Field Testing of the Subalpine-Montane Riparian Shrublands Ecological Integrity Assessment (EIA) in the Blue River Watershed, Colorado

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Colorado Natural Heritage Program
Colorado State University
254 General Services Building
Fort Collins, CO 80523

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Prepared for:

Colorado Department of Natural Resources
Division of Wildlife, Wetlands Program
6060 Broadway
Denver, CO 80216

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

Prepared by:

Joanna Lemly and Joe Rocchio[1]

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Colorado Natural Heritage Program
Warner College of Natural Resources
Colorado State University
254 General Services Building
Fort Collins, Colorado 80523

Cover photographs:

All photos taken by Colorado Natural Heritage Program Staff.

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[1] Currently with the Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, WA.

EXECUTIVE SUMMARY

Ecological Integrity Assessments (EIAs) are multi-metric indices designed to be employed as either rapid or intensive assessments of wetland ecological condition. Practical and ecologically meaningful biotic and abiotic metrics are selected to measure the integrity of key ecological attributes. These indicators are rated and then aggregated into an overall score for four major ecological categories: (1) Landscape Context, (2) Biotic Condition, (3) Abiotic Condition, and (4) Size. The ratings for these four categories are then aggregated into an Overall Ecological Integrity Score for each site. These scores can be used to evaluate current wetland condition and track change toward management goals and objectives.

Funded by the U.S. Environmental Protection Agency (USEPA), the Colorado Natural Heritage Program (CNHP) developed seven EIAs for wetland types in the Southern Rocky Mountain Ecoregion. This project field tested the Subalpine-Montane Riparian Shrublands EIA in the Blue River watershed of Colorado. The objective of this project was to field test two aspects of the Subalpine-Montane Riparian Shrubland EIA: 1) user variability and 2) sensitivity of individual metrics to detect overall condition. To test both aspects, twelve riparian shrubland sites that represent a range of human disturbance and condition were selected for sampling. All twelve sites were previously sampled during development of a vegetation index of biotic integrity (VIBI) for headwater wetlands, thus the biotic condition was known from intensive vegetation metrics. To carry out the field testing, five wetland scientists with varying levels of experience were asked to fill out the draft EIA field form at all twelve sites.

To compare results from the five observers across twelve sites, data from each metric were arranged in an observer by plot matrix. Each metric was subjected to two tests of variability: 1) Cohen’s Kappa statistic and 2) percent of responses that varied from the median rank response by plot. Both tests were carried out for each metric, for each of the four categories, and for the overall EIA score. Two thresholds were established to evaluate the metrics. A stringent threshold was set at 85% agreement with the median and a more lenient threshold was set at 75% agreement.

To test the sensitivity of individual metrics to assess overall condition, data collected by the five observers were compared to VIBI scores and condition classes derived from previous insensitive field sampling. Counts of metric ranks assigned by all observers to all plots and counts of median ranks were ordered by condition class in a metric rank by condition class matrix. This analysis showed the sensitivity of each metric to a particular condition class. In addition to individual metrics, the overall ranks for each category (Landscape Context, Biotic Condition, Abiotic Condition, and Size) were compared in the same manner. The relationship between numerical scores for each category, overall EIA score, and VIBI scores was assessed using scatter plots, Spearman’s rank correlation coefficients (R_s), and box plots.

The final analysis performed in this study was to compare specific vegetation measures collected using the rapid plotless survey design employed in the EIA field testing to the intensive vegetation data collected using the Carolina Vegetation Survey (CVS) method.

Four specific vegetation metrics considered important to gauge biotic condition were compared: Mean C for all species, Mean C for native species, native species richness, and percent nonnative species. For each of the four metrics, values derived from each observer's species list collected using the plotless method, as well as the mean value per plot, were graphed against values derived from pervious sampling using the CVS method. Spearman's rank correlation coefficients (R_s) were calculated to assess the relationship between the two methods. A one-to-one line was plotted to assess the effect of using the plotless method.

Field testing of the Subalpine-Montane Riparian Shrubland EIA produced valuable results that will help guide refinement of this method for future projects. From tests of both user variability and sensitivity to condition class, several metrics stood out as reliable and high performing metrics, while others will be improved. Within the Landscape Context and Abiotic Condition categories, several metrics were easily interpreted by users. The strongest metrics in these categories include: (1) average buffer width, (2) percent unfragmented landscape, (3) onsite land use, (4) upstream surface water retention, and (5) distance to nearest road. Though consistently applied across users, however, these metrics alone did not always predict high integrity sites. While high integrity sites were closely linked with high Landscape Context and Abiotic Condition scores, low integrity sites received either high or low scores for any given metric. Because wetlands can be impacted by a range of human disturbances on both landscape and local scales, it is possible for a low integrity wetland to score high on certain Landscape Context and Abiotic Condition metrics and low on others. When rolled-up into overall category scores, however, the suite of metrics for each category did perform well.

The Biotic Condition category contained the most robust and reliable measures of wetland condition. Relative cover of native species and Mean C of native species were highly consistent across observers, very strongly correlated with condition class, and performed well regardless of plot method. These results are supportive of previous evidence that these two metrics are both strong stand-alone measures of wetland condition. The fact that they performed well even in the rapid, plotless method makes them ideal for using in rapidly employed EIAs.

When aggregated into an overall Ecological Integrity score, the method proved to be reliable across users. Final scores varied by only 15% over all twelve plots and five observers. The method was successful at separating high and low integrity sites, though refinements could improve the results. High integrity sites were clustered in the "A" to "B" ranks for overall scores, while low integrity sites were more variable.

Over the coming years, work on the EIAs will result in a user manual and standard field forms which will allow wetland scientists and regulatory personnel to monitor and assess wetland ecological integrity for the purposes of regulatory and/or non-regulatory applications such as permitting, mitigation, proactive restoration and/or protection projects, and reporting of ambient wetland condition. These tools will provide a means to measure the progress towards sustaining and enhancing Colorado's valuable wetland resource.

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1.0 INTRODUCTION

In response to independent critiques of the effectiveness of compensatory mitigation for authorized wetland losses under Section 404 of the Clean Water Act, the U.S. Environmental Protection Agency (USEPA) and other agencies have developed a National Wetlands Mitigation Action Plan (USEPA 2002). The Plan includes 17 tasks, including two tasks under “Clarifying Performance Standards” that deal with the need for assessing the effectiveness of biological and functional indicators. In response to this need, NatureServe[2] received a Wetland Program Development Grant from USEPA Headquarters to develop a set of pilot Ecological Integrity Assessments (EIAs) to aid in establishing wetland mitigation performance standards (Faber-Langendoen et al. 2006, Faber-Langendoen et al. 2008a). The EIA framework is designed to evaluate the integrity of individual wetlands based on multi-metric indices that range in scale from remote-sensing to rapid and intensive field assessments. Practical and ecologically meaningful biotic and abiotic metrics are selected to measure the integrity of key ecological attributes found in wetlands. These indicators are rated and then aggregated into an overall score for four major ecological categories: (1) Landscape Context, (2) Biotic Condition, (3) Abiotic Condition, and (4) Size. The ratings for these four categories are then aggregated into an Overall Ecological Integrity Score for each site. These scores can be used to track change toward management goals and objectives. As part of the NatureServe grant, the Colorado Natural Heritage Program (CNHP) developed seven EIAs for wetland types in the Southern Rocky Mountain Ecoregion (Rocchio 2006a-g; Ecoregion definition from Omernik 1987). With additional funding from a USEPA Region 8 Wetland Program Development Grant, this project field tested one of the seven EIAs and compared the results to a separate measure of wetland condition.

1.1 Ecological Integrity Assessment Background

1.1.1 Definition of Ecological Integrity

Ecological integrity has been defined in many ways. The Congressional Committee on Public Works defined ecological integrity as a “condition in which the natural structure and function of an ecosystem is maintained” (USGPO 1972). Karr and Dudley (1981) describe ecological integrity as “the summation of chemical, physical, and biological integrity.” Karr (1993) also offers that “ecological integrity is the sum of the elements (biodiversity) and processes” and that “integrity implies an unimpaired condition or the quality or state of being complete or undivided.”

The concept of ecological health has sometimes been used interchangeably with ecological integrity (Costanza et al. 1992), however many researchers consider each term to represent unique ecosystem properties that are related in a nested way. For example, Ramade (1995) notes that the best criteria defining ecological health are those associated with ecological processes. Rapport et al. (1998) suggested that ecological integrity describes those areas that resemble their natural state whereas ecological health applies to those areas where the maintenance of nature’s

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[2] NatureServe is a non-profit conservation organization whose mission is to provide the scientific basis for effective conservation action. NatureServe represents an international network of biological inventories – known as natural heritage programs or conservation data centers – operating in all 50 U.S. states, Canada, Latin America and the Caribbean. For more information about NatureServe, see their website: www.natureserve.org.

services remains intact. Karr and Chu (1999) suggest that ecological integrity and health occur along a continuum of human influence on biological condition. At one end are “pristine” or minimally impacted ecosystems, which support a biota that is the product of evolutionary and biogeographic processes and thus possess ecological integrity. As humans alter biological or ecological systems, they change along this continuum. If human impacts are severe enough, this could lead to an ecological state that supports no or minimal life. Ecological health represents a portion of the continuum where an ecosystem is able to provide many of the goods and services valued by society, but may not possess ecological integrity. Due to functional redundancy in an ecosystem, numerous species may be lost before the system’s ecological health is degraded. However when native species are lost, the system’s integrity declines (Walker 1992). Karr (1994) summarizes this point by noting that integrity describes a condition with little impact from human activity while ecological health describes the preferred state of ecosystems modified by human activity.

In sum, ecological integrity is an ecosystem property where expected structural components are complete and all ecological processes are functioning optimally whereas ecological health pertains only to the status of optimally functioning ecological processes (Campbell 2000). In the context of wetland regulatory programs, this would suggest that ecological integrity is a more stringent standard than ecological health in determining the successful attainment of Clean Water Act objectives.

1.1.2 Classification

Successfully developing indicators of wetland ecological integrity depends on providing a classification framework for distinguishing wetland types, accompanied by a set of keys to identify the types in the field. Classifications help wetland managers to better cope with natural variability within and among types, so that differences between occurrences with good integrity and poor integrity can be more clearly recognized. For over fifteen years, NatureServe and the Network of Natural Heritage Programs have provided international leadership in standardized ecological classification through development of the International Vegetation Classification System (Grossman et al. 1998, NatureServe 2004, Faber-Langendoen et al. 2009) and “Ecological Systems” throughout the United States (Comer et al. 2003). Ecological Systems provide a finer scale of resolution than traditional wetland classification systems such as the U. S. Fish and Wildlife Service’s Cowardin classification (Cowardin et al. 1979) and the hydrogeomorphic (HGM) classification system (Brinson 1993). The Ecological System approach uses both biotic (structure and floristics) and abiotic (hydrogeomorphic template, elevation, soil chemistry, etc.) criteria to define units. These finer classes allow for greater specificity in developing conceptual models of the natural variability and stressors of an ecological system and the thresholds that relate to impacts of stressors.

1.1.3 Key Ecological Attributes & Metrics

In the initial stages of developing an EIA, conceptual models are used to identify key ecological drivers and stressors that are most valuable to measure. Narrative models are used to describe the predicted relationships between ecological components and their potential stressors. A set of key ecological attributes and metrics are chosen from a wide list of potential ecological attributes that are feasible to monitor. For each key ecological attribute, one or more metrics are selected and these metrics are monitored to indicate the status or trends of the key ecological attribute.

1.1.4 Natural Variability and Human Impacts (Thresholds)

Each metric is rated according to deviation from its natural variability. Natural variability is defined based on the best current understanding of how ecological systems “work” under reference (no or minimal human impact) conditions. An understanding of how each metric responds to increasing human disturbance is also necessary in order to establish thresholds. The farther a metric (or index of site ecological integrity) moves away from its natural range of variability the lower the rating it would receive. The EIAs use four rating categories to describe the status of each metric relative to its natural variability (Table 1). There are two important thresholds associated with these ranks. The B-C threshold indicates the level below which conditions are not considered acceptable for sustaining ecological integrity. The C-D threshold indicates a level below which system integrity has been drastically compromised and is unlikely to be restorable.

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

Rank Value	Description
A	Occurrence is believed to be, on a global scale, among the highest quality examples with respect to major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: the landscape context contains natural habitats that are essentially unfragmented (reflective of intact ecological processes) and with little to no stressors; the size is very large or much larger than the minimum dynamic area ; vegetation structure and composition, soil status, and hydrological function are well within natural ranges of variation, exotics (non-natives) are essentially absent or have negligible negative impact; and a comprehensive set of key plant and animal indicators are present.
B	Occurrence is not among the highest quality examples, but nevertheless exhibits favorable characteristics with respect to major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: the landscape context contains largely natural habitats that are minimally fragmented with few stressors; the size is large or above the minimum dynamic area, the vegetation structure and composition, soils, and hydrology are functioning within natural ranges of variation; invasives and exotics (non-natives) are present in only minor amounts, or have or minor negative impact; and many key plant and animal indicators are present.
C	Occurrence has a number of unfavorable characteristics with respect to the major ecological attributes, natural disturbance regimes. Characteristics include: the landscape context contains natural habitat that is moderately fragmented, with several stressors; the size is small or below, but near the minimum dynamic area; the vegetation structure and composition, soils, and hydrology are altered somewhat outside their natural range of variation; invasives and exotics (non-natives) may be a sizeable minority of the species abundance, or have moderately negative impacts; and many key plant and animal indicators are absent. Some management is needed to maintain or restore these major ecological attributes.
D	Occurrence has severely altered characteristics (but still meets minimum criteria for the type), with respect to the major ecological attributes. Characteristics include: the landscape context contains little natural habitat and is very fragmented; size is very small or well below the minimum dynamic area; the vegetation structure and composition, soils, and hydrology are severely altered well beyond their natural range of variation; invasives or exotics (non-natives) exert a strong negative impact, and most, if not all, key plant and animal indicators are absent. There may be little long term conservation value without restoration, and such restoration may be difficult or uncertain.

1.1.5 Ecological Integrity Assessment Ratings

The role of the EIA is to help translate information gathered at the level of key ecological attributes so that it can be understood at higher levels of integrity (e.g. integrity of biotic community or overall ecological integrity). The EIA integrates ratings of the individual metrics and produces an overall score for four categories: (1) Landscape Context, (2) Biotic Condition, (3) Abiotic Condition (e.g., soils or hydrology), and (4) Size to help set performance standards and assess wetland ecological integrity. In addition, the ratings for these four indices can be combined into an Overall Ecological Integrity Score. The metrics are integrated into an index score by plugging each metric score into a simple, weight-based algorithm. These algorithms are constructed based on expert scientific judgment regarding the interaction and corresponding influence of these metrics on ecological integrity (*sensu* NatureServe 2002, Parrish et al. 2003). The EIA uses a scorecard format to report scores from the various hierarchical scales of the assessment (e.g. metrics, indices, or overall integrity score) depending on which best meets the user's objectives.

1.1.6 Mitigation Performance Standards

The EIAs can identify mitigation performance standards by developing ecological integrity criteria for wetland and riparian ecological systems. These criteria could help determine when restoration actions lead to improved ecological integrity, as required by specific mitigation criteria. The EIA can identify minimum performance standards for each metric as well as identifying necessary ecological requirements that must be met to achieve excellent or "reference standard" integrity. These standards represent performance benchmarks that must be achieved in order to successfully restore/mitigate a wetland with minimum ecological integrity. The EIA can be used as a tool to monitor mitigation progress toward case-specific standards. For example, impacting a wetland with poor ecological integrity may only require mitigating to minimum ecological integrity, whereas impacting a wetland with excellent ecological integrity may require successfully restoring or creating a wetland with similar integrity.

1.2 Comparison to Other Wetland Assessment Approaches

There are very few condition-based assessments available for Colorado. The wetland assessments currently available are either grounded in functional assessments (e.g., SAIC 2000, Johnson et al. 2009) or based on monitoring specific project objectives (e.g., Steel & Cariveau 2006). Similar to condition assessments, functional assessments often seek to estimate the status of ecological integrity (Table 2). However, these assessments differ from condition assessments in that they evaluate the level or capacity of wetland functions while condition assessments evaluate the condition of key ecological factors or driving ecological processes to indicate ecological integrity. Many functional assessments simply are concerned with the level or capacity of each function regardless of how or whether it relates to ecological integrity.

Condition assessments are 'holistic' in that they consider ecological integrity to be an "integrating super-function" (Fennessy et al. 2004). In other words, a wetland with excellent integrity will perform all functions at the full level expected for its wetland class or type. Functional assessments are compartmental and consider each function individually, making it more difficult to assess overall integrity. Thus, the development of condition assessments for Colorado will provide the opportunity to directly assess wetland condition.

Table 2. Comparison of condition and functional wetland assessments.

	Condition Assessment	**Functional Assessment**
Purpose	Estimate current ecological integrity	Estimate societal value of ecological functions
"Currency"	Condition of key ecological factors	Level of functions and ecological services
Approach	Holistic: ecological integrity = "integrating super function"	Compartmental: each function assessed individually
Method	Combines indicators into conceptual model of key ecological factors	Combines indicators into conceptual model of ecological functions and values
Application	Mitigation, monitoring, state water quality standards, and Heritage Network	Mitigation and monitoring

Besides the EIAs, the Bureau of Land Management's Proper Functioning Condition (PFC) method (Prichard et al. 1998) is the only known condition assessment currently available for Colorado. However, although PFC aims to assess wetland condition, it takes a very different approach than the EIAs. For example, PFC utilizes a series of Yes/No questions about ecological condition and requires a team of experts including hydrologists, soil scientists, botanists, geomorphologists, etc. to subjectively integrate these answers into a conclusion about a wetland's condition. With the proper team of experts, this method can be very effective; however its conclusions depend on the experience of the team conducting the assessment. The EIAs seek to make the assessment more repeatable by providing a series of rating categories for each metric in which a knowledgeable wetland scientist can arrive at an overall ecological integrity score without the input of an interdisciplinary team. EIAs maintain the input of expert opinion by incorporating the scientific literature, expert consultation, and best scientific judgment into the selection of metrics and their rating criteria.

1.3 Project Description

The development of an assessment tool is often categorized into three major phases (Wakeley and Smith 2001, Collins et al. 2008):

(1) **Initial Development:** The overall framework or model of the assessment is designed and describes the overall purpose and method of the assessment. Conceptual models are used to identify the key ecological attributes and metrics useful for measuring ecological integrity. Natural variability and the response of each metric to human-induced disturbance is described and used to establish rating thresholds. These tasks are accomplished through an intensive literature review, expert consultation, and use of best scientific judgment. A protocol for rating each of the attributes or sites is developed.

(2) **Field Testing (Verification):** Determines whether the ecological attributes and metrics identified during Initial Development adequately describe ecological integrity. In addition, this exercise may reveal other useful attributes and metrics which had not been previously identified. The sensitivity of the metrics to changes in ecological condition is checked as well as the repeatability of metric scores in wetlands of similar condition. The consistency of metric scores between different users is also assessed. Details concerning EIA instructions

and field forms are informed by field testing. All necessary changes are made to ensure the assessment adequately describes and discerns different states of ecological condition and that the results of the assessment are repeatable among different users.

(3) **Validation:** The accuracy or reliability of the EIA is tested by comparing it to an independent measure of integrity (e.g., vegetation index of biotic integrity). The EIAs are recalibrated to ensure that the best possible fit is achieved with the independent measure. This may include reassessing the metrics included in the EIAs, altering metric rating criteria, or simply changing the weights associated with each metric to more accurately reflect their influence on the overall scores.

