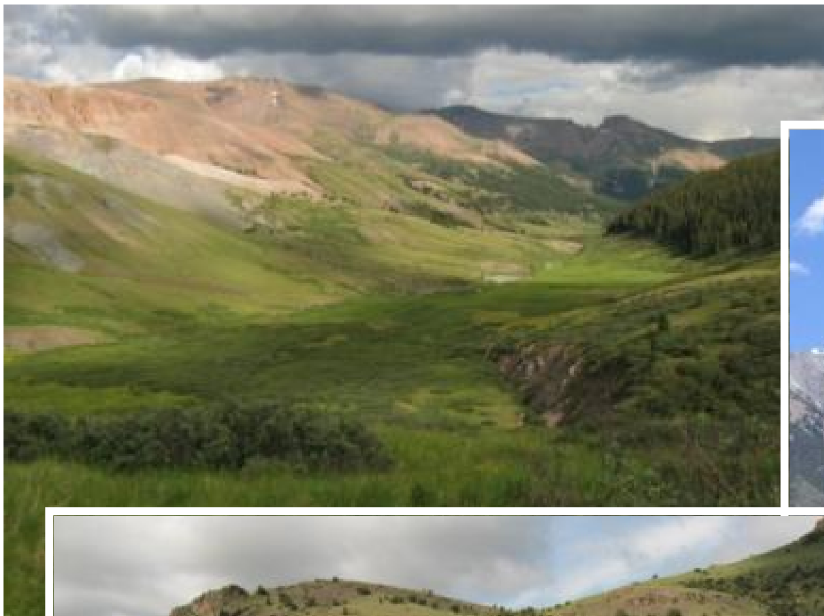
Statewide Strategies to Improve Effectiveness in Protecting and Restoring Colorado's Wetland Resource

Including the Rio Grande Headwaters Pilot Wetland Condition Assessment



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Statewide Strategies to Improve Effectiveness in Protecting and
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Including the Rio Grande Headwaters
Pilot Wetland Condition Assessment

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EXECUTIVE SUMMARY

The Wetland Wildlife Conservation Program is a voluntary, incentive-based program established by Colorado Parks and Wildlife (CPW) to protect wetlands and wetland-dependent wildlife on public and private land. To date, much of the Program's work has been based on local priorities and/or opportunities. Although the Program has made significant strides to protect and restore Colorado's wetland resource, CPW identified a need to establish statewide strategies to better guide their efforts toward strategic objectives based on credible information about the types, abundance, distribution, and condition of Colorado's wetland resource. This report describes initial steps in a multi-year effort on behalf of CPW and the Colorado Natural Heritage Program (CNHP) to determine the types, abundance, distribution, threats to, and level of protection currently provided to Colorado's wetlands and to assess their ecological condition. The outcome of this effort will be the ongoing development of statewide strategies for protecting and restoring wetlands in Colorado for the benefit of wetland-dependent wildlife.

The four primary objectives of this project were to: (1) compile existing geospatial data regarding the location and type of wetlands in Colorado; (2) initiate an on-the-ground pilot project to assess the ecological condition of common wetland types in one hydrologic basin (Rio Grande Headwaters, HUC 6: 130100); (3) develop statewide strategies for setting wetland restoration priorities funded by CPW's Wetlands Program; and (4) develop an interactive online mapping tool to transfer this information to local and statewide partners in wetlands conservation. This report is broken into three sections. Section 1 is an overview of the project; Section 2 describes Objective 1, part of Objective 3, and Objective 4; and Section 3 details Objective 2. The actual strategic plan of the CPW Wetlands Program can be found in a companion document.

For Objective 1, CNHP and CPW worked collaboratively to compile five main GIS data sources that represent the best known representation of wetland extent and distribution of wetlands in Colorado, though no single data source covers more than 60% of the state. Through this process, U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) mapping was identified as the most significant source of wetland mapping. Wetland profiles that summarize known information on the extent and distribution for wetlands were compiled for ten major river basins, though only two of these basins have complete coverage of NWI mapping. CNHP and CPW have committed to working with the NWI Program to expand the availability of digital NWI mapping for Colorado by converting original NWI paper maps to digital data and updating NWI maps where time and funding permits.

In addition to compiling digital data for wetlands, to support the Wetlands Program Strategic Plan (Objective 3), CNHP developed a Landscape Integrity Model (LIM) for wetlands that predicts the intensity of stressors faced by wetlands across the state. This model indicates that approximately half the land area in Colorado shows little or no stressors for wetlands, while the other half has moderate, high, or severe levels. However, in basins where wetland mapping can be overlaid with model results, a greater proportion of wetland acres falls within the higher stress classes. Until

more complete digital wetland mapping is available, the range of wetland condition and stress can only be estimated.

To facilitate the transfer of this information to many different partners across the state, CPW and CNHP developed the Colorado Wetlands Inventory website (Objective 4). There are two main parts of the website, the online mapping tool and the wetland profile and summary page. Through the online mapping tool, viewers can see the status of selected mapping efforts and the actual mapped polygons themselves. In addition to the wetland datasets, the tool includes two data products created by CNHP: 1) Potential Conservation Areas (PCAs) drawn for wetland and riparian dependent elements and 2) the wetland LIM. As a background, users can choose between streets, aerial photos, and topographic maps. Users can also toggle on and off supplemental information including county boundaries, two levels of USGS Hydrologic Units (major river basins and river subbasins), two levels of EPA Ecoregions, and general land ownership. The wetland profile and summary page is hosted on CNHP's website and is the homepage for the Colorado Wetlands Inventory. Along with an introduction to the Colorado Wetlands Inventory and the online mapping tool, the CNHP page also summarizes available wetland information shown in the mapping tool by major river basin, river subbasin, and county.

Objective 2 of this project was a pilot project to assess the condition of wetlands in the Rio Grande Headwaters river basin. The study followed the EPA's Level 1-2-3 framework of wetland assessment, using various degrees of data collection intensity to estimate the condition of wetlands. A Level 1profile of wetlands in the basin based on NWI mapping and the wetland LIM shows that there are 282,804 acres of wetlands and waterbodies and that these acres are unequally distributed across the basin and across major land owners. More wetland acres are concentrated within the San Luis Valley, though these acres are more likely to be irrigated and face more severe stressors. Wetlands in the mountainous areas of the basin are more diverse and less stressed. Field-based Level 2 & 3 assessments concur with patterns seen in the Level 1 GIS exercise. Marshes and saline wetlands, found more commonly at lower elevations, have lower condition scores in general. Fens and riparian shrublands, found more commonly at higher elevations, have higher condition scores. Wet meadows were the most common wetland type surveyed and span both the geographic range of the study are and the condition gradient. Results from the first pilot wetland condition assessment will both aid CPW's Wetlands Program in establishing more quantitative objectives and will help guide future studies.

ACKNOWLEDGEMENTS

The authors at Colorado Natural Heritage Program (CNHP) would like to acknowledge the U.S. Environmental Protection Agency (EPA) Region 8 and Colorado Parks and Wildlife (CPW)'s Wetlands Program for their financial support and encouragement of this project. Special recognition goes to Jill Minter, EPA Region 8 Wetland Monitoring and Assessment Coordinator, for continued support for Colorado's growing wetland assessment program. Brian Sullivan, CPW Wetlands Program Coordinator, and Grant Wilcox and Chris Johnson, CPW GIS Analysts, all contributed extensive time and energy to this project, as did CPW GIS Team Lead Jon Kindler before his retirement. Grant and Chris in particular are responsible for making the idea of an online mapping tool for wetlands into reality. The building blocks of this project and the partnership between CNHP and CPW were largely put in place by Joe Rocchio, former CNHP Wetland Ecologist, currently with the Washington Natural Heritage Program. Special thanks go to Joe for articulating the vision.

Several external partners provided data to the Colorado Wetlands Inventory Online Mapping Tool. Thanks go to Mark Mullane of Boulder County; Rich Ferris and Jim Curnutte of Summit County; Tammy VerCauteren, David Pavlacky and others at Rocky Mountain Bird Observatory; Becca Smith, Jeff Redder, and Mark Roper of the San Juan National Forest; Gay Austin of BLM's Gunnison Field Office; Dr. David Cooper and Dr. Rod Chimner for fen data from the San Juan Mountains; and Dr. J. Bradley Johnson for fen data from North and South Parks. Kevin Bon, Bruce Droster, and Jane Harner from U.S. Fish and Wildlife Services (USFWS)'s National Wetland Inventory Program have been incredibly helpful over the years as we grow our capacity to map wetlands in Colorado. Zack Reams, former GIS Analyst with both CPW and CNHP, deserves particular recognition as the first Wetland Mapping Specialist hired through this project. Zack's hard work, resourcefulness and ingenuity laid the foundation for all current and future wetland mapping done by our programs. Thanks also go to John Sanderson and Jan Koenig of The Nature Conservancy (TNC) for sharing their time, expertise and data through the Freshwater Measures of Conservation Success dataset. And thanks to Garrett Pichler and Ryan Nelson, CNHP Systems Administrators, for coding and creating the CNHP side of the Colorado Wetlands Inventory.

For the Rio Grande Headwaters pilot wetland condition assessment, we extend much gratitude to Stacey Anderson, Melody Bourret, Conor Flynn, Anne Maurer, Rachel Newton, and Jenny Soong for their hard work in collecting the field data. CNHP Wetland Ecology Data Technician Ellen Heath was invaluable for entering and QC'ing pages and pages of field data. The project could not have happened without the support and assistance of local partners in the Rio Grande basin. Pete Magee, Director of the San Luis Valley GIS/GPS Authority, provided parcel data to determine land ownership in the basin. Special thanks go particularly to Rio de la Vista, former chair of the San Luis Valley Wetland Focus Area Committee (FAC). Rio's energy and passion for wetlands in the Valley is infectious and has led to tremendous conservation success. Along with Rio, thanks go to her colleague at the Rio Grande Headwaters Land Trust, Nancy Butler, and members of the San Luis Valley FAC who provided support and suggestions for the project and helped put us in touch with several land owners. Thanks also go to several hardworking agency and land trust biologists and managers who let us survey on their lands, including Floyd Treutken and Mike Blenden of USFWS; Rick Basagoitia of CPW; Don Koskelin of the City of Alamosa; Jill Lucero and Sue Swift-Miller of the BLM; and Paul Robertson of TNC. And a very special thanks to all the private landowners who allowed onto their lands.

During the course of this project, we gained tremendous technical assistance, ideas and overall guidance from our colleagues at CNHP, especially Dave Anderson, Denise Culver, Karin Decker, Amy Lavender, Renee Rondeau, and Joe Stevens. Colleagues at the Montana Natural Heritage Program (MTNHP) have been equally important in guiding the ideas of our work in both wetland mapping and wetland condition assessment. Special thanks go to Meghan Burns, Cat McIntyre, Karen Newlon, and Linda Vance. Finally, we would like to thank Paula Nicholas with the Colorado Parks and Wildlife and Mary Olivas and Carmen Morales with Colorado State University for logistical support and grant administration.

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SECTION 1.0: INTRODUCTION

The Wetland Wildlife Conservation Program (Wetlands Program or Program for short)[1] is a voluntary, incentive-based program established by Colorado Parks and Wildlife (CPW)[2] to protect wetlands and wetland-dependent wildlife on public and private land. Since its inception in 1997, the Wetlands Program has preserved and restored more than 270,000 acres of wetlands and adjacent habitat and over 700 miles of streams. The Program is responsible for almost $56 million in total funding devoted to wetland and riparian restoration in Colorado. To date, much of this effort has been based on local priorities and/or opportunities. Although the Program has made significant strides to protect and restore Colorado's wetland resource, in 2007 CPW identified a need to establish statewide strategies to better guide their efforts toward strategic objectives. Credible information about the types, abundance, distribution, and condition of Colorado's wetland resource is integral to developing and implementing statewide strategies for effective wetland restoration and management. The project described in this report marks the initial steps in a multi-year effort on behalf of CPW and the Colorado Natural Heritage Program (CNHP) to determine the types, abundance, distribution, threats to, and level of protection currently provided to Colorado's wetlands and to assess their ecological condition. The outcome of this effort will be the ongoing development of statewide strategies for protecting and restoring wetlands in Colorado for the benefit of wetland-dependent wildlife.

An inventory of Colorado's wetland resource is the first step toward establishing statewide strategies. Many researchers and projects have developed maps and other information on Colorado's wetland resources. Such efforts include the US Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI) maps, CPW's wetland and riparian maps, CNHP's wetland and riparian plot database, CNHP's Potential Conservation Areas, Rocky Mountain Bird Observatory (RMBO)'s maps of potential playa lakes, US Forest Service (USFS) and Bureau of Land Management (BLM) vegetation and ecological health assessment data, and county wetland inventory maps. However, none of these are available consistently across the state as digital data, nor are they compiled into a single resource available to regulators, decision makers, and others concerned with wetland conservation in the state. A major goal of this project was to pull together existing geospatial data for wetlands in Colorado and establish a single, centralized database that contains the current knowledge of the types, abundance, and distribution of wetlands in Colorado and to make these data available to wetland conservation partners statewide.

To aid in decision making, this information has been summarized by several geographic scales to produce "wetland profiles" that describe the wetland resources within a given area. Wetland profiles have been shown to be an effective means of summarizing wetland diversity, abundance, and functions, and they can be used to establish baseline conditions, assess cumulative impacts to wetland condition and function, and inform strategic goals (Bedford 1996, Gwin et al. 1999, Johnson 2005). Through the use of hydrogeomorphic (HGM) classification, wetland types in the profile can be grouped into "bundles" of similar ecological functions (e.g., slope wetlands perform similar functions which differ from those performed by riverine wetlands). For this project, those

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[1] See the Wetlands Program website for more information: (http://wildlife.state.co.us/LandWater/WetlandsProgram/).

[2] As of July 2011, the former Colorado Division of Wildlife (CDOW) began a process to merge with the Division of Parks and Outdoor Recreation. All reference to CDOW in this report uses the new division name: Colorado Parks and Wildlife (CPW).

bundles would represent wildlife habitat values associated with various wetland types (e.g., Cowardin class: Cowardin et al. 1979; HGM class: Brinson 1993; NatureServe's Ecological System type: Comer et al. 2003). For example, depressional wetlands provide important waterbird and amphibian habitat, while riverine wetlands provide habitat and corridors for migratory birds, fish, and mammals. By tracking the location and abundance of these bundles, general statements about the status and trends of wetland wildlife habitat (as well as other wetland functions) can be made at a variety of scales (watersheds, basin, statewide, etc.).

In addition, this project began to assess the ecological condition of Colorado's wetlands, which will provide necessary information to prioritize on-the-ground efforts that contribute to statewide wetland goals. By incorporating data indicating ecological condition and associated stressors into the wetland profiles, conclusions can be drawn regarding the integrity of Colorado's wetland resource and its ability to provide natural ecological functions and sustainable ecological services, such as suitable wildlife habitat. An assumption is made that a wetland in its natural, minimally impacted state will provide maximum suitable habitat for all wetland-dependent wildlife which naturally use that wetland type. In other words, a suite of wildlife species is associated with certain wetland types. Some wildlife species may use a variety of wetland types (e.g., large mammals) while others may be restricted to specific types (e.g., boreal toad or Southwest willow flycatcher). These species evolved with natural wetlands in the absence of severe human stressors. As human stressors negatively impact a wetland, the habitat value of that wetland for many species will also be negatively impacted. Thus, the ecological condition of each wetland is a general surrogate measure of wildlife habitat value. The pilot wetland condition assessment included in this project is the first of a series of projects that will rotate through each major river basin in the state.

Assessing the ecological condition of wetlands provides a coarse filter for prioritizing on-the-ground efforts targeted at protecting and restoring wetlands and their associated wildlife. For example, depending on the wetland types, abundance, and ecological condition within a watershed, each wetland type can be categorized into "action" categories, thereby providing a systematic means of prioritizing protection, restoration, and enhancement actions. The categories may look something like this:

> <u>Protection</u>: wetlands possessing ecological integrity (e.g., wetlands whose ecological processes are functioning within their natural range of variation); wetlands supporting rare species (e.g., CNHP Potential Conservation Areas, Colorado Natural Areas Designated and Research Natural Areas, BLM Areas of Critical Environmental Concern, and USFS Research Natural Area); wetlands providing critical wildlife habitat (e.g., assessment of key wildlife habitat features, Colorado's Comprehensive Wildlife Action Plan, Important Bird Areas, boreal toad breeding habitat, southwest willow flycatcher habitat); and/or wetlands providing other important watershed functions.
>
> <u>Restoration:</u> wetlands whose key ecological processes and/or wildlife habitat features have been impacted but are restorable to their natural range of variation.
>
> <u>Enhancement</u>: wetlands whose ecological processes have been severely impacted and cannot be restored to their natural range of variation; however, these wetlands can be enhanced for achieving specified ecological functions or services. For example, riverine

wetlands along major river corridors whose hydrology has been severely impacted by diversions, dams, etc. (e.g., South Platte River) but still offer opportunities for enhancement of wildlife habitat, water quality improvement, etc.

To share the information developed and compiled through this project with wetland partners throughout the state, CPW and CNHP have developed the Colorado Wetlands Inventory[3], an interactive online mapping tool in which users may identify an area of interest and obtain information pertaining to the types, abundance, condition, threats to and level of protection of wetlands in that area. The only similar tool currently available for Colorado is the USFWS' Wetland Mapper,[4] but this tool only displays NWI data and does not produce wetland profile summary reports. Partners that might use Colorado Wetlands Inventory include natural resource professionals from local, state, and federal agencies, The Nature Conservancy, Ducks Unlimited, Intermountain West and Playa Lakes Joint Ventures, RMBO, local land trusts, and local Wetland Focus Area Committees (FACs) established throughout Colorado.[5] Membership of the local FACs includes private landowners, concerned citizens, educators, sportsmen, non-profits and land trusts. These committees bring together a diverse knowledge of local wetland resources, offer venues to discuss wetland needs, provide wetland expertise, and generate project ideas. With access to statewide wetland data, the FACs will be able to better assess and prioritize local wetland projects according to both statewide and local objectives.

1.1 Project Description and Organization of this Report

1.1.1 Project Objectives

The four primary objectives of this project were to: (1) compile existing geospatial data regarding the location and type of wetlands in Colorado; (2) initiate an on-the-ground pilot project to assess the ecological condition of common wetland types in one hydrologic basin (Rio Grande Headwaters, HUC 6: 130100); (3) develop statewide strategies for setting wetland restoration priorities funded by CPW's Wetlands Program; and (4) develop an interactive online mapping tool to transfer this information to local and statewide partners in wetlands conservation.

The project objectives were implemented with the following tasks:

1. **Compile existing digital geospatial data regarding the location and type of wetlands in Colorado.**
    - Existing geospatial data on wetlands were compiled from resources such as USFWS' NWI maps, CPW's wetland and riparian maps, county wetland inventory maps, RMBO maps of potential playa lakes, maps of potential fens from USFS and other sources, and CNHP Potential Conservation Areas drawn for wetland and riparian areas.
    - Status maps for each major data source were created showing the extent of each project and identifying significant data gaps.

[3] See the Colorado Wetlands Inventory website for more information: (http://www.cnhp.colostate.edu/download/projects/wetlands/index.asp).
[4] The USFWS' Wetland Mapper displays NWI mapping across the country. See the website for more information: (http://www.fws.gov/wetlands/Data/Mapper.html).
[5] See the CPW Wetlands Program webpage for more information about Wetland FACs established throughout the state: (http://wildlife.state.co.us/LandWater/WetlandsProgram/FocusAreaCommittees/).

- For the Rio Grande Headwaters river basin (study area for the pilot wetland condition assessment), NWI paper maps were digitized to fill in spatial data gaps in order to complete the assessment. The National Wetland Mapping Standard developed by the Federal Geospatial Data Committee (FDGC 2009) was used to maximize compatibility with regional and nationwide mapping efforts. This process will be repeated in future work as wetland condition is assessed in other basins.
- To estimate the time and resources needed to complete wetland mapping across the state, existing NWI paper maps were also digitized for one complete river basin (North Platte River, HUC 6: 101800, within Colorado). A plan was developed to complete digital conversation of existing NWI maps with additional funding in the coming years.

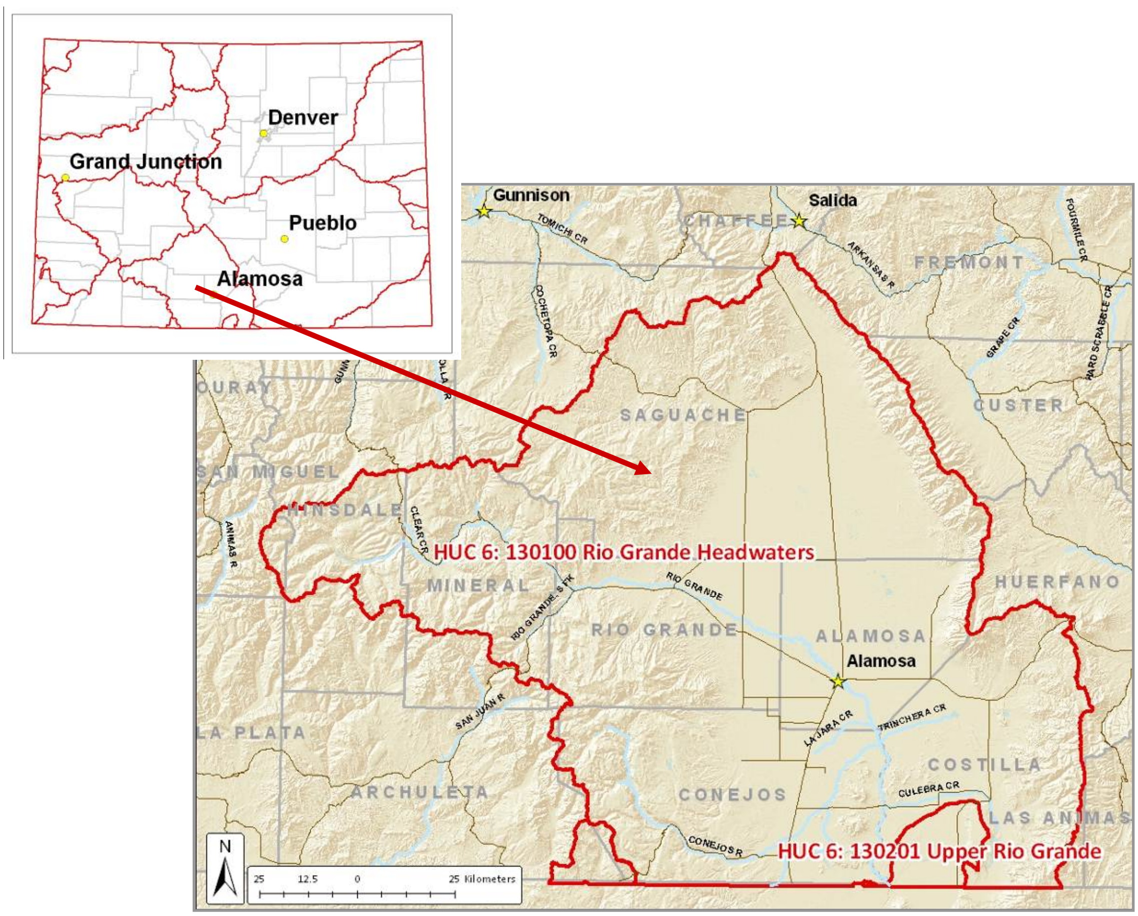

Figure 1.1. Map of Rio Grande Headwaters River Basin, HUC 6:130100. Inset map shows location of study area within the state of Colorado. Two small sections of Upper Rio Grande, HUC 6: 130201 (shown in the southern portion of the map), were included in the study area.

2. **Initiate an on-the-ground pilot project to assess the ecological condition of common wetland types in one hydrologic basin (Rio Grande Headwaters, HUC 6: 130100, Figure 1.1).**
   - Based on the digital NWI mapping, a spatially balanced random sample survey design was developed for the Rio Grande Headwaters basin based on principles outlined by

U.S. Environmental Protection Agency (EPA)'s Environmental Monitoring and Assessment Program (EMAP: Stevens and Olson 2004, Detenbeck et al. 2005).

- The ecological condition of 137 randomly selected wetlands was measured using rapid and intensive protocols developed by CNHP. These protocols include the Floristic Quality Assessment (FQA: Rocchio 2007b), Vegetation Index of Biotic Integrity (VIBI: Rocchio 2007a, Lemly and Rocchio 2009b), and Ecological Integrity Assessment (EIA: Faber-Langendoen et al. 2008a, Lemly and Rocchio 2009a), all of which were developed for Colorado with funds provided by EPA Region 8 Wetland Program Development Grants and CPW's Wetlands Program.
- The proportion of wetland area within major condition classes was estimated based on both a landscape level model (explained in the objective below) and the field collected data.
- Success of the pilot project was evaluated and recommendations made for future basinwide wetland condition assessments.

3. **Develop statewide strategies for setting wetland protection and restoration priorities funded by CPW's Wetlands Program.**
    - A statewide landscape level model of potential wetland stressors was developed using existing geospatial data, such as roads, oil and gas development, water impoundments, water diversions, groundwater wells, point source discharges, land cover, etc. Data on land ownership and management status was also evaluated.
    - Stressor and land ownership data listed above was incorporated with the geospatial data for wetlands (Objective 1) to gauge overall conservation urgency for wetlands in each major river basin, to the extent possible. Particular emphasis was placed on the Rio Grande Headwaters river basin, study area for the pilot wetland condition assessment (Objective 2), as much finer scale data were available.
    - All of the aforementioned information was used to develop and refine strategies for CPW's Wetlands Program. The Wetlands Program Strategic Plan is a living document that will be updated as wetland mapping and condition assessment projects are carried out for additional river basins across the state.

4. **Develop an interactive online mapping tool to transfer information to local and statewide partners in wetlands conservation.**
    - The Colorado Wetlands Inventory, an interactive website[6], was developed to display and share data collected through the project (i.e., wetland type, area, ecological condition, land ownership, and potential stressors, etc.).
    - There are two main sections to the Colorado Wetlands Inventory: 1) an online mapping tool that displays several datasets depicting the location and classification of wetlands in Colorado and 2) the wetland profile page that summarizes available wetland information shown in the mapping tool at various geographic scales.

[6] View the Colorado Wetlands Inventory at: http://www.cnhp.colostate.edu/download/projects/wetlands/index.asp.

- The tool is based on an ArcIMS Flex platform and draws on years of experience within CPW's GIS team presenting spatial information through the Natural Diversity Information Source (NDIS)[7].

