential Effects of a Water Table Drawdown. Unpublished report prepared for Colorado Division of Wildlife, U.S. Fish and Wildlife Service, and the Rio Grande Water Conservation District.

Cooper, D.J., D.P. Groenveld, R.A. Chimner, and J. Sanderson. 2000. Characterization of Three Functional Ecosystems Based upon Evapotranspiration Relationships in the San Luis Valley, Colorado. Unpublished report.

Craft CB, Richardson CJ. 1993. Peat accretion and phosphorus accumulation along a eutrophication gradient in the Northern Everglades. Biogeochem 22:133-156.

Craft CB, Richardson CJ. 1998. Recent and long-term organic soil accretion and nutrient accumulation in the Everglades. Soil Sci Soc Amer J 62:834-843.

Craft CB, Vymazal J, Richardson CJ. 1995. Response of Everglades plant communities to nitrogen and phosphorus additions. Wetlands 15:258-271.

Davis SM. 1991. Growth, decomposition and nutrient retention of Cladium jamaicense Crantz and Typha domingensis Pers. in the Florida Everglades. Aqua Bot 40:203-224.

Fennessy, M. Siobhan, John J. Mack, Abby Rokosch, Martin Knapp, and Mick Micacchion. 2004. Integrated Wetland Assessment Program. Part 5: Biogeochemical and Hydrological Investigations of Natural and Mitigation Wetlands. Ohio EPA Technical Report WET/2004-5. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Foster, S.Q. 1986. Wetland values. Pages 177-214 *in* J.T. Windell, B.E. Willard, D.J. Cooper, S.Q. Foster, C.F. Knud-Hansen, L.P. Rink, and G.N. Kiladis, editors. An ecological characterization of Rocky Mountain montane and subalpine wetlands. U.S. Fish and Wildlife Service, Biological Report 86.

Gammonley, J.H. 2004. Wildlife of Natural Palustrine Wetlands. Pages 130-153 *in* M. C. McKinstry, W.A. Hubert, and S.H. Anderson, editors. Wetland and Riparian Areas of the Intermountain West: Ecology and Management. University of Texas Press, Austin, TX.

Hall, J. J. Powell, S. Carrick, T. Rockwell, G. Hollands, T. Water, and J. White. 2003. Wetland Functional Assessment Guidebook: Operational Draft Guidebook for Assessing the Functions of Slope/Flat Wetland Complexes in the Cook Inlet Basin Ecoregion, Alaska, using the HGM Approach. State of Alaska Department of Environmental Conservation / U.S. Army Corps of Engineers Waterways Experiment Station Technical Report: WRP-DE-

Hauer, F.R., B.J. Cook, M.C. Gilbert, E.J. Clairain Jr., and R.D. Smith. 2002. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Riverine Floodplains in the Northern Rocky Mountains. U.S.Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS. ERDC/EL TR-02-21.

Henszey, R.J. (1991). A simple, inexpensive device for measuring shallow groundwater levels. Journal of Soil and Water Conservation 39: 304-306.

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, and W.W. Brodowicz. 1996. Floristic quality assessment with wetland categories and computer application programs for the State of Michigan. Michigan Department of Natural Resources, Wildlife Division, Natural Heritage Program. In partnership with U.S. Department of Agriculture Natural Resources Conservation Service, Rose Lake Plant Materials Center, Michigan.

Keate, N.S. 2005. Functional Assessment of Great Salt Lake Ecosystem Slope and Depressional Wetlands. Unpublished report prepared for the U.S. Environmental Protection Agency, Region VIII. Utah Department of Natural Resources, Division of Wildlife Resource. Salt Lake City, UT.

Knight, D. H. 1994. Mountains and plains: Ecology of Wyoming landscapes. Yale University Press, New Haven, MA. 338 pp.

Ladd, D. The Missouri floristic quality assessment system. The Nature Conservancy, St. Louis, MO.

Laubhan, M.K. 2004. Variation in Hydrology, Soils, and Vegetation of Natural Palustrine Wetlands Among Geologic Provinces. Pages 23-51 *in* M. C. McKinstry, W.A. Hubert, and S.H. Anderson, editors. Wetland and Riparian Areas of the Intermountain West: Ecology and Management. University of Texas Press, Austin, TX.