To date, Initial Development has been completed for 18 Ecological Systems located in four regions of the United States: Northeast, Southeast, Arkansas, and Colorado (Faber-Langendoen et al. 2006, Faber-Langendoen et al. 2008a). In addition, NatureServe developed a standard set of Level 2 metrics for wetlands across the United States (Faber-Langendoen et al. 2008b). NatureServe subcontracted with the Colorado Natural Heritage Program (CNHP) to develop seven EIAs for specific wetland and riparian Ecological Systems in the Southern Rocky Mountain Ecoregion:

- Subalpine-Montane Riparian Shrublands
- Subalpine-Montane Riparian Woodlands
- Lower Montane Riparian Woodlands and Shrublands
- Suablpine-Montane Fen
- Alpine-Montane Wet Meadow
- North American Arid Freshwater Marsh
- Intermountain Basin Playas

Although initial development of the EIAs in the Southern Rocky Mountain Ecoregion has been completed (Rocchio 2006a-g), more effort is needed to determine the accuracy and repeatability of these assessments in the field. This current project aims to complete the next two phases (field testing and validation) for the Subalpine-Montane Riparian Shrublands EIA in the Blue River watershed. The Subalpine-Montane Riparian Shrublands Ecological System as well as the Blue River watershed were chosen for a variety of reasons: (1) both are threatened by many stressors such as grazing, development, hydrological modifications, etc.; (2) riparian shrublands are a conspicuous component of the Blue River watershed; (3) intensive data was collected for this system as part of the vegetation index of biotic integrity (VIBI) project in the same watershed[3]; and (4) many of the metrics in the Riparian Shrublands EIA are shared by other Ecological Systems, thus allowing for potential extrapolation of field testing, validation, and mitigation performance standards to other EIAs in the Ecoregion.

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[3] The VIBI is a multi-metric index developed using quantitative measurements of vegetation changes along a human-disturbance gradient. VIBI development and calibration was completed during the same time-frame as this project and thus was available for validation purposes (Rocchio 2007a, Lemly & Rocchio 2009).

2.0 STUDY AREA

The Blue River watershed is characterized by strong biophysical gradients, with elevations ranging from lower montane (~2,200 m) to alpine (~ 4,250 m). Much of the watershed is public land, including high-use recreation areas and low-use wilderness areas. However, private lands are developed extensively along the I-70, Hwy 9, and Hwy 6 corridors and near the major ski resorts. Thus, the watershed offers a variety of condition classes in which the Subalpine-Montane Riparian Shrublands EIA can be tested. In addition, several other wetland research projects have been conducted in the Blue River watershed (White Horse Associates 1996, CNHP 1997, SAIC 2000, Johnson 2001, Johnson 2002, Johnson 2005, Rocchio 2007a, Rocchio 2007b) that can be used to evaluate the EIA and could contribute to a comprehensive analysis of wetland condition across the watershed. Furthermore, this watershed is representative of much of the landscape of the Southern Rocky Mountain Ecoregion and a field-tested EIA should be applicable across the ecoregion.

The Blue River watershed (HUC 8: 14010002) generally corresponds with the political boundaries of Summit County, which lies on the west flank of the Continental Divide and is approximately 176,922 hectares (437,183 acres). Elevations range from 4,280 m (14,265 ft) on Quandary Peak to 2,274 m (7,580 ft) where the Blue River leaves Summit County. More than 85% of the county is above 2750 m (9,000 ft). The watershed is bordered by the Gore Range on the northwest, the Williams Fork Mountains on the northeast, and the Tenmile Range on the west. Hoosier Pass and Loveland Pass lie on the continental divide, which forms the watershed boundary to the south and east. Major tributaries to the Blue River include the Swan River, Snake River, and Tenmile Creek. Three major reservoirs (Blue Lakes, Dillon Lake, and Green Mountain) influence the Blue River and its associated wetlands.

The climate is generally characterized by long, cold, moist winters, and short, cool, dry summers. The Town of Dillon, where climate data are recorded, receives approximately 41 cm (16 in) of precipitation each year and the average total snowfall is 323 cm (127 in). Average annual minimum and maximum temperatures are -8^o and 11^o C (18^o and 52^o F), respectively. Average minimum monthly temperature during the coldest month (January) is -18^o C (-1^o F), while average maximum monthly temperature for the warmest month (July) is 23^o C (74^o F) (Western Regional Climate Center 2008). These data reflect mid-elevation regions of the watershed along the I-70 corridor; higher elevations experience colder temperatures and greater snowfall, while the lower elevations are warmer and drier.

The geology of Summit County is complex. The Williams Fork Mountains, Gore Range, and the Tenmile Range consist of Precambrian granitic rock with several faults (Tweto 1979). The lower Blue River Valley at the base of the Williams Fork Mountains consists of Pierre Shale. There are outcrops of Dakota sandstone near the Dillon Dam. High elevation outcrops of Leadville limestone are found in the southern portion of the county. The Blue River Valley has glacial origins as evidenced by the numerous boulder-strewn moraines (Chronic 1980).

Typical Southern Rocky Mountain flora is prevalent in Summit County. Elevations between approximately 2,200–2,400 m (7,500–8,000 ft) are dominated by *Amelanchier alnifolia* (service berry), *Artemisia tridentata* ssp. *vaseyana* (mountain sagebrush) and *Symphoricarpos rotundifolius* (snowberry). At these elevations, riparian wetlands are dominated by *Salix* spp.

(willows), *Populus angustifolia* (narrowleaf cottonwood), *Picea pungens* (Colorado blue spruce) and *Alnus incana* (thinleaf alder). Other wetlands within this elevation range include seeps, springs, wet meadows, and fens supported by groundwater discharge. These wetland types are often dominated by graminoid species, mostly of the *Cyperaceae* (sedge) family. Above 2,400 m (8,000 ft), *Populus tremuloides* (quaking aspen), *Pinus contorta* (lodgepole pine), *Pseudotsuga menziesii* (Douglas-fir), and *Picea engelmannii* (Engelmann spruce) dominate uplands and can occasionally be found in confined riparian areas. The most conspicuous wetland types at this elevation are riparian shrublands or willow carrs dominated by various species of willow *(Salix planifolia, S. wolfii, S. brachycarpa,* etc.) and sedges *(Carex utriculata, C. aquatilis,* etc.). Groundwater supported wetlands are common at these elevations as well. In the elevation zone between 3,000 m to 4,300 m (10,000 to 14,000 ft), *Picea engelmannii* (Engelmann spruce), *Abies lasiocarpa* (subalpine fir), *Salix brachycarpa* (short-fruit willow), and *Salix planifolia* (planeleaf willow) occur along riparian zones. Various *Salix* spp. (willow), *Carex* spp. (sedges), and herbaceous species are also found in groundwater discharge sites and snow melt areas.

Historical hard rock and placer mining and timbering operations have dramatically affected lands throughout the county. Many of the larger rivers have extensive tailings deposits throughout the floodplain and some areas remain affected by acid mine drainage. Currently, ski areas and associated residential and commercial developments are widespread in the county. Additionally, gravel mining, grazing, and agricultural activities are found in isolated pockets. Three large reservoirs, Blue Lakes, Dillon Lake and Green Mountain, are also significant components of the human influences in the county. These various land uses which have caused topographical and hydrological alterations have in turn led to habitat fragmentation, non-native species invasions and natural fire suppression.

3.0 METHODS

3.1 Site Selection and Field Methods

The objective of this project was to field test two aspects of the Subalpine-Montane Riparian Shrubland EIA: 1) user variability and 2) sensitivity to detect and assess condition derived from a separate measure. To test both aspects, twelve riparian shrublands sites that represented a range of human disturbance and condition were selected for sampling (Figure 1). All twelve sites were previously sampled during the development phases of the vegetation index of biotic integrity (VIBI) for headwater wetlands project (Rocchio 2006h, Rocchio 2007a), thus the biotic condition of the sites was known from intensive vegetation metrics.

A field form was developed based primarily on core metrics identified in Rocchio (2006f), which details the use of the Subalpine-Montane Riparian Shrubland EIA. For this project, only those metrics that can be assessed remotely using GIS data and/or aerial imagery (Level 1) and those that can be assessed using rapid field methods (Level 2) were used in the analysis.[4] The goal was to test the use of the EIA as a rapid condition assessment tool. Two supplemental metrics (biotic patch richness and interspersion of biotic patches) were included along with the core metrics to test their applicability, and two new metrics were also included (percent effective impervious area and distance to nearest road). In addition, one Level 3 metric was included (Mean C of native species). Level 3 metrics are those that require more intensive field sampling, such as vegetation plots, soil or water chemistry analysis, or long-term hydrologic monitoring. Mean C of native species is the average coefficient of conservatism for all native species found within the site. This metric is based on values identified for the Colorado flora by a panel of experts (Rocchio 2007b). To maintain the rapid approach to the EIA, the metric was assessed using a plotless survey technique in which field testers spent no more than one hour at each site documenting a list of all species encountered throughout the assessment area. The field form is included as Appendix A. See Faber-Langendoen et al. (2008a), Rocchio (2006f), and the appended field form for more details on metrics, attributes, and overall EIA scoring.

To carry out the field testing, five wetland scientists with varying levels of experience were asked to fill out the draft EIA field form at all twelve sites. Field work took place over one week in July 2007. Participants were given verbal instructions on how to interpret the form and aerial photos of each site were provided to assist in determining certain landscape metrics. Example field maps are provided in Appendix B. Test participants could not talk to each other while filling out the form in order to prevent individuals from influencing each other. At the end of the test period at each site, the participants could talk amongst themselves to clarify instructions on the form and to compare answers, but their written answers could not be changed.

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[4] US EPA´s National Wetlands Monitoring Workgroup has endorsed the concept of a Level 1, 2, 3 approach to monitoring. Level 1 (landscape assessment) relies on coarse, landscape scale inventory information, typically gathered through remote sensing and preferably stored in, or convertible to, a geographic information system (GIS) format. Level 2 (rapid assessment) is at the specific wetland site scale, using relatively simple, rapid protocols. Level 2 assessment protocols are to be validated by and calibrated to Level 3 assessments. Level 3 (intensive site assessment) uses intensive research-derived, multi-metric indices of biological integrity.

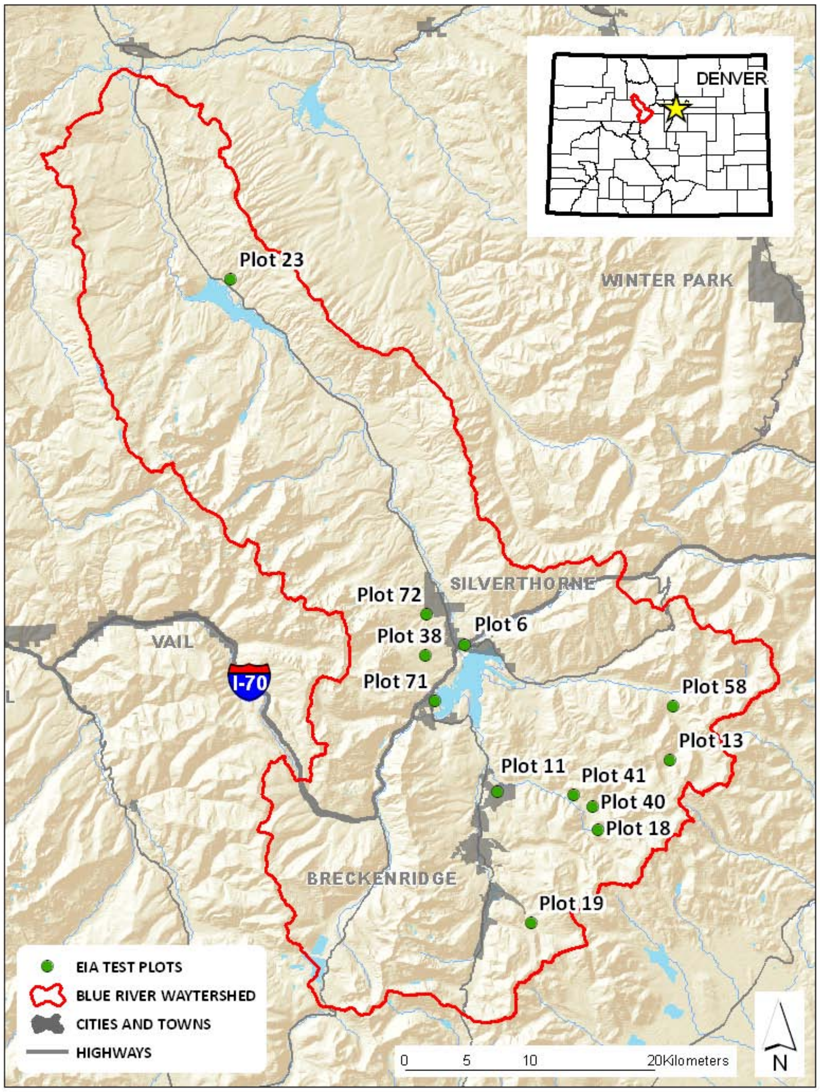

Figure 1. Plot locations within the Blue River watershed, Summit County, Colorado. Numeric plot labels are from the VIBI project, which included more than 75 wetlands. Inset map shows the state of Colorado and the study area (red outline) in reference to Denver.

3.2 Data Analysis

3.2.1 Test of User Variability

To compare results from the five observers across twelve plots, data from each metric were arranged in an observer by plot matrix using the numerical response instead of the alpha-numerical response (A, B, C, D converted to the 5, 4, 3, 1 scoring values). The minimum, maximum, median, and mean responses were calculated per plot, along with the standard deviation. Each metric was subjected to two tests of variability: 1) Cohen's Kappa statistic and 2) percent of responses that varied from the median rank response by plot. Both tests were carried out for each metric, for each of the four categories, and for the overall EIA score.

Cohen's Kappa statistic (*K*) measures the agreement between observers (Cohen 1960). The calculation takes into account both the actual agreement ("observed") and the agreement that may happen purely by chance ("expected"). The observed agreement is simply the percent of responses that are same divided by the total number of responses. The expected agreement quantifies how likely observers may agree if they were randomly assigning the ratings (Viera & Garrett 2005). Cohen's *K* is calculated with the following formula:

$$K = \left(\frac{p_o - p_e}{1 - p_e} \right)$$

where p_o = observed agreement and p_e = expected agreement (Cohen 1960). The statistic is most often calculated for two observers, but has been modified for multiple observers by averaging across pair-wise comparisons (Krippendorff 1980). The Kappa statistic for each metric, each categorical rank, and overall EIA rank was calculated using an online calculator (Geertzen 2009). Kappa statistics are generally interpreted using the guidelines presented in Table 3.

Table 3. Interpretation of the Kappa statistic.

Kappa statistic	Strength of agreement
< 0.00	Less than chance agreement
0.01–0.20	Slight agreement
0.21–0.40	Fair agreement
0.41–0.60	Moderate agreement
0.61–0.80	Substantial agreement
0.81–0.99	Almost perfect agreement
1.00	Perfect agreement

In addition to the Kappa statistic, the percent of responses that differed from the median rank response per plot was also evaluated. This was done by identifying all responses that differed from the median response per plot. For instance, if four responses for a plot were "A" (5) and one response was "B" (4), then the median would be an "A" (5) and one response would be flagged as differing. If two responses were "D" (1), two responses were "C" (3), and one response was "B" (4), then the median response would be "C" (3) and three responses would be flagged as differing. For each metric, all responses that differed across all plots were tallied and divided by 60, the total number of responses for that metric across all observers and all plots. This provided a percentage of responses that differed from the median. The inverse was taken to derive the percent of responses that agreed with the median.

Two thresholds were established to evaluate the metrics. A more stringent threshold was set at 85% agreement with the median. Metrics that met this threshold were considered to be metrics that performed well and were easily interpreted by users. A second threshold was established at 75% agreement with the median. Metrics that failed the 85% threshold, but met the 75% threshold were considered marginal performers and subject to some confusion in interpretation. Metrics that did not meet the 75% threshold were closely evaluated to determine if the cause of variability could be detected, particularly to see if the variability could be minimized with better instructions or wording associated with each metric, or if they should be dropped from the EIA.

3.2.2 Sensitivity Analysis

In order to test the EIA's sensitivity to detect and assess condition, data collected by the five observers were compared to vegetation index of biotic integrity (VIBI) scores and condition classes derived from previous insensitive field sampling (Rocchio 2006h, Rocchio 2007a). All

VIBI scores and condition classes were derived using the calibrated Riparian Shrubland VIBI model, Version 2.0 (Lemly & Rocchio 2009). This model is able to detect three condition classes: 1) high biotic integrity, 2) moderate biotic integrity, and 3) low biotic integrity. Details on the condition classes and the threshold VIBI scores for each class can be found in Lemly & Rocchio (2009). Of the twelve plots selected for EIA field testing, five plots had high biotic integrity, two plots had moderate biotic integrity, and five plots had low biotic integrity.

Counts of metric ranks assigned by all observers to all plots were ordered by condition class in a metric rank by condition class matrix. For example, for the five plots with high integrity, 25 metric ranks were assigned (five plots by five observers). These 25 ranks were divided into "A", "B", "C", and "D" bins. In addition to counts for all observations, counts of the median ranks were also compared. This analysis showed the sensitivity of each metric to a particular biotic condition class. In addition to individual metrics, the overall ranks for each category (Landscape Context, Biotic Condition, Abiotic Condition, and Size) were compared in the same manner.

The relationship between numerical scores for each category (Landscape Context, Biotic Condition, Abiotic Condition, and Size), overall EIA score, and VIBI scores was assessed using scatter plots, Spearman's rank correlation coefficients (R_s), and box plots. Spearman's rank correlation coefficients were used because the category scores were derived by summing ordinal data for each component metric. This analysis was performed using all observations, and mean scores were overlain on the graphs for display.

3.2.3 Plot Method Effect

The final analysis performed in this study was to compare specific vegetation measures collected using the rapid plotless survey design employed in the EIA field testing to the intensive vegetation data collected using the Carolina Vegetation Survey (CVS) method (Peet et al. 1998, Rocchio 2007a). Four specific vegetation metrics considered important to gauge biotic condition were compared: Mean C for all species, Mean C for native species, native species richness, and percent nonnative species. For each of the four metrics, values derived from each observer's species list collected using the plotless method and the mean values per plot were graphed against values derived from pervious sampling using the CVS method. Spearman's rank correlation coefficients (R_s) were calculated to assess the relationship between the two methods. A one-to-one line was plotted to assess the effect of using the plotless method.

4.0 RESULTS

4.1 Test of User Variability

Overall ranks for each category had a high degree of agreement (Table 4, Appendix C). Based on the Kappa statistics, which ranged from 0.61–0.70, all four categories showed substantial agreement between observers. Overall Landscape Context, Biotic Condition, and Abiotic Condition ranks each had 87% agreement across all observers and all plots, meaning that only 8 out of 60 total responses (twelve plots, five observers) differed from the median response for that plot. These three category scores met the 85% agreement threshold set for high performing metrics. Overall Size ranks were slightly more variable with 77% agreement with the median (14 out of 60 varied from the median). The increased variability meant that this category did not meet the 85% agreement threshold, but did meet the 75% agreement threshold. Because of increased variability in the Size category, overall EIA ranks had 85% agreement (9 out of 60 varied from the median), slightly less than the three top performing categories. However, the overall EIA ranks did meet the more stringent 85% agreement threshold and the Kappa statistic (0.62) showed substantial agreement between observers, indicating that the EIA method provides a repeatable measure of ecological integrity across observers.