1.1.2 Report Organization

Due to the broad and diverse nature of the project, the remainder of this report is divided into two main sections. Section 2.0 describes the compilation of digital wetlands data (Objective 1), development of the statewide landscape level model of potential wetland stressors (part of Objective 3), and an overview of the Colorado Wetlands Inventory interactive online mapping tool (Objective 4). Section 3.0 focuses on the Rio Grande Headwaters pilot wetland profile and condition assessment. This section also includes lessons learned from the first river basin-scale wetland condition assessment project ever conducted in Colorado and presents suggestions for future projects. Actual statewide strategies developed by CPW's Wetland Program are incorporated into the Program's Strategic Plan, which is available as a separate document.

1.2 Wetland Monitoring and Assessment Frameworks

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

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

Acknowledging that it is impossible to visit every wetland across a landscape to determine the range of condition, EPA recommends a three tiered approach to wetland assessment. Within the Level 1-2-3 Framework[8], Level 1 assessments are broad in geographic scope and used to characterize resources across an entire landscape. They generally rely on information available digitally in a GIS format or through remote sensing. Goals of Level 1 assessments may include summarizing the extent and distribution of a resource (such as wetland mapping from air photography) or modeling the condition of wetlands based on anthropogenic stressors such as roads, land use, resource extraction, etc. The wetland profile concept is essentially a Level 1 assessment. Level 1 assessments can be applied across a large area and can summarize general patterns, but may not accurately represent the condition of a specific wetland on the ground.

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

[7] The Natural Diversity Information Source (NDIS) website (http://ndis.nrel.colostate.edu) provides mapping, data, information, and links to similar websites concerning hunting, fishing, wildlife, habitat, and conservation planning issues in Colorado. The NDIS website is designed to provide these services for multiple audiences with differing needs and levels of subject expertise. The general public can quickly access basic information, interactive maps, and links to similar websites; while conservation planners, biologists, and mapping professionals have ready access to much more detailed information, and digital (GIS) map layers for planning and analysis.

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

number of wetlands on the ground to make an overall estimate of condition or evaluate which sites deserve more intensive monitoring.

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

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

1.2.2 NatureServe's Ecological Integrity Assessment Framework

The Ecological Integrity Assessments (EIA) Framework was developed by NatureServe[9] and ecologists from several Natural Heritage Programs across the country (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, following the Level 1-2-3 approach. 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 and these scores can be used to track change and progress toward meeting management goals and objectives. With past funding from EPA Region 8 and CPW, CNHP developed EIA protocols for seven wetland types in the Southern Rocky Mountain Ecoregion (Rocchio 2006a-g) and field tested one set of these protocols (Lemly and Rocchio 2009a). Through the Rio Grande Headwater pilot wetland assessment, this project is the first effort in Colorado to apply the EIA framework and protocols to a range of wetland types across a large geographic area.

Ecological integrity has been defined as "the summation of chemical, physical, and biological integrity" or the ability of an ecosystem to support and maintain a full suite of organisms with species composition, diversity, and function comparable to systems in an undisturbed state (Karr and Dudley 1981). High ecological integrity is generally regarded as an ecosystem property where expected structural components are complete and all ecological processes are functioning optimally (Campbell 2000). However, ecological integrity can occur along a continuum of human influence. At one end are "pristine" or minimally impacted ecosystems, which support a full suite of expected

[9] 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.

species and processes. As humans alter biological or ecological systems, these systems change along the continuum and species composition changes or processes are altered. If human impacts are severe enough, this could lead to an ecological state that supports vastly altered, simplified, and impaired systems (Karr and Chu 1999).

To capture the level of ecological integrity, each metric in the EIA framework is rated according to deviation from its range of natural variability, which is defined based on the best current understanding of how ecological systems "work" under reference conditions and how they respond to increased human disturbance. The farther a metric 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 perceived natural state (Table 1.1). 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 1.1. 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.

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.

SECTION 2.0: STATEWIDE WETLAND MAPPING AND LANDSCAPE LEVEL STRESSOR ANALYSIS

2.1 Compilation of Digital Geospatial Data for Wetlands

2.1.1 Existing Wetland Data Sources

A major goal of this project was to compile and centralize sources of digital spatial data for wetlands in Colorado. To produce the most comprehensive digital data set possible, numerous potential sources were evaluated. A few basic criteria helped guide the selection process:

1) *Broad geographic coverage.* We sought data sources that had the widest coverage possible across the state. Preference was given to data sources created at the state level or those covering a major geographic area like the eastern plains, an entire county, or entire National Forests. Site specific projects covering a small area were not included.

2) *Digital polygons available as GIS-compatible files.* Early projects involving wetland mapping produced maps on paper or maps in electronic formats not compatible with GIS. These were excluded from the project as they could not be easily integrated into the GIS platform. One major exception is NWI mapping, for which only 12% of the state was digital at the beginning of this project. Though little NWI mapping for Colorado was digital, NWI is the federal standard for wetland mapping and the associated classification and mapping protocols are well documented and used throughout the nation. The NWI program did create wetland maps for the entire state of Colorado in the early years of the program, between the late 1970s and early 1980s. These maps were originally produced on paper, but have been transferred to digital, geo-rectified scans by NWI. Though not polygons that can be used for analysis, the scanned images can be displayed in GIS on top of aerial images, topographic maps, or other data layers. Besides NWI, no other paper wetland maps were included.

3) *Adequate documentation.* Data sources selected primarily came from projects for which reports or metadata were available. This was critical to understand the definitions and classifications used. In some cases, mapping projects targeted all wetland types, while other projects targeted a specific wetland type such as potential playas or potential fens.

After evaluating several potential sources, five data sources were included (Table 2.1). All GIS layers were converted to the same projection and are displayed together on the Colorado Wetlands Inventory Online Mapping Tool.

Evaluation and compilation of data sources was first conducted by CNHP. Selected data sources were then transferred to GIS Analysts at CPW, where the online mapping tool was developed and is hosted. Final versions of all data sources compiled through this project are housed on servers at both CNHP and CPW to insure against loss of data. Any update or revision to the data sources will be coordinated between the two organizations. GIS layers for each data source are maintained individually, allowing for ease of editing and/or replacement. Because each data source was created based on different target populations and different classification systems, the GIS layers will not be merged. Federal Geographic Data Commission compliant metadata were created for each data source, documenting basic information about the data, when the data were acquired, and a contact where further information can be obtained. Updates will be made on an annual basis in October beginning in 2011. Because many of the data sources were acquired from outside parties, regular communication will be made with external contacts to see whether updates are available. Updates will be most important for the NWI data, as CNHP has continued to work with the NWI program and numerous funding partners to convert NWI paper maps into digital data (see following sub-section). Work on this project has initiated a major effort by CNHP and partners to digitize all NWI maps for the state by 2015.

Table 2.1. Data sources included in the Statewide Wetland Strategies project and the Colorado Wetlands Inventory Online Mapping Tool. More detail can be found within the metadata for each data source on the Colorado Wetlands Inventory Mapping Tool.

Data Source	Creator	Target Population	Percent of State Covered
NWI Digital Data and Scanned Images	USFWS NWI Program	Wetlands and deepwater habitats	Digital Data: 22% Scans: 78%
CPW Riparian Mapping	CPW	Wetlands and riparian areas	50%
Local Government Wetland Mapping	Boulder and Summit Counties	Wetlands	2%
Potential Fen Mapping	Grand Mesa National Forest, San Juan National Forest, Mountain Studies Institute, Dr. J. Bradley Johnson	Potential Fen Wetlands	4%
RMBO Potential Playa Mapping	Rocky Mountain Bird Observatory	Potential Playa Wetlands	43%

2.1.2 Digitizing Original NWI Paper Maps

Through the process of compiling existing data sources, it became obvious that a concerted effort should be made to create one consistent, statewide coverage of wetlands for Colorado. Of the datasets evaluated, NWI mapping emerged as a clear priority for this effort. Though not the most comprehensive at this time, NWI's status as the federal standard for wetland mapping and its well established classification system (Cowardin et al. 1979) make it the clear choice. To supplement the extent of digital NWI available at the start of this project, scanned images of paper NWI maps were converted to digital polygons for two areas of the state: the Rio Grande Headwaters and North Platte River Basins.

NWI paper maps for both areas were converted to digital polygons by CPW GIS Analysts during 2008–09. Each NWI map covers one USGS topographic quadrangle (quad). To convert these maps to digital data, CPW obtained paper maps from the NWI program for all quads in the target areas lacking digital data and scanned the maps on a drum scanner. Since 2009, NWI has provided CNHP and CPW with scanned images of all remaining NWI paper maps for Colorado, alleviating the need to scan the maps ourselves. The scanned images were then ortho-rectified and converted to digital polygonal data using Definiens eCognition 8.0 (Definiens Inc. 2008), an image recognition software. The specific process of selecting only wetland polygons from the scanned images and excluding other features, such as the hand drawn attribute labels and other reference lines, was developed by CPW Analysts specifically for this project and is a highly efficient means of converting original NWI data into a digital format. Once polygons were extracted, they were converted to the ESRI geodatabase format using ArcGIS 9.3 software (ESRI 2008). In ArcGIS, any remaining jagged lines were smoothed and adjoining features were merged. Each polygon was attributed based on the attribute given in the paper map and all polygons were checked for invalid codes and minimum size requirements. Some codes were changed to reflect updates to the nomenclature since the time of the original mapping. In some limited cases, where distortion of the scanned image had clearly shifted the original polygons from their intended spatial location, polygons were moved to reflect the true location of wetlands. However, the purpose of converting the original NWI data was not to update or correct the photo-interpretation, but to efficiently convert a large amount of hardcopy data to a digital format.

In total, 105 USGS topographic quadrangles were converted to digital polygonal data through this project. These maps increased the amount of digital NWI mapping available in Colorado from 12% at the start of this project to 22%. Since 2009, responsibility for the conversion of NWI paper maps was shifted from CPW to CNHP and the process has continued to evolve. Through additional EPA funded projects as well as project funded by other partners including the U.S. Forest Service and Bureau of Land Management, CNHP is projected to convert another ~450 quads by the end of 2011. This will bring the coverage of digital NWI data closer to 40% of the state.

2.1.3 Major River Basins and Wetland Profiles

For the purpose of this project, the strategies developed from this project, and all future projects that flow out of those strategies, CNHP and CPW have defined ten major river basins within Colorado (Table 2.2, Figure 2.1). The major river basins are modified from the U.S. Geological Survey (USGS) 6-digit hydrologic unit code (HUC6) level. HUC6 basins were modified because several small pieces of HUC6 basins occur around the edges of the state, while the majority of their area occurs in neighboring states. To divide the state into intuitive units, smaller HUC6 basins were merged with more major HUC6 basins where logical. A similar approach has been taken by most natural resource or water resource agencies within Colorado, though each divides the state in slightly different ways. These ten major river basins are referred to throughout this report and are used in the Colorado Wetlands Inventory Mapping Tool.

Table 2.2. Major river basins used by CNHP and CPW for wetland projects and their component HUC6 basins.

Major Basin Name	HUC6 River Basins Included
North Platte	101800: North Platte
South Platte	101900: South Platte
Republican	102500: Republican, 102600: Smokey Hill
Upper Arkansas	110200: Upper Arkansas, 110300: Middle Arkansas, 110400: Upper Cimarron, 110800: Upper Canadian
Rio Grande Headwaters	130100: Rio Grande Headwaters, 130201: Upper Rio Grande
Colorado Headwaters	140100: Colorado Headwaters
Gunnison	140200: Gunnison
Dolores	140300: Upper Colorado-Dolores
White-Yampa-Green	140500: White-Yampa, 140401: Upper Green, 140600: Lower Green
San Juan	140801: Upper San Juan, 140802: Lower San Juan

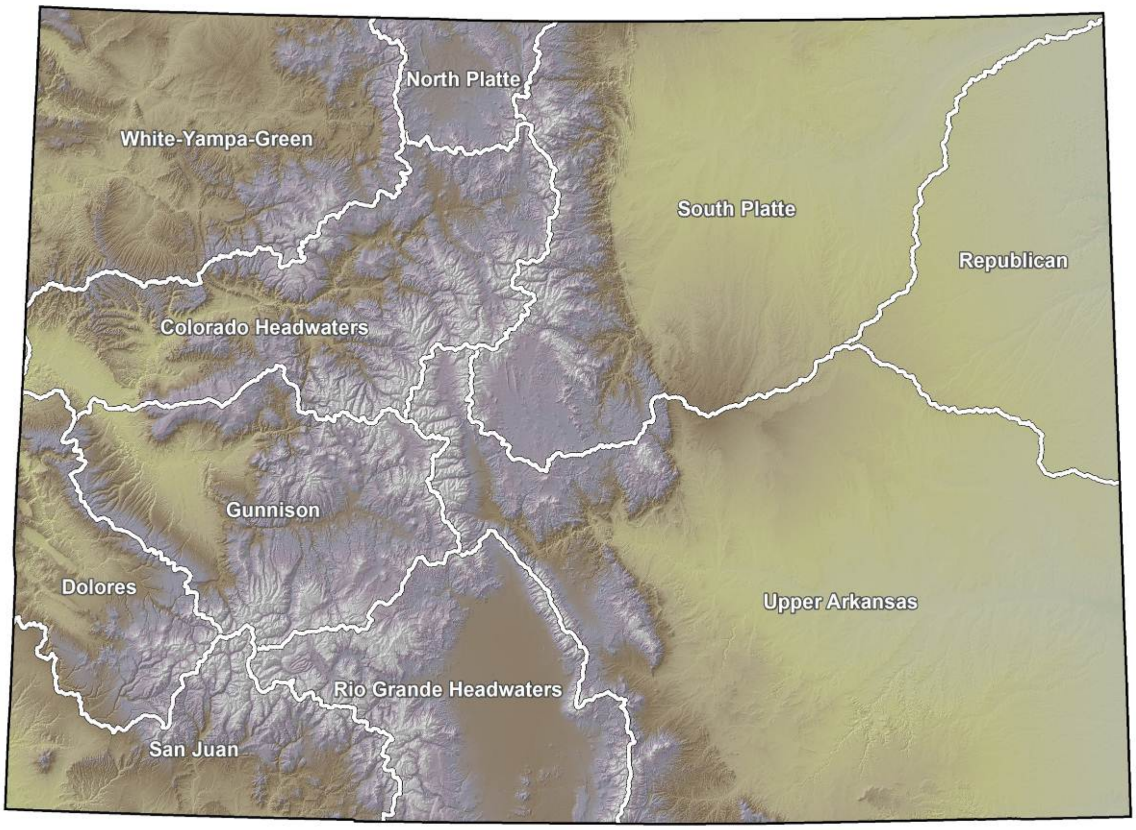

Figure 2.1. Major river basins used by CNHP and CPW for wetland projects.

Based on the digital wetland data compiled through this project, coarse wetland profiles were created for each of the major river basins in Colorado and are available on the Colorado Wetlands Inventory website. Profiles for each HUC8 river subbasin and county will also be available on the website by the end of August 2011. Due to the limited nature of digital data (Table 2.3), the profiles do not fully reflect the extent and distribution of wetlands in most basins. Work over the coming years will add data to the profiles and we will update all profile summaries when data are available. Within Section 3 of this report, a more detailed wetland profile of the Rio Grande Headwaters basin is presented.

Table 2.3. Status of digital wetland mapping by major river basin.

Major River Basin	**Percent of basin mapped by each data source**				
	Digital NWI	**CPW Riparian**	**Local Gov't**	**Potential Fens**	**Potential Playas**
North Platte	100%	37%	--	33%	--
South Platte	21%	61%	7%	3%	69%
Republican	3%	12%	--	--	100%
Upper Arkansas	17%	64%	--	--	79%
Rio Grande Headwaters	100%	43%	--	4%	--
Colorado Headwaters	9%	41%	10%	1%	--
Gunnison	6%	64%	--	4%	--
Dolores	10%	53%	--	17%	--
White-Yampa-Green	2%	36%	--	--	--
San Juan	40%	38%	--	28%	--

2.2 Statewide Landscape Integrity Model of Potential Wetland Stressors

2.2.1 Model Development Methods

To analyze threats and stressors impacting wetland across Colorado, CNHP developed a statewide, GIS-based Landscape Integrity Model (LIM) for wetlands. This model is similar to a terrestrial LIM created by CNHP for past projects (CNHP and TNC 2008, CNHP 2008), except that it incorporates data layers specific to wetlands and aquatic habitats. The concept behind the model is that specific anthropogenic stressors, for which GIS layers are available, can be identified and compiled. The impact of each stressor is weighted and scored based on best professional judgment (BPJ) of the stressor's relative importance. Individual scores are then combined to create a cumulative, continuous surface of relative impact. High values equate to high stress and low landscape integrity while low scores equate to low stress and high landscape integrity. Within EPA's Level 1-2-3 Framework, the LIM is a Level 1 tool that produces a coarse estimate of wetland condition based on the level of potential stress facing wetlands.

For the wetland LIM, four stressor categories encompassing thirteen individual stressors were identified (Table 2.4). To develop the model, the team evaluated three aspects of each stressor: 1) whether the impact is restricted to an exact location (i.e., footprint) or extends past the footprint and diminishes with distance (i.e., distance decay); 2) if the impact does diminish with distance, what shape and dimension best depicts the decline (e.g., linear, asymptotic, logarithmic, sigmoid, etc.); and 3) the relative weight of each stressor compared to others in the model. For the terrestrial LIM developed by CNHP in the past, ecologists found that the impact of most stressors does extend beyond the footprint and that a sigmoid curve adequately represented the behavior of the modeled impacts over distance. The sigmoid curve is more flexible than a linear function as many parameters can be specified. The curve can decay rapidly, meaning the impact drops off substantially at a short distance from the stressor, or it can decay gradually, meaning the impact remains high close to the source before declining rapidly with increasing distance. Both the height (impact weight) and the overall distance of the curve can also be set. We used an adjustable sigmoid function of the form:

$$y = \frac{1}{1 + \exp(b(\frac{x}{c} - a))} \times w$$

where
a - shifts curve to right or left
b - determines spread of curve, or slope of the rapidly decreasing part of curve.
c - scalar to adjust total distance of interest (= distance in meters divided by 20)
x - distance in meters from threat
w - weight of threat (maximum value)

By adjusting the shift and spread of the curve (*a* and *b*), it can be tailored to specific threats. Different values of *a* and *b* were used to derive four decay curves describing gradual, moderate, moderately abrupt, and abrupt distance decay behavior (Table 2.5). The inflection point of the curve marks the distance where the effect of the impact is reduced by half. These curves are asymptotic

Table 2.4. Stressors included in the Wetland LIM by category, treatment, and data source. Graph series defines which curve represents the stressor in Figure 2.2. See Appendix A for more information on each data source. For stressors marked with asterisk (*), information under curve and graph series describe the data transformation instead of distance decay functions.

Category	Stressor	Treatment	Weight	Curve	Graph Series	Data Source
Land Use and Development						
	Industrial / urban development	Distance decay	1000	Moderate	A	LandFire Current Vegetation: High and medium intensity development (values 23 & 24)
	Suburban / rural development	Distance decay	500	Moderate	D	LandFire Current Vegetation: Low intensity development (value 22)
	Highly modified open space	Distance decay	100	Abrupt	I	LandFire Current Vegetation: Developed open space (value 21)
	Primary roads (interstate highways)	Distance decay	1000	Moderate	A	U.S. Census Bureau TIGER/Line: Primary roads (CFCC2 = A1)
	Secondary roads (state highways)	Distance decay	500	Moderate	D	U.S. Census Bureau TIGER/Line: Secondary roads (CFCC2 = A2, A3)
	Local and primitive roads	Distance decay	300	Abrupt	G	U.S. Census Bureau TIGER/Line: Local/primitive roads (CFCC2 = A4-A6)
	Final scoring = Maximum value of the above six inputs					
	Agriculture	Distance decay	600	Moderately Abrupt	C	LandFire Current Vegetation: Pasture/hay and cultivated/irrigated crops (values 81 & 82)
	Final scoring = Considered separately					
Energy Development and Resource Extraction						
	Active oil and gas wells	Distance decay	600	Moderately Abrupt	C	Colorado Oil and Gas Conservation Commission: Active wells
	Inactive oil and gas wells	Distance decay	200	Moderately Abrupt	H	Colorado Oil and Gas Conservation Commission: Plugged/abandoned wells
	Final scoring = Maximum value of the above two inputs					

Category	Stressor	Treatment	Weight	Curve	Graph Series	Data Source
	Wind turbines	Distance decay	400	Moderately Abrupt	F	Colorado Natural Heritage Program
	Final scoring = Considered separately					
	Active sand and gravel mines	Distance decay	800	Moderate	B	Colorado Division of Mine Safety: Active sand and gravel mines
	Other active and abandoned mines	Distance decay	600	Moderately Abrupt	C	Colorado Division of Mine Safety: All other active mines
	Final scoring = Maximum value of the above two inputs					
Hydrologic Modification						
	Reservoir storage as proportion of mean annual flow*	Accumulated upstream	800	Cube root transformed, scaled by range, truncated to the 99th percentile, clipped to modeled riparian zone.		The Nature Conservancy Freshwater Measures Database
	Water use as a proportion of mean annual flow*	Accumulated upstream	800			
	Dams and diversions by stream length*	Accumulated upstream	500	Square root transformed, scaled by range, truncated to the 99th percentile, applied to entire landscape.		
	Final scoring = Maximum value of the above three inputs					
	Groundwater wells	Distance decay	400	Moderate	E	Colorado Division of Water Resources: Active groundwater wells
	Final scoring = Considered separately					
Weed Infestations						
	Tamarisk populations	Footprint	400	NA	NA	The Tamarisk Coalition and The Nature Conservancy
	Final scoring = Considered separately					

at both ends, therefore the results of the equation must be manually adjusted to equal the maximum weight at zero distance and minimum weight at a distance at which the weight becomes essentially zero ("cutoff distance"). Each individual impact type has its own relevant weight and decay function type (Figure 2.2). The individual layers are then additively combined to produce an overall landscape integrity layer.

Table 2.5. Parameter setting for potential curve types used in a LIM. For the Wetland LIM, only the abrupt, moderately abrupt, and moderate curves were used.

Curve Type	*a*	*b*	Inflection Point	Cutoff
Abrupt	1.0	5.0	100 m	250 m
Moderately Abrupt	2.5	2.0	300 m	600 m
Moderate	5.0	1.0	500 m	1,250 m
Gradual	10.0	0.5	1,000 m	2,000 m

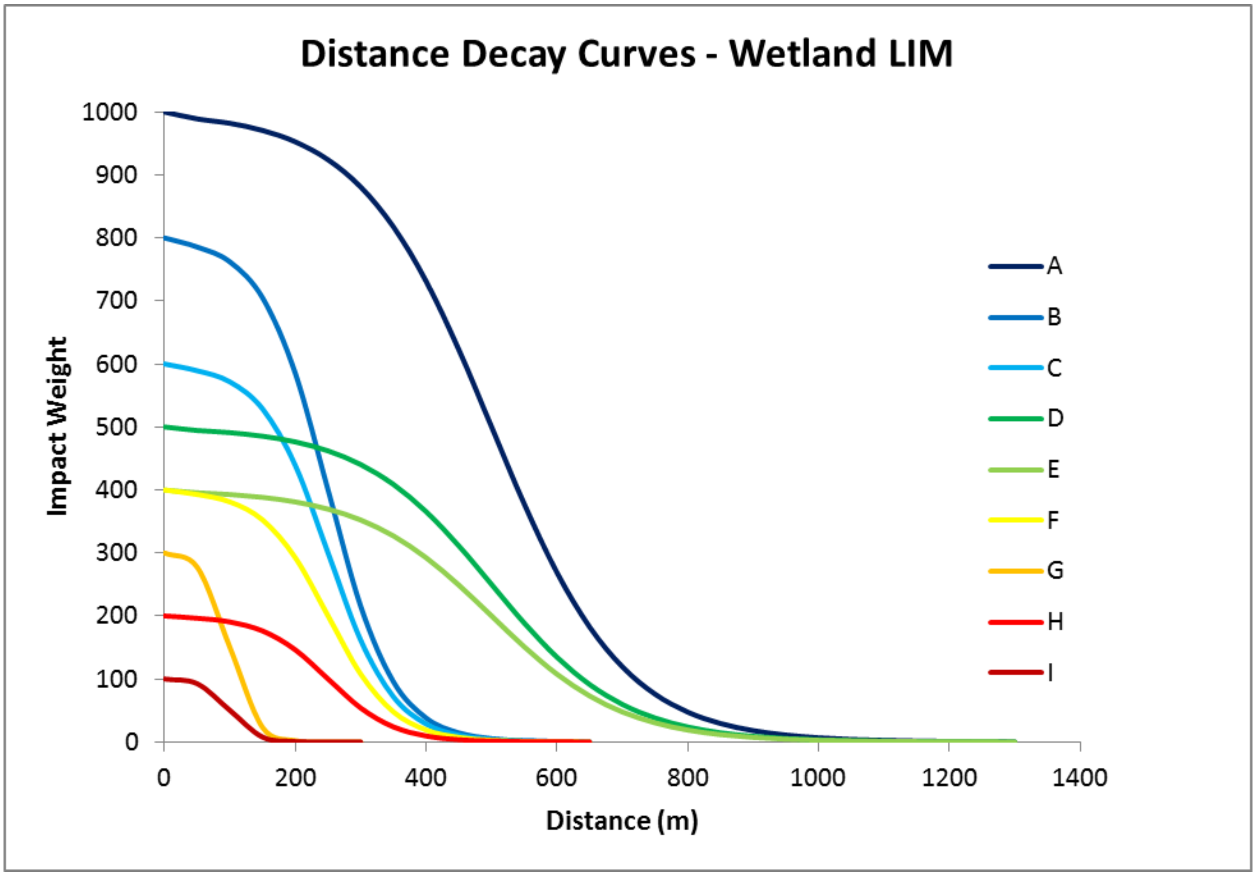

Figure 2.2. Distance decay curves used in the Wetland LIM for Colorado. Refer to Table 2.4 for stressors depicted by each graph series.

For the Wetland LIM, sigmoid distance decay curves made sense for nearly all stressors incorporated into the model, with two exceptions: tamarisk populations and hydrologic modification. Tamarisk populations were treated as a footprint disturbance based on limited distribution of the data. For most stressors within the hydrologic modification category, the impact of disturbance accumulates as water flows downstream and does not decay equally in all directions. For these data, CNHP benefited from analysis recently conducted by The Nature Conservancy (TNC) on alterations to stream reaches across Colorado (Sanderson et al. 2010). In the TNC analysis, factors related to hydrologic modifications were calculated by accumulating the alteration upstream of a given reach and relativizing by predicted mean annual flow. As the hydrology at any given point in a river network is determined by everything that happens upstream, this approach was best to evaluate the impact of hydrologic stressors. The impact of a small alteration upstream would gradually disappear as mean annual flow increases downstream. However, if alteration along the course of a stream accumulates more rapidly than the mean annual flow, the impact downstream would be greater than upstream. The only hydrologic variable not treated with upstream accumulation was groundwater wells, which are not tied to stream networks. A distance decay function was applied to these data points.