Lines, G.C. 1979. Hydrology and Surface Morphology of the Bonneville Salt Flats and Pilot Valley Playa, Utah. U.S. Geological Survey Water-Supply Paper 2057. Prepared in Cooperation with the Bureau of Land Management. United States Government Printing Office, Washington D.C.

MacArthur, R. and E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton: Princeton University Press.

Mack, J.J., 2001. Ohio rapid assessment method for wetlands v. 5.0, user's Manual and scoring forms. Ohio EPA Technical Report WET/2001-1. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Mack, John J. 2004. Integrated Wetland Assessment Program. Part 9: Field Manual for the Vegetation Index of B iotic Integrity for W etlands v. 1.3. Ohio EPA Technical Report W ET/2004-9. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Morris JT, PM. Bradley. 1999. Effects of nutrient loading on the carbon balance of coastal wetland sediments. Limnol Oceanogr 44:699-702.

Mutel, C.F. and J.C. Emerick. 1984. From Grassland to Glacier : the Natural History of Colorado. Johnson Books, Boulder, CO.

Nachlinger, J., K. Sochi, P. Comer, G. Kittel, and D. Dorfman. 2001. Great Basin: An ecoregion-based conservation blueprint. The Nature Conservancy, Reno, NV. 160 pp. plus appendices.

National Research Council. 2000. Ecological Metrics for the Nation. National Academy Press, Washington, D.C.

Natural Resources Conservation Service. 2001. Rangeland Soil Quality – Compaction. Soil Quality Information Sheet, Rangeland Sheet 4. U.S. Department of Agriculture, Natural Resources Conservation Service. Accessed online at: http://soils.usda.gov/sqi/publications/sqis.html

Natural Resource Conservation Service. 2005. Ecological Site Descriptions for Utah, Wyoming, and Montana. These can be found online at http://www.nrcs.usda.gov/technical/efotg/

Nnadi, F.N. and B. Bounvilay. 1997. Land Use Categories Index and Surface Water Efficiencies Index. Unpublished report prepared for U.S. Army Corps of Engineers, West Palm Beach, FL. University of Central Florida, Orlando, FL.

Northern Great Plains Floristic Quality Assessment Panel. 2001. Floristic quality assessment for plant communities of North Dakota, South Dakota (excluding the Black

Hills), and adjacent grasslands. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/2001/fqa/fqa.htm

Oldham, M.J., W.D. Bakowsky, and D.A. Sutherland. 1995. Floristic quality assessment system for southern Ontario. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario.

Peet, R. K., T. R. Wentworth, and P. S. White, 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63, 262-274.

Riley, C.D. 2001. Population dynamics and ecological characteristics of *Cleome multicaulis*, a rare annual wetland halophyte of the San Luis Valley, Colorado. PhD Dissertation. Colorado State University. Fort Collins, CO.

Rink, L.P. and G.N Kiladis. 1986. Geology, hydrology, climate, and soils of the Rocky Mountains. Pages 42-65 *in* J.T. Windell, B.E. Willard, D.J. Cooper, S.Q. Foster, C.F. Knud-Hansen, L.P. Rink, and G.N. Kiladis, editors. An ecological characterization of Rocky Mountain montane and subalpine wetlands. U.S. Fish and Wildlife Service, Biological Report 86.

Rondeau, R. 2001. Ecological System Viability Specifications for Southern Rocky Mountain Ecoregion. First Edition. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. 181 pp.

Rondeau, R. J. and J. Sanderson. 1998. White Ranch wetlands biological survey and permanent vegetation monitoring plots Prepared for U. S. Fish and Wildlife Service, Alamosa CO 81101.

Rybczyk JM, Garson G, Day JW Jr. 1996. Nutrient enrichment and decomposition in wetland ecosystems: models, analyses and effects. Current Topics Wetland Biogeochem 2:52-72.

Scott, J. A. 1982. The Life History and Ecology of an Alpine Relect, *Boloria improba acrocnema* (Lepidoptera: Nymphalidae), Illustrating a New mathematical Population Census Method. Papilio New Series. No. 2.

Soil Science Society of America. 2005. Internet Glossary of Soil Science Terms. http://www.soils.org/sssagloss/cgi-bin/gloss_search.cgi?QUERY=sodic+soil&SOURCE=2 (accessed June, 26, 2005). Soil Science Society of America.