Results for individual metrics were more variable than for the category roll-up scores. Kappa statistics ranged from 0.00–0.71 and percent agreement with the median rank ranged from 63–92% (Table 4). Within the Landscape Context category, average buffer width and percent unfragmented landscape both performed very well, with 88% and 90% agreement, respectively. Both showed substantial agreement based on the Kappa statistics (K = 0.63 and 0.70, respectively). These metrics appear to be straightforward and easily interpreted by users. Adjacent land use performed moderately well with 77% agreement and K = 0.40. The final landscape metric, riparian corridor continuity, was among the most variable metrics with 63% agreement and K = 0.23.

Within the Biotic Condition category, two of six metrics passed the stringent 85% agreement threshold and showed substantial agreement based on the Kappa statistics, two additional metrics passed the 75% threshold and showed moderate agreement, while the remaining two either did not pass the 75% threshold or showed poor agreement based on the Kappa statistic. The strongest metrics in this category were relative cover of native species (92% agreement, K = 0.71) and Mean C of native species (87% agreement, K = 0.66). Relative cover of native species is an overall ocular estimate, but Mean C (native) is calculated from each observer's species list. Even though species lists varied by observer, Mean C (native) was remarkably consistent. Native species richness was also calculated from observers' species lists, but was slightly more variable (80% agreement, K = 0.41). Of the final three metrics, interspersion of biotic and abiotic patches and the degree of regeneration within the plots, as measured by the occurrence of native saplings and seedlings, both had 78% agreement. However, native saplings and seedlings had a Kappa statistic of 0.00, essentially indicating agreement by chance. Observers ranked this metric "A" nearly 80% of the time, and there was little consistency when observer used lower ranks. Observers also had difficulty assessing the number of biotic and abiotic patches. This metric was the only biotic condition metric to not pass the 75% agreement threshold, though it did have a Kappa statistic of 0.47, considered moderate agreement.

Fewer than half of the seven metrics within the Abiotic Condition category passed the stringent 85% agreement threshold and no metric showed substantial agreement according to the Kappa statistic. Those metrics that did pass—onsite land use, upstream surface water retention, and distance to nearest road—each had exactly 85% agreement and showed only moderate strength of agreement ($K = 0.44$, 0.41, and 0.56, respectively). Percent effective impervious area performed moderately well, with 78% agreement and $K = 0.56$. The remaining three metrics, upstream and onsite water diversions and additions, floodplain interaction, and bank stability, were much more variable based on both tests.

Only two metrics make up the Size category: absolute size and relative size. The absolute size metric showed 85% agreement with the median response, however the Kappa statistic ($K = 0.21$) indicated that this agreement was only somewhat higher than chance. Sites were nearly consistently ranked “D”, with only a few responses varying. Relative size was among the most variable metrics tested with 65% agreement and $K = 0.31$. Because of the variability in the relative size metric, the overall Size category score was more variable than the other three categories. However, when the scores were rolled up, the overall Size rank showed substantial agreement according to the Kappa statistic ($K = 0.70$).

Table 4. Summary results for the test of user variability. Table shows Kappa statistic and strength of agreement for each metric. Percent agreeing with the median was derived from the median rank for each plot across all users (see Appendix C for all raw scores and ranks). Two agreement thresholds (85% and 75%) were used to test the performance of each metric.

Metric	***Kappa statistic***	***Strength of agreement***	***Percent agreeing with median***	***Agreement threshold***	
				85%	***75%***
Landscape Context					
Average Buffer Width	0.63	Substantial	88%	X	X
% Unfragmented Landscape	0.71	Substantial	90%	X	X
Adjacent Land Use	0.40	Fair	77%	---	X
Riparian Corridor Continuity	0.23	Fair	63%	---	---
Overall Landscape Context	**0.61**	Substantial	**87%**	**X**	**X**
Biotic Condition					
Native Species Richness	0.41	Moderate	80%	---	X
Relative Cover Native Species	0.71	Substantial	92%	X	X
Mean C (Native)	0.66	Substantial	87%	X	X
Native Saplings / Seedlings	0.00	Poor	78%	---	X
Biotic / Abiotic Patches	0.45	Moderate	72%	---	---
Interspersion of Patches	0.47	Moderate	78%	---	X
Overall Biotic Condition	**0.64**	Substantial	**87%**	**X**	**X**
Abiotic Condition					
Onsite Land Use	0.44	Moderate	85%	X	X
Upstream Surface Water Retention	0.41	Moderate	85%	X	X
Upstream / Onsite Water Diversion / Addition	0.37	Fair	73%	---	---
Floodplain Interaction	0.23	Fair	68%	---	---
Bank Stability	0.20	Slight	72%	---	---
% Effective Impervious Area	0.50	Moderate	78%	---	X
Distance to Nearest Road	0.56	Moderate	85%	X	X
Overall Abiotic Condition	**0.67**	Substantial	**87%**	**X**	**X**
Size					
Absolute Size	0.21	Fair	85%	X	X
Relative Size	0.31	Fair	65%	---	---
Overall Size	**0.70**	Substantial	**77%**	**---**	**X**
Overall EIA Score and Rank	**0.62**	Substantial	**85%**	**X**	**X**

4.2 Sensitivity Analysis

4.2.1 Landscape Context

Landscape Context component metrics and overall scores had varying sensitivity to biotic condition class (Table 5). In general, plots with high biotic integrity were ranked high for Landscape Context metrics, while plots with moderate or low biotic integrity had either high or low scores for Landscape Context metrics depending on the plot. All five high integrity plots scored median ranks of “B” for average buffer width, while three out of five low integrity plots also scored “B” median ranks. Adjacent land use was similarly consistent for high integrity plots and variable for low integrity plots. Percent unfragmented landscape was scored lower for all plots, with four out of five high integrity plots and four out of five low integrity plots all scoring a “C” rank. The riparian corridor continuity metric was highly variable, though high integrity plots generally scored higher ranks than low integrity plots. When the four component metrics were aggregated, five out of five high integrity plots scored median ranks of “B” for overall Landscape Context. In the rapidly developing Blue River watershed, a “B” rank for landscape context may be the best possible rank for a wetland, even one with high biotic integrity. The two moderate integrity sites scored a “C” and “D” rank for Landscape Context. Out of the five low integrity sites, two scored a “B” rank, one scored a “C” rank, and two scored a “D” rank for overall Landscape Context.

Table 5. Metric ranks by condition class matrix for Landscape Context metrics. Metric ranks are those assigned through EIA field testing. Condition classes are derived from intensive vegetation data during previous sampling. All observers’ ranks are noted first (n = 60), followed by the median rank for each plot in parenthesis (n = 12).

Metric Rank	Average Buffer Width			Adjacent Land Use			% Unfragmented Landscape		
	Condition Class			Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
A	1		1	4			1		
B	24 (5)	2	13 (3)	14 (4)	1	12 (3)	6 (1)	2	2
C		3 (1)	4 (1)	7 (1)	5 (1)	4	18 (4)	3 (1)	18 (4)
D		5 (1)	7 (1)		4 (1)	9 (2)		5 (1)	5 (1)

Metric Rank	Riparian Corridor Continuity			***Overall Landscape Context***		
	Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low
A	11 (2)		4 (1)	2		1
B	9 (2)	4 (1)	6 (1)	21 (5)	1	10 (2)
C	5 (1)	5 (1)	5	2	5 (1)	4 (1)
D		1	10 (3)		4 (1)	10 (2)

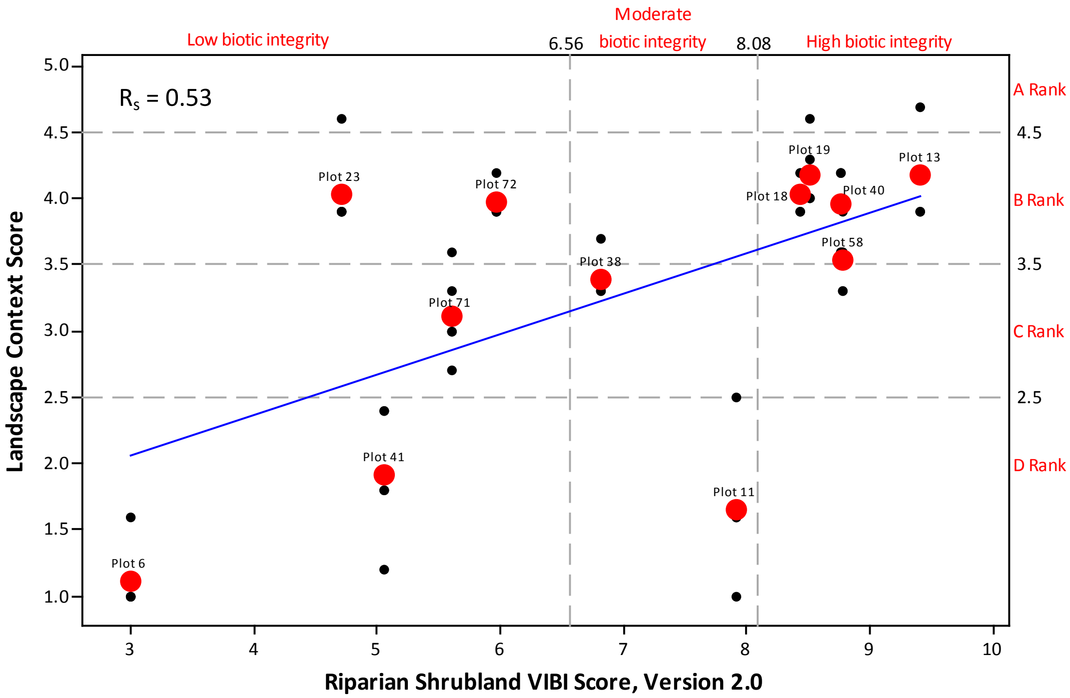

Figure 2. Correlation of Landscape Context scores to VIBI scores. Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Spearman's rank correlation coefficient (R_s) inset within the graph. Condition classes marked at VIBI threshold values along the x-axis. Thresholds for each lettered rank also mark along the y-axis.

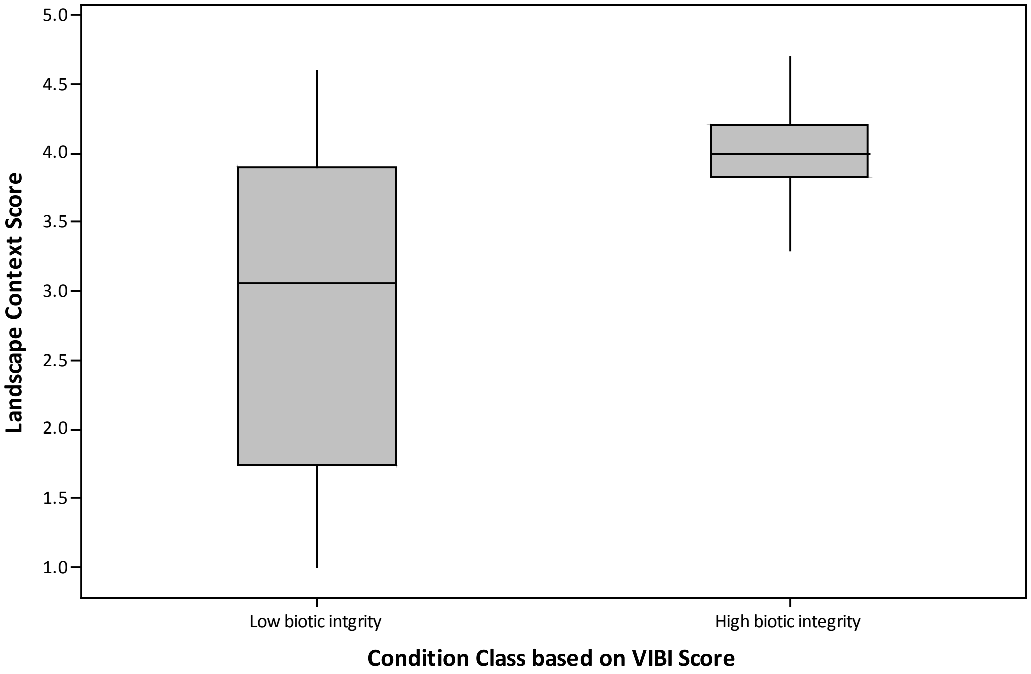

Figure 3. Discriminatory power of Landscape Context scores. Condition classes are based on VIBI scores. Boxes represent 75th percentile (top) to 25th percentile (bottom). Horizontal lines represent the median. Whiskers extend to the upper and lower limits.

Overall Landscape Context scores were positively correlated with VIBI scores (Figure 2), with a Spearman's rank correlation coefficient of 0.53. As the graph indicates, high integrity sites are clustered within the "B" rank for Landscape Context, while moderate and low integrity sites are more widely spread. The ability of Landscape Context scores to discriminate between sites with high and low biotic integrity is moderate (Figure 3). The interquartile ranges for high and low biotic integrity sites overlap, but the medians of both condition classes are outside the other's interquartile range. It appears that high Landscape Context scores are important to maintain high integrity sites, but that as a single measure, they do not predict biotic integrity. Sites with high Landscape Context scores may have either high integrity or low integrity depending on local stressors.

4.2.2 Biotic Condition

Biotic Condition component metrics and overall scores were strongly associated with condition class (Table 6). Plots with high biotic integrity were consistently ranked high (either "A" or "B" median ranks) for each of the seven Biotic Condition metrics. Low integrity sites were far more likely to be ranked "C" or "D", though not every metric exhibited this pattern. Four out of five high integrity sites scored median ranks of "A" for species richness of native plants. However, both moderate integrity sites and three of five low integrity sites also scored "A" ranks. For relative cover of native species, only one high integrity site ranked "A". The remaining four high integrity sites were scored "B", and moderate and low integrity sites were split between "B" and "C" ranks. Mean C (native) was strongly linked to condition class. All five high integrity sites ranked "A", the moderate integrity sites ranked "B", and low integrity sites were split between "C" and "D" ranks, making this the strongest of all single metrics. Patch richness and interspersion of patches both show sensitivity to condition classes, with high integrity sites ranked either "A" or "B" and no low integrity sites ranked above a "B". Native saplings and seedlings, however, showed no sensitivity to condition class, as all 12 sites had a median rank of "A".

With all six component metrics aggregated, four out of five high integrity plots scored median ranks of "A" for overall Biotic Condition and one scored a "B". Both moderate integrity sites ranked "B" for Biotic Condition. Low integrity sites were split between "B" and "C" ranks. High ranks for native species richness and native saplings and seedlings likely brought up the overall ranks for the low integrity sites. On the whole, however, the Biotic Condition category of the EIA shows strong association with VIBI condition classes based on more intensive data collection.

Overall Biotic Condition scores from the EIA showed the strongest correlation to VIBI scores of any category (Figure 4: $R_s = 0.83$). For the most part, high integrity sites are clustered within the "A" rank for Biotic Condition, moderate integrity sites in the "B" rank, and low integrity site spread between "B" and "C". Biotic Condition scores are clearly able to discriminate between sites with high and low biotic integrity (Figure 5). There is no overlap between the interquartile ranges for high and low biotic integrity sites.

Table 6. Metric ranks by condition class matrix for Biotic Condition metrics. Metric ranks are those assigned through EIA field testing. Condition classes are derived from intensive vegetation data during previous sampling. All observers' ranks are noted first (n = 60), followed by the median rank for each plot in parenthesis (n = 12).

Metric Rank	Species Richness Native Plants			Relative Cover of Native Plants			Mean C (Native)		
	Condition Class			Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
A	18 (4)	9 (2)	13 (3)	3 (1)		1	25 (5)	1	
B	5 (1)	1	2	21 (4)	4 (1)	10 (2)		6 (2)	12 (2)
C			5 (2)	1	6 (1)	13 (3)		3	12 (3)
D	2		5			1			

Metric Rank	Biotic/Abiotic Patch Richness			Interspersion of Patches			Native Saplings and Seedling		
	Condition Class			Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
A	11 (3)	3 (1)	1	16 (3)	2		24 (5)	7 (2)	16 (4)
B	14 (2)	1	6 (1)	8 (2)	3 (1)	11 (2)	1	1	7
C		2	11 (2)	1	5 (1)	11 (3)		2	2
D		4 (1)	7 (2)			3			

Metric Rank	***Overall Biotic Condition***		
	Condition Class		
	High	Moderate	Low
A	21 (4)	1	
B	4 (1)	7 (2)	11 (2)
C		2	13 (3)
D			1

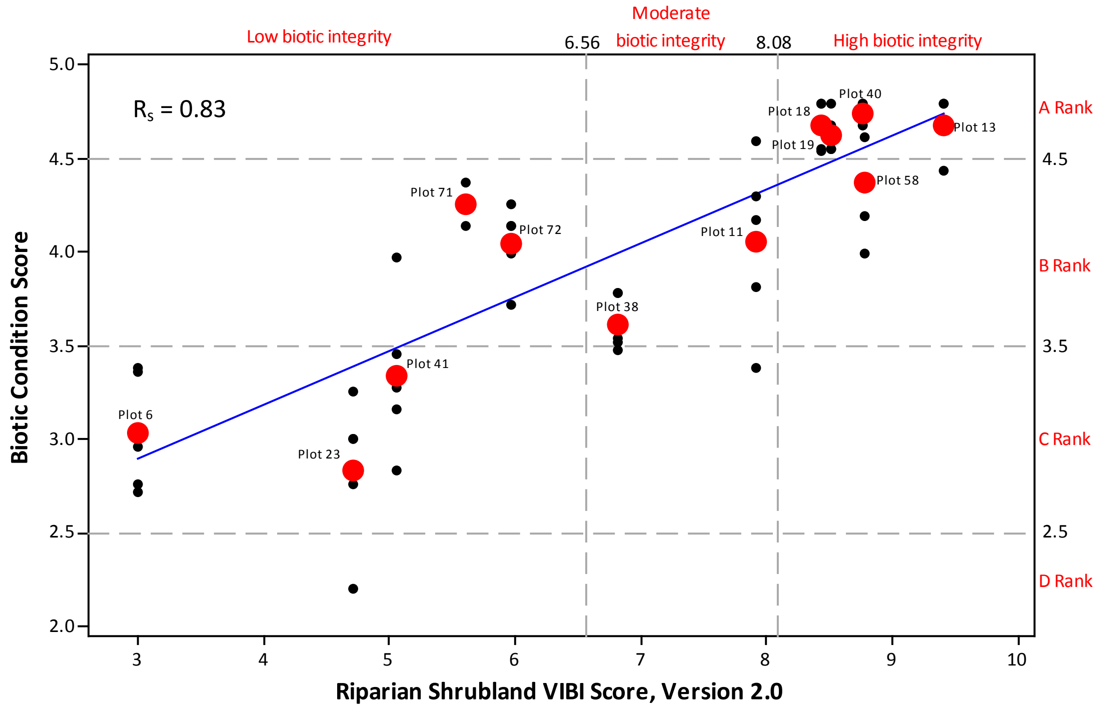

Figure 4. Correlation of Biotic Condition scores to VIBI scores. Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Spearman's rank correlation coefficient (R_s) inset within the graph. Condition classes marked at VIBI threshold values along the x-axis. Thresholds for each lettered rank also mark along the y-axis.