All TNC hydrologic alteration values were first calculated by linear stream reach and then applied to the catchment area for that reach. Both reservoir storage and water use as proportions of mean annual flow could only be calculated for stream reaches with upstream catchments greater than 10 km^2, the lower limit for modeling mean annual flow. These values, therefore, could not be applied to headwater reaches. In addition, because they apply more specifically to streams and stream-associated wetlands, these values were clipped to a TNC model of riparian floodplains. Values for dams and diversions by stream length, however, were available across all stream reaches. As diversion can affect slope and depressional wetlands as well as stream associated wetlands, these values were applied to all catchments and not clipped to the riparian corridor. Values derived from all TNC calculations contained a very wide, non-normal spread. To constrain the spread and increase normality, values were either cube or square root transformed, scaled by the range of values, and truncated by the upper 99^{th} percentile (Table 2.4).

In order to not double count stressors that are often confounded, such as roads and urban development or active and inactive wells located adjacent to each other, the final scoring algorithm contained several sets of stressors for which a maximum value was taken in place of an additive value (Table 2.4). This was particularly necessary for local roads and land use. The land use model used for the Wetland LIM (LandFire Current Vegetation, see Appendix A), was the most recent, fine-scale, and accurate of the various land use/land cover models available for Colorado. However, small rural roads were often mapped in this model as "Developed open space" (value 21). Within urban areas, this value describes urban parks and recreation areas such as golf courses, for which an impact score should be assigned. However, when this value represents rural roads, it overlaps with the local and primitive roads from the linear roads layer. To not double count rural roads, "Developed open space" was weighted as low as possible in the model and only counted towards the final score when other stressors in the land use/development category were absent.

2.2.2 Model Results and Discussion

The Wetland LIM was applied to the entire state of Colorado (Figure 2.3). To summarize the final scores into meaningful classes, thresholds were chosen that represent five levels of potential stress or integrity across the landscape. The five classes and their value ranges were set as:

1) no discernable stress (values = 0)
2) low stress (values >0–333)

3) moderate stress (values >333–666)
4) high stress (values >666–1,000)
5) severe stress (values > 1,000)

A wetland immediately adjacent to an interstate highway or within a high intensity developed area would automatically receive a score of 1,000, meaning any additional stressor would drive the wetland into the severe stress class. Only areas in the landscape where all measured stressors were absent were placed in the no discernable stress class. Scores across the range could be derived from any number of combinations of stressors. This interpretation is appropriate for aquatic environments, which can experience stress and degradation due to a range of impacts.

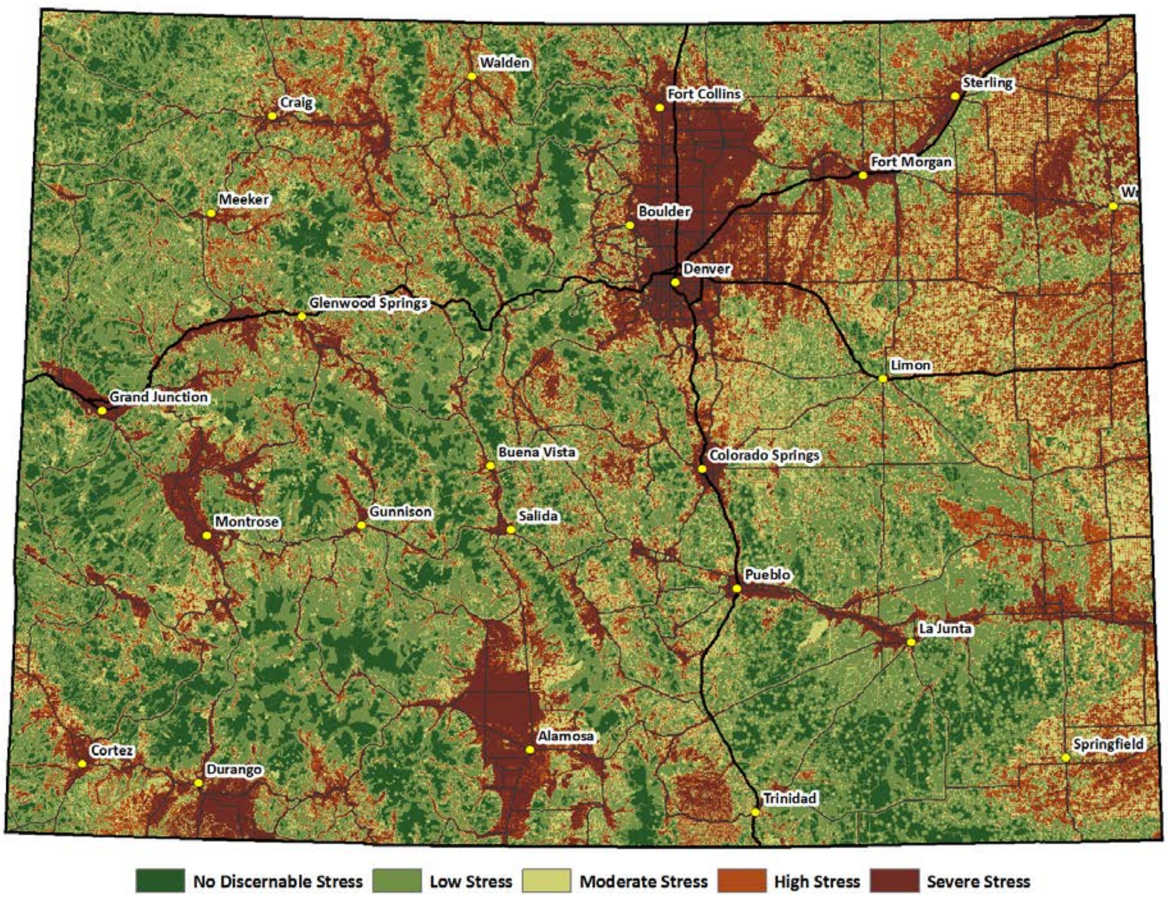

Figure 2.3. Wetland LIM developed for Colorado. Redder colors indicate higher stress and lower integrity; greener colors indicate lower stress and higher integrity. Black and gray lines on the map represent the interstate and state highway network.

When summarized across Colorado, nearly half the state falls within stressor class 1 or 2, indicating little or no stressors are found in nearly half the state (Figure 2.4). The second half of the state is split almost evenly between stressor classes 3, 4, and 5, with the severe stress class concentrated in highly urbanized areas (e.g., the Denver metropolitan area) and areas of intensive agriculture and hydrologic modification (e.g., the San Luis Valley). In general, a strong elevation gradient is evident across the state, with higher stress areas generally located at lower elevations. Low elevation areas in southeast Colorado, however, appear to maintain a relatively high degree of integrity. These results can be further broken down by major river basins (Table 2.6), revealing patterns across different areas of the state. River basins on the eastern plains (e.g., South Platte and Republican basins) generally contain more area modeled within the moderate, high, or severe stress classes, while river basins located at higher elevations contain more area modeled as no or low stress classes (e.g., Dolores and Gunnison basins). Patterns become even more evident when the data are summarized at finer spatial scales, such as river subbasins and counties. These values are shown in Appendix B and are summarized within the wetland profile reports on the Colorado Wetlands Inventory website.

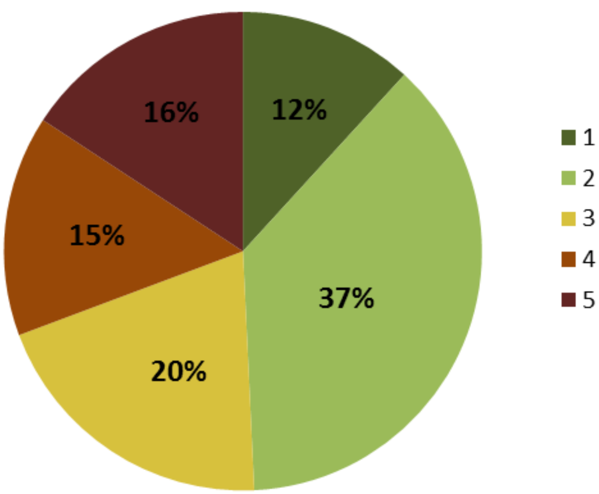

Figure 2.4. Breakdown of Wetland LIM stressor class for the entire state of Colorado. Stressor classes = 1) no discernable stress (model values = 0); 2) low stress (model values >0–333); 3) moderate stress (model values >333–666); 4) high stress (model values >666–1,000); and 5) severe stress (values > 1,000).

Table 2.6. Wetland LIM stressor classes by major river basin.

Major River Basins	No Discernable Stress	Low Stress	No and Low Stress Subtotal	Moderate Stress	High Stress	Severe Stress	Mod–Sev Stress Subtotal
Colorado Headwaters	14%	45%	**59%**	17%	11%	13%	**41%**
Dolores	23%	49%	**72%**	15%	7%	6%	**28%**
Gunnison	17%	46%	**63%**	16%	8%	13%	**37%**
North Platte	13%	35%	**48%**	20%	22%	10%	**52%**
Republican	0%	12%	**12%**	31%	34%	23%	**88%**
Rio Grande Headwaters	16%	37%	**53%**	15%	10%	22%	**47%**
San Juan	14%	34%	**48%**	17%	16%	19%	**52%**
South Platte	5%	27%	**33%**	21%	18%	28%	**67%**
Upper Arkansas	12%	43%	**55%**	22%	13%	9%	**45%**
White-Yampa-Green	16%	47%	**63%**	18%	12%	8%	**37%**

Several important caveats should be mentioned about the current Wetland LIM. For one, summarizing model results across the entire state or across an entire river basin does not necessarily reflect the breakdown of stressor classes for wetland areas. As this model is a continuous surface area for the entire state of Colorado, areas naturally unsuitable for wetlands are also included. In basins where wetland spatial data is complete, currently limited to the Rio Grande Headwaters and North Platte River basins, patterns in stressor classes for wetland area are much different than for the entire basin. In the Rio Grande Headwaters (discussed further in Section 3 of this report), the proportion of wetland area within the severe stress class was > 50%, while this value is < 25% across the entire basin (Table 2.7). This is largely related to the distribution of wetland acreage in the basin. In the Rio Grande Headwaters basin, wetlands are concentrated in the lower elevation San Luis Valley, which is characterized by agriculture and hydrologic modification and therefore higher stress. Until wetland mapping is completed for the entire state, this same comparison is not possible for most major river basins, but it should be assumed that similar patterns may be found.

Table 2.7. Comparison of Wetland LIM stressor classes within the Rio Grande Headwaters basin between the entire basin and area mapped as wetland.

Portion of basin	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
Entire basin	16%	37%	15%	10%	22%
Wetland area	6%	9%	7%	23%	56%

Secondly, the current model is based primarily on BPJ regarding the relative importance of the stressor layers included. To improve the accuracy of the model and to calibrate the weights given to individual stressors, CNHP will compare model results with data collected within wetlands across the state. A comparison of model values with field data has been conducted for the Rio Grande Headwaters river basin and is included in Section 3 of this report. Further analysis is currently being conducted for the North Platte River basin, study area for the second river basin scale wetland condition assessment project, and will be available in 2012. The Wetland LIM presented here should be considered provisional and unvalidated until further calibration has been conducted. In addition, datasets used for the model were at the scale of the entire state or greater, and none are guaranteed to be fully accurate or complete. Analyzing the results of the model at finer and finer scales will result in increasingly inaccurate results. Temporal aspects (i.e., seasonal fluctuations in water availability and use) are not addressed.

Another important caveat is that several major stressors, as well as threats that may become stressors in the future, are not integrated into the model. For instance, there is currently no way to include the effects of grazing in a landscape scale model. Consistent GIS-based data characterizing the intensity and frequency of grazing do not exist for the state. In some areas of the state, grazing may represent the most significant local scale impact faced by wetlands that the model would otherwise depict within a low stress class, particularly higher elevation forested areas leased for summer grazing or dry areas on the plains where wetlands are highly attractive to cattle. In addition to grazing, variables related to climate or vulnerability to climate change were not included. In a similar project to create a Wetland LIM for Montana, ecologists found that wetlands on the plains portion of their state showed lower field-based condition scores than their model predicted, which they attributed partly to a prolonged drought in the eastern plains and lowered resilience of wetlands within dry landscapes (Vance 2009). Climate variables, such as mean annual precipitation or potential evaporation, could be included in future iterations of the model, if they are found to be related to field-based condition scores. In addition to current or past climate variables, it would be interesting to include variables related to climate change vulnerability in order to forecast which areas of the state might experience a decline in wetland condition given certain climate change scenarios. This question is outside the scope of this project, but is important to consider for future research.

2.3 Colorado Wetlands Inventory Online Mapping Tool and Profile Page

To facilitate the transfer of this information to many different partners across the state, CPW and CNHP developed the Colorado Wetlands Inventory website. There are two main parts of the website, the online mapping tool and the wetland profile and summary page. Both are explained briefly below. As a dynamic and evolving website, the descriptions below represent the state of the website when this report was prepared. It is likely the site will change in coming months and years as more data are available and technological advances allow for increased functionality of the website design.

2.3.1 Colorado Wetlands Inventory Online Mapping Tool

The online mapping tool (Figure 2.5) was designed by CPW GIS Analysts and draws on years of experience within CPW's GIS team presenting spatial information through the Natural Diversity Information Source (NDIS)[10]. The mapping tool is built on an ArcIMS Flex platform using a standard template designed by CPW for many different mapping applications. The tool is hosted by CPW along with other NDIS online maps through a partnership with Colorado State University. The web address is: http://ndis-flex.nrel.colostate.edu/wetlands/maps/. Users can go directly to the mapping tool from this address, or can access the mapping tool from links on CNHP's website and the wetland profile and summary page (described below).

Through the mapping tool, viewers can see the status of selected mapping efforts (Table 2.1) and the actual mapped polygons themselves. In addition to the wetland datasets, the tool includes two data products created by CNHP:

- Potential Conservation Areas (PCAs) drawn for wetland and riparian dependent elements. These PCAs represent wetland and riparian areas with high biodiversity value across Colorado[11].
- The Wetland LIM (described in Section 2.2). This statewide model integrates stress from land use and development, resource extraction, and hydrologic modification into one seamless map, highlighting areas of high potential stress and low potential stress for aquatic resources.

[10] The Natural Diversity Information Source (NDIS) website (http://ndis.nrel.colostate.edu) provides mapping, data, information, and links to similar websites concerning hunting, fishing, wildlife, habitat, and conservation planning issues in Colorado. The NDIS website is designed to provide these services for multiple audiences with differing needs and levels of subject expertise. The general public can quickly access basic information, interactive maps, and links to similar websites; while conservation planners, biologists, and mapping professionals have ready access to much more detailed information, and digital (GIS) map layers for planning and analysis.

[11] For more information on Potential Conservation Areas, please see: http://www.cnhp.colostate.edu/download/dictionary/Data%20Dictionary%20for%20PCA%20Reports.pdf.

As a background, users can choose between streets, aerial photos, and topographic maps. Users can also toggle on and off supplemental information including county boundaries, two levels of USGS Hydrologic Units (major river basins and river subbasins)[12], two levels of EPA Ecoregions[13], and COMaP general land ownership[14].

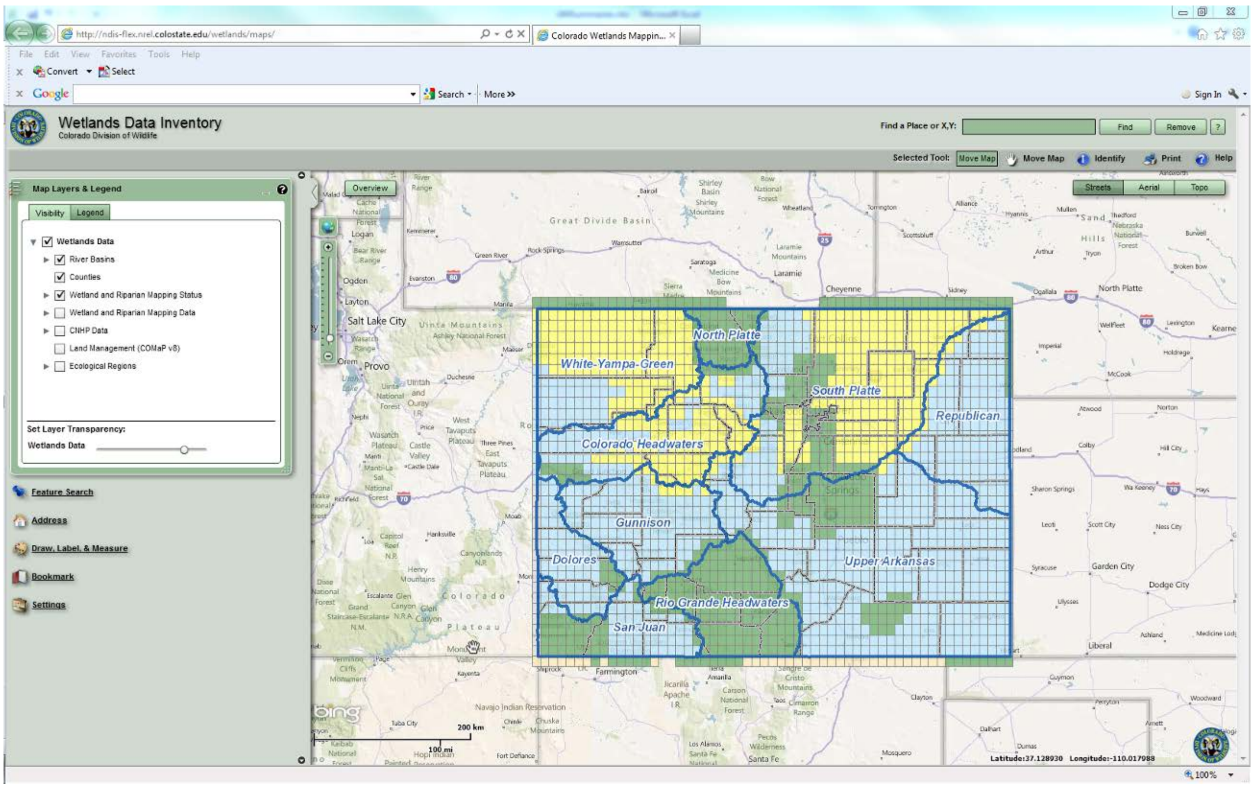

Figure 2.5. Opening page of the Colorado Wetlands Inventory Online Mapping Tool. Note menu boxes on the left hand side of the screen, which can each be expanded or collapsed, and tools in the upper right.

Several important features add functionality to the online mapping tool. The left hand side of the screen includes six menu boxes that can be expanded or collapsed individually (Figure 2.5). The first is "Map Layers and Legends" through which users and turn on and off the various layers and can view legends for selected data layers. The second is "Feature Search" through which users can search using either text strings or shapes drawn on the map. Searchable layers include: major river basins, river subbasins, counties, USGS topo quads, section township range, and CNHP PCA names. In addition to those specific layers, the "Address" menu box allows users to search based on a physical street address. A "Find Place or X,Y" tool is also built into the very upper right panel of the mapping tool that expands the search functionality even more by allowing users to input any place name or X,Y coordinates. Below the "Address" menu box is the "Draw, Label, & Measure" box. This box allows users to draw and measure shapes within the main mapping screen and to add text labels. These are useful if a user is interested in customizing a screen view in order to print it out for inclusion in a report or other document. The "Bookmark" menu box allows users to bookmark

[12] For more information on Hydrologic Units, please see: http://water.usgs.gov/GIS/huc.html.
[13] For more information on EPA Ecoregions, please see: http://www.epa.gov/bioiweb1/html/usecoregions.html.
[14] COMap is a statewide map of landownership, management and protection created for Colorado. For more information, please see: http://www.nrel.colostate.edu/projects/comap/.

particular views within the mapper, such as a particular wetland of interest. Lastly, the "Settings" menu allows users to change between different coordinate systems (e.g., UTMs vs. Lat/Long) and to set which data layers are displayed when using the "Identify" tool.

Along with the menu boxes within the left panel, tools in the upper right of the map allow users to move the map, identify feature, print sections of the map, and obtain more information through a help screen. Metadata will also be available by the end of August 2011 in the upper right section of the map. When the "Identify" button is used, several links will pop up that will direct the user to additional information. For instance, when a PCA is identified, the name and biodiversity significance will be shown along with a link to the descriptive PCA report on CNHP's website. By August 2011, links will also be shown for major river basins, river subbasins, and counties directing the user back to the CNHP Wetland Profile and Summary webpage.

2.3.2 Colorado Wetlands Inventory Wetland Profiles and Summary Page

The wetland profile and summary page is hosted on CNHP's website (http://www.cnhp.colostate.edu/wetlandinventory) and is the homepage for the Colorado Wetlands Inventory (Figure 2.6). The opening page contains an overview of the project with links to partner agencies. Along with an introduction to the Colorado Wetlands Inventory and the online mapping tool, the CNHP page also summarizes available wetland information shown in the mapping tool.

Figure 2.6. Opening page of the Colorado Wetlands Inventory, hosted on CNHP's website.

Wetland profiles and summary information are available at three different geographic scales:

- Major River Basins (modified HUC6s)
- River Subbasins (HUC8s)
- Counties

Four different summary reports are available for each geographic scale:

- Wetland profiles that describe the general geography of the area, the extent of wetland mapping, and the acreage of various wetland classes mapped by NWI
- A list of CNHP's wetland and riparian dependent PCAs within the area, including a link to the individual PCA reports
- A list of CNHP's tracked wetland and riparian dependent elements (plants, animals, and natural communities) found within the area, including a count of known occurrences
- A list of CNHP reports for projects that include information on wetland and riparian areas either within the specific area or applicable across the state or region

To access the profiles and summary reports, users select on a geographic scale of interest from the menus at the top of the page. Once the area of interest is selected, users are directed to the wetland profile page. To view CNHP data summaries, users can pick from the list on the left sidebar.

SECTION 3.0: RIO GRANDE HEADWATERS PILOT WETLAND PROFILE AND CONDITION ASSESSMENT

The Rio Grande Headwaters pilot wetland profile and condition assessment is the first project of its kind in Colorado. Major goals were two-fold: 1) to estimate the range of wetland condition in the basin using principles developed by EPA for large scale assessments and methodology developed by CNHP and 2) to test the effectiveness of these techniques and make recommendations for future studies. Rio Grande Headwaters was chosen as the pilot basin for three reasons: 1) it is a priority area for the CPW Wetlands Program due to abundant waterfowl habitat, 2) digital National Wetlands Inventory (NWI) data already existed for a portion of the basin before the project began, and 3) CNHP has conducted several projects in the area and is familiar with the range of wetland types. As a pilot, many valuable lessons were learned about carrying out a wetland assessment project at this spatial scale. These lessons are described throughout the report and will be applied to future projects.

3.1 Study Area

3.1.1 Geography

The Rio Grande Headwaters basin is located in south central Colorado (Figure 1.1). For the purpose of this project, the basin includes the entire Colorado portion of HUC6 130100: Rio Grande Headwaters and two small areas of HUC6 130201: Upper Rio Grande. The remaining majority of the Upper Rio Grande river basin is located in New Mexico. Within the study area, there are seven HUC8 river subbasins and 251 HUC12 watersheds (Figure 3.1).

The basin spans 133 miles (214 km) from east to west and 101 miles (163 km) from north to south, encompassing 4,830,001 acres (7,547 miles^2 or 1,954,630 ha). The center of the basin is characterized by the San Luis Valley, a broad high elevation valley flanked on three sides by rugged mountains. Elevation of the valley floor starts at 7,390 ft (2253 m)and rises steeply to the eastern Sangre de Cristo mountains, which top out at 14,343 ft (4,372 m), and more gradually to the western San Juan mountains, which also peak above 14,000 ft (4,267 m). The Continental Divide along the ridge of the San Juan Mountains delineates the west edge of the basin, dividing it from the neighboring San Juan and Gunnison river basins. To the east, the Sangres separate the basin from the Upper Arkansas. Great Sand Dunes National Park and Preserve sits in a bend of the western Sangre de Cristo foothills before they give way to the relatively flat and agricultural-dominated valley. The Cochetopa Hills and La Garita Mountains form the basin's northern border. The Colorado/New Mexico state line delineates the south side of the study area and much of the actual Rio Grande Headwaters HUC6 basin, while the Upper Rio Grande basin continues south into New Mexico. The southeast portion of the study area includes a smaller valley between the San Pedro Mesa and the Culebra Range, supporting geology and hydrology different from than the larger valley.

The San Juan Mountains are the headwaters for the 1,758 mile (2,830 km) Rio Grande River, which flows south through New Mexico before emptying into the Gulf of Mexico, with some of its flow delineating the Texas/Mexico border. Major headwater rivers in the basin that flow into the Rio

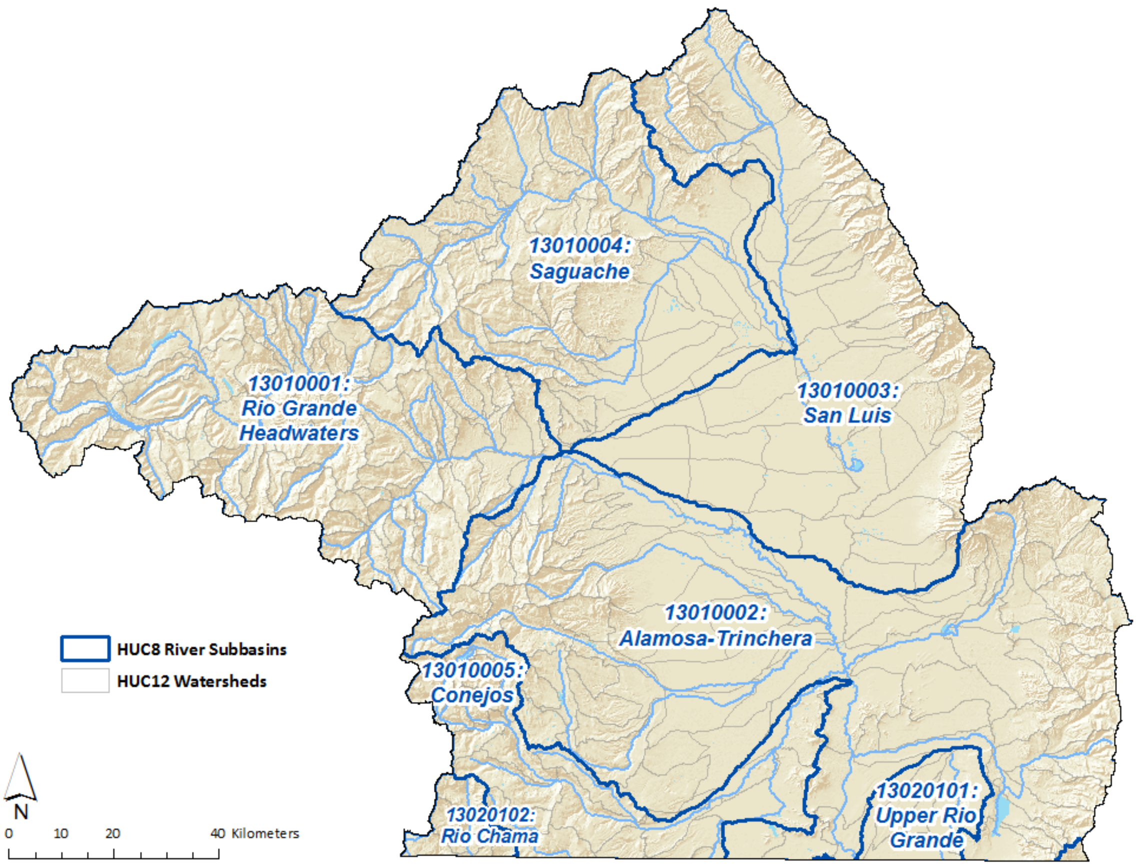

Figure 3.1. HUC8 river subbasins and HUC12 watersheds within the Rio Grande Headwaters basin.