Sposito, R. 1989. Chemistry of Soils. Academic Press, San Diego, CA.

Swink F. and G. Wilhelm. 1979. Plants of the Chicago Region. Revised and expanded edition with keys. The Morton Arboretum, Lisle, IL.

Swink F. and G. Wilhelm. 1994. Plants of the Chicago Region. 4th Edition. Morton Arboretum, Lisle, IL.

U.S. Army Corps of Engineers. 1987. *Corps of Engineers Wetlands Delineation Manual*. Environmental Laboratory, U.S. Army Corps of Engineers Waterways Exp. Stn. Tech. Rep. Y-87-1.

U.S. Army Corps of Engineers. 2002. Installing Monitoring Wells/Piezometers in Wetlands. Wetlands Regulatory Assistance Program. ERDC TN-WRAP-00-02 Online: http://el.erdc.usace.army.mil/wrap/pdf/tnwrap00-2.pdf

United State Department of Agriculture (USDA). 1994. Keys to Soil Taxonomy. Soil Survey Staff, Soil Conservation Service, U.S. Department of Agriculture. Sixth Edition. Pocahontas Press, Inc. Blacksburg, VA.

United States Department of Agriculture. 1954. Diagnosis and Improvement of Saline and Alkali Soils. L.A. Richards, editor. Agriculture Handbook No. 60. United States Salinity Laboratory. U.S. Government Printing Office, Washington D.C.

USDA, NRCS. 2002. Field Indicators of Hydric Soils in the United States: Guide for identifying and delineating hydric soils. V.5.0. G.W. Hurt, P.M. Whited, and R.F. Pringle (eds.). USDA, NRCS in cooperation with the National Technical Committee for Hydric Soils, Fort Worth, TX.

U.S. EPA. 2002. Methods for Evaluating Wetland Condition: Using Vegetation to Assess Environmental Conditions in Wetlands. Office of Water, U.S. Environmental Protection Agency, Washington D.C. EPA-822-R-02-020.

United States Fish and Wildlife Service (USFWS). 2002. Alamosa – Monte Vista National Wildlife Refuge Complex: Draft Comprehensive Conservation Plan and Environmental Assessment. Alamosa – Monte Vista National Wildlife Refuge Complex, Alamosa, CO.

Valiela I, Howes B, Howarth R, Giblin A, Foreman K, Teal JM, Hobbie JE. 1982. Regulation of primary production and decomposition in a salt marsh ecosystem. In: Gopal B, Turner RE, Wetzel RG Whigham DF (eds). Wetlands: ecology and management. Jaipur, India: National Institute of Ecology and International Scientific Publications, pp. 151-168.

Woods, S.W. 2001. Ecohydrology of subalpine wetlands in the Kawuneeche Valley, Rocky Mountain National Park, Colorado. PhD Dissertation. Department of Earth Sciences, Colorado State University, Fort Collins, CO.

Wilhelm, Gerould. Personal communication, 1995.

Wilhelm, G.S. and L.A. Masters. 1995. Floristic Quality Assessment in the Chicago Region. The Morton Arboretum, Lisle, IL.

Windell, J.T., B.E. Willard, and S.Q. Foster. 1986. Introduction to Rocky Mountain wetlands. Pages 1-41 *in* J.T. Windell, B.E. Willard, D.J. Cooper, S.Q. Foster, C.F. Knud-Hansen, L.P. Rink, and G.N. Kiladis, editors. An ecological characterization of Rocky Mountain montane and subalpine wetlands. U.S. Fish and Wildlife Service, Biological Report 86.

Wright, H.E. Jr. 1983. The Late Pleistocene. Volume 1 of Late-Quaternary environments of the United States. S.C. Porter, editor. University of Minnesota Press, Minneapolis, MN.

Young, J.A., R.A. Evans, B.A. Roundy, and J.a. Brown. 1986. Dynamic landforms and plant communities in a pluvial lake basin. Great Basin Naturalist. Vol. 46(1): 1-21.