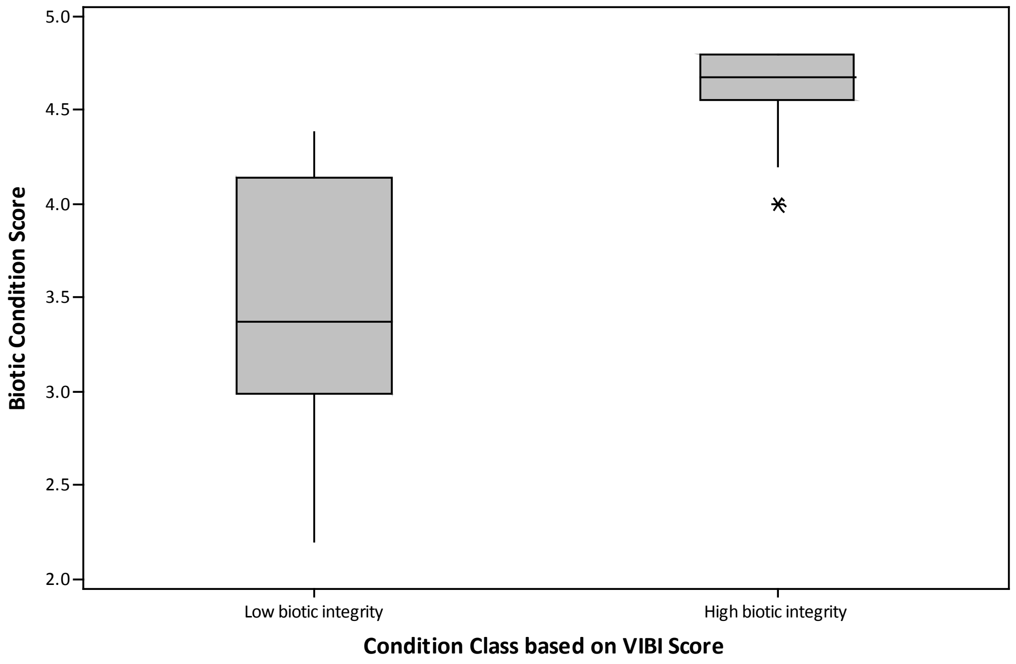

Figure 5. Discriminatory power of Biotic Condition scores. Condition classes are based on VIBI scores. Boxes represent 75th percentile (top) to 25th percentile (bottom). Horizontal lines represent the median. Whiskers extend to the upper and lower limits. Stars indicate outliers.

4.2.3 Abiotic Condition

The seven component metrics and overall scores for the Abiotic Category exhibited a similar pattern as metrics within the Landscape Context category (Table 7). Plots with high biotic integrity more commonly ranked high, but individual metrics for moderate and low integrity sites were spread across the ranks. When aggregated into overall Abiotic Condition, however, high integrity sites ranked either "A" or "B" and moderate and low integrity sites ranked "B" or "C".

In five of the seven metrics—onsite land use, upstream water retention, floodplain interaction, bank stability, and percent effective impervious area—high integrity sites consistently ranked "A", while low integrity sites were more variable. Water diversions and additions exhibited somewhat of a reverse pattern, with high condition sites showing more variability than low integrity sites. The final metric, distance to nearest road, was scored low for nearly all sites in the study. Even high integrity sites scored "B", "C" or "D" for this metric, moderate sites both scored "D", and low integrity sites were ranked either "C" or "D".

Table 7. Metric ranks by condition class matrix for Abiotic Condition metrics. Metric ranks are those assigned through EIA field testing. Condition classes are derived from intensive vegetation data during previous sampling. All observers' ranks are noted first (n = 60), followed by the median rank for each plot in parenthesis (n = 12).

Metric Rank	Onsite Land Use			Upstream Water Retention			Water Diversions or Additions		
	Condition Class			Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
A	24 (5)	5 (1)	9 (2)	21 (4)	8 (2)	16 (3)	11 (2)	4 (1)	3
B	1	4 (1)	6 (1)	2 (1)	1	5 (1)	10 (2)	3	9 (3)
C		1	6 (1)	2	1	3 (1)	4 (1)	3 (1)	11 (2)
D			4 (1)			1			1

Metric Rank	Floodplain Interaction			Bank Stability			% Effective Impervious Area		
	Condition Class			Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
A	18 (4)	2	12 (3)	22 (5)	6 (1)	11 (2)	17 (4)	1	10 (2)
B	6 (1)	5 (2)	3	3	3 (1)	8 (2)	6 (1)	5 (2)	4 (1)
C	1	2	6 (2)		1	5 (1)	2	3	1
D		1	4			1		1	10 (2)

Metric Rank	Distance to Nearest Road			***Overall Abiotic Condition***		
	Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low
A	1		1	7 (1)		2
B	3 (1)		1	17 (4)	8 (1)	8 (2)
C	9 (2)		10 (2)	1	2 (1)	15 (3)
D	12 (2)	10 (2)	13 (3)			

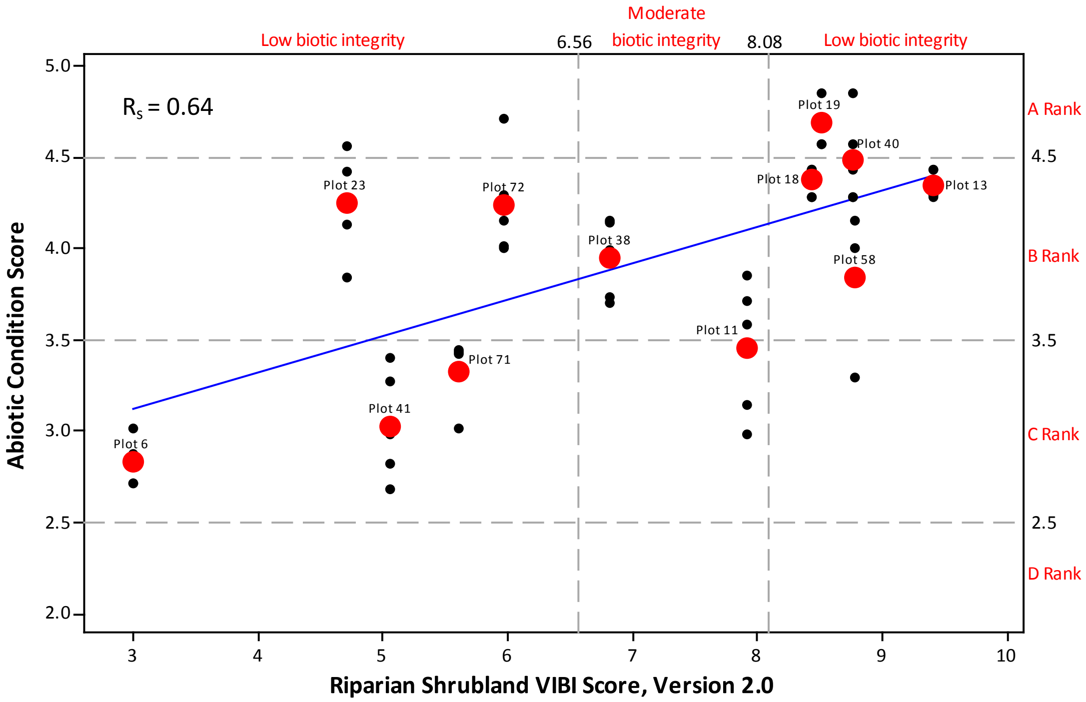

Figure 6. Correlation of Abiotic Condition scores to VIBI scores. Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Spearman's rank correlation coefficient (R_s) inset within the graph. Condition classes marked at VIBI threshold values along the x-axis. Thresholds for each lettered rank also mark along the y-axis.

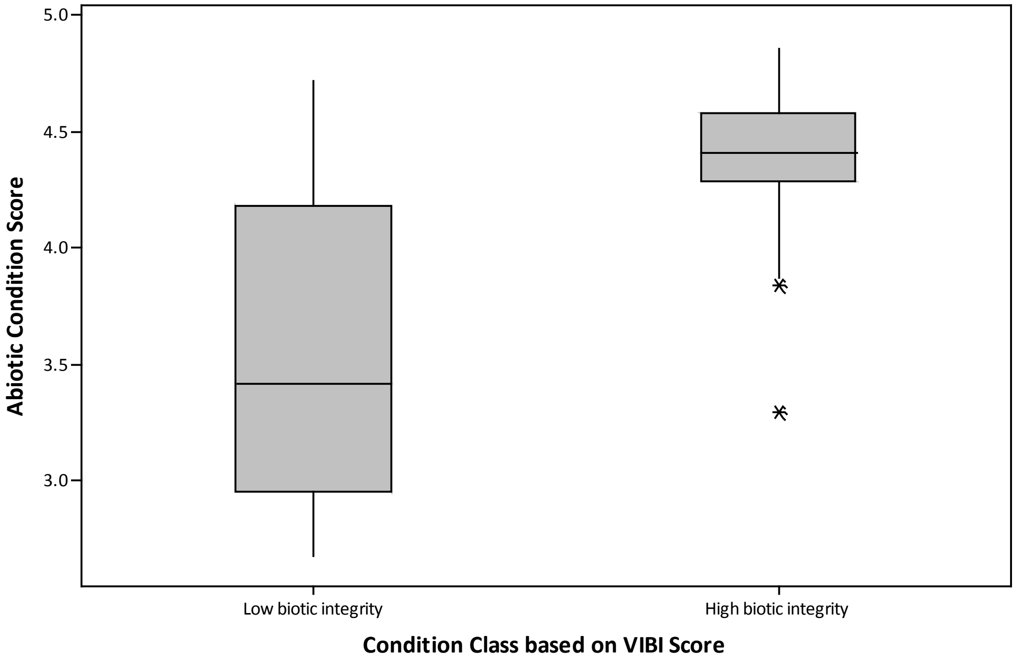

Figure 7. Discriminatory power of Abiotic Condition scores. Condition classes are based on VIBI scores. Boxes represent 75th percentile (top) to 25th percentile (bottom). Horizontal lines represent the median. Whiskers extend to the upper and lower limits. Stars indicate outliers.

Overall Abiotic Condition scores were positively correlated with VIBI scores (Figure 6). With a Spearman's rank correlation coefficient of 0.64, this category is more strongly associated with VIBI scores than Landscape Context, but less so than Biotic Condition. Based on the available data, Abiotic Condition scores are able to discriminate between sites with high and low biotic integrity (Figure 7). There is no overlap between the interquartile ranges for high and low biotic integrity sites, however low integrity sites have considerable more spread.

4.2.4 Size

Only two component metrics are included in the Size category (Table 8). As scored during this study, there was no correlation between absolute size and condition class. Eleven out of the twelve test plots were ranked "D" for absolute size. Relative size, however, had a stronger association to condition. High integrity sites were ranked either "A" or "B", while low integrity sites were "A", "B", or "D".

Table 8. Metric ranks by condition class matrix for Size metrics. Metric ranks are those assigned through EIA field testing. Condition classes are derived from intensive vegetation data during previous sampling. All observers' ranks are noted first (n = 60), followed by the median rank for each plot in parenthesis (n = 12).

Metric Rank	Absolute Size			Relative Size			***Overall Size***		
	Condition Class			Condition Class			Condition Class		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
A				17 (3)		7 (2)	16 (3)		6 (2)
B				7 (2)	5 (1)	7 (1)	7 (2)	1	5
C	7 (1)	1	4	1	3 (1)	3		1	
D	18 (4)	9 (2)	21 (5)		2	8 (2)	2	8 (2)	14 (3)

On the EIA field form, the roll-up formula for scoring the overall Size category is different than for other categories. If the Landscape Context rating equals "A" or "B", the Size rating equals the relative size metric rating and the absolute size is disregarded. However, if the Landscape Context rating equals "C" or "D", the size rating is a weighted formula of absolute size x 0.70 and relative size x 0.30. This formula was designed to rank larger wetlands higher in disturbed landscapes because the increased resilience of larger wetlands is more important in the face of increased disturbance. When rolled up following this formula, high integrity sites were ranked "A" or "B" and low integrity sites were split between "A" and "D" because those with lower Landscape Scores were brought down by the low absolute size scores. This split of low integrity sites lead to a lower correlation between Size scores and VIBI scores. The Spearman's rank correlation coefficient for Size was only 0.50, the lowest of all categories (Figure 8) and the discriminatory power of this category was also low (Figure 9).

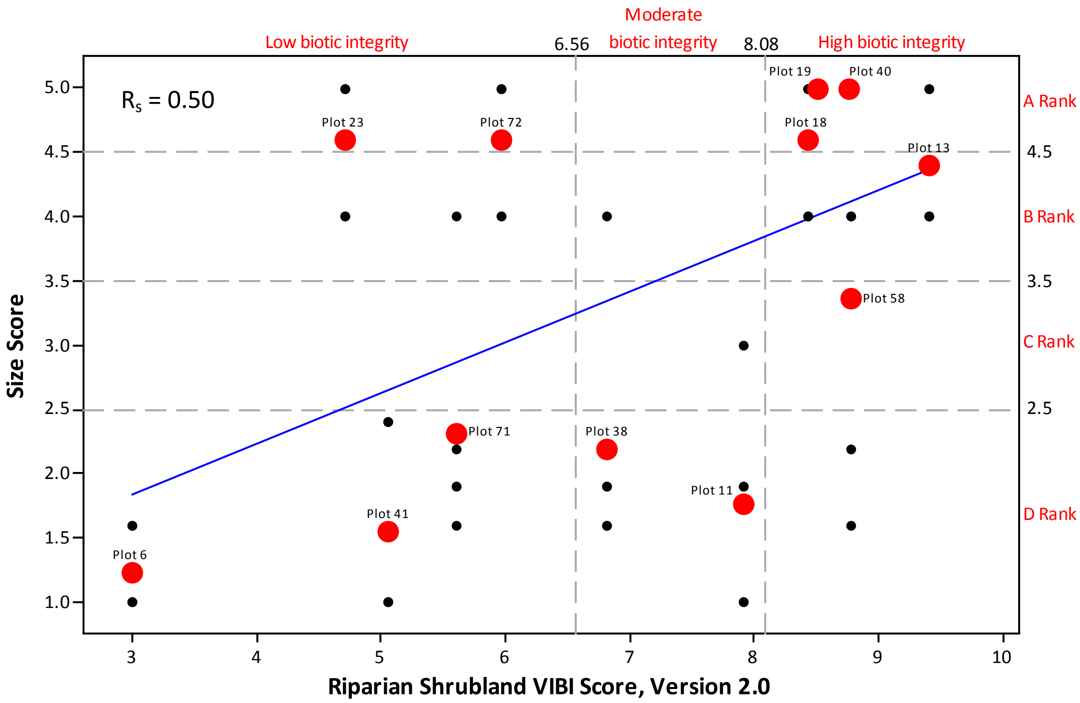

Figure 8. Correlation of Size scores to VIBI scores. Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Spearman's rank correlation coefficient (R_s) inset within the graph. Condition classes marked at VIBI threshold values along the x-axis. Thresholds for each lettered rank also mark along the y-axis.

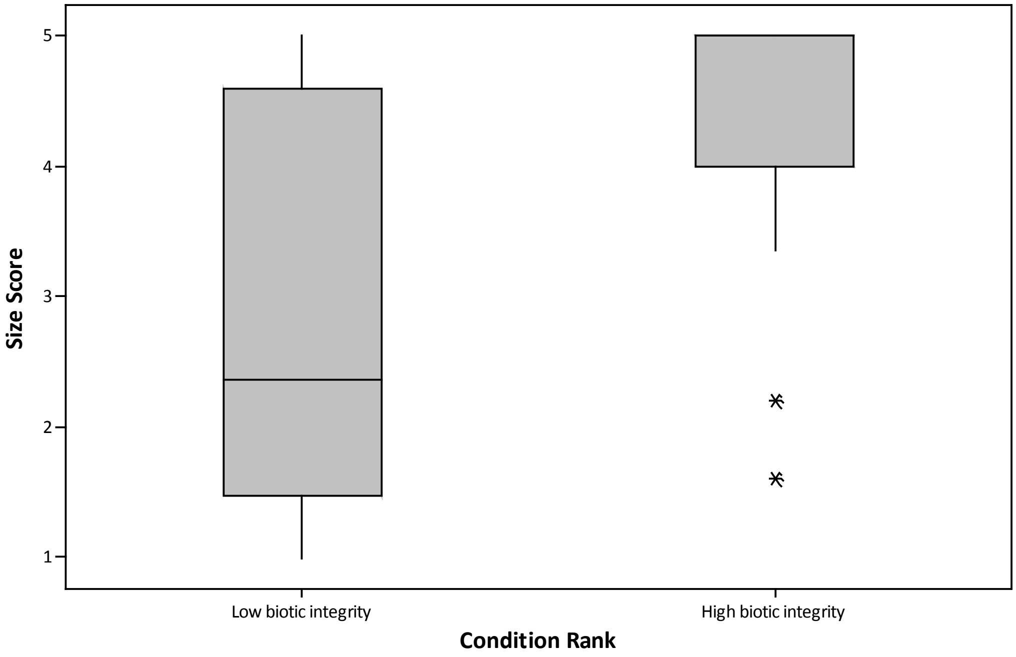

Figure 9. Discriminatory power of Size scores. Condition classes are based on VIBI scores. Boxes represent 75th percentile (top) to 25th percentile (bottom). Horizontal lines represent the median. Whiskers extend to the upper and lower limits. Stars indicate outliers.

Table 9. Metric ranks by condition class matrix for Overall EIA Rank. Metric ranks are those assigned through EIA field testing. Condition classes are derived from intensive vegetation data during previous sampling. All observers' ranks are noted first (n = 60), followed by the median rank for each plot in parenthesis (n = 12).

Metric Rank	*Overall EIA Rank*		
	Condition Class		
	High	Moderate	Low
A	11 (2)		
B	13 (3)	1	11 (2)
C	1	9 (2)	8 (2)
D			6 (1)

4.2.5 Overall EIA

When all categories were rolled-up into the Overall EIA score and rank, the method performed well. High integrity sites were either ranked "A" or "B", moderate integrity sites were ranked "B" or "C", and low integrity sites were spread between "B", "C" and "D" (Table 9). Overall EIA scores were positively correlated with VIBI scores with a Spearman's rank correlation of 0.70 (Figure 10) and discriminates between high and low integrity sites (Figure 11). As with many of the component categories, high integrity sites have far less variability in EIA scores than low integrity sites.