Grande include the San Juan mountain tributaries of La Jara Creek, Alamosa River, and Conejos River and the Sangre de Cristo tributaries of Culebra, Ute, and Trinchera Creeks. The San Juan Mountains cover more land area and rise less abruptly from the valley than the Sangre de Cristos. As a result, the tributaries and rivers draining from the San Juans are more extensive and host more wetlands than the Sangres (Essington 1996 excerpted from Rondeau et al. 1998). Historically, flow from streams in the northern portion of the basin, including Saguache, La Garita, and San Luis Creeks, was naturally separated from the Rio Grande River. Surface flow from these creeks gradually sank into deep alluvial deposits in the east-central portion of the valley, recharging the valley's deep aquifer and creating a closed basin. Water use practices today, however, bring water from the northern streams into the Rio Grande drainage.

Collectively, the large size of the basin and the high variation in topography, elevation, and complex natural and artificial hydrologic dynamics support a broad array of plant communities and wildlife habitat. Level 3 Ecoregions (Omernick 1987) separate the mountain areas into the Southern Rocky Mountains Ecoregion and the valley floor into the Arizona / New Mexico Plateau. Level 4 Ecoregions divide the landscape into even finer units based on geology and dominant vegetation (Figure 3.2, Table 3.1). The mountain ranges are densely forested, while natural vegetation in the valley itself is dominated by sagebrush and greasewood (locally known as chico brush). Land use

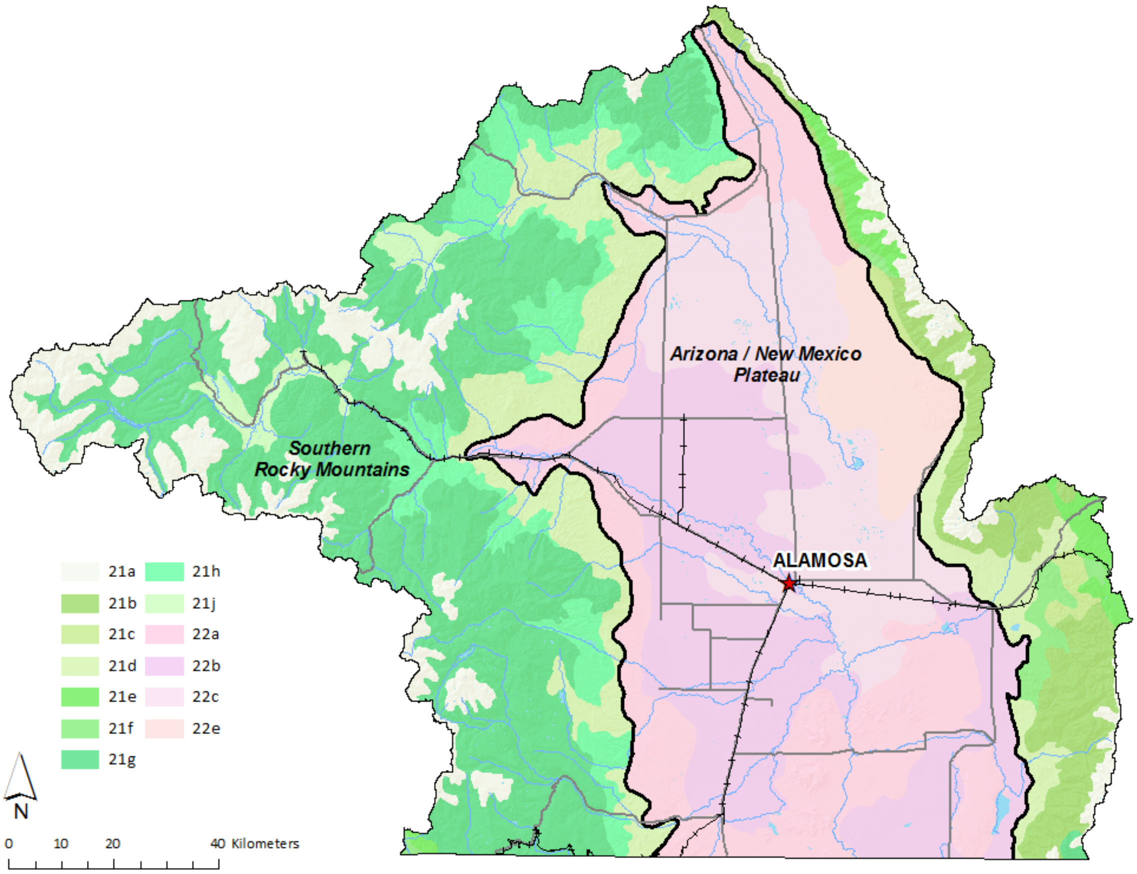

Figure 3.2. Level 3 and 4 Ecoregions within the Rio Grande Headwaters River Basin. Level 3 Ecoregions demarcated by the black like that separates the mountains from the valley. See Table 3.1 for Level 4 Ecoregion names.

Table 3.1. Level 3 and 4 Ecoregions within the Rio Grande Headwaters River Basin.

Level 3 / 4 Ecoregion		Acres	% of Basin
21	**Southern Rockies**	**2,704,962**	**56%**
21a	Alpine Zone	380,869	8%
21b	Crystalline Subalpine Forests	236,309	5%
21c	Crystalline Mid-Elevation Forests and Shrublands	29,815	1%
21d	Foothills and Shrublands	440,707	9%
21e	Sedimentary Subalpine Forests	68,970	1%
21f	Sedimentary Mid-Elevation Forests and Shrublands	45,058	1%
21g	Volcanic Subalpine Forests	1,135,558	24%
21h	Volcanic Mid-Elevation Forests and Shrublands	297,984	6%
21j	Grassland Parks	69,693	1%
22	**Arizona/New Mexico Plateau**	**2,125,039**	**44%**
22a	Shrublands and Hills	632,606	13%
22b	San Luis Alluvial Flats and Wetlands	776,027	16%
22c	Salt Flats	553,740	11%
22e	Sand Dunes and Sand Sheets	162,665	3%
Total		4,830,001	100%

oriented around center-pivot irrigation and grazing dominates the valley. The most common land cover type in the basin is Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland, which occupies much of the mountains; and second is agriculture (pasture/hay and cultivated crops), which occupies much of the valley. In the lowest regions of the basin, land covers are generally composed of drought tolerant plant associations (sagebrush and greasewood), some of which are adapted to saline environments. Increasing elevations give way to taller shrub-woodland dominance, such as pinyon-juniper woodlands, aspens, and increasing tree cover. Less than 1% of the study area supports medium-high intensity development within the major towns.

3.1.2 Geology and Hydrology

Geology and resulting hydrology of the Rio Grande Headwaters basin is among the most unique and complex in Colorado. The Rio Grande rift, initially formed 35–29 million years ago, marks the path of the Rio Grande River, and the rift's resulting depression forms the San Luis Valley (McCalpin 1996). Naturally, the northern half of the San Luis Valley is a closed basin spreading east to west from the San Juan Mountain foothills to the base of the Sangre de Cristos and south approximately to the city of Alamosa. Underneath the San Luis Valley and the closed basin lies an unconfined aquifer that drains southward into the Rio Grande River. The closed basin boundary is delineated in the south by a topographic divide formed from the Rio Grande River's large alluvial fan network. Alluvial sediments have been filling in the San Luis Valley for millions of years, separating the valley floor from bedrock by >3,000 ft (9100 m) and forming a sink that catches water from Saguache, La

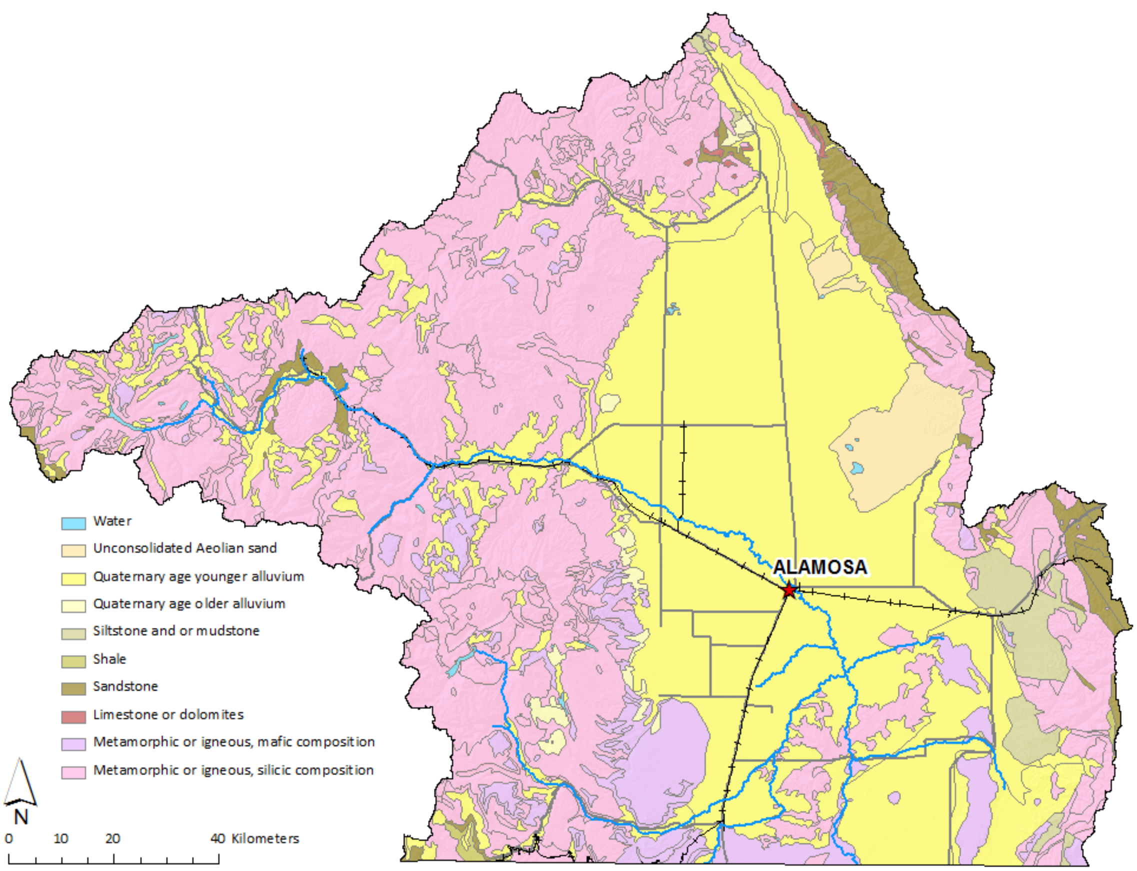

Figure 3.3. Dominant geology of the Rio Grande Headwaters basin.

Garita, and San Luis Creeks. Though most tributaries flow readily into Saguache and La Garita Creeks in the northwest, waters in the northeast draining the Sangre de Cristos often do not connect with the San Luis Creek, instead filtering through the alluvial fans into a deep aquifer. This water once recharged the creek through groundwater, but today is often diverted (in particular by the large Closed Basin Canal Project that connects the closed basin to the Rio Grande River). In some areas today, the historically perennial San Luis Creek runs only intermittently and wetlands on the floodplains are dry.

Parent geology of the basin's mountains is variously aged metamorphic and igneous rock with a dominant silica composition, with mafic insertions in the southern mountains (Tweto 1979; Figure 3.3). The far eastern and western sides of the basin transition into sandstone. The valley floor is mostly alluvium-formed substrates from the Quaternary age or younger, with Aeolian deposits of sandstone, and siltstone and mudstone inclusions abutting the eastern side of the Sangre de Cristos. Soil depths in the mountains range from shallow and rocky on slopes, to deep peat accumulating wetland soils. Valley soils are often alkaline and support halophytic vegetation. The most saline soils occur around the San Luis Lakes at the lowest point of the valley.

3.1.3 Climate

The climate of the Rio Grande Headwaters basin is characterized by long cold winters and moderate summers, with summer temperature highs averaging 87–96°F. Climatic conditions strongly vary between the valley floor and the mountains. As elevations increase, the mountains receive much more precipitation and temperatures drop. Mean annual temperatures average 35°F in the mountains and 42°F in the valley (WRCC 2011). The mountains both to the east and west create a double rain shadow and are responsible for the semi-arid/arid nature of the valley, yet snowmelt and runoff from the mountains are crucial to hydrating the foothills with runoff and the valley with groundwater. The San Luis Valley is Colorado's largest and driest montane valley (Rondeau et al. 1998). The watershed is wettest in July–August from monsoon rains, and averages 227–270 frost days (minimum temperature < 32°F). Precipitation averages 7 in (18 cm)/yr at the weather station in the valley floor at Alamosa and 20 in (51 cm)/yr at the Rio Grande Reservoir Station in the San Juans. Precipitation and snowfall increase substantially as mountain elevations increase, with an average 48 in (122 cm) precipitation and 436 in (1107 cm) snowfall annually at Wolf Creek Pass. In comparison, average annual snowfall is 32 in (81 cm) in the valley (WRCC 2011). Potential evapotranspiration (ET) is greater than precipitation (PPT) in the valley until the pinyon-juniper vegetation zone, where the ET/PPT line shifts to precipitation-dominant.

3.1.4 Ownership and Land Use

Historical artifacts display evidence of human use in the San Luis Valley >10,000 years ago. However, evidence also indicates that use of valley was likely intermittent for much of this time, perhaps due to inhospitable conditions. Following the Spanish settlement of New Mexico in the 1590s, sporadic episodes of conflict and attempted settlements occurred between the Spanish and Native Americans. In the 1840s, Spanish settlers set up permanent camps based on land grants from the Spanish throne and following the U.S./Mexican war, the town of San Luis was settled by New Mexicans in 1851. In the 1870s, U.S. settlement rates greatly increased following the discovery of gold in the San Juan Mountains. The pulses of land use interests by settlers were varied but intensive on the land; the agricultural economy has been the strongest and longest-lasting land use through today, including grazing, hay and food crop production, and the development of large ditch and reservoir networks. Other significant land uses have been bouts of mining camps and associated road developments, and later railroads and tourism.

Today, the Rio Grande Headwaters basin includes much of Alamosa, Conejos, Costilla, and Rio Grande counties, and portions of Archuleta, Hinsdale, Mineral, Saguache, and San Juan Counties. Public lands comprise 57% of the study area, and privately owned lands 43% (Figure 3.4; Wilcox et al. 2007), though the distribution of land ownership is not even across the basin. The valley is largely private except for the large Great Sand Dune National Park and Preserve at the basin of the Sangre de Cristos, three National Wildlife Refuges, and a number of smaller State Wildlife Areas. The foothills are generally under the Bureau of Land Management (BLM), while the surrounding mountains are managed by the Rio Grande National Forest (RGNF).

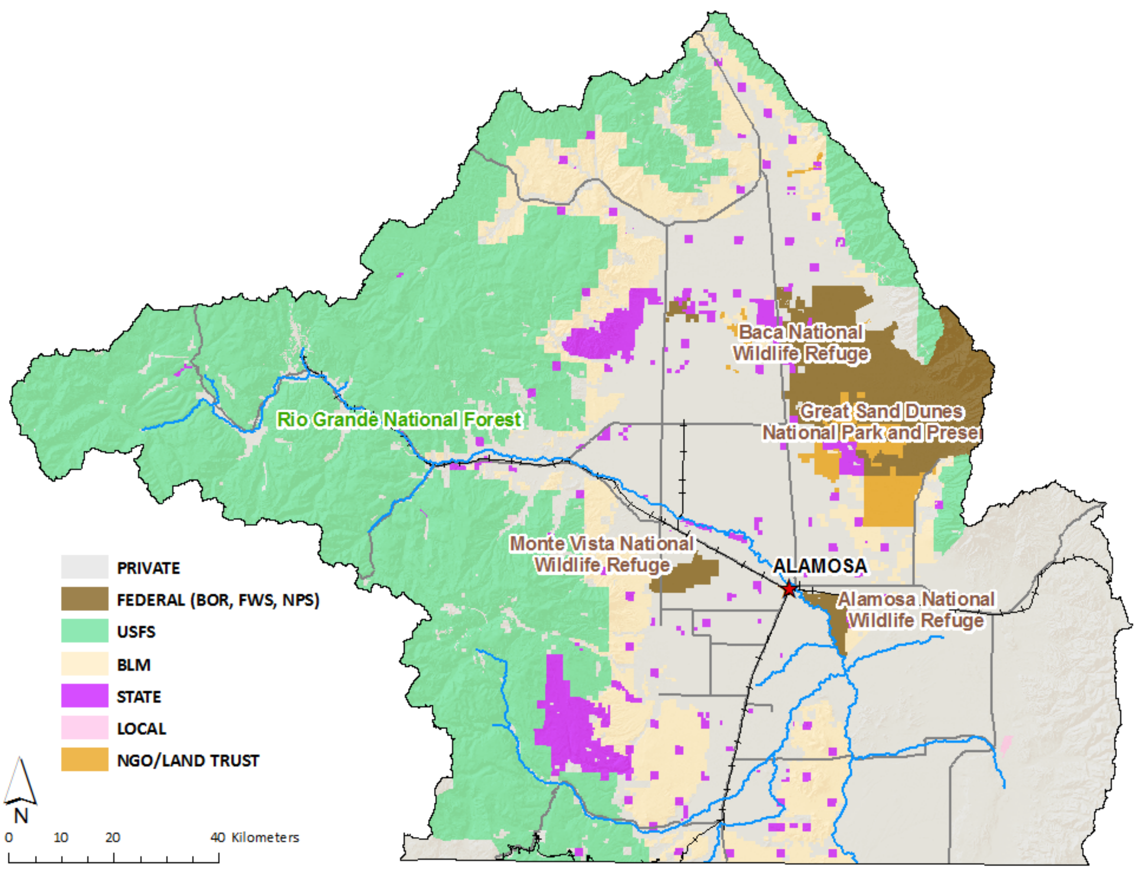

Figure 3.4. Land ownership within the Rio Grande Headwaters basin.

Irrigation management in the valley has a long history, and the current hydrologic regime is a product of complex relationships between shifting climates, hundreds of years of anthropogenic management, and millions of years of geologic disturbance that are difficult to tease apart. The valley has been irrigated since the 1630s or earlier with the arrival of Spanish settlers. But flood-irrigated acreage vastly increased in the 1880s to 1890s with the construction of major canal and ditch networks to divert water from the Rio Grande River system and reservoir construction to supply late season irrigation (Bexfield and Anderholm 2010). Within ~20–30 years, sub-irrigation raised water levels in the valley to the point of waterlogging and degraded soils with high alkalinity, which flooded the Rio Grande alluvial fan and probably altered the position of the divide between the closed and open basin. Records of groundwater pumping from wells, first for domestic purposes and later for irrigated agriculture, go back to the late 1880s, when pumping accessed both the confined and unconfined aquifers. Flood irrigation dominated the valley until the 1930s and 1950s, when droughts triggered more groundwater well dependence. The development of center-pivot sprinklers in the 1970s further magnified groundwater use, and groundwater pumping currently supplies >90% of irrigation and public water (Figure 3.5). Today, when surface water supplied to agriculture exceeds use, further diversion into groundwater recharge pits is encouraged to avoid unnecessary lowering of the unconfined water levels. With the completion of the Closed Basin Project in the 1990s, 'salvaged' groundwater is pumped from the unconfined basin at surface discharge points and piped directly to the Rio Grande River to avoid evapotranspiration loss, returning water to southern Colorado agriculture and New Mexico for water debt.

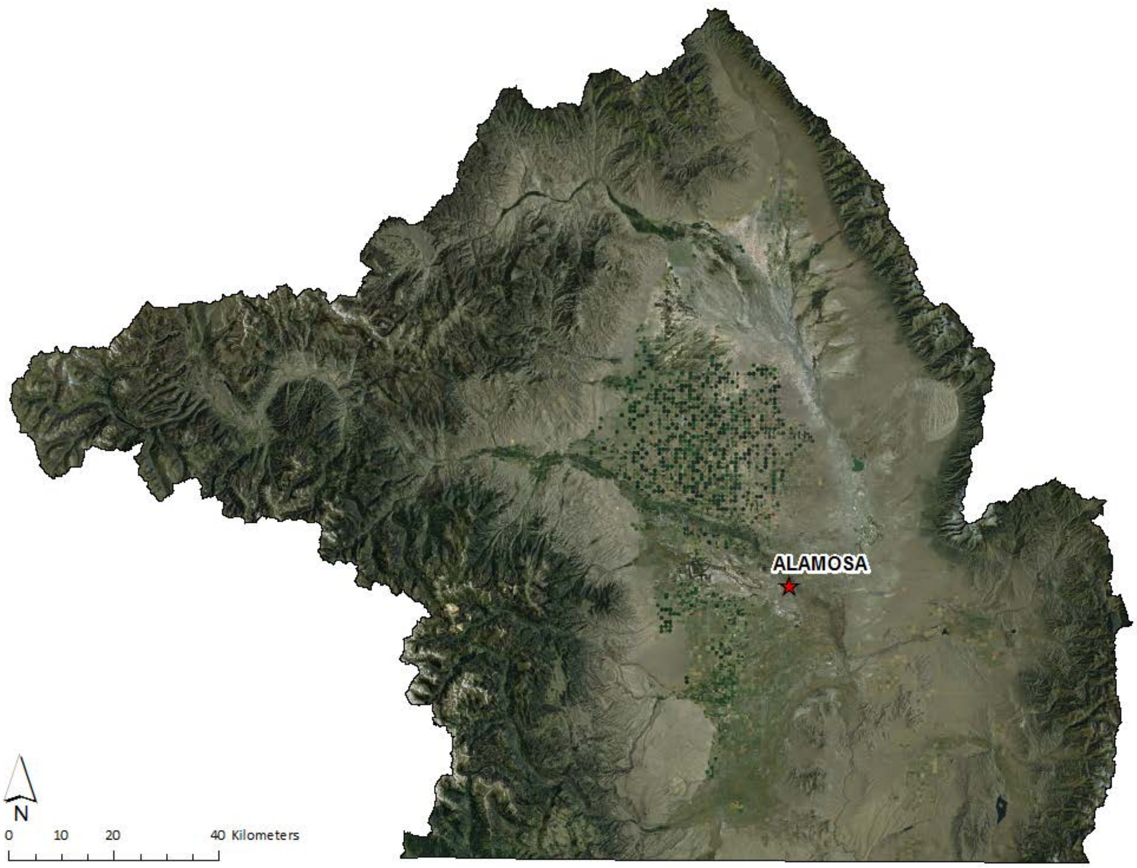

Figure 3.5. Aerial image of land cover within the Rio Grande Headwaters basin. Note prevalence of center-pivot irrigation in the central portion of the basin.

Evapotranspiration was historically the only significant discharge from the San Luis Closed Basin, but now irrigation is the major discharge and evapotranspiration is limited. When various water use and artificial return flow is stacked over hundreds of years, and as water is artificially transported between the open and closed basins, determining the nature and extent of hydrologic alteration becomes nearly impossible. These alterations are most obvious along stretches of rivers, such as San Luis Creek, where groundwater wells and diversions have drawn down flow almost completely, but the historic floodplain is still evident on the landscape.

3.2 Methods

Methods for the Rio Grande Headwaters pilot wetland assessment followed the EPA's Level 1-2-3 Framework for wetland assessment (Section 1.2.1). Wetland condition scores are reported out at each level within the framework.

3.2.1 Level 1 Assessment

Based on completed digital NWI mapping and ancillary data sources, a detailed wetland profile for the Rio Grande Headwaters river basin was prepared. The profile summarizes the extent of wetland acreage throughout the basin by Cowardin system/class, hydrologic regime, extent modified, extent irrigated, and land ownership. Summaries are also produced for HUC8 river subbasins and for the watershed strata used in the survey design (see Figure 3.7 below). Along with the wetland profile, a Level 1 assessment of wetland condition within the entire river basin, each HUC8, and each watershed strata was conducted based on the statewide Wetland LIM developed through this project (Section 2.2).

3.2.2 Level 2 & 3 Assessments: Survey Design and Site Selection

The following paragraphs detail the survey design for the field-based component of the Rio Grande Headwaters pilot wetland condition assessment, including the target population, classification, sample size, sample frame, and site selection rules. Modifications to the survey design between the 2008 and 2009 field season are spelled out. The survey design follows principles outlined by the EPA's EMAP program (Detenbeck et al. 2005).

<u>Target Population:</u> The target population for this study is all naturally occurring, vegetated wetlands within the study area. The target population does not include deep water lakes or artificial, unvegetated wetlands. A minimum size criterion of 0.2 hectares was also implemented. The operational definition used in this project is the USFWS definition used for NWI mapping (Cowardin et al. 1979):

> *"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."*

<u>Subpopulations/Classification:</u> The target population was classified into subpopulations based on groups that consist of one or more Ecological Systems (Table 3.2, Appendix C: Comer et al. 2003). Because elements within the sample frame (NWI polygons) were not attributed according to the Ecological System classification, these subpopulations were not part of the survey design *a priori*. Individual estimates of condition were calculated *post hoc* for subpopulations where sufficient data were collected.

Table 3.2. Subpopulations of the Rio Grande Headwaters pilot wetland condition assessment.

Subpopulation	***Ecological System***
1. Riparian areas	
	Rocky Mountain Subalpine-Montane Riparian Shrublands
	Rocky Mountain Subalpine-Montane Woodland
2. Wet meadows	
	Rocky Mountain Alpine-Montane Wet Meadows
3. Freshwater marshes	
	Western North American Emergent Freshwater Marshes
4. Fens	
	Rocky Mountain Subalpine-Montane Fens
5. Saline wetlands	
	Inter-Mountain Basins Playas
	Inter-Mountain Basins Alkaline Closed Depressions
	Inter-Mountain Basins Greasewood Flats

The Ecological System classification (Comer et al. 2003) is a component of the International Vegetation Classification System (Grossman et al. 1998, NatureServe 2004, Faber-Langendoen et al. 2009), developed by NatureServe and the Natural Heritage Network. It provides a finer scale of resolution than traditional wetland classification systems such as the 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. While Ecological Systems were the primary classification system used, each sampled wetland was also classified onsite by the Coward and HGM systems in order to report on numbers of sites and scores by those systems as well.