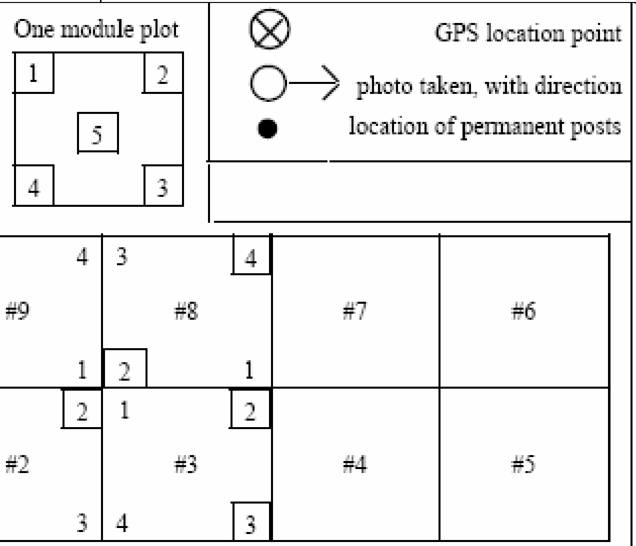
Zedler, J.B and S. Kercher. 2004. Causes and Consequences of Invasive Plants in Wetlands: Opportunities, Opportunists, and Outcomes. Critical Reviews in Plant Sciences 23(5): 431-452.

# APPENIDX A: FIELD FORMS

Scorecard Field Form, pg 1 of 5

| General Information | Location | | Site Characteristics | |
|---|---|---|---|---|
| Project | General: | | Elevation (m/ft): | |
| Team: | County: | | Slope (deg): | |
| Plot: | USGS quad: | | Aspect (deg): | |
| Date (Start): / / | Ownership: | | Compass: magnetic /corrected | |
| Date (End): / / | GPS location in plot: x= y= | | Buffer width: | |
| | | | | |
| | UTM Zone: 13 | | % unfragmented area of wetland: | |
| **Plot Documentation** | Uncorrected | UTM-E: | | |
| Cover method: | | UTM-N: | **Land use w/in 100m of wetland** | |
| | | Coord. Accuracy (m radius): | Types: | Relative %: |
| **Photos** | | | | |
| Film roll: /Frame(s) | GPS File Name: | | | |
| Focal length: | T: R: S: | | | |
| | | | | |

**Map:** Fill in the template below (2 modules or more) or right (1 module plot), using the guide at far right. Also note actual arrangement of modules, which corners were sampled, and location of any witness trees.




| Land use in contributing watershed | |
|---|---|
| Ground watershed | |
| | |
| | |
| Surface watershed | |
| | |
| | |

| Physiognomic Class* | Leaf Type* | Leaf Phenology* |
|---|---|---|
| __ I Forest<br>__ II Woodland<br>__ III Shrubland<br>__ IV Dwarf Shrubland<br>__ V Herbaceous<br>__ VI Nonvascular<br>__ VII Sparsely vegetated | __ B Broad-leaved<br>__ N Needle-leaved<br>__ M Microphyllous<br>__ G Graminoid<br>__ F Forb<br>__ P Pteridophyte | __ EG Evergreen<br>__ CD Cold-deciduous<br>__ DD Drought- deciduous<br>__ MC Mixed evergreen- cold deciduous<br>__ MD Mixed evergreen- drought deciduous |

| Soil Chemistry* | Cowardin System* | Community Classification* |
|---|---|---|
| ____ pH<br>__ __ Conductivity<br>__ __ Temperature | __ UPL Upland<br>__ EST Estuarine<br>__ RIP Riparian<br>__ PAL Palustrine<br>__ LAC Lacustrine | CNHP Type ________________<br>Cowardin ________________<br>HGM________________<br>Classifier ________________<br>Date ________________ |