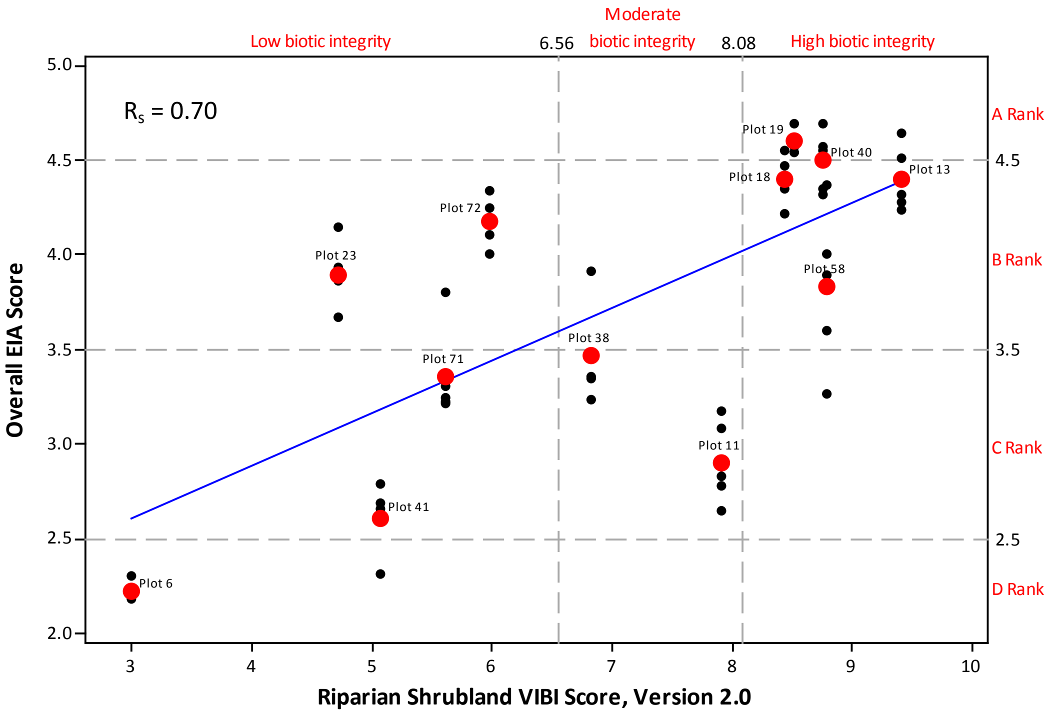

Figure 10. Correlation of overall EIA scores to VIBI scores. Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Spearman's rank correlation coefficient (R_s) inset within the graph. Condition classes marked at VIBI threshold values along the x-axis. Thresholds for each lettered rank also mark along the y-axis.

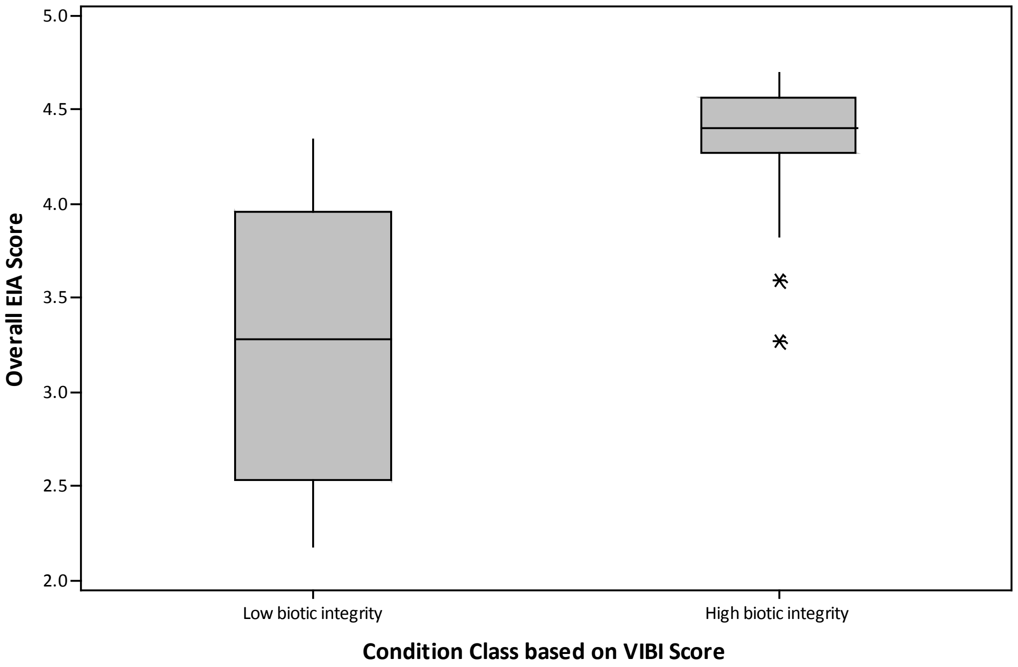

Figure 11. Discriminatory power of overall EIA scores. Condition classes are based on VIBI scores. Boxes represent 75th percentile (top) to 25th percentile (bottom). Horizontal lines represent the median. Whiskers extend to the upper and lower limits. Stars indicate outliers.

4.3 Plot Method Effect

Data collected by all five observers using the rapid plotless method was compared to data collected previously using the intensive Carolina Vegetation Survey (CVS) method. The strength of the correlation between these two methods depended on the metric in question. For both Mean C (all species) and Mean C (native), data collected using the plotless method was strongly correlated to data collected using the intensive CVS method (Figures 12 & 13). For Mean C (all species), Spearman's rank correlation coefficient was very high ($R_s = 0.91$), and for Mean C (native) the correlation coefficient was only slightly less ($R_s = 0.86$). On both graphs, nearly all of the points fall below the one-to-one line, indicating that values derived from the plotless method were slightly less than those derived from the CVS method.

For native species richness, the results look very different (Figure 14). The relationship is not as strong ($R_s = 0.62$), and data collected using the plotless method fall well below data collected using the intensive CVS method. Observers did not record as many species using the timed plotless method as previous sampling efforts using the CVS method. However, though the species list was shorter, it does appear that the ratio of native to nonnative species remained similar (Figure 15). For percent nonnative species, the correlation between data derived from the two methods was strong ($R_s = 0.83$), and points fell both above and below the one-to-one line.

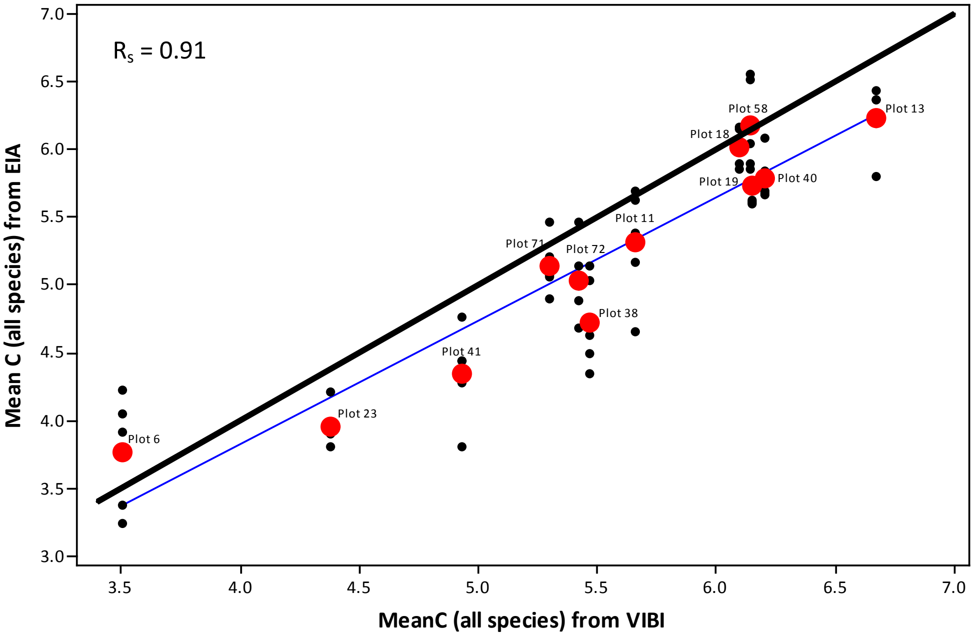

Figure 12. Correlation of Mean C (all species) derived from data collected for using the plotless method (EIA) and data collected using the intensive CVS plot method (VIBI). Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Black line represents a one-to-one correlation between the two methods, blue line represents the actual correlation. Spearman's rank correlation coefficient (R_s) inset within the graph.

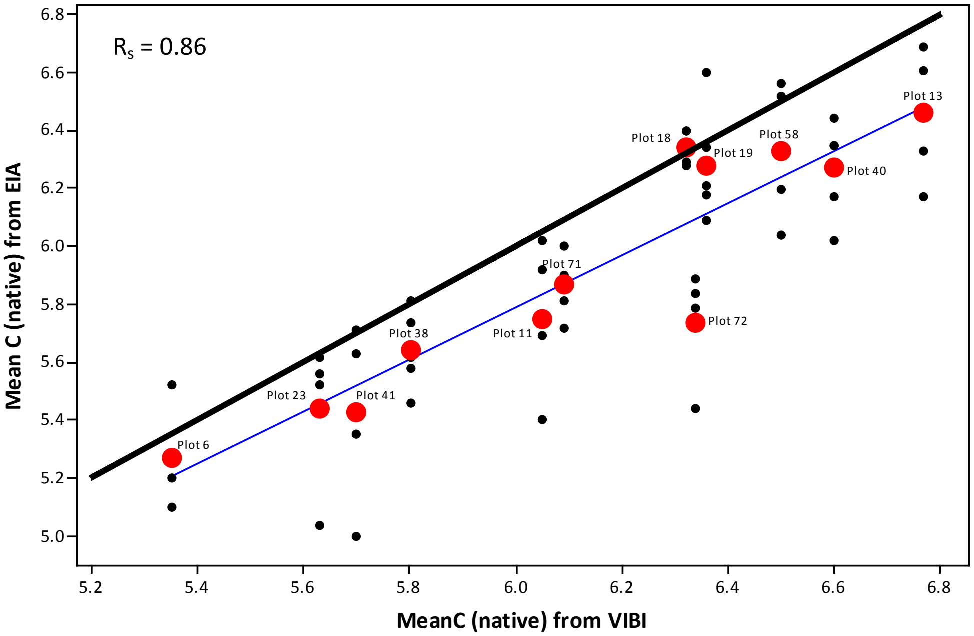

Figure 13. Correlation of Mean C (native) derived from data collected using the plotless method (EIA) and data collected using the intensive CVS plot method (VIBI). Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Black line represents a one-to-one correlation between the two methods, blue line represents the actual correlation. Spearman's rank correlation coefficient (R_s) inset within the graph.

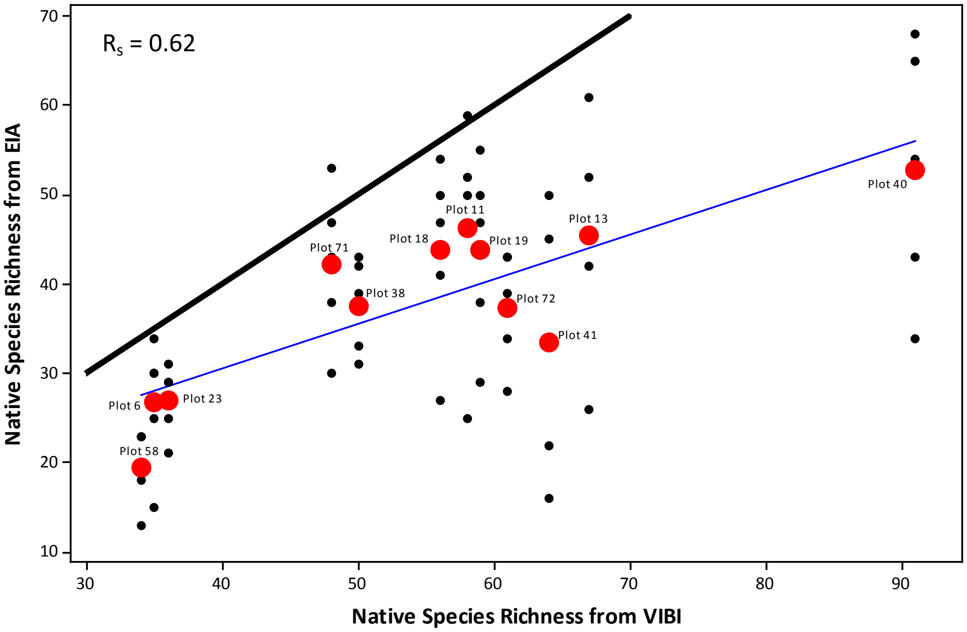

Figure 14. Correlation of native species richness derived from data collected using the plotless method (EIA) and data collected using the intensive CVS plot method (VIBI). Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Black line represents a one-to-one correlation between the two methods, blue line represents the actual correlation. Spearman's rank correlation coefficient (R_s) inset within the graph.

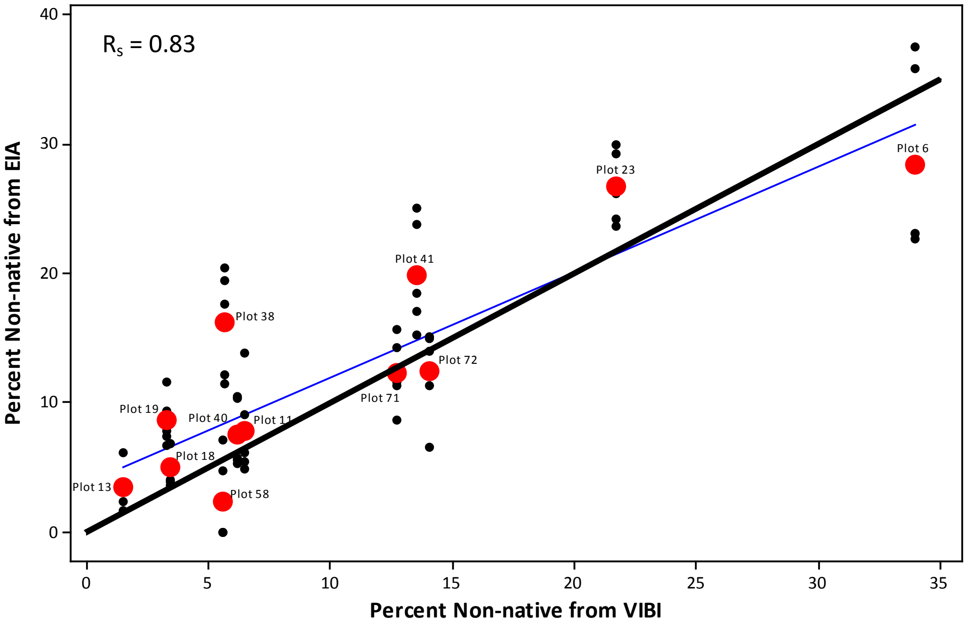

Figure 15. Correlation of percent nonnative species derived from data collected using the plotless method (EIA) and data collected using the intensive CVS plot method (VIBI). Data points represent scores by each observer (small black dots •) and mean scores per plot (large red dots •). Black line represents a one-to-one correlation between the two methods, blue line represents the actual correlation. Spearman's rank correlation coefficient (R_s) inset within the graph.

5.0 DISCUSSION

5.1 Effectiveness of Ecological Integrity Assessment

Field testing of the Subalpine-Montane Riparian Shrubland EIA produced valuable results that will help guide refinement of this method for future projects. The EIAs are currently being used in two basin-wide wetland condition assessment projects in Colorado, both funded by USEPA Region 8 Wetland Program Development Grants and the Colorado Division of Wildlife, and one regional wetland assessment project that will include wetlands across the states of Colorado, Wyoming, and Montana. Through each of these projects, field protocols for the EIA will be continually improved. This field testing project provides sound evidence for maintaining, modifying, or replacing particular metrics.

From tests of both user variability and sensitivity to condition class, several metrics stood out as reliable and high performing, while others need to be improved. Within the Landscape Context category, average buffer width and percent unfragmented landscape were the most easily interpreted by users. Adjacent land use was also considered a strong metric in both tests, but the wording will be revised in future iterations to improve user accuracy. This metric will be improved with clearer definitions within the land use coefficient table to ensure that all potential land uses encountered in the field are included in the list. Future field maps will include a guide for calculating percentages, as users had differing estimates of the percent of land occupied by different land uses. Standardized assessment area and buffer area sizes could also help the interpretation. Alternatively, this metric could be calculated in the office with up-to-date land cover data in GIS; however, land uses noted in the field may not be evident in GIS information, such as the intensity of recreation or grazing. The final Landscape Context metric, riparian corridor continuity, was a poor performing metric and was not easily interpreted in the field. Protocols for using this metric will be rewritten before it is used it in future projects.

Overall, the Landscape Context category was correlated to biotic condition, but was not a reliable predictor of high integrity wetlands as measured by the VIBI. The results from this study show that high integrity sites are closely linked with high Landscape Context scores, but that low integrity sites can occur with either high or low Landscape Context scores. This does not detract from the importance of assessing metrics related to landscape context, however. Within the EIA framework, landscape metrics relate to processes that function on a larger scale, such as the influx of native and nonnative species and long-term population dynamics, and may indicate greater risk facing a wetland in the future. But it does show that landscape context alone is not enough information to understand onsite wetland condition.

The Biotic Condition category contains the most robust and reliable measures of wetland condition. Mean C (native) and relative cover of native species were both highly consistent across observers and very strongly correlated with condition. Mean C (native) is included in the VIBI model from which condition classes were derived, but is only one of nine separate metrics included in the model. Its high correlation is therefore not surprising, but is supportive of previous evidence that this is a strong stand-alone measure of wetland condition (Lemly & Rocchio 2009). The fact that this metric performs well even in the rapid plotless method makes it ideal for using in Level 2 EIAs. One slight improvement will be made to relative cover native species. Given the strict criteria for this metric (A = 100% cover of native species), very few plots were ranked “A” for this metric, even in sites with high VIBI scores. In future iterations, this criteria will be lower to >99%, allowing sites to have <1% cover of ubiquitous non-native species such as common dandelion (*Taraxacum officiale)*.

Species richness of native plants performed moderately well in this study based on both user variability and sensitivity to condition class. However, results from the comparison of plot methods are cause for concern. It appears that the plotless method produces very different estimates of native species richness than the intensive CVS method. This is likely because the plotless method is timed – observers record all species found during one hour of searching effort – and the CVS method can take several hours to complete. It may also be that the CVS method requires observers to focus on one area and record every species found, even if that entails collecting the species for later identification. With the plotless method, observers may unintentionally overlook unknown species in favor of searching for known species and may not thoroughly search for low growing and inconspicuous species. In the VIBI project, species richness of native species was not found to be highly correlated with disturbance for subalpine riparian shrublands (Rocchio 2007a, Lemly and Rocchio 2009). Instead, the percent of native vs. nonnative species was more predictive of disturbance. In the current analysis, percent native vs. nonnative species proved more robust regardless of plot method and may represent a better metric for the EIA.

Of the remaining biotic metrics, native saplings and seedlings performed moderately well in terms of user variability, but all twelve plots were ranked “A”. As currently written, users were unable to detect decreased regeneration using this metric. The thresholds for this metric should be examined along with literature on regeneration in riparian areas to improve the usefulness of this metric, as it is certainly an important component of riparian health. The number and interspersion of biotic and abiotic patches were also moderate performers and did have some fidelity to condition class. Clarity in patch definitions and size requirements may improve this metric for future uses. Observers may have been confused about how large a patch needed to be in order to be counted or with the definition of different patch types included on the field form.

The Abiotic Condition category contains several important, yet challenging metrics. Wetlands can be impacted by a range of human disturbances that have varying effects on abiotic condition and processes. To incorporate this range of potential disturbance and effects, the EIA is designed so that wetlands can score high on some Abiotic Condition metrics and low on others. It is clear from this analysis that high integrity wetlands consistently lack disturbances and receive high ranks for all Abiotic Condition metrics, while low integrity wetlands can rank high on any one given metric and low on others. Therefore, the correlation between overall condition and each individual metric may be low, but when rolled-up into an overall Abiotic Condition score, the suite of metrics had a strong relationship to disturbance. The individual abiotic metrics can also be used to highlight potential causes for lower biotic condition, as they incorporate many of the most common stressors faced by wetlands.