Sample Size: As a pilot project, it was difficult to estimate the exact number of sample sites that could be visited. As originally designed, the target number of sample sites was 176. This was reduced to 172 based on changes to the sample design for the 2009 field season (see explanation below). However, not all sites were able to be sampled given access issues and time constraints. Through two seasons of data collection (2008–09), 137 sites that fell within the target population were sampled. Sixteen additional sites were also sampled, but were removed from the dataset because they fell outside the target population.

Sample Frame: Initially, two spatial datasets were used for the sample frame. The primary dataset was existing digital NWI polygons, drawn in the early 1980s. From the NWI dataset, we eliminated all polygons that represent unvegetated surfaces, deep water lakes, and artificial hydrologic regimes following the decision rules in Table 3.3. A list of NWI codes included in the sample frame can be found in Appendix D.

Table 3.3. Decision rules for inclusion of NWI polygons in the sample frame.

No – do not use in sample frame
1) CLASS = Streambed OR Unconsolidated Bottom OR Unconsolidated Shore
2) SPC_MOD = Excavated
3) REGIME = Artificially * (any regime beginning with "Artificially")
Yes – do use in sample frame
1) SPC_MOD = Beaver OR Partially Drained / Ditched OR Diked / Impounded
2) Any other category not specifically mentioned

However, digital NWI mapping covered only 60% of the study area at the beginning of the project. Due to time constraints, we were unable to complete NWI digital mapping in advance of setting up the survey design. We were able to fill in targeted watershed (explained below), but not the whole basin. To supplement the digital NWI mapping, CPW's riparian and wetland mapping was also used. This dataset covered 30–40% of the study area, but overlapped with the NWI mapping in some places (Figure 3.6). From the CPW dataset, we eliminated polygons that represent irrigated agriculture, upland vegetation, and unvegetated surfaces. A list of vegetation categories from the CPW dataset excluded from and included in the sample frame can be found in Appendix D.

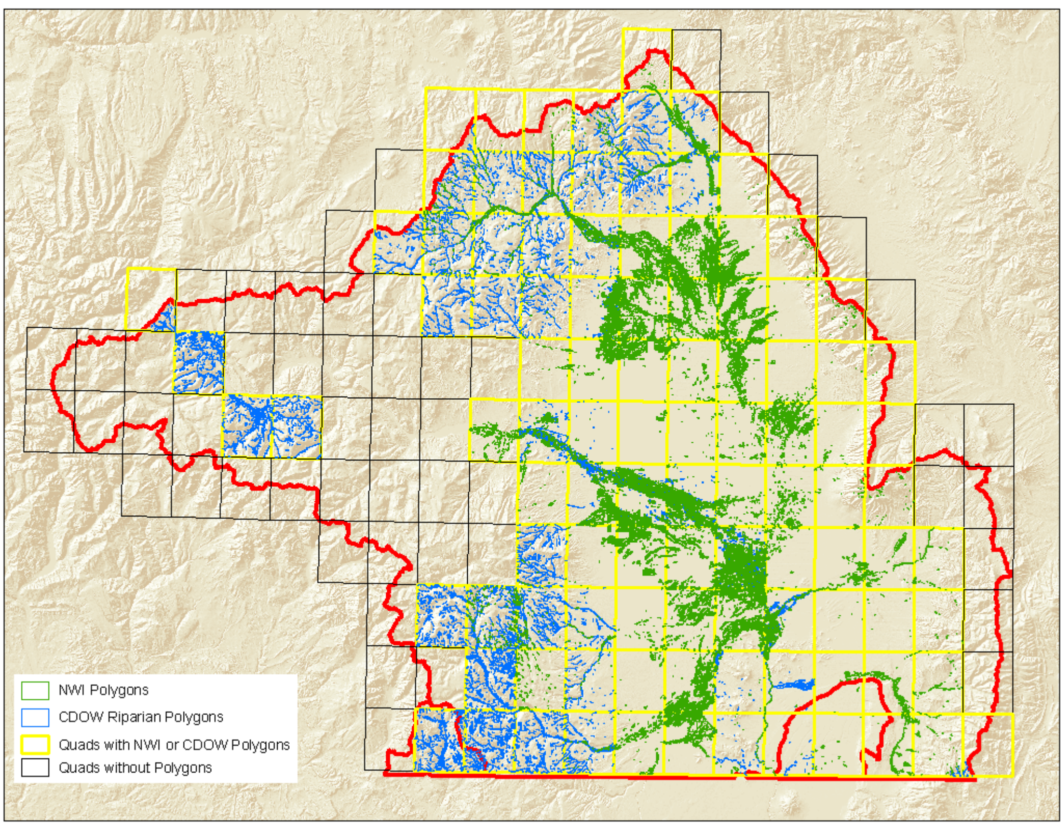

Figure 3.6. Coverage of both NWI and CPW (CDOW in figure) polygons at the beginning of the project. The quad index is included to show which quads have polygons.

To build the final sample frame, the two datasets were merged and all internal polygons lines were dissolved to form one dataset of all wetland area for which we had data. This merged polygon dataset was then converted into a 9-meter grid of potential sample points. A 9-meter grid was chosen as the smallest sample unit possible under the constraints of computer processing time and file size.

Site Selection Rules: Two important considerations influenced site selection rules within the survey design. The primary consideration was the incomplete sample frame. We could not select points across the entire study area because of large holes in the wetland mapping. We could, however, target specific areas to fill in wetland mapping prior to selecting points. The second consideration was the size of the study area and remoteness of the high mountains. We knew in advance that travel between regions of the study area could take hours and even days. A study design that produced clustered sample points would be more time efficient for sampling.

Given the above considerations, the study employed a two stage survey design. Target watershed were selected in stage one and target sample points were selected from within the target watersheds in stage two. To select target watershed, the study area was subdivided into regions of similar landscape properties. A hierarchical agglomerative cluster analysis of HUC12 watersheds was conducted in PC-ORD 4.39 (McCune and Mefford 1999) using variables related to elevation, climate, gradient, geology, Level IV Ecoregions, and landforms. The cluster analysis produced six clusters of watersheds, referred to as Watershed Strata. From these six strata, between three and

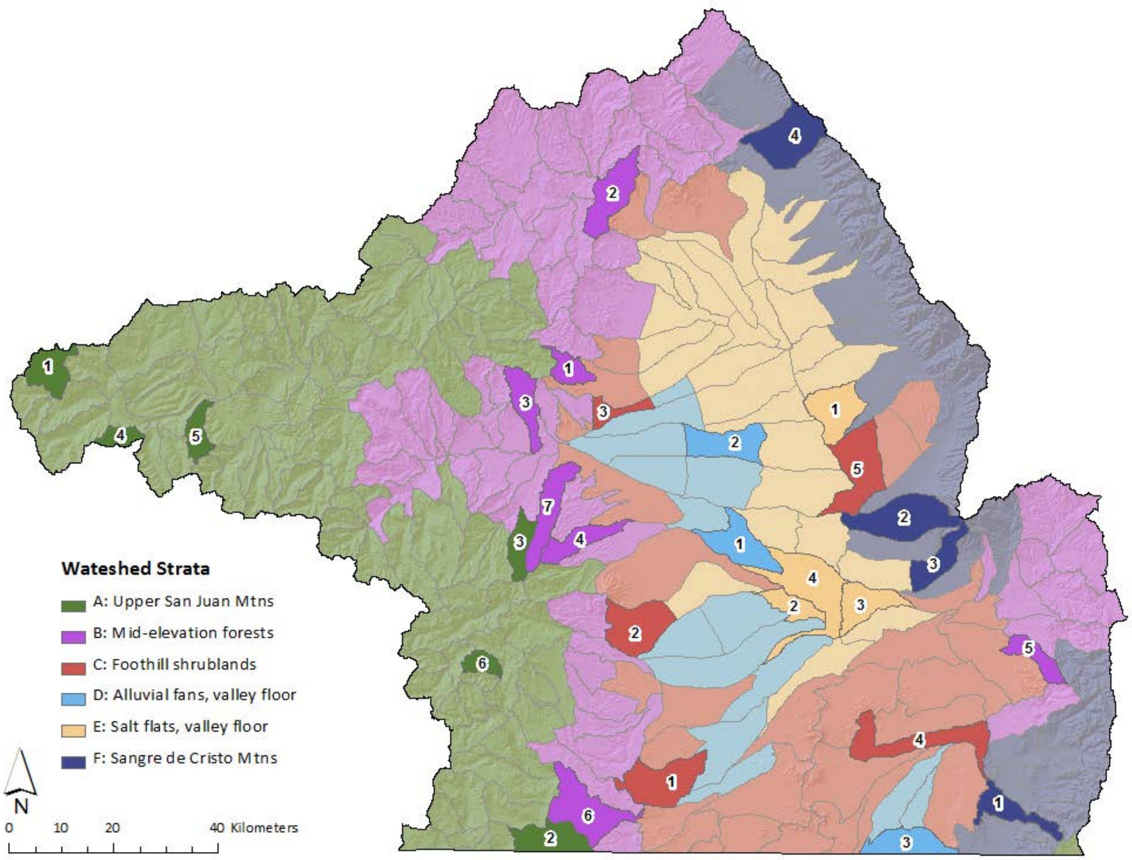

Figure 3.7. Target watershed selected from the six watershed strata produced through hierarchical agglomerative cluster analysis of landscape variables. Target watersheds are in bold color and are numbered according to the order they were selected.

six individual HUC12 watersheds were selected for sampling (Figure 3.7). The number of watersheds selected per stratum was relative to the total area occupied by that stratum, with three being the fewest possible selected watersheds and six being the greatest. Target watersheds were selected using the Reversed Randomized Quadrant-Recursive Raster process (RRQRR: Theobald et al. 2007) in ArcGIS 9.3 (ESRI 2008), a GIS-based approach to carrying out a Generalized Random Tessellation Stratified (GRTS) sampling design (Stevens and Olson 2004).

For stage two of the study design, target sample points were drawn from the selected HUC12 watersheds (Figure 3.8). For targeted watersheds that had no digital wetland data, paper maps of NWI polygons were scanned and digitized following the procedure described in Section 2.1.2 of this report. This included four entire watersheds and two partial watersheds. Within each target watershed, sample points were also drawn using the RRQRR process in ArcGIS 9.3. The number of sample points per target watershed (1–12) was based on the density of wetland area and was calculated by the following formula:

$$\# \text{ Target Sample Points} = 2 \text{ X } \ln(WD)$$

where WD = the density of wetland area within a watershed and ln is the natural log. WD is calculated by dividing the total area of wetland (represented by the total area within polygons of either the NWI or CPW dataset) by the total area of the watershed. This formula provided a systematic way to select the number of target sample points from among watersheds with vastly

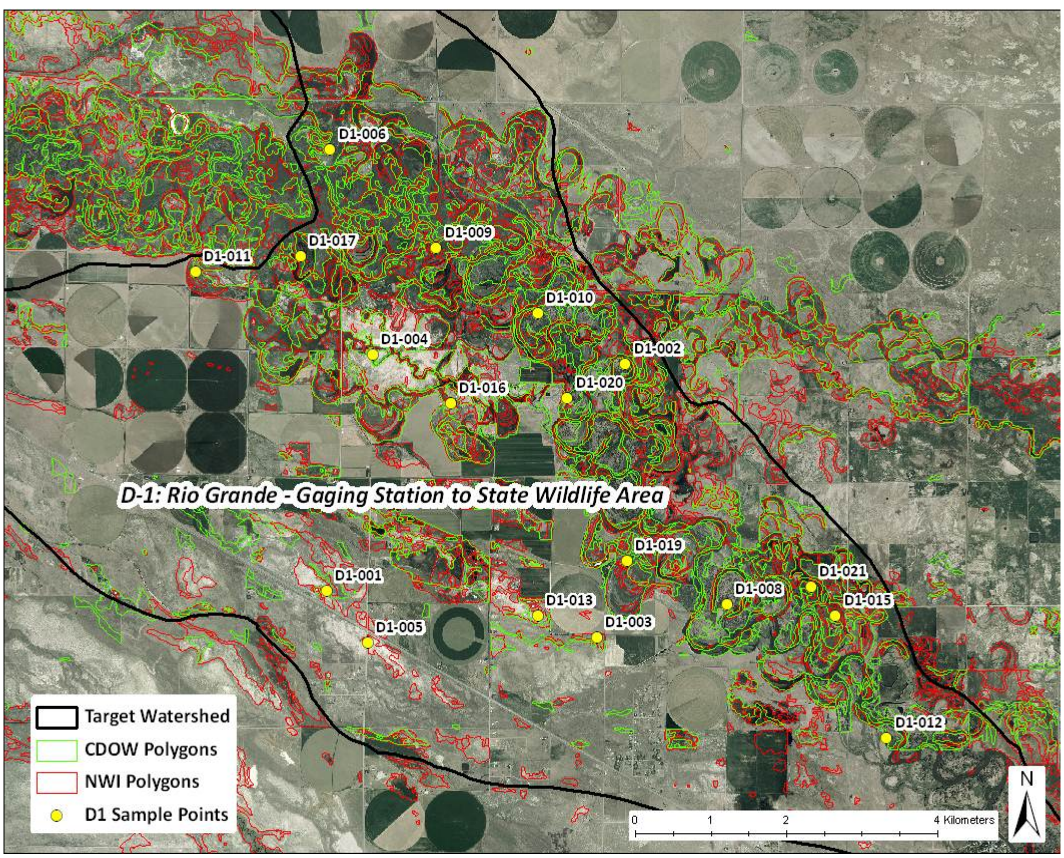

Figure 3.8. Example target watershed showing target sample points selected from either NWI mapping or CPW (CDOW on figure) riparian mapping.

different densities of wetland area. The targeted sample points were selected from within the grid of total wetland area and not from polygon centroids. Sample points based on area were chosen instead of polygon centroids because there is extreme variation in the size of contiguous wetland areas that form individual polygons.

Modifications for the 2009 Field Season: Based on lessons learned during the 2008 field season, changes were made to the survey design. The first involved the sample frame. During the 2008 field season, we learned that the NWI data more reliably represented our population of interest than the CPW dataset. CPW wetland and riparian mapping often included drier stream channels that did not meet our definition of wetland. This meant that several target points had to be rejected or were sampled and later removed from the dataset. Between 2008 and 2009, we were able to complete the conversion of NWI mapping into digital polygons for the entire basin. For all 2009 field work, this allowed us to only use points that fell within the NWI data and not the CPW riparian data. For watersheds with new NWI data, we re-ran the RRQRR point selection process and dropped points that only fell within CPW riparian mapping.

In addition to changes in the sample frame, we added one new watershed (B7) to the design because we had difficulty obtaining access to any private property in B-4. Because the watersheds are relatively small units some land owners own very large tracks of land, a handful of rejections mean that the entire watershed had to be removed from the design.

3.2.3 Level 2 & 3 Assessments: Field Methods

The field methods used in this project have been developed at CNHP with previous funding form EPA Region 8 and CPW. Field protocols are based on the Ecological Integrity Assessment (EIA) framework (see Section 1.2.2; Faber-Langendoen et al. 2008a, Lemly and Rocchio 2009a), which borrows from established wetland assessment methods such as the California Rapid Assessment Method for Wetlands (Collins et al. 2008) and the Ohio Rapid Assessment Method (Ohio EPA 2001). A rapid Level 2 survey using the EIA framework was carried out at all sites. This methodology took ~2 hours at each site and was based on draft EIA protocols developed for each wetland Ecological System (Rocchio 2006a-g). At roughly 50% of sites, intensive Level 3 vegetation data collection was carried out based on the Vegetation Index of Biotic Integrity (VIBI: Rocchio 2007a, Lemly and Rocchio 2009b). This method takes up to 4–8 hours and VIBI score calculations vary by Ecological System. For sites that did not include the full Level 3 VIBI survey, a rapid species list was compiled in order to calculate metrics from the Floristic Quality Assessment for Colorado Wetlands (Rocchio 2007b). See Appendix E for a copy of the field form, field form definitions, and example field maps. More detail on each protocol follows.

Defining the Wetland Assessment Area (AA): The AA is the boundary of the wetland (or a portion of the wetland) targeted for sampling and analysis. At each target sample point, the AA was defined as all wetland area of the same Ecological System (Comer et al. 2003) within a 100 m radius of the sample point. Prior to field visits, a set of two field maps were made for each targeted sample point. The field maps outline the potential AA boundary (100 m radius from the sample point), and a 100-m and a 1-km buffer around the AA.

Once at the target sample point, field crew members determined the extent of the 100 m radius circle considered the AA. This determination was made by first estimating the approximate boundaries of the wetland within the potential AA. Readily observable ecological criteria such as vegetation, soil, and hydrological characteristics were used to define wetland boundaries, regardless of whether they met jurisdictional criteria for wetlands regulated under the Clean Water Act. The second step was to delineate the targeted Ecological System present within the wetland boundary. Because field methods vary by Ecological System, it was important to focus the assessment on one Ecological System type. In most instances, the potential AA included only one Ecological System; but in some instances, there were more than one type within the area. For example, fens may occur along the margins of a valley and adjacent to riparian shrublands on the valley floor. Similarly, wet meadows with mineral soil are often interspersed with organic soil fens, depending on groundwater flow patterns. For such scenarios, it was necessary to delineate the boundaries of the separate Ecological Systems based on the minimum size criteria associated with each system. If an Ecological System patch is less than its minimum size, it was considered an inclusion within the type in which it is embedded. If the target sample point is at the edge of a wetland or at the edge of one Ecological System type, field crews were able to adjust the center of the AA up to 60 m to be more squarely the within wetland.

Vegetation Data Collection – Level 3 VIBI Plots: If the target sample point was selected for intensive Level 3 sampling, a 20 m x 50 m reléve plot was used to collect vegetation data. The method has been in use by the North Carolina Vegetation Survey for over 10 years (Peet et al. 1998), has been used to successfully develop a VIBI in Ohio (Mack 2001, Mack 2004a, Mack 2004b), and was used to develop the Colorado VIBI (Rocchio 2006h, Rocchio 2007b). The structure of the plot consists of ten 10 m x 10 m (100 m^2) modules typically arranged in a 2 x 5 array (Figure 3.9). The plot was subjectively placed within the AA to maximize abiotic/biotic heterogeneity. Capturing heterogeneity within the plot ensures adequate representation of local micro-variations in the floristic data produced by such things as hummocks, water tracks, side-channels, pools, wetland edge, micro-topography, etc. The following guidelines were used to determine plot locations within the AA[15]:

- The plot should be located in a representative area of the AA which incorporates as much microtopographic variation as possible.
- If the AA is homogeneous and there is no direction or orientation evident in the vegetation, the plot should be laid out either N-S or E-W using the second hand on a watch to determine which direction (00–29 seconds = N-S orientation; 30–59 seconds = E-W orientation).
- If the AA is not homogeneous, is oddly shaped, or is directional (i.e., follows a stream), the plot should be oriented so it adequately represents the wetland features. In the case of a riparian area, this may mean along the stream bank or cutting across the stream obliquely.
- If the wetland has an irregular shape and the 20 m x 50 m plot does not "fit" within the AA, the 2 x 5 array of modules can be restructured to accommodate the shape of the AA. For example, a 1 x 5 array of 100 m^2 modules can be used for narrow, linear areas and a 2 x 2 array of 100 m^2 modules can be used for small, circular sites.
- The plot should attempt to capture the range of diversity within the AA, but should avoid crossing over into the upland. No more than 20% of the plot should be in upland areas beyond the wetland. If end modules do cross into the upland, these should not be sampled as intensive modules.

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

- If a small patch of another wetland type is present in the AA (but not large enough to be delineated as a separate ecological system type), the plot should be placed so that at least a portion of the patch was in the plot.
- Localized, small areas of human-induced disturbance should be included in the plot according to their relative representation of the AA.

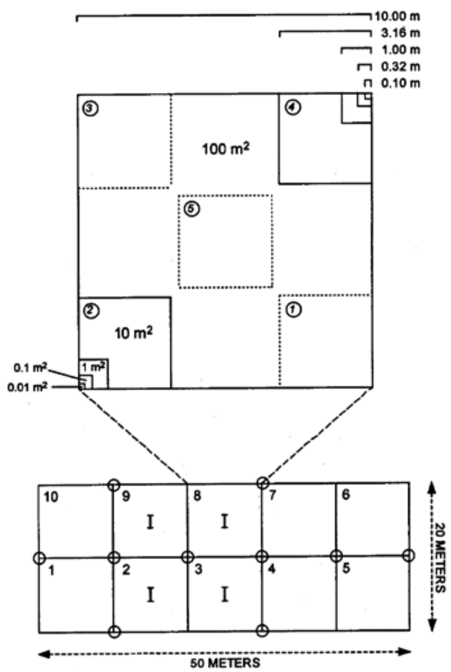

Figure 3.9. Relève Plot Method (from Peet et al. 1998). I = intensive modules. Nested subquadrats are shown in the inset diagram at the top.

Floristic measurements including presence/absence and abundance were made within at least four of the 100 m^2 modules, referred to as "intensive" modules. Within intensive modules, a series of nested subquadrats were established in two corners to obtain estimates of species composition at multiple spatial scales (1.0, 10, 100 m^2). The number of subquadrats in a nest is referred to as depth, where a depth of 3 indicates species presence was recorded in the 1.0 m^2 subquadrat, depth of 2 indicates 10 m^2, and depth of 1 indicates 100 m^2. Sampling began at the smallest subquadrat and each species identified within the module received a number corresponding to the depth at which it was initially encountered. Presence recorded for a particular depth implies presence at all lower-numbered depths, thus both corners were sampled before documenting species that occur at depth 1 (100 m^2). When all species within a module have been identified, cover was visually estimated at the level of the 100 m^2 module using the following cover classes (Peet et al. 1998):

1 = trace (one individual)
2 = 0–1%
3 = >1–2%
4 = >2–5%
5 = >5–10%
6 = >10–25%

7 = >25–50%
8 = >50–75%
9 = >75–95%
10 = >95%

After sampling each of the intensive modules, the remaining (residual) modules were walked to document presence of any species not recorded in the intensive modules. Percent cover of these species was estimated over the entire 1000 m^2 plot. Nomenclature for all plant species followed Weber and Wittmann (2001a, 2001b). Further details on VIBI plot layout can be found in (Rocchio 2007b).

Plant specimens were collected for any unknown species encountered in the vegetation surveys. Specimens were also collected of rare species (only if the population was large) or other unique occurrences (such as a species range extension) to document the population. All specimens were pressed in a plant press as soon as practical, dried, and stored for later identification. Specimens were identified at the completion of each field season by a trained botanist with experience in Rocky Mountain wetland species. Nomenclature for species identification followed Weber and Wittmann (2001a, 2001b), but many other botanical resources, including existing herbarium collections, were used to ensure accurate identification. All identifications were stored in a database and were integrated with the field-collected data during data entry and QA/QC. At the completion of this project, high quality specimens will be prepared and submitted to local herbaria (University of Colorado, Boulder, or the Rocky Mountain Herbarium at the University of Wyoming, Laramie).

Vegetation Data Collection – Level 2 Non-VIBI Plots: If the target sample point was not selected for a full VIBI plot, vegetation data was collected in a plotless sample design. All species present within the AA were identified and listed on the field form and, for most plots, the overall cover within the AA was visually estimated using the same cover classes as the VIBI plots. Cover class was not estimated for a handful of Level 2 sites early in the 2008 field season, but this protocol was changed shortly into the season when the field crew decided that an overall cover class estimate would be easy to carry out. The search for species was limited to no more than one hour to minimize the amount of time spent at the site.

EIA Metrics and the Human Disturbance Index: For every target sample point surveyed, the EIA field form (Appendix E) was filled out according to the Ecological System type of the AA. Prior to this project, CNHP had developed draft EIA protocols for seven wetland Ecological System types in the Southern Rocky Mountain Ecoregion[16]:

- Subalpine-Montane Riparian Shrublands
- Subalpine-Montane Riparian Woodlands
- Lower Montane Riparian Woodlands and Shrublands
- Subalpine-Montane Fen
- Alpine-Montane Wet Meadow

[16] All seven draft EIA reports were authored by Joe Rocchio in 2006 and are available on the documents and reports page of the CNHP website: http://www.cnhp.colostate.edu/reports.html.

- North American Arid Freshwater Marsh
- Intermountain Basin Playas

For the Rio Grande Headwaters wetland condition assessment, EIA metrics for all seven wetland types were combined into one field form for ease of use in the field. Of the seven draft protocols, only one had been field tested prior to this project (Lemly and Rocchio 2009a). The rest were considered in early development and a major objective of this pilot study was to determine which metrics were meaningful and feasible to collect when applied across a large landscape.

In addition to the metrics included in the EIA Scorecards, information related to human disturbance was collected using the Human Disturbance Index (HDI), a semi-quantitative index that provides an independent measure of alteration (Rocchio 2007a, Rocchio 2007b). The HDI is an estimate of the degree to which each site has been impacted by human disturbance. This method assumes that the absence of historic and/or contemporary human disturbance indicates that the wetland possesses biotic and ecological integrity and that increasing human disturbance results in a predictable deviation from the ecological reference condition. The HDI uses several of the same metrics included in the EIA protocols, as well as metrics employed in other rapid wetland condition assessment methods (Ohio EPA 2001, Montana DEQ 2005, Collins et al. 2008). HDI metrics that were in addition to the EIA metrics were also integrated into the field form and were pulled out during data analysis.

<u>Additional Data Collection:</u> In addition to the vegetation data and EIA/HDI metrics, standard site variables were collected from each sample location. This included:

- UTM coordinates (0m and 50m end points if VIBI plot, AA center if not VIBI plot)
- Elevation, slope, and aspect
- Place name, county, and land ownership
- Ecological System classification (Comer et al. 2003)
- Classification of plant association(s) (Carsey et al 2003)
- HGM classification (Brinson 1993)
- Cowardin classification (Cowardin et al. 1979)
- Nearby landforms (alluvial fans, narrow bedrock valley, alluvial valley, etc.)
- Description of onsite and adjacent ecological processes and land use
- Description of general site characteristics and a site drawing
- Selected soils data: depth and identification of soil horizons, texture, and color
- Water table depth
- Water pH, conductivity, and temperature measured using a Hanna Instruments hand-held meter (Model # HI98129)

At least four photos were taken at each site (Figure 3.10). For sites sampled with Level 3 intensive protocols, the four photos included one photo at the 0 m point looking down the center line, one photo at the 50 m point looking down the center line, and one photo from each side of the plot looking across the plot and perpendicular to the plot center line. If the site was sampled using Level 2 rapid methods, the four photos were taken at the plot center facing the four cardinal directions. For all standard photos, placards were placed in the very corner of the photo with the Plot ID written on the placard. Additional photos were taken as need to document the wetland and surrounding landscape.