** Definitions and/or values are in the Reference section of the Pulse Filed Guide

## Scorecard Field Form, pg 2 of 5

| Present? | Biotic/abiotic patch type | √ one | Interspersion of patches |
|---|---|---|---|
| | Open water –stream | | **Excellent:** Horizontal structure consists of a very complex array of nested and/or interspersed, irregular biotic/abiotic patches, with no single dominant patch type. |
| | Open Water - Pools | | |
| | Open Water – Rivulets/Streams –fen | | |
| | Open water – beaver pond | | **Good:** Horizontal structure consists of a moderately complex array of nested or interspersed biotic/abiotic patches, with no single dominant patch type. |
| | Oxbow/backwater channels | | |
| | Tributary or secondary channels | | |
| | Streams – pool/riffle complex | | **Fair:** Horizontal structure consists of a simple array of nested or interspersed biotic/abiotic patches. |
| | Active beaver dams | | |
| | Wet meadows | | **Poor:** Horizontal structure consists of one dominant patch type and thus has relatively no interspersion. |
| | Occasional trees | | |
| | Point bars | | **Abundance of willows/cottonwoods** |
| | Adjacent hillside seeps/springs | | **Excellent:** Saplings/seedlings present in expected amount; obvious regeneration |
| | Beaver canals | | |
| | Interfluves on floodplain | | **Good:** Saplings/seedlings present but less than expected; some seedling/saplings present |
| | Debris jams (woody debris) in stream | | |
| | Mudflats | | **Fair:** Saplings/seedlings present but in low abundance; Little regeneration by native species |
| | Saltflats | | |
| | Submerged/floating vegetation | | **Poor:** No reproduction of native woody species |
| | Emergent vegetation | | **Beaver Activity** |
| | Moss bed | | **Excellent:** New, recent, and/or old beaver dams present. Beaver currently active in the area. |
| | Occasional shrubs | | |
| | Emergent vegetation | | **Good:** Recent and old beaver dams present. Beaver may not be currently active but evidence suggests that have been with past 10 years. |
| | Hummock/tussock - fen | | |
| | Water Tracks/Hollows - fen | | |
| | Lawns - fen | | **Fair:** Only old beaver dams present. No evidence of recent or new beaver activity despite available food resources and habitat. |
| | Floating Mat - fen | | |
| | Spring fen | | **Poor:** No beaver dams present when expected (in unconfined valleys). |
| | Shrubs - fen | | |
| | Marl/Limonite beds - fen | | |

| √ one | Relative Size |
|---|---|
| | **Excellent:** Wetland area = outside abiotic potential |
| | **Good:** Wetland area < abiotic potential; Relative size = 90 – 100%; (<10% of wetland has been reduced, destroyed or severly disturbed due to roads, impoundments, development, human-induced drainage, etc. |
| | **Fair:** Wetland area < abiotic potential; Relative size = 75 – 90%; (10-25% of wetland has been reduced, destroyed or severly disturbed due to roads, impoundments, development, human-induced drainage, etc. |
| | **Poor:** Wetland area < abiotic potential; Relative size = <75 – > 25 %; of wetland has been reduced, destroyed or severly disturbed due to roads, impoundments, development, human-induced drainage, etc. |

### Ground Cover (%)

| | |
|---|---|
| Bryo/lichen: | Sand/soil: |
| Decaying wood: | Water: |
| Bedrock/boulder: | Litter/OM: |
| Gravel/cobble: | Other |

### Cover by Strata

Canopy height (m):

| Abr. | Stratum | Height range (m) | Total Cover (%) |
|---|---|---|---|
| S | Shrub | | |
| F | Forb | | |
| G | Graminoid | | |
| T | Tree | | |
| FL | Floating | | |
| A | Aquatic submerged | | |

**Landform type*:** ______________________________

** Definitions and/or values are in the Reference section of the Pulse Filed Guide

**Scorecard Field Form, pg 3 of 5**

**Diversions in/near wetland?**

| Water Source (√ one) | |
|---|---|
| Ground water | |
| Seasonal surface water | |
| Permanent surface | |
| Precipitation | |

**Layout Notes:** (anything unusual about plot layout and shape)

**Location Notes:** (include why location was chosen and a small map, more space on reverse)

**Hydro Regime***

__ SP Semipermanently flooded
__ SE Seasonally flooded
__ ST Saturated
__ TM Temporarily flooded
__ IN Intermittently flooded
__ PR Permanently flooded
__ TD Tidally flooded
__ IR Irregularly flooded
__ IE Irregularly exposed
__ UN Unknown
__ RD Rapidly drained
__ WD Well drained
__ MW Moderately well drained
__ SP somewhat poorly drained
__ PD Poorly drained
__ VP Very poorly drained