For future project, wording will be changed on several Abiotic Condition metrics to strength their performance and repeatability. The same changes to the land use coefficient table mentioned above for adjacent land use would also help onsite land use. Checking GIS in the office would ensure all upstream dams and reservoirs were noted, which could help the upstream surface water retention metric. Clear scale bars on the field form to estimate distance would make the distance to nearest road metric easily interpreted by all users. In this particular study, low scores for this metric are likely because the study subjectively chose sites that the five observers could easily access. There are numerous wetlands in the Rocky Mountains far from roads, but they were not included in this study for logistical reasons. Percent effective impervious area may need improved wording to clarify the difference between low and medium density land use and could be improved with the standardized graphical illustration of 1, 5, and 10% of the landscape. The remaining three metrics, upstream and onsite water diversions and additions, floodplain interaction, and bank stability all failed the 75% agreement threshold of consistency and need significant improvements. These three metrics represents important aspects of riparian integrity, but need clear protocols to be used effectively.

The final category included in the EIA framework is Size. Users were able to determine absolute size consistently, but this measure was not related to biotic condition class. These results may have been an artifact of the assessment area boundaries. In some instances, the full extent of the riparian shrubland was larger than the portion assessed, but observers ranked the wetland according to the assessment area size. As many wetland condition assessment projects move to using standardized assessment areas (e.g., 0.5 hectares) rather than assessing the full extent of the wetland, the guidelines of the Size metrics will have to be reviewed. It may be that absolute size should be calculated in the office and not estimated in the field. However, it can be difficult to determine the boundaries on certain wetland types from air photography.

Conversely, relative size does provide some indication of condition, but was far more difficult for users to interpret. Based on the guidance currently given in the EIA, interpreting relative size is highly subjective. This metric estimates the extent to which the size of the wetland has been reduced by human disturbance. In order to estimate relative size, observers must first estimate the total potential size of the wetland. It appears that total potential size was too subjective for observers to estimate consistently. Clear guidance and protocols will be developed to use this metric more effectively in the future.

When aggregated into an overall Ecological Integrity score, the method did prove to be reliable across users. Final scores varied by only 15% over all twelve plots and five observers. The method was successful at separating high and low integrity sites and was positively correlated with VIBI scores. High integrity sites were clustered in the “A” to “B” ranks for overall scores, though low integrity sites were more variable.

It is important to note that comparing the EIA results to VIBI-derived condition classes provides a framework for assessing the effectiveness of the method, but it should be done with the following caveat. The Subalpine-Montane Riparian Shrubland VIBI model was developed to measure biotic condition with the assumption that vegetation integrates the effects of landscape and abiotic stressors. It is not surprising that the Biotic Condition category of the EIA had the strongest association with condition class derived from VIBI scores, as this category also focuses on biotic condition. There are several reasons why VIBI scores and condition classes may not correlate as well with the other categories. One is that a site may be impacted by a handful of separate landscape level or local level stressors, so that any one metric or category will not be closely correlated with condition. Another is that there may be time lags between stressors and biotic response (Findlay & Bourdages 2000). The biotic condition of a wetland may be degraded due to disturbances in the past that are not evident in the present, and therefore not picked up by the Landscape Context or Abiotic Condition metrics. Or very recent disturbances picked up at the landscape scale may degrade a site over time, but not be reflected in the current biotic condition. With that understanding, the current analysis does much to point out the strongest and weakest elements of the method.

5.2 Conclusion and Next Steps

Once refined by further use and field testing through upcoming projects, the EIAs could be applied to a number of different purposes. For example, the EIAs could strengthen the ability for the Colorado Division of Wildlife's Wetlands Program to monitor and evaluate the ecological response and effectiveness of wetland management and protection projects. The EIAs could help refine the protection of vulnerable wetlands by providing a tool to prioritize sites with the highest ecological integrity. Conversely, the EIAs could also provide a means to prioritize sites in need of restoration and/or management actions and the underlying metrics could provide guidance on the ecological processes in need of restoration.

The EIA metrics and their associated ratings could also serve a valuable role in compensatory mitigation. Given that metric ratings are based on deviation from natural variability for a specified wetland type, EIAs could be used to establish the integrity of both the impact and mitigated site relative to reference conditions. This information can then be used to determine what aspects of ecological integrity should be mitigated for (e.g., biotic composition and hydrologic integrity), set ecological performance criteria, and track mitigation progress toward these endpoints. However, the EIAs are best used in conjunction with other tools and standards for mitigation such as design standards, intermediate stage assessments, and trajectories. EIA application to compensatory mitigation could be very similar to how functional assessments are applied, except instead of "functional capacity units" the EIAs use "ecological integrity units" associated with each metric.

Over the coming years, work on the EIAs will result in a user manual and standard field forms which will allow wetland scientists and regulatory personnel to monitor and assess wetland ecological integrity for the purposes of regulatory and/or non-regulatory applications such as permitting, mitigation, proactive restoration and/or protection projects, and reporting of ambient wetland condition. These tools will provide a means to measure the progress towards sustaining and enhancing Colorado's valuable wetland resource.

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APPENDIX A: Subalpine-Montane Riparian Shrubland Ecological Integrity Assessment Field Form

Subalpine-Montane Riparian Shrubland
Ecological Integrity Assessment Field Form

Plot #: **Date:** **Observers:**

LANDSCAPE CONTEXT

	Rating
1a. Average Buffer Width. Wetland buffers are natural vegetated areas with no or minimal human-use. Buffer boundaries extend from the assessment area edge to anthropogenic patches which are areas which have been converted or are dominated by human activities such as heavily grazed pastures, roads, bridges, urban/industrial development, golf courses, mowed or highly managed parks/lawns, agriculture fields, and utility right-of-ways. 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 assessment area and nearby, more intensive land uses. To measure, estimate buffer width on four sides of the assessment area, then calculate average buffer width.	
A EXCELLENT > 100 m	
B GOOD 51 m to <100 m	
C FAIR 25 m to 50 m	
D POOR < 25m	
1b. Adjacent Land Use. This metric is measured by documenting surrounding land use(s) within 100 m of the assessment area boundary. To calculate a Total Land Use Score estimate the % of the adjacent area within 100 m of the assessment area boundary under each Land Use type and then plug the corresponding coefficient (Table 1) 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 assessment area, 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). The percent of land uses needs to = 100. Thus, if two or more land uses overlap (e.g. moderate grazing occurs over 100% of the area and an unpaved road occupies 20% of the assessment area) use the land use with the lower coefficient (e.g. moderate grazing = 80% and unpaved road 20%).	
A EXCELLENT Average Land Use Score = 1.0-0.95	
B GOOD Average Land Use Score = 0.80-0.94	
C FAIR Average Land Use Score = 0.4-0.79	
D POOR Average Land Use Score = < 0.4	
1c. Percentage of Unfragmented Landscape Within One Kilometer (ALL) An unfragmented landscape has no barriers to the movement and connectivity of species, water, nutrients, etc. between natural ecological systems.. This metric is measured by estimating the area of the largest remaining block of unfragmented area in a one km buffer surrounding the assessment area and dividing that by the total area. This can be completed in the office using aerial photographs or GIS. In the field, use the supplied map to make estimate.	
A EXCELLENT Embedded in 91-100% unfragmented, roadless natural landscape	
B GOOD Embedded in 61-90% unfragmented, roadless natural landscape	
C FAIR Embedded in 20-60% unfragmented, roadless natural landscape	
D POOR Embedded in < 20% unfragmented, roadless natural landscape	
1d. Riparian Corridor Continuity This metric is measured as the percent of anthropogenic patches within the riparian corridor within the 1 km buffer. Anthropogenic patches are defined as areas which have been converted or are dominated by human activities such as heavily grazed pastures, roads, bridges, urban/industrial development, agriculture fields, and utility right-of-ways. The riparian corridor itself is defined at the width of the geomorphic floodplain. Using GIS, field observations, and/or aerial photographs determine the largest remaining block of riparian corridor that is not fragmented by anthropogenic patches. Refer to the supplied map to make estimate.	
A EXCELLENT < 5% of riparian reach with gaps / breaks due to cultural alteration	
B GOOD > 5 - 20% of riparian reach with gaps / breaks due to cultural alteration	
C FAIR >21 - 50% of riparian reach with gaps / breaks due to cultural alteration	
D POOR > 50% of riparian reach with gaps / breaks due to cultural alteration	

Table1. Adjacent Land Use Coefficient Table

Current Land Use	Coefficient
Paved roads; parking lots; domestic or commercially developed buildings; gravel pit operation; commercial feedlots.	0.0
Unpaved Roads (e.g., driveway, tractor trail) / Mining	0.1
Agriculture (tilled crop production)	0.2
Heavy grazing by livestock; intense active recreation (ATV use; intense camping/fishing/hunting use, etc.); Urban parks, lawns, golf courses, sports fields; Orchards or nurseries	0.3
Logging or tree removal with 50-75% of trees >50 cm dbh removed	0.4
Hayed; Utility line corridors under vegetation management (e.g. tree/shrub removal; mowed);	0.5
Moderate grazing	0.6
Moderate passive recreation (high-use trail) or Forest Road (2-track) with minimal use or Utility line corridors not managed (e.g. tall electric lines not requiring vegetation management)	0.7
Selective logging or tree removal with <50% of trees >50 cm dbh removed	0.8
Light grazing / light, passive recreation (low-use trail, bird watching, occasional fishing, etc.)	0.9
Fallow with no history of grazing or other human use in past 10 yrs AND area has recovered from past human use to the point that past land use is not obvious. If impacts occurred greater than 10 years ago but are still impacting or affecting the site, then rate the land use as you would normally.	0.95
Natural area / land managed for native vegetation	1.0

Land Use Calculations:

LU Type #1 Coeff _______ x % of Area = ___________ /100 = Sub-land use score ______
LU Type #2 Coeff _______ x % of Area = ___________ /100 = Sub-land use score ______
LU Type #3 Coeff _______ x % of Area = ___________ /100 = Sub-land use score ______
LU Type #4 Coeff _______ x % of Area = ___________ /100 = Sub-land use score ______
LU Type #5 Coeff _______ x % of Area = ___________ /100 = Sub-land use score ______

Total Land Use Score______

Landscape Context Rating Protocol

Use the table below to roll up the metrics into an overall Landscape Context rating.

Calculation of Landscape Context Rating.

Measure	A	B	C	D	Weight	Score (weight x rating)
Adjacent Land Use	5	4	3	1	0.30	
Buffer Width	5	4	3	1	0.30	
Percentage of unfragmented landscape within 1 km.	5	4	3	1	0.10	
Riparian Corridor Continuity	5	4	3	1	0.30	
Landscape Context Rating A = 4.5 - 5.0 B = 3.5 – 4.4 C = 2.5 – 3.4 D = 1.0 – 2.4					**Total (sum)**	

BIOTIC CONDITION

		Rating
2a. Species Richness of Native Plants. Walk through the assessment area and identify plant species which occurs in the area. Enter species data into Table 5 (back of form). DO NOT spend more than 1 hour compiling the species list. Use the table below to determine which rating applies:		

	Lower subalpine riparian shrublands dominated by tall willows	Subalpine riparian shrublands dominated by short willows
Total Species Richness	Reference range of species richness = 39-71	Reference range of species richness = 28-67

		Rating
A EXCELLENT	Total Species Richness falls within the natural range of variability	
B GOOD	Total Species Richness no more than five species less than natural range of variability	
C FAIR	Total Species Richness is between 6-10 species less than natural range of variability	
D POOR	Total Species Richness is > 10 species less than natural range of variability	
2b. Percent of Cover of Native Plant Species. Percent of the plant species which are native to the Southern Rocky Mountains. Walk through the assessment area and estimate the percent cover of native plants present.		
A EXCELLENT	100 % cover of native plants	
B GOOD	90-100% cover of native plants	
C FAIR	50-90% cover of native plants	
D POOR	< 50% cover of native plants	
2c. Floristic Quality Index (Mean C). Based on species listed in Table 5, calculate the average C-value for all the native species found at the site. Use the Colorado FQA database to determine nativity and C values.		
A EXCELLENT	Mean C > 6.0	
B GOOD	Mean C = 5.6 – 6.0	
C FAIR	Mean C = 5.0 – 5.5	
D POOR	Mean C < 5	
2d. Biotic/Abiotic Patch Richness. The number of biotic/abiotic patches or habitat types present in the wetland. (see Table 2 for possible patch types) Write number of patches on line.		
A EXCELLENT	≥ 12 patch types present	
B GOOD	8-11 patch types present	
C FAIR	4-7 patch types present	
D POOR	< 4 patch types present	
2e. Interspersion of Biotic/Abiotic Patches. Interspersion is the spatial complexity 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). Match the interspersion of patches in the assessment area with the categorical ratings in the scorecard.		
A EXCELLENT	Horizontal structure consists of a very complex array of nested and/or interspersed, irregular biotic/abiotic patches, with no single dominant patch type	
B GOOD	Horizontal structure consists of a moderately complex array of nested or interspersed biotic/abiotic patches, with no single dominant patch type	
C FAIR	Horizontal structure consists of a simple array of nested or interspersed biotic/abiotic patches.	
D POOR	Horizontal structure consists of one dominant patch type and thus has relatively no interspersion	
2f. Saplings/seedlings of Native Woody Species. Determine the degree of regeneration of native woody species present along the streambank and edges of beaver ponds/dams. Ocular estimates are used to match regeneration with the categorical ratings below.		
A EXCELLENT	Saplings/seedlings present in expected amount; obvious regeneration; More than 5% of willow cover is established seedlings and/or saplings.	
B GOOD	Saplings/seedlings present but less than expected; some seedling/saplings present; 1-5% of willow cover is established seedlings and/or saplings.	
C FAIR	Saplings/seedlings present but in low abundance; Little regeneration by native species; Less than 1% of willow cover is established seedlings and/or saplings.	
D POOR	No reproduction of native woody species; None of the willow cover consists of established seedling/saplings	

Table 2. List of Possible Biotic Patch Types.

Patch Type	**Check if present in Assessment Area**
Oxbows or backwater channels no longer associated with main channel except during major flood events	
Tributary or secondary channels which flow with base flow levels or during seasonal flood events.	
Open water – beaver pond	
Active beaver dams	
Wet meadow patches	
Point bars	
Occasional trees	
Adjacent or onsite hillside seeps/springs	
Beaver canals	
Stream pool/riffle complex	
Debris jams/woody debris in stream channel	
Submerged/floating vegetation	
Interfluves on floodplain	
Emergent vegetation	
Mudflats	
Moss bed	

Biotic Condition Rating Protocol

Use the table below to roll up the metrics into an overall Biotic Condition rating.

Calculation of Biotic Condition Rating.

Measure	**A**	**B**	**C**	**D**	**Weight***	**Score** (weight x rating)
Species Richness of Native Plants	5	4	3	1	0.14	
Percent of Cover of Native Plant Species	5	4	3	1	0.20	
Floristic Quality Index (Mean C of Native Plants)	5	4	3	1	0.30	
Biotic/Abiotic Patch Richness	5	4	3	1	0.12	
Interspersion of Biotic/Abiotic Patches	5	4	3	1	0.12	
Saplings/seedlings of Native Woody Species	5	4	3	1	0.12	
Biotic Condition Rating A = 4.5 - 5.0 B = 3.5 – 4.4 C = 2.5 – 3.4 D = 1.0 – 2.4					**Total (sum)**	

ABIOITIC CONDITION

	Rating
3a. Onsite Land Use. This metric is measured by documenting onsite land use(s) occurring in the assessment area. Follow the same procedures as in Metric 1a. Adjacent Land Use (use Table 3).	
A EXCELLENT Average Land Use Score = 1.0-0.95	
B GOOD Average Land Use Score = 0.80-0.94	
C FAIR Average Land Use Score = 0.4-0.79	
D POOR Average Land Use Score = < 0.4	
3b Upstream Surface Water Retention Measured as the % of the contributing watershed that occurs upstream of a structure which impounds surface water (e.g. dams or roads which impound water). Use supplied watershed maps to estimate the area of the contributing watershed which is behind a water retention facility.	
A EXCELLENT < 5% of drainage basin drains to surface water storage facilities	
B GOOD >5 - 20% of drainage basin drains to surface water storage facilities	
C FAIR >21 - 50% of drainage basin drains to surface water storage facilities	
D POOR > 50% of drainage basin drains to surface water storage facilities	
3c. Upstream/Onsite Water Diversions/Addition. Consider the number of water diversions occurring onsite and in the contributing watershed then consider their relative impact on the hydrology of the assessment area.	
A EXCELLENT No upstream or onsite water diversions/additions present	
B GOOD Few diversions/additions present or impacts minor relative to contributing watershed size. Onsite diversions/additions, if present, have minor impact on local hydrology.	
C FAIR Many diversions/additions present or impacts moderate relative to contributing watershed size. Onsite diversions/additions, if present, have a major impact on local hydrology.	
D POOR Water diversions/additions are very numerous or impacts high relative to contributing watershed size. Onsite diversions/additions, if present, have drastically altered local hydrology.	
3d. Floodplain Interaction This metric is estimated in the field by observing signs of overbank flooding, channel migration, channel incision, and geomorphic modifications that are present within the assessment area.	
A EXCELLENT Floodplain interaction is within natural range of variability. There are no geomorphic modifications (dikes, levees, riprap, bridges, road beds, etc.), made to contemporary floodplain and channel is not incised due to anthropogenic disturbances.	
B GOOD Floodplain interaction is disrupted due to the presence of a few geomorphic modifications (up to 20% of streambanks are affected) or slightly incised channel.	
C FAIR Floodplain interaction is highly disrupted due to multiple geomorphic modifications (between 20 – 50% of streambanks are affected) or deep, incised channel.	
D POOR More than 50% of streambanks have geomorphic modifications OR the channel occurs in a steep, incised gulley due to anthropogenic impacts.	
3e. Bank Stability Walk the assessment area and observe signs of eroding and bank instability such as crumbling, unvegetated banks, exposed tree roots, and exposed soil due to anthropogenic disturbances. Stable streambanks are vegetated by native species that have extensive root masses (*Alnus incana*, *Salix* spp., *Populus* spp., *Betula* spp., *Carex* spp., *Juncus* spp., and some wetland grasses). In general, most plants with a Wetland Indicator Status of OBL (obligate) and FACW (facultative wetland) are considered stabilizing plants species.	
A EXCELLENT Banks stable; evidence of erosion or bank failure absent or minimal; < 5% of bank affected. Streambanks dominated (> 90% cover) by stabilizing plant species	
B GOOD Mostly stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. Streambanks have 75-90% cover of stabilizing plant species	
C FAIR Moderately unstable; 31-60% of bank in reach has areas of erosion; Streambanks have 60-75% cover of stabilizing plant species	
D POOR Unstable; many eroded areas frequent along straight sections and bends; obvious bank sloughing; 61-100% of bank has erosional scars. Streambanks have < 60% cover of stabilizing plant species	

3f. Percent Effective Impervious Area Effective impervious area (EIA) is defined as the impervious surfaces with direct hydraulic connection to the downstream drainage (or stream) system. To measure, use the supplied map and estimate the percent of each land use in the contributing watershed within the 1 km buffer. Multiply that percent by each land use's EIA coefficient from Table 4, and then sum the results. For example, if the 1km contributing watershed was comprise of 10% low density and 10% medium density with the remaining 80% being natural the calculation would be: Low density 0.10 * 0.04 = 0.004 Medium Density 0.10 * 0.10 = 0.01 Natural 0.8j0 * 0.0 = 0 Percent Effective Impervious Area = 0.014 (or 1.4%)	
A EXCELLENT No effective impervious area in contributing watershed	
B GOOD Up to 5% effective impervious area in contributing watershed	
C FAIR 5-10% effective impervious area in contributing watershed	
D POOR >10% effective impervious area in contributing watershed	
3g. Distance to Nearest Road Calculate distance from assessment area boundary to nearest road (any type of road) using GIS or field estimate	
A EXCELLENT Very Far > 300 m	
B GOOD Far. 100 m to 300 m	
C FAIR Near. 50 m to 99 m	
D POOR Very Near. < 50m	

Table3. Onsite Land Use Coefficient Table

Current Land Use	**Coefficient**
Paved roads; parking lots; domestic or commercially developed buildings; gravel pit operation; commercial feedlots.	0.0
Unpaved Roads (e.g., driveway, tractor trail) / Mining	0.1
Agriculture (tilled crop production)	0.2
Heavy grazing by livestock; intense active recreation (ATV use; intense camping/fishing/hunting use, etc.); Urban parks, lawns, golf courses, sports fields; Orchards or nurseries	0.3
Logging or tree removal with 50-75% of trees >50 cm dbh removed	0.4
Hayed; Utility line corridors under vegetation management (e.g. tree/shrub removal; mowed);	0.5
Moderate grazing	0.6
Moderate passive recreation (high-use trail) or Forest Road (2-track) with minimal use or Utility line corridors not managed (e.g. tall electric lines not requiring vegetation management)	0.7
Selective logging or tree removal with <50% of trees >50 cm dbh removed	0.8
Light grazing / light, passive recreation (low-use trail, bird watching, occasional fishing, etc.)	0.9
Fallow with no history of grazing or other human use in past 10 yrs AND area has recovered from past human use to the point that past land use is not obvious. If impacts occurred greater than 10 years ago but are still impacting or affecting the site, then rate the land use as you would normally.	0.95
Natural area / land managed for native vegetation	1.0

Land Use Calculations:

LU Type #1 Coeff _______ x % of Area = ____________ /100 = Sub-land use score ______
LU Type #2 Coeff _______ x % of Area = ____________ /100 = Sub-land use score ______
LU Type #3 Coeff _______ x % of Area = ____________ /100 = Sub-land use score ______
LU Type #4 Coeff _______ x % of Area = ____________ /100 = Sub-land use score ______
LU Type #5 Coeff _______ x % of Area = ____________ /100 = Sub-land use score _____

Total Land Use Score______

Table 4. Presumed Relationship between Imperviousness and Land Use (from Dinicola, 1989)

LAND USE	**EIA (%)**
Natural	**0**
Low density residential (1 unit per 2-5 acres)	**4**
Medium density residential (1 unit per acre)	**10**
"Suburban" density (4 units per acre)	**24**
High density (multi-family or 8+ units per acre)	**48**
Commercial and industrial	**86**

Abiotic Condition Rating Protocol

Use the table below to roll up the metrics into an overall Abiotic Condition rating.