Figure 3.10. Example plot photos for the Rio Grande Headwaters condition assessment.

<u>Modifications for the 2009 Field Season:</u> Based on lessons learned during the 2008 field season, one significant change was made to the field protocols. It became clear throughout the 2008 field season that the nested corners in the vegetation plot extended the sampling time significantly. Vegetation plots alone took up to 6–8 hours to complete, which left little time for the other components of the protocol. It was important to be able to carry out the entire set of protocols for a site within 6 hours, as most sites also required 1–4 hours of transportation time. To expedite the vegetation sampling, the nested corners were removed from the protocols (Figure 3.11). A full plant list and cover value estimates were still collected in four intensive models, but without requiring a separate search at each depth.

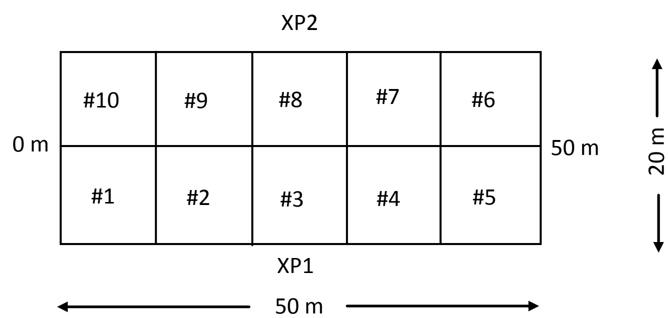

Figure 3.11. Schematic of the 20 m x 50 m vegetation plot without nested corners. This plot was used in the 2009 field season.

3.2.4 Level 2 & 3 Assessments: Data Management

To efficiently store and analyze data collected from the wetland condition assessment, a Microsoft Access™ database was built by a database specialist at CNHP. EIA/HDI metrics and vegetation data were entered into the database at the completion of each field season. For VIBI plots, relative and mean cover values for each species were averaged across the intensive modules for use in data analysis. For those species only occurring in the residual plots, the cover value for the residual plots was used for analysis. To eliminate spelling errors, a pre-defined species list was used for species entry. During data entry, if a number in a couplet from the nested corners (depth/cover) was missing, it was assumed that the species was present in the plot and that the second value was simply overlooked. For these situations, a default value of 1 was entered no matter whether the missing value was depth or cover. Unknown or ambiguous species (e.g., *Carex* sp.) were entered into the database, but not included in data analysis. Data entry was reviewed by an independent observer for quality control.

The species table from the Colorado FQA (Rocchio 2007b) was used as the pre-defined species list and to populate life history traits, wetland indicator status, and C-values in the database for each species in each plot. The FQA species table was updated and modified when converted to Microsoft Access™ in 2008 and species primary nomenclature now follows Weber and Wittmann (2001a, 2001b), though all names are cross-referenced to the nationally accepted names in the US Department of Agriculture's PLANTS Database[17]. Life history traits and cover data were used to calculate FQA and VIBI metric values using Visual Basic queries programmed in the database. Calculations made by the queries were randomly checked to ensure that the queries were constructed correctly.

3.2.5 Level 2 & 3 Assessments: Data Analysis

<u>Characterization of Wetland Vegetation:</u> To characterize wetland vegetation across the Rio Grande Headwaters basin, summary statistics on species abundance and distribution were compiled and multivariate analyses were conducted on vegetation community composition. We used Nonmetric Multidimensional Scaling ordination (NMS: Kruskal 1964, Mather 1976) to analyze patterns in species variation across all wetland sites and to investigate relationships between species composition and a secondary matrix of sampling variables, environmental variables, and condition class.

The species matrix (137 plots x 355 species) consisted of species presence/absence data by plot, as species percent cover data was not recorded at all sites in the field. Species that occurred in ≤ 2 plots (304 of 659 species recorded) were dropped from the dataset to reduce noise. The species matrix was transformed with Beal's smoothing because the data had high beta species diversity between plots, a high coefficient of variation, and numerous zeros (McCune and Grace 2002).

Sampling variables were selected to assess if plot species composition was affected by temporal effects, size, or level (intensity) of sampling. Environmental variables were selected using available GIS and field-recorded data that may affect species gradients in Rio Grande Headwaters wetlands. Condition class was based on overall EIA score and category scores (see below). The secondary matrix (95 plots x 31 variables) was assessed for covariance between plots by species and sampling effects, environmental attributes, and plot condition.

The ordination identified 6 of 137 plots as outliers (SD > 2.0). Deleting either the three largest or all the outliers resulted in a similar plot scatter, similar strengths of relationships to the secondary matrix, and nine new outliers. The outliers were not biologically anomalous. All the initial outliers were in the A5 watershed, and the secondary outliers were in the A5, A1, and D1 watersheds. The A watershed strata included wetlands on the high end of the wetland integrity gradient and many wetlands sampled were in good condition. Therefore, all outlier plots were retained in analyses to facilitate comparisons of wetlands across a broad range of wetland condition.

The ordination settings used were the Sorensen Distance Measure, and the 'slow and thorough' autopilot setting in PC-ORD 5.32 (McCune and Mefford 2006). The final PC-ORD recommended 2-D solution had a low final stress of 5.9 (final instability =0.0001, 500 iterations). All randomized runs had stress < observed stress (P=0.004; Monte Carlo tests with 250 runs).

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

Level 2 Analysis: For all sites sampled, data collected with either the Level 2 or Level 3 protocols were used to calculate FQA metrics (Rocchio 2007b). One FQA metric (Mean C) is included in the Biotic Condition category of the EIA protocol (see below) and represents one of the single strongest measures of biotic wetland condition (Lemly and Rocchio 2009a). For all sites sampled, FQA metrics are shown both independently and as a component of the EIA scores.

EIA metrics were used to calculate Level 2 scores for each site visited in the Rio Grande Headwaters basin. Scores were calculated for each major ecological category, as well as the overall Ecological Integrity score. The hybrid field form created for this project included many EIA metrics that were suggested in the draft EIA protocols prepared in 2006 (Rocchio 2006a-g). During the 2008–09 field seasons and subsequent analysis, each metric was evaluated based on field crew members' ability to consistently rate the metrics and whether the metric discriminated between high and low integrity sites. This evaluation was aided by a rigorous field test of the Subalpine-Montane Riparian Shrubland EIA protocols (Lemly and Rocchio 2009a), which was completed midway through this project. Several metrics on the field form were discarded or modified as a result. The final set of EIA metrics is summarized in Table 3.4. Final metric narrative ratings are included as Appendix F.

Table 3.4. Final EIA metrics used for the Rio Grande Headwaters pilot project.

Ecological Categories	Key Ecological Attributes	Indicators and Metrics
Landscape Context	Buffer	1a. Average Buffer Width 1b. Buffer Condition
	Landscape Connectivity	1c. Percent Unfragmented Landscape 1d. Riparian Corridor Continuity[1]
Biotic Condition	Community Composition	2a. Relative Cover Native Plant Species 2b. Absolute Cover Noxious Weeds 2c. Absolute Cover Aggressive Native Species 2d. Mean C
	Community structure	2e. Native Saplings and Seedlings[2] 2f. Interspersion of Patches
Abiotic Condition	Hydrology	3a. Hydrologic Alteration[3] 3b. Upstream Water Retention[1] 3c. Water Diversions / Additions[1] 3d. Floodplain Interaction[1] 3e. Bank Stability[1] 3f. Beaver Activity[1,4]
	Physiochemistry	4a. Water Quality – Sediment and Turbidity 4b. Water Quality – Algal Growth 4c. Substrate / Soil Disturbance

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

The last Level 2 assessment tool calculated for this project is the HDI score. While similar to the EIA, the HDI includes a handful of different metrics, does not include vegetation metrics associated with the FQA, and focuses instead on major causes of human-induced stress. The HDI utilizes three major categories of stressors, listed in Table 3.5 with their respective metrics.

Table 3.5. HDI metrics and stressor categories.

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

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

Each metric has descriptive criteria indicating the number of points assigned to it. The two highest indicator scores for each metric are summed, then multiplied by a weighting factor (0.33 for Buffer/Landscape Context and Physical/Chemical Disturbances; 0.34 for Hydrology) to arrive at a final score ranging from 0 (reference condition; no/minimal human-induced disturbance) to 100 (highly impacted). See Lemly and Rocchio (2009b) and Rocchio (2007a) for more details on the HDI.

To estimate overall wetland condition across the basin, FQA, EIA, and HDI scores were summarized by watershed strata. Each watershed stratum represents a different proportion of the wetland area within the basin. Summaries by strata, paired with the proportion each stratum represents, illustrate the range of overall condition within the basin. Scores are also summarized by Ecological System group (wetland type) to illustrate the range of condition for each type.

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

Comparison of Level 1, 2, 3 Methods: To understand how each method performed in the basin and to further guide methodology development, results from each assessment level were compared using linear regression and Spearman's rank correlation coefficients.

3.3 Results

3.3.1 Level 1 Assessment Results: Wetland Profile and Wetland LIM

Wetland Profile of the Rio Grande Headwaters Basin: The Rio Grande Headwaters river basin covers 4,830,001 acres of south central Colorado. Based on digital NWI mapping, there are 282,804 acres of wetland and water bodies within the basin, representing just under 6% of the total land area (Table 3.6; Figure 3.12). It is important to note that NWI mapping includes deep water bodies, such as lakes and river channels, that are important aquatic resources but are not considered wetlands. In the Rio Grande, lakes and rivers comprise only 17,433 acres or 6% of the total NWI acres. The vast majority (84%) of the mapped acres are Palustrine Emergent or freshwater herbaceous wetlands. When lakes and rivers are excluded, herbaceous wetlands make up nearly 90% of all wetlands. Shrub wetlands are the second most common class, but make up only 7% of all NWI acres and 8% of wetland acres.

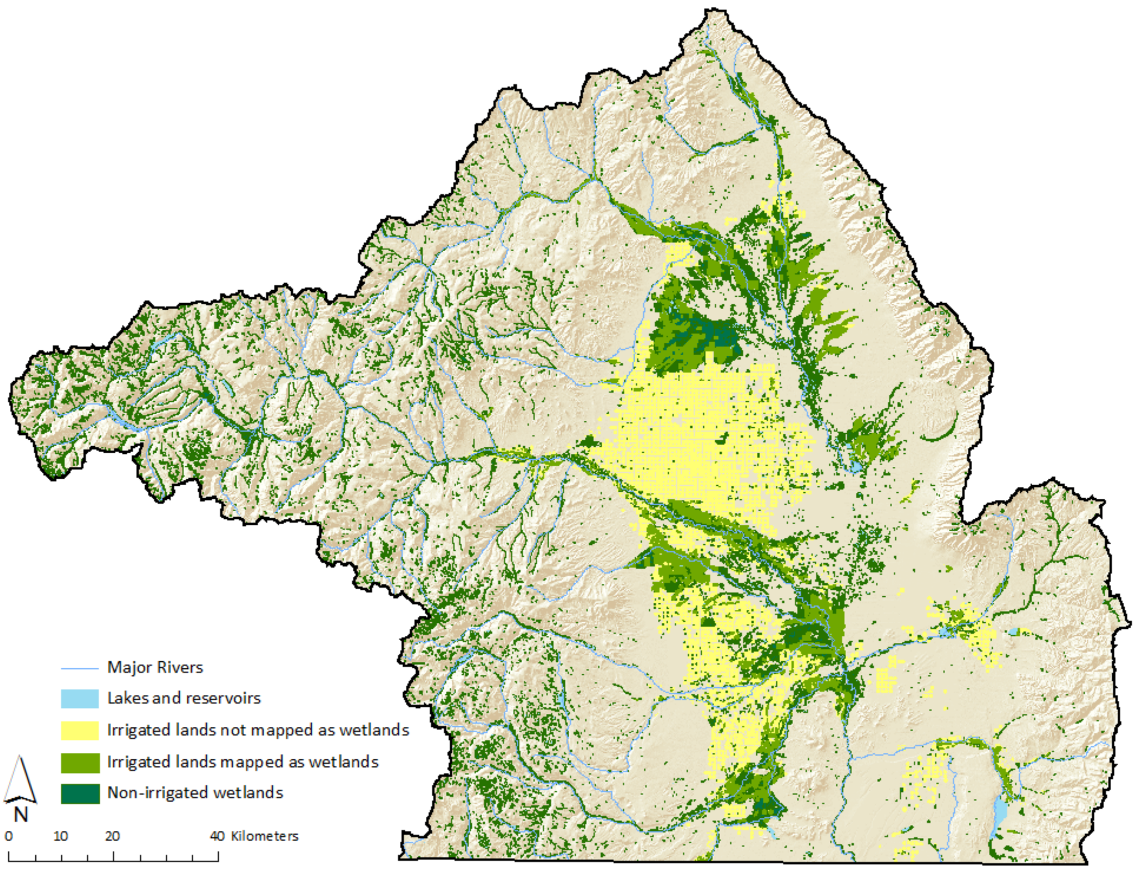

Figure 3.12. Digital NWI mapping in the Rio Grande Headwaters basin, including extent of lands mapped as both wetlands and irrigated. Lighter green polygons represent lands mapped as both wetlands and irrigated. Darker green polygons represent lands mapped only as wetlands. All polygons are buffered slightly to improve visibility.

When broken down by hydrologic regime, temporarily and seasonally flooded wetlands are the most common, comprising 47% and 23% of wetland acres, respectively (Table 3.7). These hydrologic regimes represent wetlands that are wet for a few weeks to a few months each year, but typically dry down by the end of the growing season. Saturated wetlands, which maintain high groundwater tables throughout the growing season, make up 13% of wetland acreage. Another 12% of wetland acres are classified as intermittently flooded. This is the driest hydrology regime and represents ephemeral wetlands that may only be wet during certain years, such as playas and other precipitation driven systems. Nearly all of these wetlands occur on the valley floor. Wetter hydrologic regimes of semi-permanently flooded and intermittently exposed account for few acres of wetlands, comparatively (3% and 1%, respectively). The permanently flooded regime is used almost exclusively for lakes.

Table 3.6. Wetland acreage in the Rio Grande Headwaters River Basin by NWI System / Class.

NWI Code	NWI System / Class	Wetland Type (Common Name)	All NWI Acres	% Wetlands & Waterbodies	% Wetlands (excl. Lakes & Rivers)
L1/2	Lacustrine	Lakes	11,607	4%	NA
R2/3/4	Riverine	Rivers	5,826	2%	NA
PUB/US	Palustrine Unconsolidated Bottom/Shore	Unvegetated Ponds/Shores	1,738	1%	1%
PAB	Palustrine Aquatic Bed	Vegetated Ponds	5,490	2%	2%
PEM	Palustrine Emergent	Herbaceous Wetlands	236,553	84%	89%
PSS	Palustrine Scrub-Shrub	Shrub Wetlands	20,111	7%	8%
PFO	Palustrine Forested	Forested Wetlands	1,478	1%	1%
Total Wetlands & Waterbodies			282,804	100%	NA
Total Wetlands (excl. Lakes & Rivers)			265,371	NA	100%

Table 3.7. Wetland acreage in the Rio Grande Headwaters River Basin by NWI hydrologic regime.

NWI Code	NWI Hydrologic Regime	Degree of Wetness (1 = driest, 7 = wettest, artificially flooded not included)	All NWI Acres	% Wetlands & Waterbodies	% Wetlands (excl. Lakes & Rivers)
A	Temporarily Flooded	2	124,871	44%	47%
B	Saturated	4	35,065	12%	13%
C	Seasonally Flooded	3	63,854	23%	23%
F	Semipermanently Flooded	5	9,514	3%	3%
G	Intermittently Exposed	6	4,290	2%	1%
H	Permanently Flooded	7	11,048	4%	< 1%
J	Intermittently Flooded	1	32,509	11%	12%
K	Artificially Flooded		1,652	1%	1%
Total Wetlands & Waterbodies			282,804	100%	NA
Total Wetlands (excl. Lakes & Rivers)			265,371	NA	100%

The NWI classification includes several modifiers that describe aspects of human and natural alteration. Three human-induced modifiers were used in the Rio Grande basin (excavated, dammed/impounded, and ditch/drained) and one natural modifier was used (beaver influenced). The vast majority of acres were not mapped with a modifier (94% of all NWI acres and 97% of wetland acres: Table 3.8). For certain wetland classes, however, there are exceptions. Within the basin, 73% of all lakes are mapped with a dammed/impounded modifier, indicating that most lakes are reservoirs of one kind or another. Some are entirely created while others are natural lakes that

Table 3.8. Wetland acreage in the Rio Grande Headwaters River Basin by NWI modifier and extent irrigated. All NWI acres shown, with totals for wetlands only in the last row. For NWI codes associated with each wetland type, see Table 3.6.

Wetland Type	No modifier		Excavated		Dammed / Impounded		Ditched / Drained		Beaver Influenced		Irrigated Wetlands[1]		
	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	% of Irrigated Wetlands
Lakes	2,984	26%	167	1%	8,456	73%	-	-	-	-	237	2%	< 1%
Rivers	5,795	99%	31	1%	-	-	-	-	-	-	15	< 1%	< 1%
Ponds/Shores	1,079	62%	414	24%	244	14%	-	-	-	-	89	5%	< 1%
Vegetated Ponds	2,649	48%	1,428	26%	927	17%	2	< 1%	484	9%	517	9%	1%
Herbaceous Wetlands	232,809	98%	329	0%	3,212	1%	5	< 1%	198	< 1%	92,633	39%	99%
Shrub Wetlands	18,924	94%	8	< 1%	235	1%	20	< 1%	924	5%	512	3%	1%
Forested Wetlands	1,476	100%	1	< 1%	1	0%	-	-	-	< 1%	31	2%	< 1%
Wetlands & Waterbodies	265,716	94%	2,379	1%	13,075	5%	28	< 1%	1,607	1%	94,033	33%	100%
Wetlands (excl. Lakes & Rivers)	256,936	97%	2,181	1%	4,619	2%	28	< 1%	1,607	1%	93,781	35%	

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

have been modified to increase water holding capacity. Roughly a quarter of both vegetated and unvegetated ponds are mapped as excavated and another 14 and 17% (respectively) are mapped as impounded. These represent stock ponds, stormwater retention ponds, and other modified or created small ponds. Beavers influence only 1% of all wetland acres, but 9% of vegetated ponds are mapped as beaver ponds and 5% of shrub wetlands are mapped with beaver influence.

Another important aspect of human modification to wetlands is the degree to which they are affected by irrigation. Some wetland acres have developed on historic uplands due to long term flood irrigation practices that maintain higher water tables than the natural hydrologic regime. Other irrigation-influenced wetlands are historically natural, but are augmented by irrigation flows. It is very difficult to tease apart the differences between these two classes of irrigation influenced wetlands, but it is possible to estimate the extent of all wetlands affected by irrigation to one degree or another. By overlaying a GIS layer of irrigated acres produced by the Colorado Water Conservation Board (CDSS 2009) with the NWI wetland acres, it is possible to estimate the proportion of wetlands that are influenced by irrigation (Figure 3.12). Within the basin as a whole, roughly a third of wetlands are irrigated and these acres are overwhelmingly (99%) freshwater herbaceous wetlands (Table 3.8). Among all herbaceous wetlands, nearly 40% are irrigated. In many cases, these irrigated wetlands are actively managed as hayfields and harvested during most years, but they still provide important services such as water retention and wildlife habitat.

When broken down by major landowner, 66% of wetland acres are privately owned (Table 3.9). Private landowners own a relatively greater share of wetland acres than they do of total area within the basin. This is largely because the density of wetland acres is greater on the valley floor, where private landownership is concentrated, than in the publically owned mountain areas. This may also be because private landowners are more likely to be irrigating hay pastures, which can increase wetland acreage. Roughly 40% of privately owned wetland acres are irrigated, which makes up 75% of the total irrigated wetland acreage. The Rio Grande National Forest (RGNF) owns and manages the second highest share of wetland acres (15%), though they own 38% of the total basin land area. Less than 1% of wetland acres on the RGNF are irrigated. The U.S. Fish and Wildlife Service (USFWS) owns 10% of wetland acreage in the basin, much greater than their 2% share of total land area. Of their acres, 62% are irrigated, making up the only other major share of irrigated acres (18% of all irrigated wetland acres). Lands owned by the USFWS are generally managed for the purpose of creating or enhancing wetland habitat for wildlife species. There are three major National Wildlife Refuges within the San Luis Valley: the Alamosa, Monte Vista, and Baca National Wildlife Refuges. All three are highly productive feeding and breeding grounds for waterfowl. For the USFWS, irrigation is used to manage water levels for optimum plant growth to provide nesting cover and feeding areas for waterbirds. Wetland acreage by public land owner and specific management unit is presented in Appendix K.

A similar breakdown of wetland acres by class, hydrologic regime, and land ownership for each of the seven HUC8 river subbasins, each of the six watershed strata, and each Level 3 and 4 Ecoregion is provided as Appendix G. These analyses show how geographic differences across the basin affect wetland distribution. Wetlands are more concentrated in subbasins and watershed strata on the valley floor and less so in the higher elevations. However, the range of wetland types is greater at higher elevations, where there are more shrub wetlands, lakes, rivers, and ponds.

Table 3.9. Wetland acreage in the Rio Grande Headwaters River Basin by grouped land owner and extent irrigated.

Grouped Owner	Total Land Area within Basin		Total NWI Acres within Basin		Irrigated Wetlands		
	Acres	% of Basin	Acres	% of NWI Acres	Acres	% Irrigated	% of Irrigated Wetlands
Federal Lands							
Rio Grande National Forest	1,813,976	38%	42,768	15%	6	< 1%	< 1%
Bureau of Land Management	498,004	10%	2,711	1%	34	1%	< 1%
National Park Service	136,976	3%	2,462	1%	905	37%	1%
U.S. Fish and Wildlife Service	111,734	2%	27,598	10%	17,076	62%	18%
U.S. Bureau of Reclamation	3,065	< 1%	2,675	1%	783	29%	1%
Other U.S. Forest Service	1,309	< 1%	32	< 1%	-	-	-
State Lands							
State Land Board	147,165	3%	8,070	3%	1,204	15%	1%
Colorado Division of Wildlife	13,761	< 1%	3,409	1%	1,030	30%	1%
Colorado State Parks	340	< 1%	309	< 1%	-	-	-
Other							
Private	2,045,526	42%	186,650	66%	70,056	38%	75%
Land Trusts	56,754	1%	6,059	2%	2,877	47%	3%
Counties	1,391	< 1%	62	< 1%	61	99%	< 1%
Total	4,830,001	100%	282,804	100%	94,033	33%	100%

Wetland Landscape Integrity Model: Results from the Wetland LIM for the Rio Grande Headwaters basin show that although only 22% of total basin area falls within the severe stress category, this number is much higher for wetlands themselves (Table 3.10, Figure 3.13). Across the basin, more than half of all wetland acres fall within the severe stress category. This is largely due to the distribution of wetland acres, which are more concentrated on the valley floor and therefore affected by roads and development, agriculture, and hydrologic modification (Figure 3.14). Certain wetland types are more affected by modeled stressors than others. The most severely stressed wetland types include forested wetlands, rivers, and herbaceous wetlands. Lakes and shrub wetlands, more common at higher elevations, are the least stressed.

Modeled stress on wetlands also shows strong patterns related to land ownership (Table 3.11). Wetlands managed by RGNF are the least stressed across the basin, with 35% and 44% of acres falling within the no or low stress classes. In comparison, private wetland acres, and wetlands owned by USFWS, CPW, and Land Trusts are all ~60% within the severe stress class. A breakdown of Wetland LIM stress classes for each HUC8 subbasin, watershed strata, and Ecoregion is shown in Appendix H.

Table 3.10. Wetland LIM stressor class for wetlands by major wetland type. Percentages are given for NWI mapped acres in all cases except the bottom row, which shows stressor classes for all area within the basin.

Wetland Type	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
Lakes	5%	42%	25%	17%	12%
Rivers	1%	11%	10%	15%	63%
Ponds/Shores	10%	10%	13%	19%	47%
Vegetated Ponds	14%	14%	6%	13%	52%
Herbaceous Wetlands	4%	6%	6%	24%	60%
Shrub Wetlands	24%	28%	7%	14%	27%
Forested Wetlands	1%	1%	2%	18%	78%
All Wetlands & Waterbodies	6%	9%	7%	23%	56%
Entire Basin	16%	37%	15%	10%	22%

Table 3.11. Wetland LIM stressor class for wetlands by major landowner. Percentages are given for NWI mapped acres in all cases except the bottom row, which shows stressor classes for all area within the basin.

Grouped Owner	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
Federal Lands					
Rio Grande National Forest	35%	44%	10%	7%	4%
Bureau of Land Management	< 1%	9%	19%	37%	35%
National Park Service	2%	25%	14%	32%	27%
U.S. Fish and Wildlife Service	-	2%	8%	32%	58%
U.S. Bureau of Reclamation	-	< 1%	2%	14%	85%
Other U.S. Forest Service	14%	75%	10%	-	-
State Lands					
State Land Board	3%	10%	18%	30%	40%
Colorado Division of Wildlife	< 1%	7%	9%	25%	60%
Colorado State Parks	-	41%	26%	18%	14%
Other					
Private	< 1%	2%	5%	24%	68%
Land Trusts	-	4%	10%	26%	60%
Counties	-	-	-	1%	99%
All Wetlands & Waterbodies	6%	9%	7%	23%	56%
Entire Basin	16%	37%	15%	10%	22%

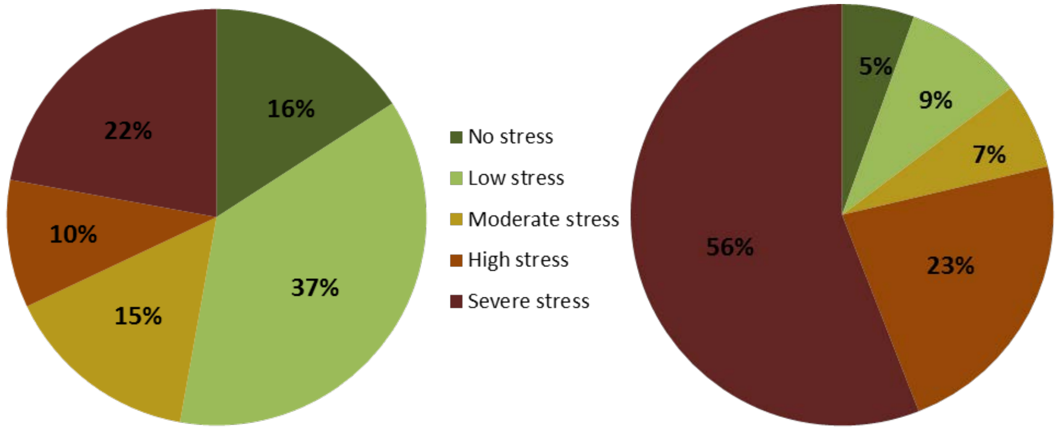

Figure 3.13. Comparison of Wetland LIM stressor classes for the entire Rio Grande Headwaters basin (left) and all NWI acres within the basin (right).