**Vegetation Notes:** (characterization of community, dominants, and principle strata)

**Additional Notes:**

**Topographic Position ***

__ H interfluve (crest,summit,ridge)
__ E High slope (shoulder, upper, convex)
__ M High level
__ D Mid slope
__ F Back slope (cliff)
__ C Low slope (lower, foot, colluvial)
__ B Toeslope
__ G Low level (terrace)
__ J Channel wall (bank)
__ K Channel bed (valley bottom)
__ I Basin floor (depression)

** Definitions and/or values are in the Reference section of the Pulse Filed Guide

## Scorecard Field Form, pg 4 of 5

**Soils Data**

| Horizon | Range (depth cm) | Texture | Soil & Mottle Color | Depth to water table (cm) | Depth to Saturated Soils (cm) | Depth of Peat (cm) | Structure | % Coarse (Est.% per horizon by type- gravel, cobble, boulder) | Comments (90% root depth, charcoal, etc.) Mottle Abundance(few <2%, common 2-20%, many >20%), Size (fine <5 mm dia., medium 5-15 mm, large >15 mm) and Contrast (faint-similar to matrix, distinct-contrast slightly, prominent-mottles vary by several units of hue, value or chroma) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
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**Scorecard Field Form, pg 5 of 5**

**Vegetation Plot data** (see Carolina Vegetation Survey for digital versions of their data forms: http://www.bio.unc.edu/faculty/peet/lab/CVS/)

| **Species Code** | 2 | 2 | 2 | 4 | 3 | 2 | 3 | 3 | 8 | 2 | 8 | 4 | 9 | 2 | 9 | 3 | R | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | |
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# APPENDIX B: SUPPLEMENTARY DATA:

Coefficient Table (coefficients were calculated from numerous studies throughout the U.S. (Keate (2005)

| Land Use | Surface Water Runoff | Nutrient/ Pollutant Loading | Suspended Solids |
|---|---|---|---|
| Natural area | 1.00 | 1.00 | 1.00 |
| Dirt Road (dirt or crushed or loose gravel, unpaved roads, local traffic) | 0.71 | 0.92 | 0.90* |
| Field Crop (actively plowed field) | 0.95 | 0.94 | 0.85** |
| Clearcut forest | 0.83 | 0.93 | 0.98 |
| Golf Course (area manipulated for golf, manicured grass) | 0.75 | 0.86 | 0.94 |
| High Intensity Commercial (area is entirely of commercial use and paved - shopping malls, construction yards) | 0.13 | 0 | 0 |
| High Traffic Highway (4 lanes or larger, railroads) | 0.26 | 0.43 | 0.48 |
| Industrial (intense production activity occurs on a daily basis - oil refineries, auto body and mechanic shops, welding yards, airports) | 0.25 | 0.54 | 0 |
| Feedlot, Dairy | 0.62 | 0 | 0.81 |
| Heavy grazing - Non-rotational grazing (year-round or mostly year-round grazing, vegetation is sparse and area trampled) | 0.76 | 0.87 | 0.85*** |
| Rotational Grazing (grazing is for short periods during the year, vegetation is allowed to recover) | 0.96 | 0.95 | 0.98 |
| Light Intensity Commercial (businesses have large warehouses and showrooms - large patches of vegetation occur between buildings) | 0.19 | 0.64 | 0.02 |
| Low Density Rural Development (areas of small structures in a farm or ranch setting - silos, barns) | 0.87 | 0.92 | 0.98 |
| Low Traffic Highway (2-3 lane paved highways) | 0.26 | 0.69 | 0.16 |
| Multi-family Residential (subdivisions with lots ½ acre or less) | 0.38 | 0.55 | 0.61 |
| Nursery (business where the production of nursery grade vegetation occurs including greenhouses, outbuildings and sales lots) | 0.86 | 0.94 | 1.00 |
| Orchards | 0.86 | 0.93 | 0.99 |
| Waterfowl Management Areas | 0.86 | 0.91 | 0.98 |
| Single Family Residential (residential lots are greater than ½ acre with vegetation between houses) | 0.75 | 0.86 | 0.94 |
| Surface Solid Waste (landfills and waste collection facilities) | 0.71 | 0.87 | 0.61 |
| Sewage Treatment Plants and Lagoons | 0.60 | 0.61 | 0.71 |
| Mining | 0.76 | 0.94 | 0.80 |

* changeed value from 0.97; ** changed value from 1.00; *** changed value from 0.98