Calculation of Abiotic Condition Rating.

Measure	**A**	**B**	**C**	**D**	**Weight***	**Score** (weight x rating)
Onsite Land Use	5	4	3	1	0.15	
Upstream Surface Water Retention	5	4	3	1	0.14	
Upstream/Onsite Water Diversions	5	4	3	1	0.14	
Floodplain Interaction	5	4	3	1	0.15	
Bank Stability	5	4	3	1	0.14	
Percent Effective Impervious Area	5	4	3	1	0.14	
Distance to Nearest Road	5	4	3	1	0.14	
Abiotic Condition Rating A = 4.5 - 5.0 B = 3.5 – 4.4 C = 2.5 – 3.4 D = 1.0 – 2.4					**Total (sum)**	

SIZE

	Rating
4a Absolute Size. 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 assessment area, larger sized wetlands and riparian areas are able to buffer against these impacts better than smaller sized wetlands and riparian areas due to the fact they generally possess a higher diversity of abiotic and biotic processes allowing them to recover and remain more resilient. Estimate the size of the assessment area.	
A EXCELLENT > 2.5 linear km (minimum of 10 m wide)	
B GOOD 1.5 to 2.5 linear km (minimum of 10 m wide)	
C FAIR 0.8 to 1.5 linear km (minimum of 10 m wide)	
D POOR < 0.5 linear km (minimum of 10 m wide)	
4b. Relative Size. Relative size is the current size of the assessment area divided by the total potential size (e.g. abiotic potential) of the assessment area multiplied by 100. Abiotic potential is the largest extent the assessment area could achieve on the site without human disturbances.	
A EXCELLENT Assessment area = abiotic potential	
B GOOD Assessment 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.)	
C FAIR Assessment 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.)	
D POOR Assessment 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.)	

Size Rating Protocol

Use the table below to calculate the Size rating based on the following rules:

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

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

Calculation of Size Rating

Measure	**A**	**B**	**C**	**D**	**Weight***	**Score** (weight x rating)
Absolute Size	5	4	3	1	0.0 (0.70)	
Relative Size	5	4	3	1	1.0 (0.30)	
Size Rating A = 4.5 - 5.0 B = 3.5 – 4.4 C = 2.5 – 3.4 D = 1.0 – 2.4						**Total = sum of N scores**

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

Overall Ecological Integrity Rating Protocol

Use the following guidelines and the table below to calculate an overall Ecological Integrity Rating.

1. Overall Ecological Integrity Rank = **[Abiotic Condition Score *(0.35)] + [Biotic Condition Score *(0.25)] + [Landscape Context Score * (0.25)] + [Size Score * (0.15)]**

UNLESS

2. Landscape Context = *C* or *D* AND Size = *A or B* 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)]**

Calculation of Ecological Integrity Rating.

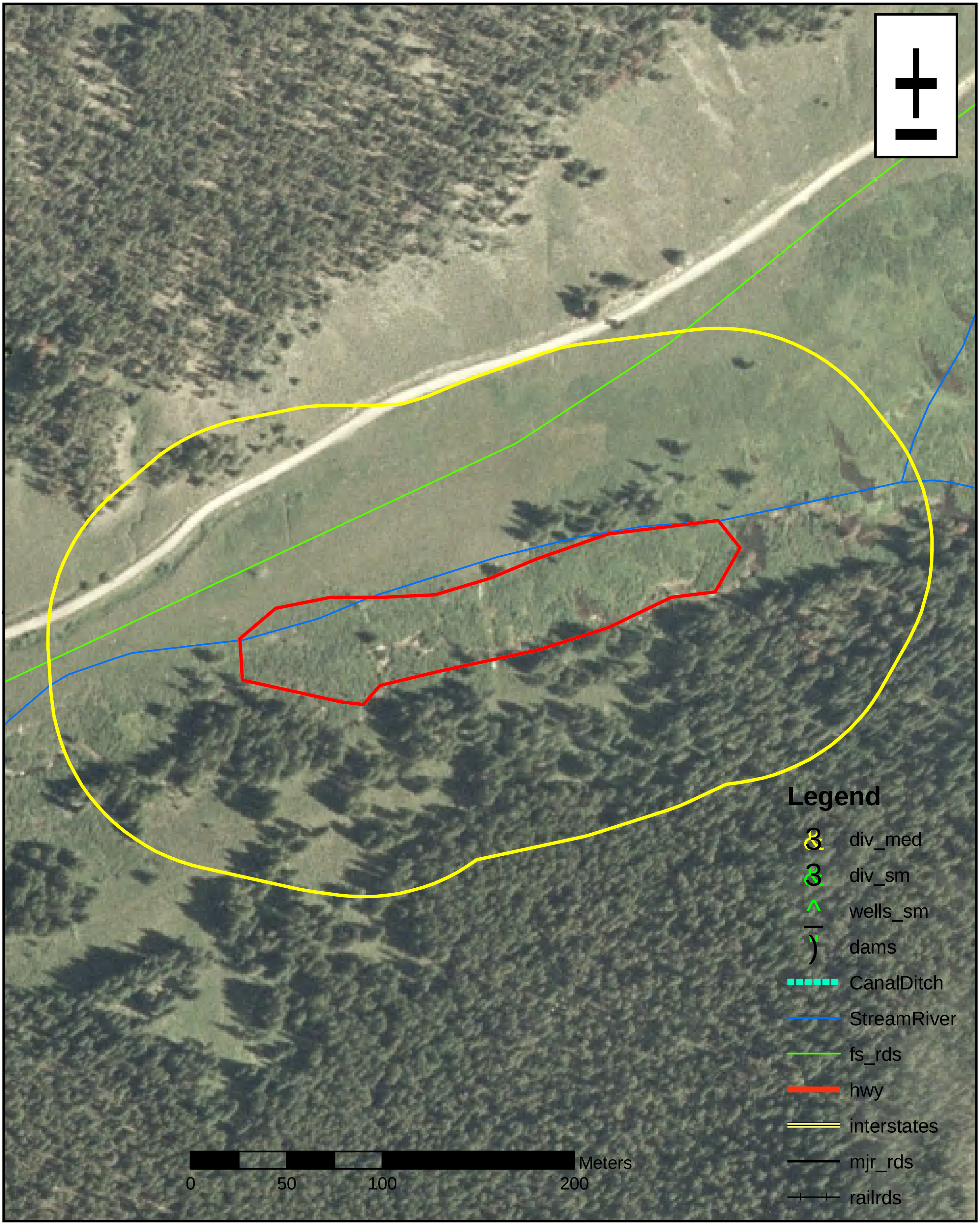
Measure	**A**	**B**	**C**	**D**	**Weight***	**Score** (weight x rating)
LANDSCAPE CONTEXT	5	4	3	1	0.25 (0.15)	
BIOTIC CONDITION	5	4	3	1	0.25	
ABIOTIC CONDITION	5	4	3	1	0.35	
SIZE	5	4	3	1	0.15 (0.25)	
Ecological Integrity Rating A = 4.5 - 5.0 B = 3.5 – 4.4 C = 2.5 – 3.4 D = 1.0 – 2.4					**Total (sum)**	

Note: Values in parentheses are for Option 2 listed above.

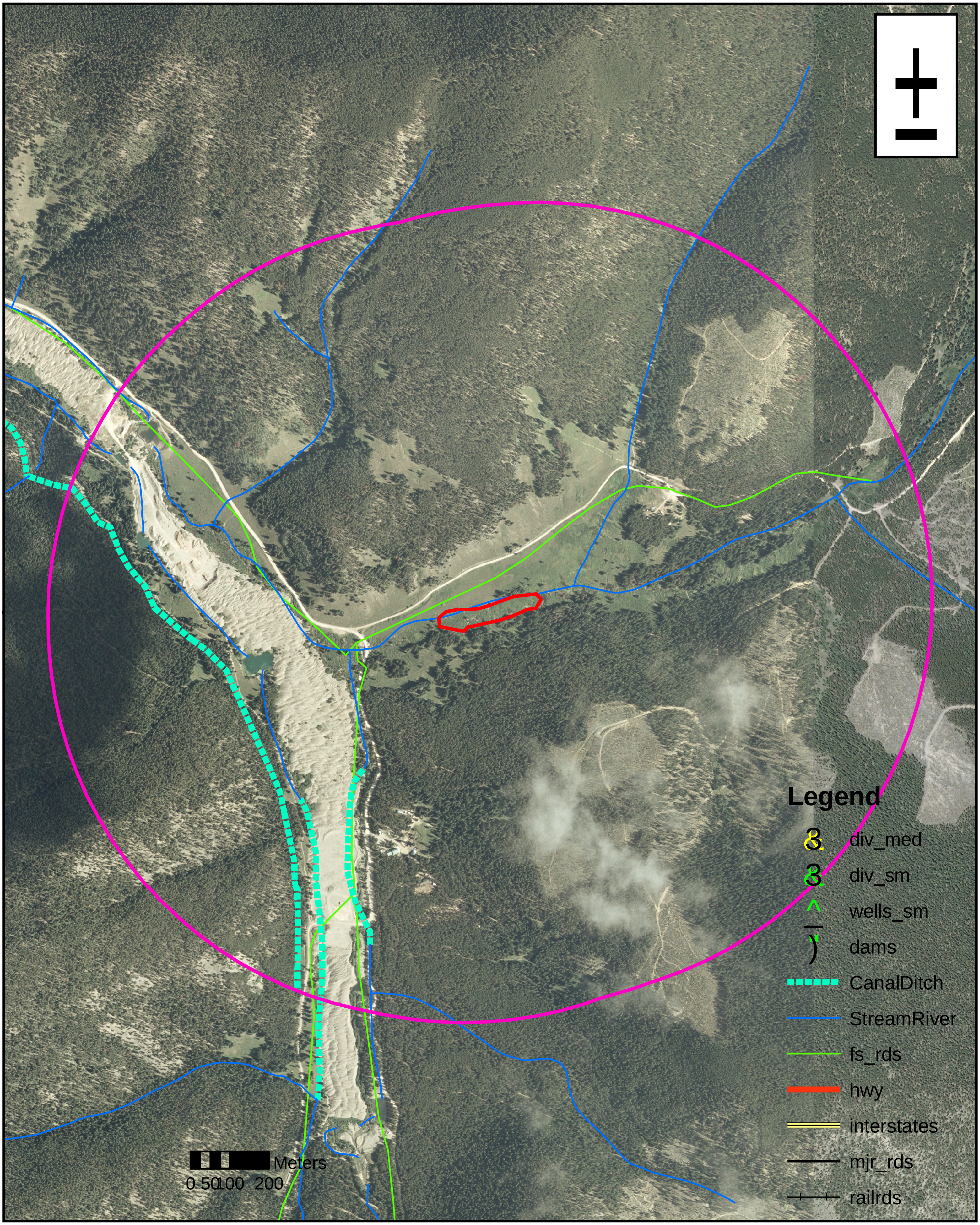
Table 5. Species List

APPENDIX B: Example Field Maps

EIA Plot 040 100m - Summit County



EIA Plot 040 1km - Summit County



APPENDIX C: Raw Scores for EIA Test Plots

(Yellow shading indicates a response differing form the median)

Average Buffer Width

Plots

Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	1	4	4	4	4	3	4	3	4	4	4
2	1	1	4	4	4	5	3	4	3	4	3	4
3	1	1	4	5	4	4	4	4	1	4	4	4
4	1	1	4	4	4	4	4	4	1	4	4	4
5	1	1	4	4	4	4	3	4	3	4	4	4
Median	1	1	4	4	4	4	3	4	3	4	4	4
Min	1	1	4	4	4	4	3	4	1	4	3	4
Max	1	1	4	5	4	5	4	4	3	4	4	4
Mean	1.0	1.0	4.0	4.2	4.0	4.2	3.4	4.0	2.2	4.0	3.8	4.0
Std Dev	0.0	0.0	0.0	0.4	0.0	0.4	0.5	0.0	1.1	0.0	0.4	0.0

Mean Std Dev **0.25** ***% varying from median*** **12%**

% Unfragmented Landscape

Plots

Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	1	3	3	4	3	3	3	3	3	3	3
2	1	1	5	4	4	4	4	3	3	3	3	4
3	1	1	3	3	4	3	4	3	3	3	3	3
4	1	1	3	3	4	3	3	3	3	3	3	3
5	1	1	3	3	4	3	3	3	3	3	3	3
Median	1	1	3	3	4	3	3	3	3	3	3	3
Min	1	1	3	3	4	3	3	3	3	3	3	3
Max	1	1	5	4	4	4	4	3	3	3	3	4
Mean	1.0	1.0	3.4	3.2	4.0	3.2	3.4	3.0	3.0	3.0	3.0	3.2
Std Dev	0.0	0.0	0.9	0.4	0.0	0.4	0.5	0.0	0.0	0.0	0.0	0.4

Mean Std Dev **0.23** ***% varying from median*** **10%**

Adjacent Land Use

Plots

Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	1	4	4	5	3	4	5	3	3	3	4
2	1	1	5	4	4	4	3	4	1	3	4	4
3	1	1	3	3	3	4	3	4	1	3	4	4
4	1	1	4	4	4	4	3	4	1	3	4	4
5	1	3	4	4	4	3	3	5	1	4	4	4
Median	1	1	4	4	4	4	3	4	1	3	4	4
Min	1	1	3	3	3	3	3	4	1	3	3	4
Max	1	3	5	4	5	4	4	5	3	4	4	4
Mean	1.0	1.4	4.0	3.8	4.0	3.6	3.2	4.4	1.4	3.2	3.8	4.0
Std Dev	0.0	0.9	0.7	0.4	0.7	0.5	0.4	0.5	0.9	0.4	0.4	0.0

Mean Std Dev **0.51** ***% varying from median*** **23%**

Riparian Corridor Continuity

Plots

Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	3	5	5	5	5	3	4	1	5	1	4
2	1	1	5	4	4	5	4	3	1	3	3	4
3	3	3	5	5	5	4	4	5	3	3	1	5
4	1	3	5	4	5	4	3	3	1	4	3	4
5	1	4	4	4	4	5	4	4	3	3	1	4
Median	1	3	5	4	5	5	4	4	1	3	1	4
Min	1	1	4	4	4	4	3	3	1	3	1	4
Max	3	4	5	5	5	5	4	5	3	5	3	5
Mean	1.4	2.8	4.8	4.4	4.6	4.6	3.6	3.8	1.8	3.6	1.8	4.2
Std Dev	0.9	1.1	0.4	0.5	0.5	0.5	0.5	0.8	1.1	0.9	1.1	0.4

Mean Std Dev **0.75** ***% varying from median*** **37%**

Overall Landscape Context Score

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1.00	1.60	4.20	4.20	4.60	3.90	3.30	4.20	2.40	3.90	2.70	3.90
2	1.00	1.00	4.70	4.00	4.00	4.60	3.40	3.60	1.80	3.30	3.30	4.00
3	1.60	1.60	3.90	4.20	4.00	3.90	3.70	4.20	1.80	3.30	3.00	4.20
4	1.00	1.60	4.20	3.90	4.30	3.90	3.30	3.60	1.20	3.60	3.60	3.90
5	1.00	2.50	3.90	3.90	4.00	3.90	3.30	4.20	2.40	3.60	3.00	3.90

Median	1.00	1.60	4.20	4.00	4.00	3.90	3.30	4.20	1.80	3.60	3.00	3.90
Min	1.00	1.00	3.90	3.90	4.00	3.90	3.30	3.60	1.20	3.30	2.70	3.90
Max	1.60	2.50	4.70	4.20	4.60	4.60	3.70	4.20	2.40	3.90	3.60	4.20
Mean	1.12	1.66	4.18	4.04	4.18	4.04	3.40	3.96	1.92	3.54	3.12	3.98
Std Dev	0.27	0.54	0.33	0.15	0.27	0.31	0.17	0.33	0.50	0.25	0.34	0.13

Mean Std Dev **0.30**

Overall Landscape Context Rank

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	D	D	B	B	A	B	C	B	D	B	C	B
2	D	D	A	B	B	A	C	B	D	C	C	B
3	D	D	B	B	B	B	B	B	D	C	C	B
4	D	D	B	B	B	B	C	B	D	B	B	B
5	D	C	B	B	B	B	C	B	D	B	C	B

Median	D	D	B	B	B	B	C	B	D	B	C	B

% varying from median **13%**

Native Species Richness

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	5	5	5	5	3	5	5	5	4	5	5
2	4	5	5	5	5	3	5	5	5	1	5	4
3	3	5	5	5	5	1	5	5	5	4	5	5
4	1	4	4	4	5	1	5	5	1	1	5	5
5	3	5	5	5	5	3	5	5	5	4	5	5
Median	3	5	5	5	5	3	5	5	5	4	5	5
Min	1	4	4	4	5	1	5	5	1	1	5	4
Max	4	5	5	5	5	3	5	5	5	4	5	5
Mean	2.4	4.8	4.8	4.8	5.0	2.2	5.0	5.0	4.2	2.8	5.0	4.8
Std Dev	1.3	0.4	0.4	0.4	0.0	1.1	0.0	0.0	1.8	1.6	0.0	0.4