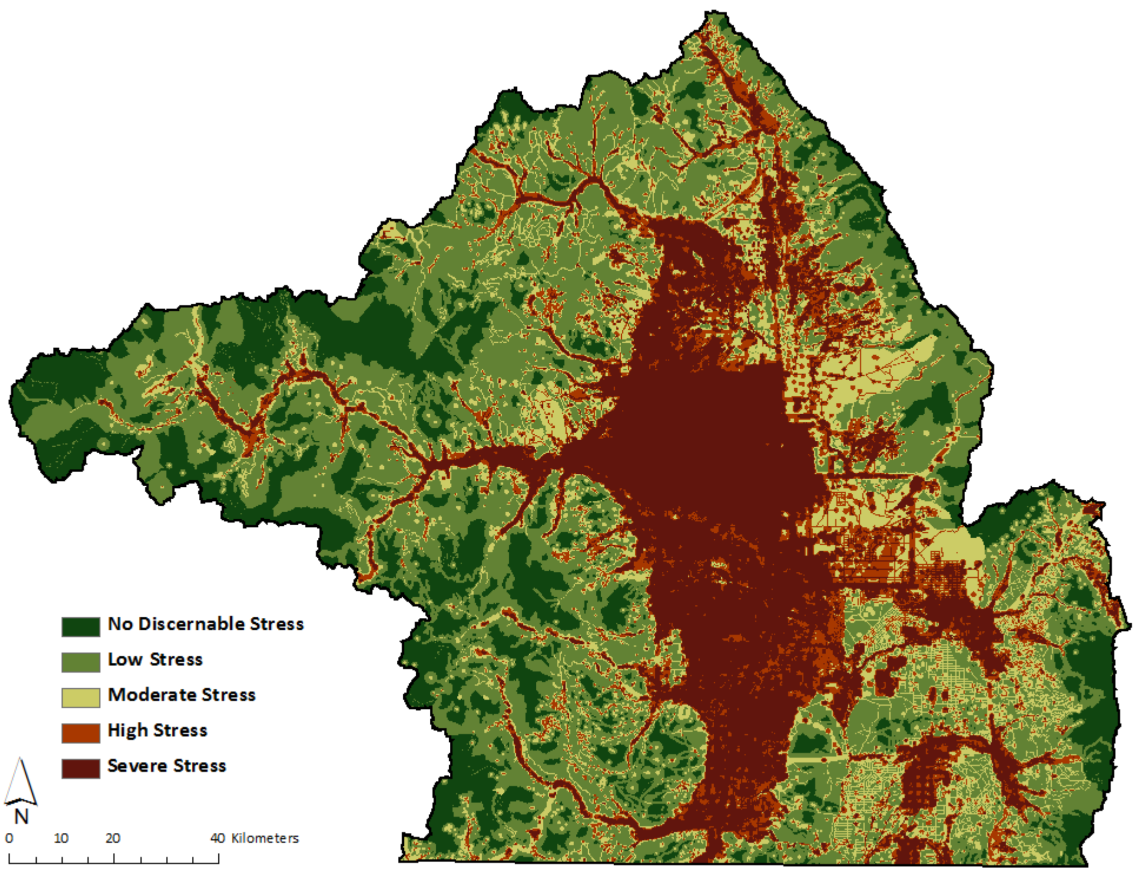

Figure 3.14. Map of Wetland LIM stressor classes across the Rio Grande Headwaters basin.

3.3.2 Level 2 & 3 Assessment Results: Sampled Wetlands

During the summers of 2008–09, 137 wetland sites were surveyed for Level 2 & 3 assessments (Figure 3.15). Sample sites were selected from target watersheds based on the survey design outlined in Section 3.2.2. Based on the original design, 176 sites were targeted, though modifications in 2009 reduced this number to 172 (Table 3.12). Difficulty obtaining access to private lands and the time needed to carry out each survey, however, limited our ability to sample all target sites. As a pilot project, it was unclear in the beginning how many sites could be sampled during the project period and not meeting the original target was not surprising. Wetlands that were sampled spanned each watershed strata. The success rate of accessing and sampling wetlands was highest in the A watersheds, which represent the Upper San Juan Mountains and are largely managed by the RGNF. All other watershed strata were more mixed between public and private land ownership.

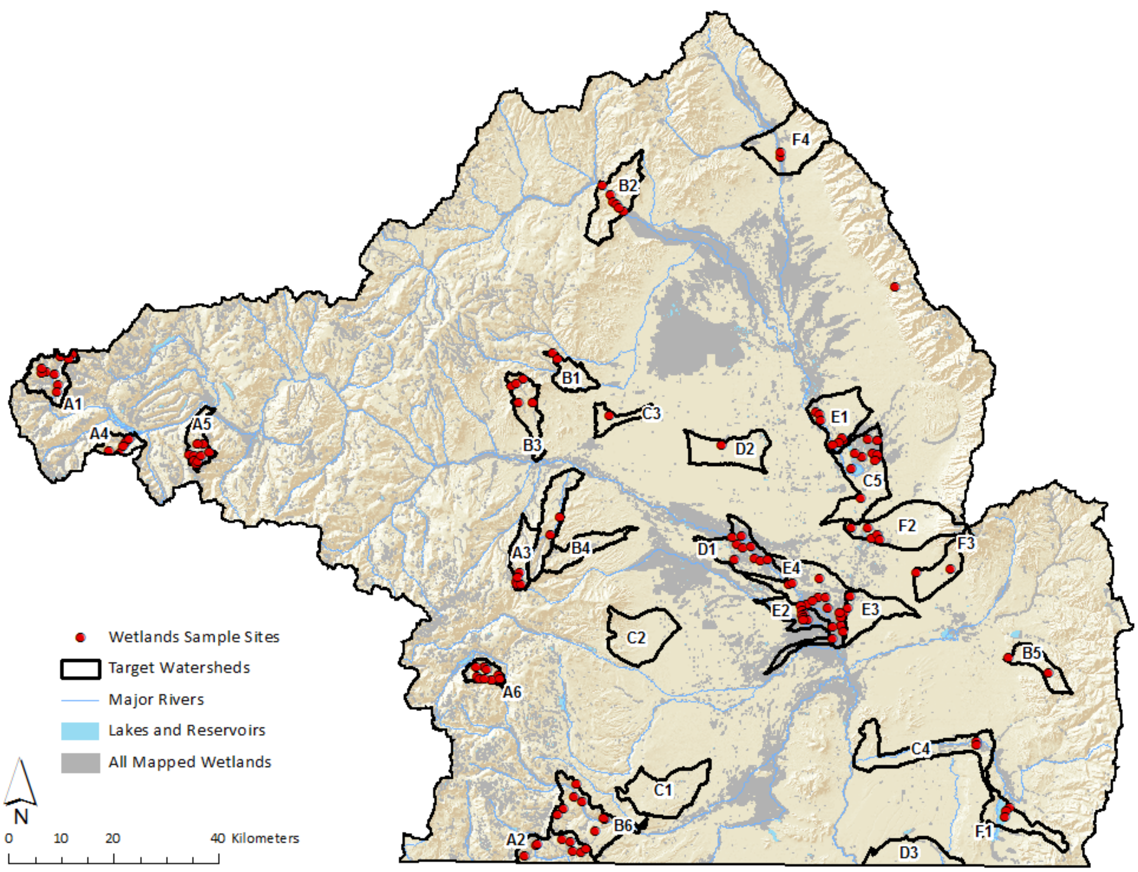

Figure 3.15. Randomly selected wetland sample sites in the Rio Grande Headwaters basin.

Table 3.12. Target number of sample points and wetlands sampled by watershed strata.

Watershed Strata	% of Mapped Wetland Area	2008 Target Points	2009 Target Points	Wetlands Sampled	% of Wetlands Sampled
A	18%	45	45	45	33%
B	6%	27	28	25	18%
C	20%	24	22	13	9%
D	11%	22	19	10	7%
E	37%	36	36	31	23%
F	7%	22	22	13	9%
Total	100%	176	172	137	100%

Sampled wetlands represented a range of Ecological Systems. For ease of discussion and analysis, the nine Ecological Systems encountered were combined into five Ecological System groups as explained in Table 3.1 of Section 3.2.2. Ecological System groups are also referred to as wetland types throughout this text. Wet meadows were the most common wetland type encountered with 60 sites and making up 44% of all sites surveyed (Table 3.13). Wet meadows were also the most broadly distributed type, occurring in all six watershed strata (Figure 3.16). Riparian areas (shrublands and woodlands) were the second most common type with 30 sites surveyed. These wetlands occurred primarily in higher and mid-elevation watersheds, though a few were sampled along the mainstem of the Rio Grande and other large rivers. Freshwater marshes and saline wetlands occurred more frequently at lower elevations within the San Luis Valley, while fens were almost exclusively found in A watersheds. Tables 3.14-16 show the breakdown of sampled wetlands by watershed strata and HGM class, watershed strata and major landowner, and Ecological System group and major landowner. Riverine and Slope HGM classes were the most common and were an even split with 54 sites each. Slope wetlands were more common in higher elevation watersheds where they often form the headwaters of many streams. Wetlands on Forest Service land were the most commonly surveyed with 51 sites, though privately owned wetlands come in a close second with 46 sites.

Table 3.13. Sampled wetlands by watershed strata and Ecological System group.

Watershed Strata	Wet Meadows	Riparian Areas	Freshwater Marshes	Saline Wetlands	Fens	Total
A	14	20	1		10	45
B	15	10				25
C	10			3		13
D	2		7	1		10
E	13	2	10	6		31
F	6	1	2	3	1	13
Total	60	33	20	13	11	137
% of Sites	44%	24%	15%	9%	8%	100%

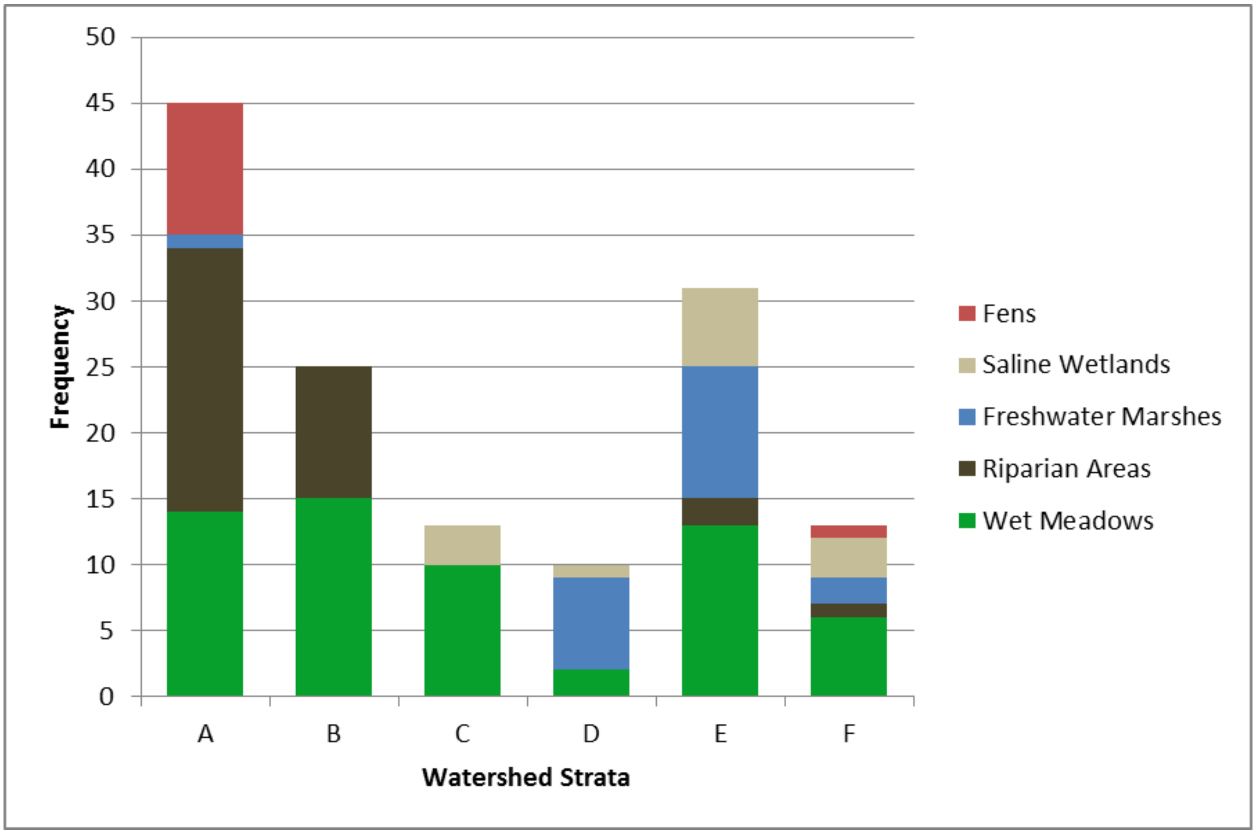

Figure 3.16. Sampled wetlands by watershed strata and Ecological System group.

Table 3.14. Sampled wetlands by watershed strata and HGM class.

Watershed Strata	Riverine	Slope	Depressional	Lacustrine Fringe	Flat	Total
A	12	28	5			45
B	12	12	1			25
C	3	8	2			13
D	6		3		1	10
E	18	3	9	1		31
F	3	3	5	2		13
Total	54	54	25	3	1	137
% of Sites	39%	39%	18%	2%	1%	100%

Table 3.15. Sampled wetlands by watershed strata and major land owner.

Watershed Strata	USFS	PRIVATE	FWS	BLM	LAND TRUST	SLB	CPW	NPS	Total
A	42	2				1			45
B	9	14		1			1		25
C		3		1	4	2		3	13
D		8					2		10
E		12	15		2	2			31
F		7		6					13
Total	51	46	15	8	6	5	3	3	137
% of Sites	37%	34%	11%	6%	4%	4%	2%	2%	100%

Table 3.16. Sampled wetlands by Ecological System group and major land owner.

Ecological System Group	USFS	PRIVATE	FWS	BLM	LAND TRUST	SLB	CPW	NPS	Total
Wet Meadows	20	25	6	1	4	2		2	60
Riparian Areas	21	9	1	1			1		33
Marshes	1	9	5	2	1		2		20
Saline Wetlands		1	3	4	1	3		1	13
Fens	9	2							11
Total	51	46	15	8	6	5	3	3	137
% of Sites	37%	34%	11%	6%	4%	4%	2%	2%	100%

3.3.3 Level 2 & 3 Assessment Results: Characterization of Wetland Vegetation

Within surveyed wetlands, both species and community diversity was high. In total, 659 individual plant taxa were encountered in the 137 sites. This number includes 67 taxa identified only to the genus or family level because they were found either early or late in the season and lacked the required flora parts for identification. Discounting those taxa, 592 species were identified to the species level, which represents ~18.5% of the entire Colorado flora. Of the 659 total taxa, 205 were only encountered once and another 99 were only encountered twice. The high percentage of species found only once or twice indicates the high diversity found in wetlands across the basin. With additional surveys, it is likely that more species would be found. The average number of species per site was 30, but this ranged from 3 to 71 species per site. Sedges *(Carex* spp.*)* were the most diverse genus found in the survey, with 39 individual species. Willows *(Salix* spp.*)* were also diverse, with 13 individual species. Of the 592 species identified to species level, 502 (85%) were native species and 90 were non-native species.

The most common species encountered across all sites was *Juncus arcticus* ssp. *ater* (mountain rush, also commonly referred to as Baltic rush). This species occurred in 82 out of 137 sites (60%). Table 3.17 lists the top ten most common species found in the survey, their wetland indicator status, nativity status, and C-value. Out of the top ten, only *Taraxacum officinale* (common dandelion) is a non-native species. This ubiquitous plant was found everywhere from highly disturbed lands to nearly pristine mountain meadows. It is highly adapted to spread widely, but is not considered a noxious weed. All other top ten species are native wetlands species with mid-range C-values, indicating they can tolerate low levels of disturbance. *Psychrophila leptosepala* (marsh marigold), number 10 on the list, has the highest C-value at 7, which indicates a higher affinity for natural, undisturbed areas. The top ten most common species encountered by watershed strata is presented in Appendix I.

Table 3.17. Top ten most common species encountered in Rio Grande Headwaters wetlands.

Scientific Name	Occurrences	Rank	Wetland Indicator Status	Native Status	C-Value
Juncus arcticus ssp. *ater*	82	1	FACW	Native	4
Taraxacum officinale	81	2	FACU+	Non-native	0
Achillea lanulosa	56	3	FACU	Native	4
Deschampsia cespitosa	52	4	FACW	Native	4
Eleocharis macrostachya	46	5	OBL	Native	3
Carex aquatilis	46	6	OBL	Native	6
Carex utriculata	42	7	OBL	Native	5
Phleum commutatum	42	8	FAC	Native	6
Critesion jubatum	41	9	FAC+	Native	2
Psychrophila leptosepala	41	10	OBL	Native	7

The NMS species ordination successfully accounted for 91.9% of the variability in the plot species community data. Plots sampled in the A and B watershed strata were more similar in species composition than those sampled in other, lower elevation strata (Figure 3.17a). The environmental/condition matrix overlay upon the species ordination detected strong relationships between species composition and climatic and wetland condition gradients along the dominant axis. The climatic gradient separated higher elevation wetlands that experience more precipitation and cooler temperatures high on Axis 2 from lower elevation wetlands that experienced less precipitation and warmer temperatures low on Axis 2. The climatic gradient paralleled the wetland condition gradient, with the higher integrity wetlands occupying the higher elevation, wetter, and cooler areas high on Axis 2; and the more disturbed wetlands occupying the lower elevation, drier, and warmer areas on the low end of Axis 2. The ordination plot was also overlain with EPA Level 4 Ecoregions (Omernik 1987) to see whether these were more or less effective at distinguishing between patterns in wetland vegetation than watershed strata, which they appear to be (Figure 3.17b).

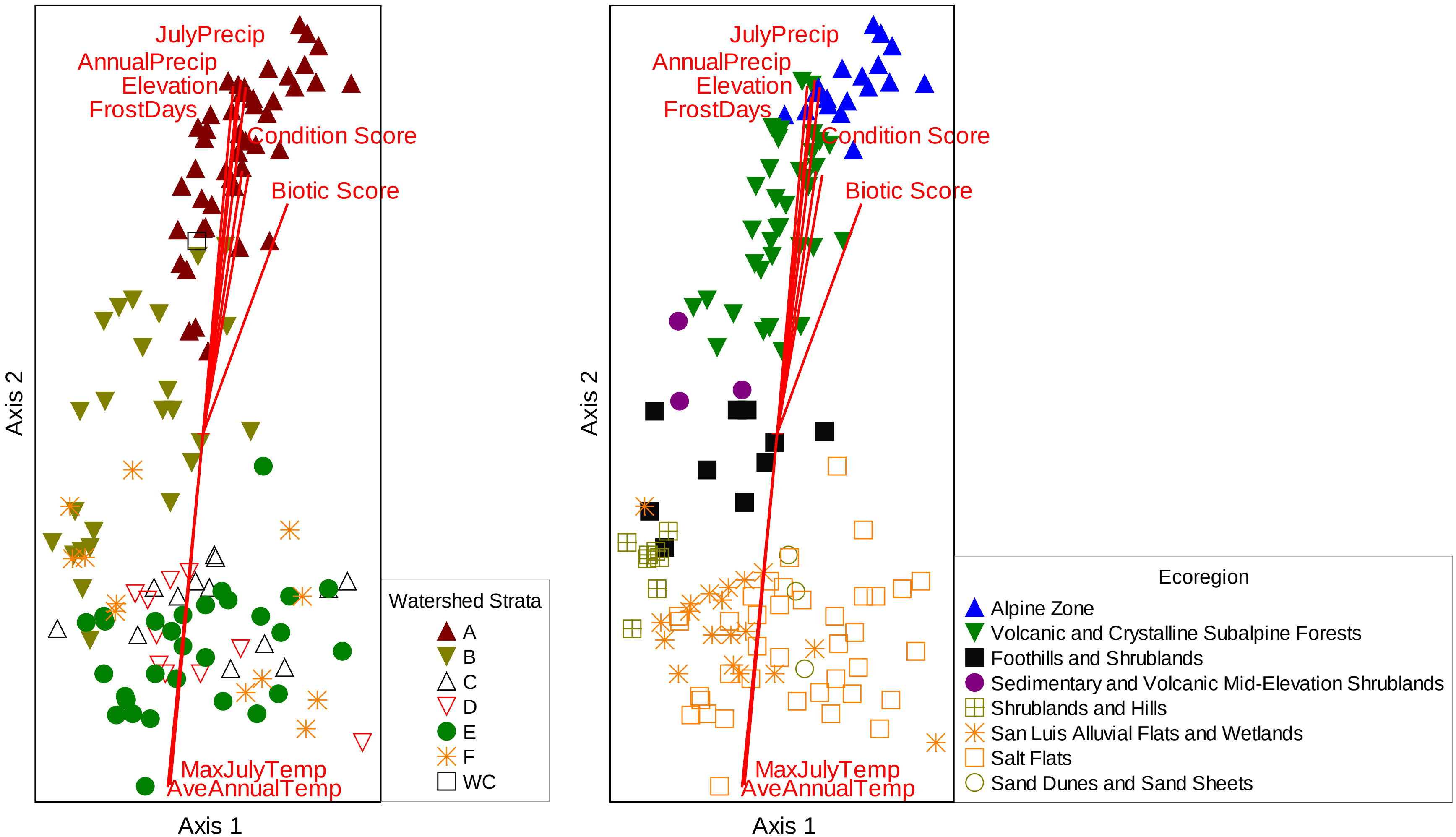

Figure 3.17. NMS ordination of sampled wetlands, grouped by (a) watershed strata on the left and (b) EPA Level 4 Ecoregions on the right.

3.3.4 Level 2 & 3 Assessment Results: Floristic Quality Assessment

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

Mean C values for sampled sites ranged from 1.55–7.50, with a strongly bimodal distribution (Figure 3.18). The overall average Mean C score was 4.41. The wide range of Mean C score are related to both a range of disturbance regimes and of wetland types. Average Mean C scores varied between both watershed strata (Figure 3.19) and Ecological System groups (Figure 3.20). Higher elevation watershed strata, particularly the A watersheds of the Upper San Juan Mountains, had higher average Mean C scores, while watershed strata within the San Luis Valley had significantly lower average Mean C scores. Not surprisingly, wetland types found at higher elevations, particularly fens and riparian areas, had the highest average Mean C values, while wetland types found at lower elevations, particularly saline wetlands and marshes, had lower average Mean C values. See Appendix J for distribution of Mean C values by Ecological System Group.

While Mean C is a strong single measure of wetland condition, it must be viewed in light of the potential Mean C of a particular wetland type (Rocchio 2007a). Even in a reference state, each wetland type is characterized by a different hydrologic and natural disturbance regime. Fens have very stable groundwater fed hydrology and experience relatively little natural disturbance. This leads to a typical suite of species with higher C-values. Marshes and saline wetlands naturally experience higher fluctuations in water levels both within and between years. This higher level of natural disturbance leads to a typical suite of species with lower C-values. Even the most undisturbed example of a saline wetland sampled through this study had a Mean C of 5.50, much lower than the average Mean C for fens and even lower than the most undisturbed fens. For this reason, when incorporated into the biotic score of the EIA methodology (see below for results and Appendix F for scoring thresholds), each wetland type is score on a different range of Mean C values.

To further illustrate that Mean C scores can be driven by both disturbance and factors inherent in geography, we plotted Mean C scores for all sites again both the Human Disturbance Index (HDI) and elevation (Figures 3.21 and 3.22). Mean C scores do have a strong linear relationship with the HDI, with an R^2 of 0.55 and a correlation coefficient of -0.74. But the relationship with elevation is even stronger, with an R^2 of 0.78 and a correlation coefficient of 0.88. The relationship with elevation is particularly strong at higher elevations. Numerous wetlands were sampled at lower elevations within the San Luis Valley (between 7,500–8,000 ft), and these sites display a wide range of Mean C values. The spread within these sites is likely related to disturbance. It would be valuable to explore the interactions between disturbance and geography/wetland types to fully understand the drivers of Mean C and other FQA metric scores.

In addition to Mean C, the FQA methodolgy includes a number of different metrics that can be evaluated to gauge biotic condition. Table 3.18 shows means and standard deviations for each FQA metic by Ecological System group. The same general pattern is seen across all metrics. Fens and riparian areas score the highest among wetland types, while saline wetlands and marshes score the lowest. Wet meadows, which span the entire elevation and disturbance range within the study area, have intermediate values.