Mean Std Dev **0.64**

% varying from median **20%**

% Cover Native Species

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	3	4	4	4	3	4	4	3	5	4	4
2	3	3	4	4	4	3	4	4	5	5	4	4
3	3	3	4	4	4	1	4	4	3	3	4	4
4	3	3	4	4	4	3	4	4	3	4	4	4
5	3	3	4	4	4	3	3	4	3	5	4	4
Median	3	3	4	4	4	3	4	4	3	5	4	4
Min	3	3	4	4	4	1	3	4	3	3	4	4
Max	3	3	4	4	4	3	4	4	5	5	4	4
Mean	3.0	3.0	4.0	4.0	4.0	2.6	3.8	4.0	3.4	4.4	4.0	4.0
Std Dev	0.0	0.0	0.0	0.0	0.0	0.9	0.4	0.0	0.9	0.9	0.0	0.0

Mean Std Dev **0.26**

% varying from median **8%**

Mean C (Native)

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	4	5	5	5	3	4	5	4	5	4	4
2	3	5	5	5	5	3	3	5	4	5	4	4
3	3	4	5	5	5	3	4	5	3	5	4	4
4	3	3	5	5	5	4	4	5	3	5	4	4
5	3	4	5	5	5	3	3	5	3	5	4	3
Median	3	4	5	5	5	3	4	5	3	5	4	4
Min	3	3	5	5	5	3	3	5	3	5	4	3
Max	3	5	5	5	5	4	4	5	4	5	4	4
Mean	3.0	4.0	5.0	5.0	5.0	3.2	3.6	5.0	3.4	5.0	4.0	3.8
Std Dev	0.0	0.7	0.0	0.0	0.0	0.4	0.5	0.0	0.5	0.0	0.0	0.4

Mean Std Dev **0.22**

% varying from median **13%**

Native Saplings / Seedlings

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	5	5	5	5	3	3	5	4	5	5	5
2	4	5	5	5	5	5	5	5	5	5	4	5
3	5	5	5	5	5	4	5	5	5	5	5	5
4	5	4	5	5	5	5	5	5	4	5	5	5
5	5	3	5	4	5	5	5	5	4	5	5	4
Median	5	5	5	5	5	5	5	5	4	5	5	5
Min	3	3	5	4	5	3	3	5	4	5	4	4
Max	5	5	5	5	5	5	5	5	5	5	5	5
Mean	4.4	4.4	5.0	4.8	5.0	4.4	4.6	5.0	4.4	5.0	4.8	4.8
Std Dev	0.9	0.9	0.0	0.4	0.0	0.9	0.9	0.0	0.5	0.0	0.4	0.4

Mean Std Dev **0.46**

% varying from median **22%**

Biotic / Abiotic Patches

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	5	5	5	5	3	1	5	1	4	4	3
2	3	5	4	4	4	1	1	5	1	4	4	3
3	1	5	4	5	4	1	1	5	3	4	4	3
4	3	3	5	5	4	3	1	4	3	4	5	4
5	4	4	5	4	4	1	3	5	1	4	4	3
Median	3	5	5	5	4	1	1	5	1	4	4	3
Min	1	3	4	4	4	1	1	4	1	4	4	3
Max	4	5	5	5	5	3	3	5	3	4	5	4
Mean	2.8	4.4	4.6	4.6	4.2	1.8	1.4	4.8	1.8	4.0	4.2	3.2
Std Dev	1.1	0.9	0.5	0.5	0.4	1.1	0.9	0.4	1.1	0.0	0.4	0.4

Mean Std Dev **0.66** ***% varying from median*** **28%**

Interspersion of Patches

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	4	5	5	5	3	3	4	3	5	4	4
2	4	5	5	5	4	3	3	5	3	4	4	4
3	1	5	3	5	4	3	3	5	1	5	4	4
4	3	4	5	4	4	3	3	5	3	4	4	4
5	3	4	5	5	5	1	3	5	3	4	4	4
Median	3	4	5	5	4	3	3	5	3	4	4	4
Min	1	4	3	4	4	1	3	4	1	4	4	4
Max	4	5	5	5	5	3	3	5	3	5	4	4
Mean	2.8	4.4	4.6	4.8	4.4	2.6	3.0	4.8	2.6	4.4	4.0	4.0
Std Dev	1.1	0.5	0.9	0.4	0.5	0.9	0.0	0.4	0.9	0.5	0.0	0.0

Mean Std Dev **0.53** ***% varying from median*** **22%**

Overall Biotic Condition Score

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	2.72	4.18	4.80	4.80	4.80	3.00	3.54	4.68	3.46	4.74	4.26	4.14
2	3.38	4.60	4.68	4.68	4.56	3.00	3.48	4.80	3.98	4.20	4.14	4.00
3	2.76	4.30	4.44	4.80	4.56	2.20	3.78	4.80	3.28	4.34	4.26	4.14
4	2.96	3.38	4.66	4.54	4.56	3.26	3.78	4.68	2.84	4.00	4.38	4.26
5	3.36	3.82	4.80	4.56	4.68	2.76	3.52	4.80	3.16	4.62	4.26	3.72
Median	2.96	4.18	4.68	4.68	4.56	3.00	3.54	4.80	3.28	4.34	4.26	4.14
Min	2.72	3.38	4.44	4.54	4.56	2.20	3.48	4.68	2.84	4.00	4.14	3.72
Max	3.38	4.60	4.80	4.80	4.80	3.26	3.78	4.80	3.98	4.74	4.38	4.26
Mean	3.04	4.06	4.68	4.68	4.63	2.84	3.62	4.75	3.34	4.38	4.26	4.05
Std Dev	0.32	0.47	0.15	0.13	0.11	0.40	0.15	0.07	0.42	0.30	0.08	0.21

Mean Std Dev **0.23**

Overall Biotic Condition Rank

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	C	B	A	A	A	C	B	A	C	A	B	B
2	C	A	A	A	A	C	C	A	B	B	B	B
3	C	B	B	A	A	D	B	A	C	B	B	B
4	C	C	A	A	A	C	B	A	C	B	B	B
5	C	B	A	A	A	C	B	A	C	A	B	B
Median	C	B	A	A	A	C	B	A	C	B	B	B

% varying from median **13%**

Onsite Land Use

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	5	4	5	5	5	3	5	5	1	5	3	4
2	5	4	5	5	5	4	5	5	1	5	3	5
3	5	5	5	5	5	4	5	5	1	5	4	5
4	4	4	5	5	5	4	5	4	1	5	3	5
5	5	4	5	5	5	3	3	5	3	5	5	5
Median	5	4	5	5	5	4	5	5	1	5	3	5
Min	4	4	5	5	5	3	3	4	1	5	3	4
Max	5	5	5	5	5	4	5	5	3	5	5	5
Mean	4.8	4.2	5.0	5.0	5.0	3.6	4.6	4.8	1.4	5.0	3.6	4.8
Std Dev	0.4	0.4	0.0	0.0	0.0	0.5	0.9	0.4	0.9	0.0	0.9	0.4

Mean Std Dev **0.42** ***% varying from median*** **15%**

Upstream Surface Water Retention

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	4	5	5	5	5	5	5	5	5	5	4	5
2	4	3	5	5	5	5	5	5	5	3	1	5
3	3	5	5	5	5	5	5	5	5	4	3	5
4	4	5	5	5	5	5	4	5	5	4	5	5
5	4	5	5	5	5	5	5	5	5	3	3	5
Median	4	5	5	5	5	5	5	5	5	4	3	5
Min	3	3	5	5	5	5	4	5	5	3	1	5
Max	4	5	5	5	5	5	5	5	5	5	5	5
Mean	3.8	4.6	5.0	5.0	5.0	5.0	4.8	5.0	5.0	3.8	3.2	5.0
Std Dev	0.4	0.9	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.8	1.5	0.0

Mean Std Dev **0.34** ***% varying from median*** **15%**

Upstream / Onsite Water Diversion / Addition

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	4	4	5	4	3	5	4	4	4	3	4
2	3	3	5	5	5	4	5	4	5	3	3	4
3	3	4	5	5	4	5	5	5	5	3	3	4
4	3	3	5	5	4	4	4	5	4	3	3	3
5	3	3	4	5	4	5	5	4	4	3	1	4
Median	3	3	5	5	4	4	5	4	4	3	3	4
Min	3	3	4	5	4	3	4	4	4	3	1	3
Max	3	4	5	5	5	5	5	5	5	4	3	4
Mean	3.0	3.4	4.6	5.0	4.2	4.2	4.8	4.4	4.4	3.2	2.6	3.8
Std Dev	0.0	0.5	0.5	0.0	0.4	0.8	0.4	0.5	0.5	0.4	0.9	0.4

Mean Std Dev **0.48** ***% varying from median*** **27%**

Floodplain Interaction

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	4	5	4	5	4	3	5	3	5	5	5
2	3	3	5	5	5	4	5	4	1	3	5	5
3	1	4	5	5	5	5	4	5	3	5	5	5
4	3	4	4	5	5	5	5	5	1	4	4	5
5	1	1	5	4	5	5	4	5	3	4	5	5
Median	3	4	5	5	5	5	4	5	3	4	5	5
Min	1	1	4	4	5	4	3	4	1	3	4	5
Max	3	4	5	5	5	5	5	5	3	5	5	5
Mean	2.2	3.2	4.8	4.6	5.0	4.6	4.2	4.8	2.2	4.2	4.8	5.0
Std Dev	1.1	1.3	0.4	0.5	0.0	0.5	0.8	0.4	1.1	0.8	0.4	0.0

Mean Std Dev **0.63** ***% varying from median*** **32%**

Bank Stability

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	5	5	5	5	4	5	5	3	5	5	4
2	4	5	5	5	5	3	5	5	4	5	5	5
3	5	5	5	5	5	5	4	5	4	4	5	5
4	4	5	5	5	5	5	4	4	3	5	5	4
5	4	3	5	5	5	3	4	4	1	5	5	5
Median	4	5	5	5	5	4	4	5	3	5	5	5
Min	3	3	5	5	5	3	4	4	1	4	5	4
Max	5	5	5	5	5	5	5	5	4	5	5	5
Mean	4.0	4.6	5.0	5.0	5.0	4.0	4.4	4.6	3.0	4.8	5.0	4.6
Std Dev	0.7	0.9	0.0	0.0	0.0	1.0	0.5	0.5	1.2	0.4	0.0	0.5

Mean Std Dev **0.49**

% varying from median **28%**

Percent Impervious Area

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	4	5	5	5	5	4	5	4	4	1	5
2	1	3	5	5	4	5	3	4	3	3	1	5
3	1	1	5	5	5	5	5	5	5	3	1	5
4	1	4	5	5	5	5	3	4	4	4	1	5
5	1	4	5	5	5	5	4	5	4	4	1	4
Median	1	4	5	5	5	5	4	5	4	4	1	5
Min	1	1	5	5	4	5	3	4	3	3	1	4
Max	1	4	5	5	5	5	5	5	5	4	1	5
Mean	1.0	3.2	5.0	5.0	4.8	5.0	3.8	4.6	4.0	3.6	1.0	4.8
Std Dev	0.0	1.3	0.0	0.0	0.4	0.0	0.8	0.5	0.7	0.5	0.0	0.4

Mean Std Dev **0.40**

% varying from median **22%**

Distance to Nearest Road

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	1	1	1	3	3	1	3	1	1	3	1
2	1	1	1	1	4	5	1	3	1	1	3	4
3	1	1	1	1	5	3	1	4	1	3	3	1
4	1	1	1	1	3	3	1	3	1	3	3	1
5	1	1	1	1	4	3	1	3	3	3	3	1
Median	1	1	1	1	4	3	1	3	1	3	3	1
Min	1	1	1	1	3	3	1	3	1	1	3	1
Max	1	1	1	1	5	5	1	4	3	3	3	4
Mean	1.0	1.0	1.0	1.0	3.8	3.4	1.0	3.2	1.4	2.2	3.0	1.6
Std Dev	0.0	0.0	0.0	0.0	0.8	0.9	0.0	0.4	0.9	1.1	0.0	1.3

Mean Std Dev **0.46**

% varying from median **15%**

Overall Abiotic Condition Score

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	2.88	3.86	4.30	4.29	4.58	3.85	4.00	4.58	2.98	4.16	3.44	4.01
2	3.02	3.15	4.44	4.44	4.72	4.28	4.16	4.29	2.82	3.30	3.02	4.72
3	2.72	3.59	4.44	4.44	4.86	4.57	4.15	4.86	3.40	3.88	3.45	4.30
4	2.87	3.72	4.29	4.44	4.58	4.43	3.74	4.29	2.68	4.01	3.43	4.02
5	2.72	2.99	4.30	4.29	4.72	4.14	3.71	4.44	3.28	3.87	3.32	4.16

Median	2.87	3.59	4.30	4.44	4.72	4.28	4.00	4.44	2.98	3.88	3.43	4.16
Min	2.72	2.99	4.29	4.29	4.58	3.85	3.71	4.29	2.68	3.30	3.02	4.01
Max	3.02	3.86	4.44	4.44	4.86	4.57	4.16	4.86	3.40	4.16	3.45	4.72
Mean	2.84	3.46	4.35	4.38	4.69	4.25	3.95	4.49	3.03	3.84	3.33	4.24
Std Dev	0.13	0.37	0.08	0.08	0.12	0.28	0.22	0.24	0.30	0.33	0.18	0.29

Mean Std Dev **0.22**

Overall Abiotic Condition Rank

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	C	B	B	B	A	B	B	A	C	B	C	B
2	C	C	B	B	A	B	B	B	C	C	C	A
3	C	B	B	B	A	A	B	A	C	B	C	B
4	C	B	B	B	A	B	B	B	C	B	C	B
5	C	C	B	B	A	B	B	B	C	B	C	B

Median	C	B	B	B	A	B	B	B	C	B	C	B

% varying from median **13%**

Absolute Size

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1	1	1	3	1	1	1	1	1	1	1	1
2	1	1	1	3	1	1	1	3	3	1	1	1
3	1	3	1	3	3	3	1	1	1	1	1	3
4	1	1	1	1	1	1	1	1	3	1	1	1
5	1	1	1	3	1	1	1	3	1	1	1	1
Median	1	1	1	3	1	1	1	1	1	1	1	1
Min	1	1	1	1	1	1	1	1	1	1	1	1
Max	1	3	1	3	3	3	1	3	3	1	1	3
Mean	1.0	1.4	1.0	2.6	1.4	1.4	1.0	1.8	1.8	1.0	1.0	1.4
Std Dev	0.0	0.9	0.0	0.9	0.9	0.9	0.0	1.1	1.1	0.0	0.0	0.9

Mean Std Dev **0.56** ***% varying from median*** **15%**

Relative Size

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	3	4	5	4	5	4	3	5	1	5	4	4
2	1	1	5	5	5	5	4	5	1	3	5	4
3	1	3	4	5	5	5	4	5	1	5	4	5
4	3	4	4	5	5	4	4	5	1	4	4	5
5	1	1	4	4	5	5	3	5	1	4	3	5
Median	1	3	4	5	5	5	4	5	1	4	4	5
Min	1	1	4	4	5	4	3	5	1	3	3	4
Max	3	4	5	5	5	5	4	5	1	5	5	5
Mean	1.8	2.6	4.4	4.6	5.0	4.6	3.6	5.0	1.0	4.2	4.0	4.6
Std Dev	1.1	1.5	0.5	0.5	0.0	0.5	0.5	0.0	0.0	0.8	0.7	0.5

Mean Std Dev **0.57** ***% varying from median*** **35%**

Overall Size Score

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	1.60	1.90	5.00	4.00	5.00	4.00	1.60	5.00	1.00	5.00	1.90	4.00
2	1.00	1.00	5.00	5.00	5.00	5.00	1.90	5.00	2.40	1.60	2.20	4.00
3	1.00	3.00	4.00	5.00	5.00	5.00	4.00	5.00	1.00	2.20	1.90	5.00
4	1.60	1.90	4.00	5.00	5.00	4.00	1.90	5.00	2.40	4.00	4.00	5.00
5	1.00	1.00	4.00	4.00	5.00	5.00	1.60	5.00	1.00	4.00	1.60	5.00
Median	1.00	1.90	4.00	5.00	5.00	5.00	1.90	5.00	1.00	4.00	1.90	5.00
Min	1.00	1.00	4.00	4.00	5.00	4.00	1.60	5.00	1.00	1.60	1.60	4.00
Max	1.60	3.00	5.00	5.00	5.00	5.00	4.00	5.00	2.40	5.00	4.00	5.00
Mean	1.24	1.76	4.40	4.60	5.00	4.60	2.20	5.00	1.56	3.36	2.32	4.60
Std Dev	0.33	0.83	0.55	0.55	0.00	0.55	1.02	0.00	0.77	1.41	0.96	0.55

Mean Std Dev **0.63**

Overall Size Rank

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	D	D	A	B	A	B	D	A	D	A	D	B
2	D	D	A	A	A	A	D	A	D	D	D	B
3	D	C	B	A	A	A	B	A	D	D	D	A
4	D	D	B	A	A	B	D	A	D	B	B	A
5	D	D	B	B	A	A	D	A	D	B	D	A
Median	D	D	B	A	A	A	D	A	D	B	D	A

% varying from median **23%**

Overall EIA Score

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	2.18	3.08	4.51	4.35	4.70	3.67	3.35	4.57	2.66	4.37	3.23	4.01
2	2.30	2.65	4.65	4.47	4.54	4.15	3.46	4.35	2.79	3.27	3.25	4.25
3	2.19	3.18	4.24	4.55	4.59	3.87	3.92	4.70	2.61	3.60	3.31	4.34
4	2.23	2.83	4.32	4.41	4.57	3.94	3.36	4.32	2.31	3.90	3.80	4.20
5	2.19	2.78	4.28	4.22	4.57	3.86	3.24	4.55	2.69	4.01	3.22	4.11
Median	2.19	2.83	4.32	4.41	4.57	3.87	3.36	4.55	2.66	3.90	3.25	4.20
Min	2.18	2.65	4.24	4.22	4.54	3.67	3.24	4.32	2.31	3.27	3.22	4.01
Max	2.30	3.18	4.65	4.55	4.70	4.15	3.92	4.70	2.79	4.37	3.80	4.34
Mean	2.22	2.90	4.40	4.40	4.60	3.90	3.47	4.50	2.61	3.83	3.36	4.18
Std Dev	0.05	0.22	0.17	0.13	0.06	0.17	0.27	0.16	0.18	0.42	0.25	0.13

Mean Std Dev **0.18**

Overall EIA Rank

	Plots											
Obs ID	6	11	13	18	19	23	38	40	41	58	71	72
1	D	C	A	B	A	B	C	A	C	B	C	B
2	D	C	A	B	A	B	C	B	C	C	C	B
3	D	C	B	A	A	B	B	A	C	B	C	B
4	D	C	B	B	A	B	C	B	D	B	B	B
5	D	C	B	B	A	B	C	A	C	B	C	B
Median	D	C	B	B	A	B	C	A	C	B	C	B

% varying from median **15%**