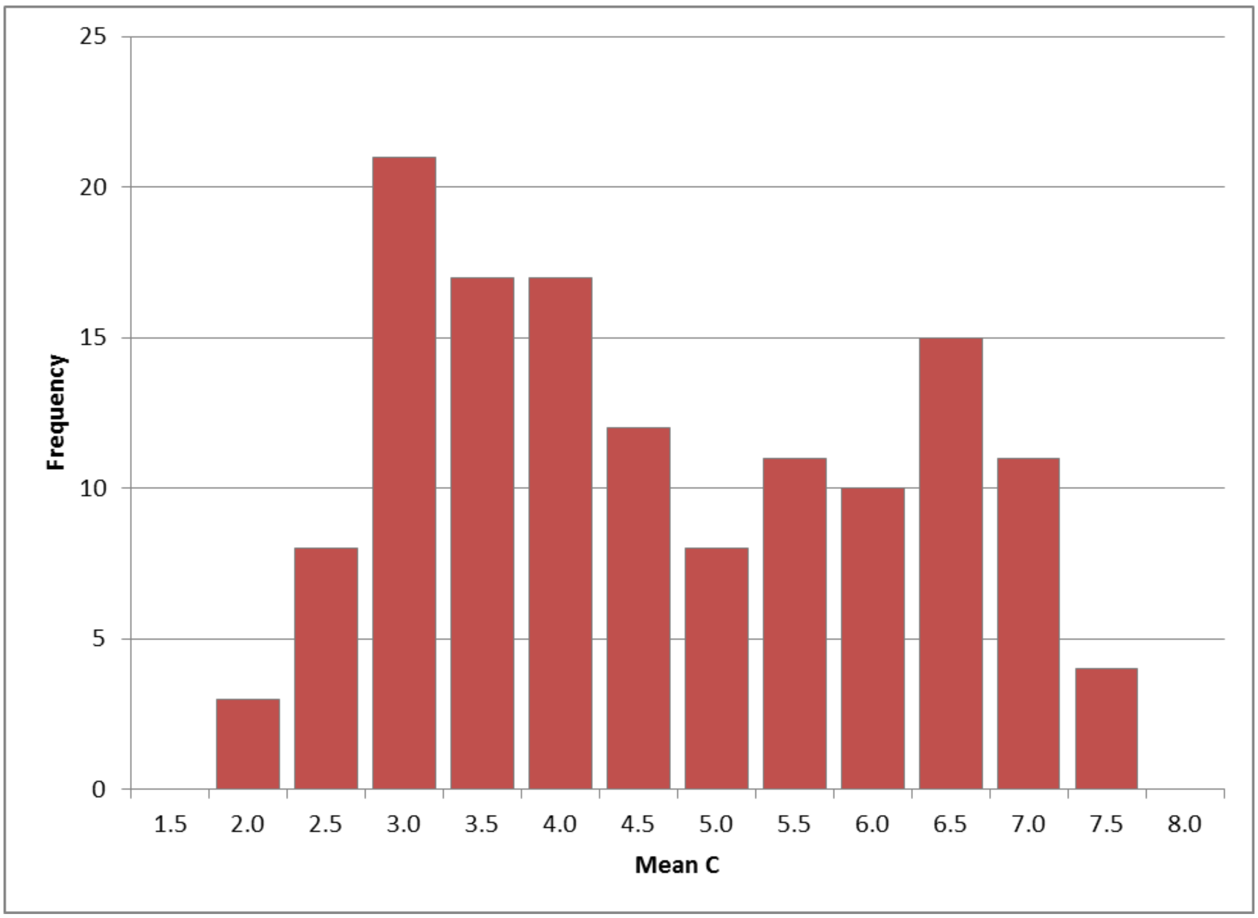

Figure 3.18. Frequency of Mean C values for all sampled wetlands. Number under each bar represents the upper bound of the bin.

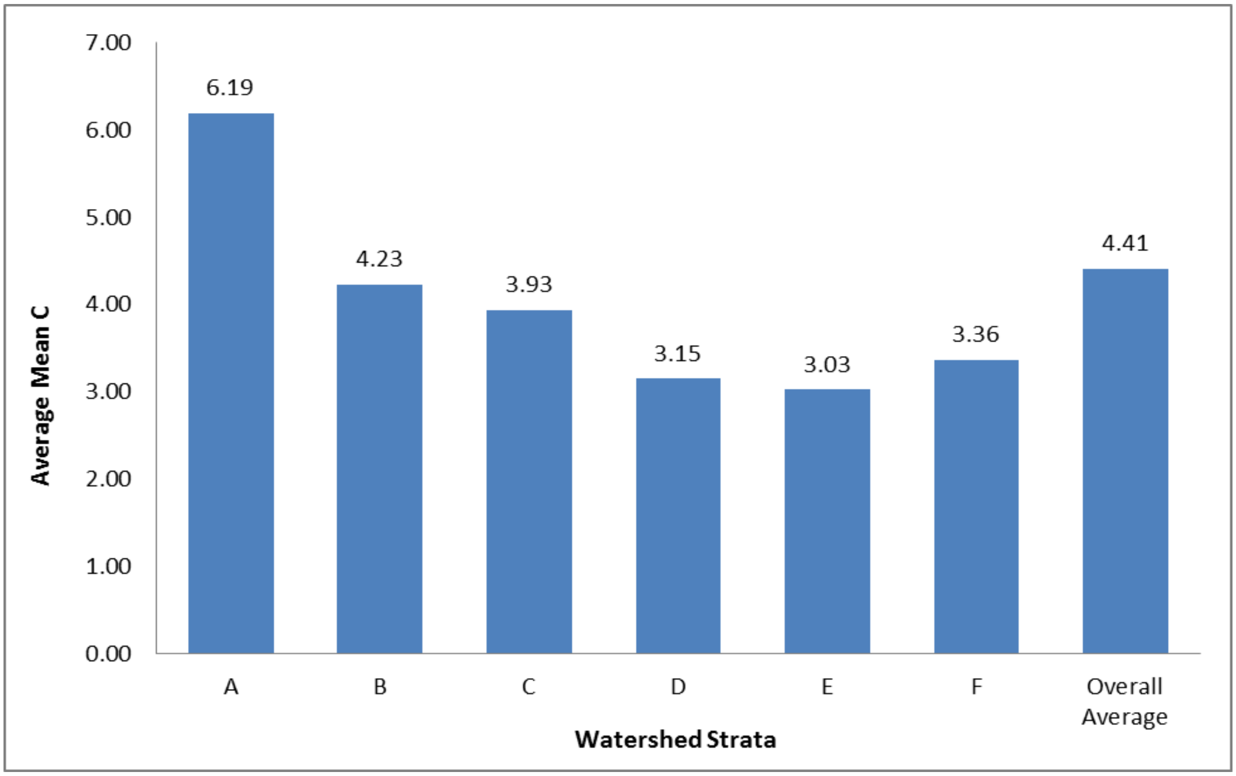

Figure 3.19. Average Mean C scores by watershed strata.

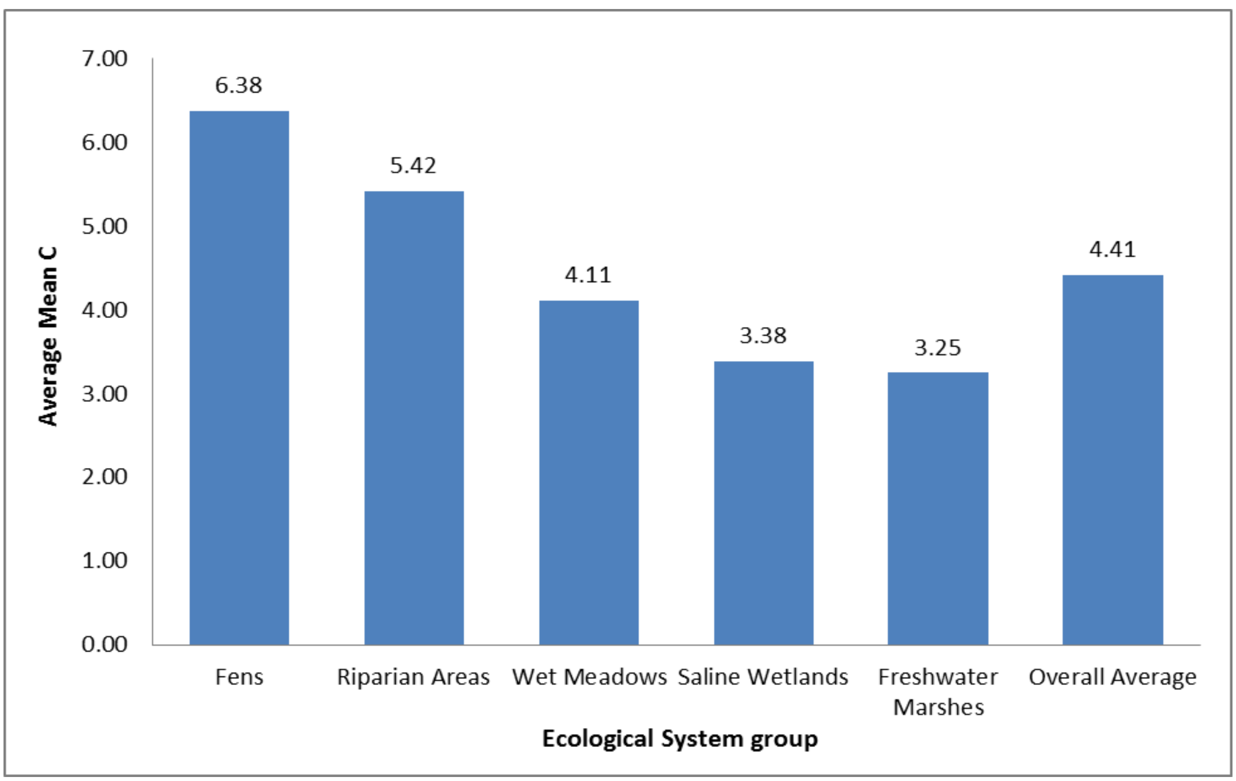

Figure 3.20. Average Mean C scores by Ecological System group.

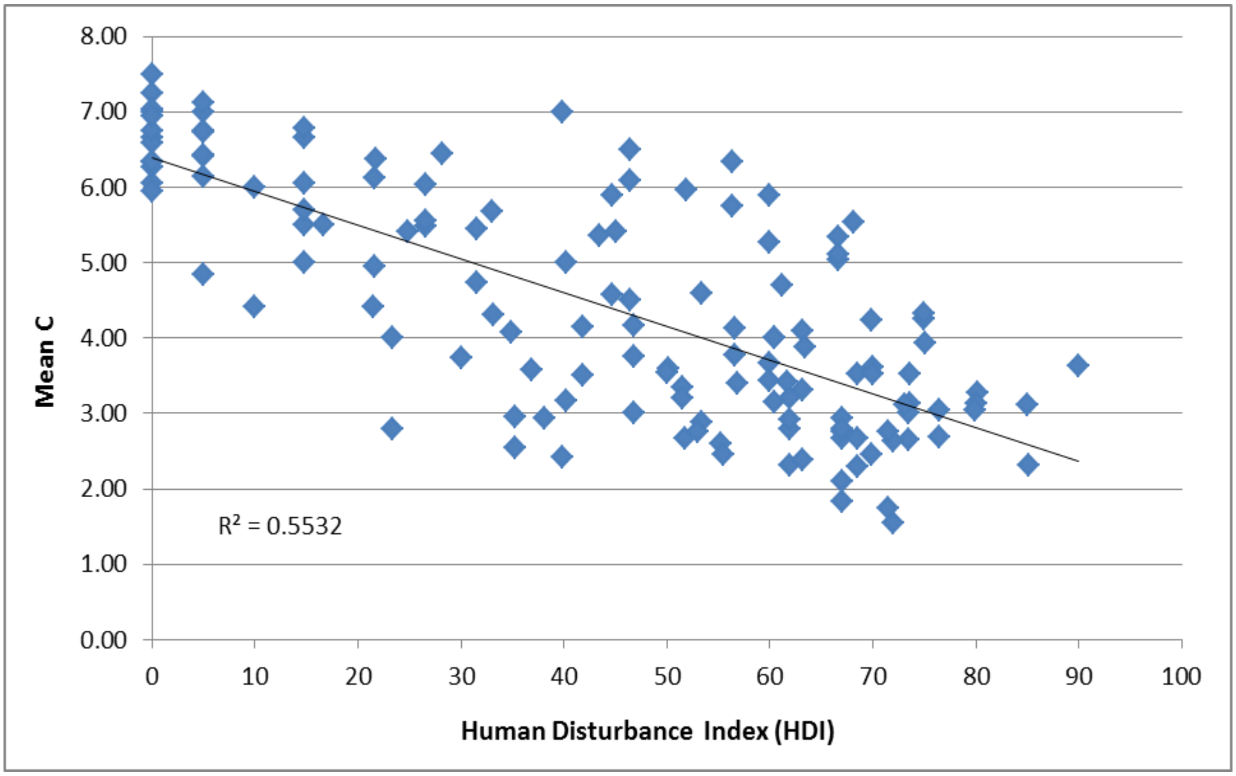

Figure 3.21. Mean C vs. the Human Disturbance Index (HDI).

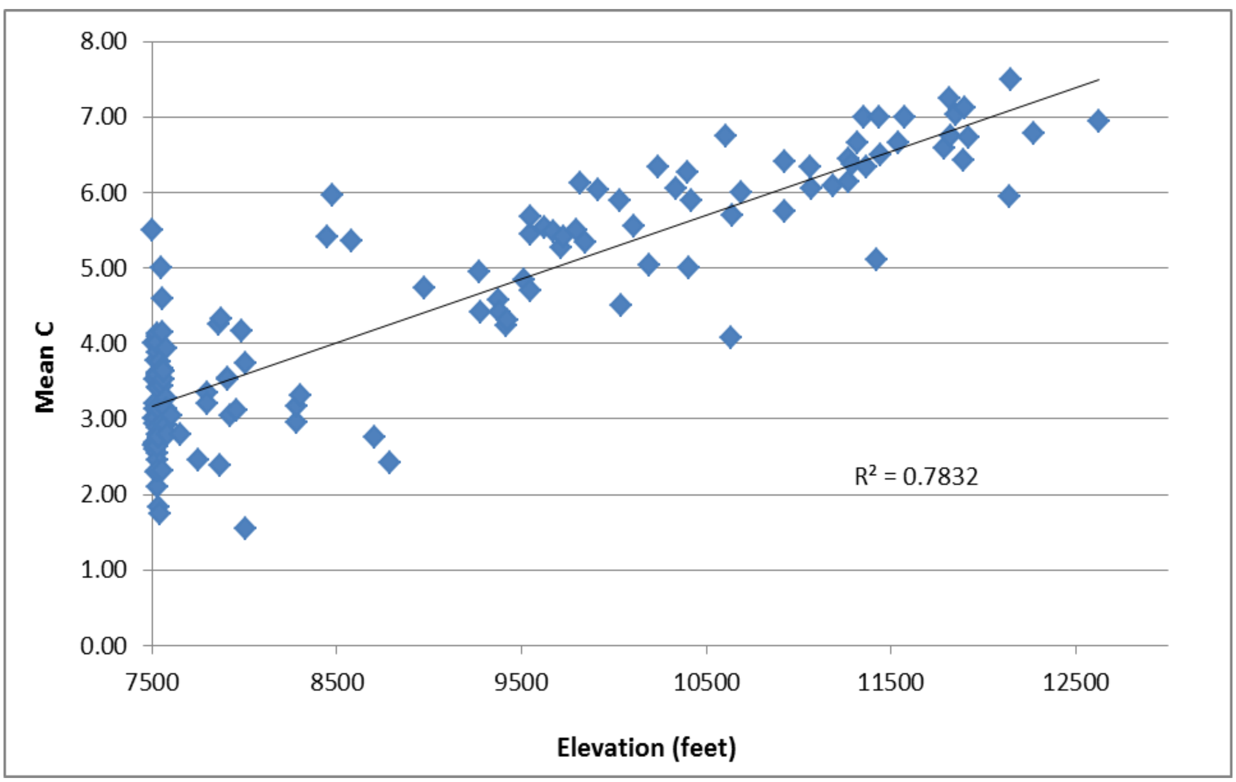

Figure 3.22. Mean C vs. elevation in feet.

Table 3.18. Means and standard deviations of all FQA metrics by Ecological System group.

FQA Indices	Wet Meadows N = 60		Riparian Areas N = 33		Freshwater Marshes N = 20		Saline Wetlands N = 13		Fens N = 11	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total species richness	31	13	41	14	23	12	8	6	25	11
Native species richness	23	11	36	14	17	9	5	4	24	10
Non-native species richness	5	4	3	4	5	4	2	2	1	1
% Non-native	20%	14%	10%	12%	19%	8%	18%	17%	2%	2%
Mean C of all species	4.11	1.41	5.42	1.42	3.25	0.52	3.38	0.92	6.38	0.53
Mean C of native species	5.08	0.97	5.95	0.98	4.08	0.55	4.16	0.57	6.51	0.52
Cover-weighted Mean C of all species	4.05	1.32	5.50	1.91	3.10	0.65	3.91	0.61	6.31	0.63
Cover-weighted Mean C of native species	4.72	1.05	5.84	1.35	3.32	0.71	4.19	0.34	6.33	0.63
FQI of all species	21.24	9.42	33.17	11.73	14.31	4.84	7.79	3.13	30.43	8.22
FQI of native species	23.45	8.95	34.60	11.11	16.16	5.52	8.85	3.75	30.79	8.46
Cover-weighted FQI of all species	20.41	8.45	33.38	14.55	13.78	5.29	9.36	4.03	30.30	8.95
Cover-weighted FQI of native species	21.61	8.88	33.44	13.12	13.13	5.17	8.94	3.63	30.02	8.74
Adjusted FQI	45.48	12.11	56.67	12.22	36.37	5.06	37.29	7.02	64.47	5.16
Adjusted cover-weighted FQI	42.00	12.12	55.39	15.49	29.56	6.43	37.56	5.29	62.61	6.08
HDI Score	48.50	24.23	31.71	26.48	63.22	14.72	47.53	18.68	20.53	20.76

3.3.5 Level 2 Assessment Results: Ecological Integrity Assessment

Level 2 condition scores were calculated for all 137 wetlands sampled in 2008-09 based on the EIA methodology. Across all sites, scores ranged from 2.10–4.96 out of a 1.00–5.00 possible range. For ease of discussion, EIA scores are translated into a 4-tiered ranking system of A, B, C, and D based on the scoring thresholds outlined in Appendix F. These ranks can be interpreted as:

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

Within the Rio Grande Headwaters basin, EIA ranks were distributed across the potential range. In all, 26 sites (19%) were ranked "A", 41 sites (30%) were ranked "B", 56 sites (41%) were ranked "C", and 14 sites (10%) were ranked "D". Trends among the ranks were clearly evident between both watershed strata and Ecological System groups. "A" ranked sites occurred almost exclusive in the A watersheds, while no "D" ranked site occur in this stratum (Table 3.19; Figure 3.23). Watershed strata at lower elevations within the San Luis Valley received the lowest ranks.

Among Ecological System groups, fens received the highest ranks, with 5 "A" ranked sites and 6 "B" ranked sites (Table 3.20; Figure 3.24). Riparian areas and wet meadows both had EIA ranks spread across the range, indicating that they face a range of disturbance depending on where they are located within the basin. Riparian shrublands had the widest spread of scores, including both the lowest and the highest overall EIA scores (2.10 and 4.96, respectively). As a group, freshwater marshes appear to be the most significantly impacted. Out of 20 sites sampled, 17 were ranked "C" and one was ranked "D". Only two marshes (10%) were ranked "B" and no marsh was ranked "A". Saline wetlands also appear to be relatively impacted, though there were proportionally more "B" ranked saline wetlands than marshes. However, there were also no "A" ranked saline wetlands.

To explore the causes of the EIA scores, it is important to look at the component ranks of landscape context, biotic condition, and abiotic condition. For this study, abiotic condition is a combined category that includes both hydrologic and physiochemical metrics. Table 3.21 shows the range of ranks within each of these component categories for each Ecological System group (including hydrology and physiochemistry shown separately along with the combined abiotic rank). Across all sites, the biotic ranks were generally the lowest, with proportionally more sites receiving "C" and "D" biotic ranks than either landscape context or abiotic ranks. Hydrology ranks are the second lowest, indicating that hydrologic modification is a strong factor in the overall condition of sites in the Rio Grande Headwaters basin.

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

Table 3.19. EIA Ranks by watershed strata.

Watershed Strata	A	B	C	D	Total
A	25	16	4		45
B	1	15	7	2	25
C		5	7	1	13
D		1	8	1	10
E		1	22	8	31
F		3	8	2	13
Total	26	41	56	14	137
% of Sites	19%	30%	41%	10%	100%

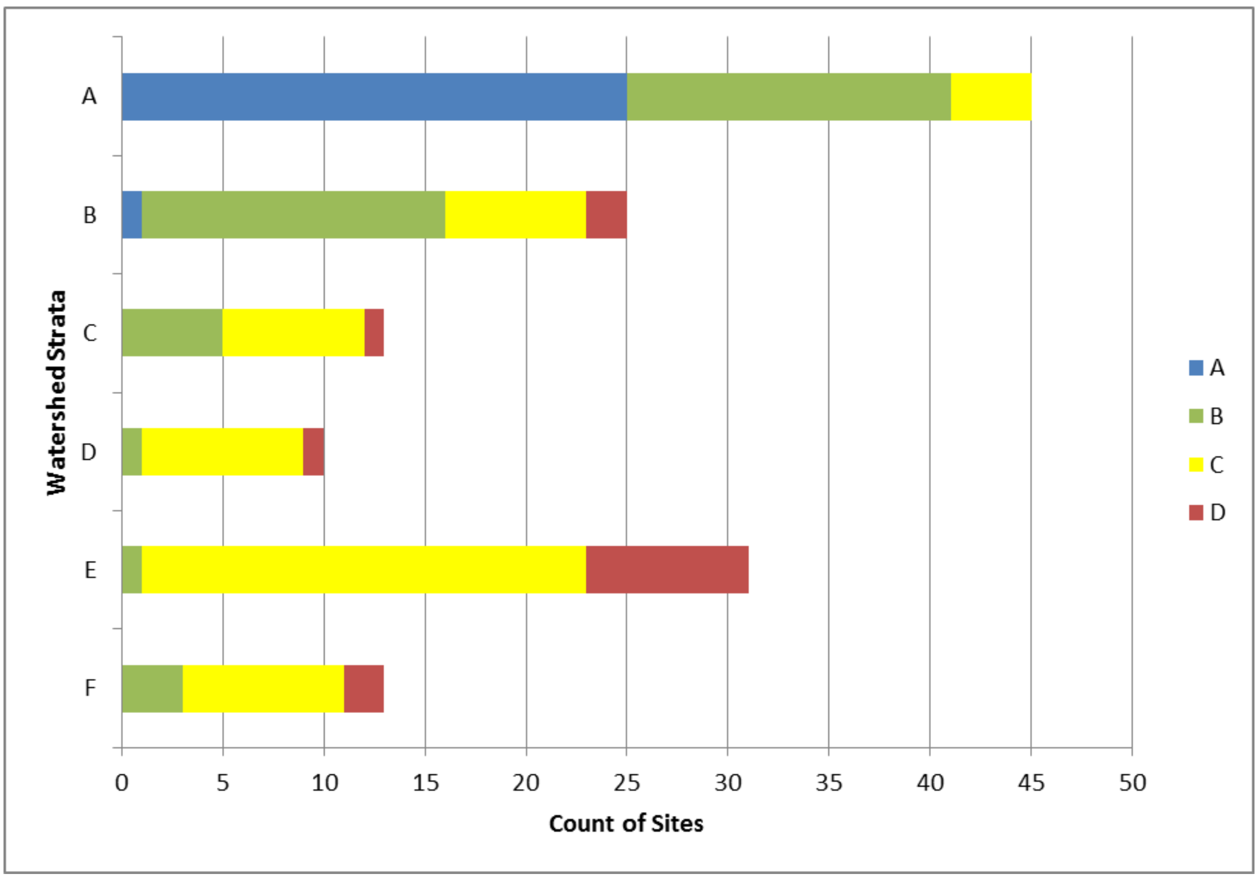

Figure 3.23. EIA Ranks by watershed strata.

Table 3.20. EIA Ranks by Ecological System groups.

Ecological System Group	A	B	C	D	Total
Wet Meadows	9	14	28	9	60
Riparian Areas	12	14	6	1	33
Freshwater Marshes		2	17	1	20
Saline Wetlands		5	5	3	13
Fens	5	6			11
Total	26	41	56	14	137
% of Sites	19%	30%	41%	10%	100%

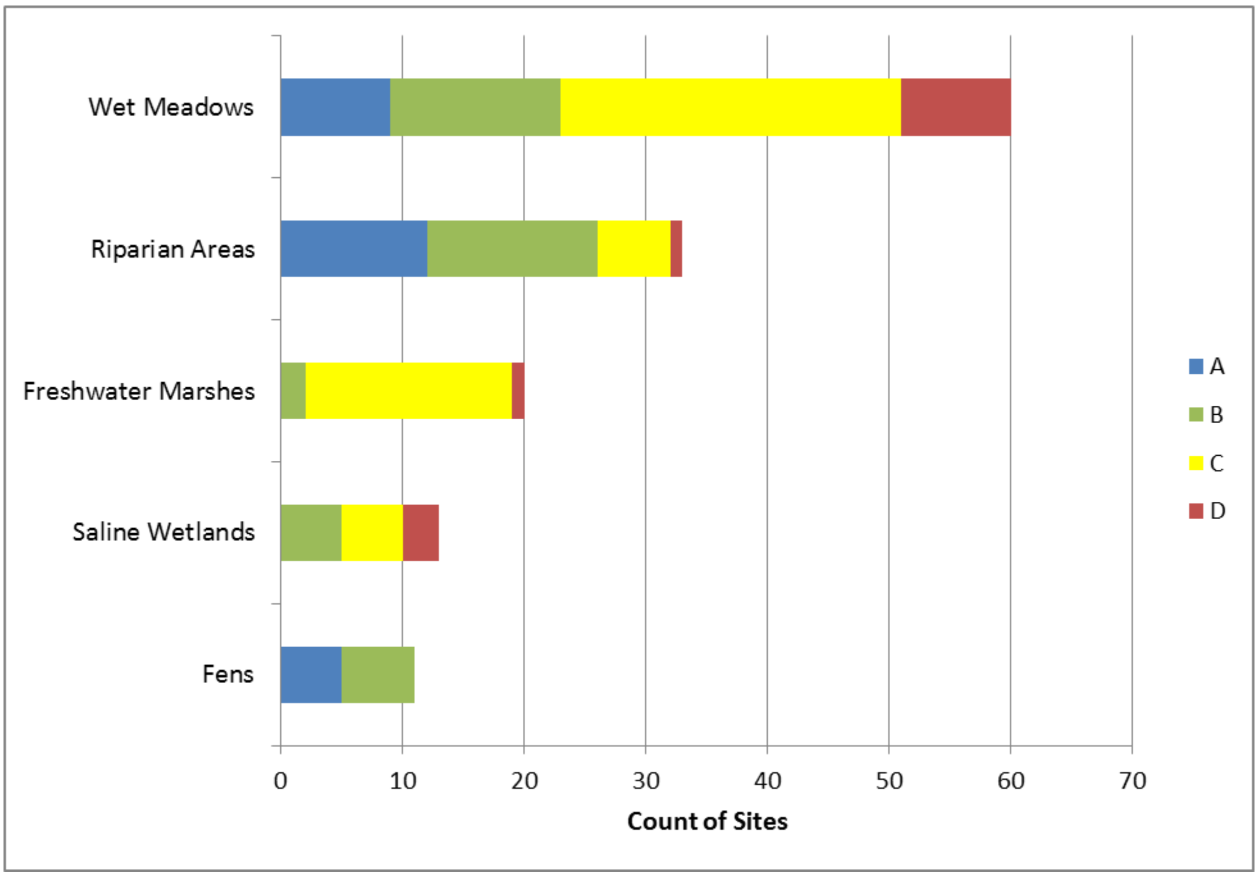

Figure 3.24. EIA Ranks by Ecological System groups.

Table 3.21. Component EIA Ranks by Ecological System groups.

	A	B	C	D	Total
Landscape Context Rank					
Wet Meadows	10	28	13	9	60
Riparian Areas	14	13	3	3	33
Freshwater Marshes		9	8	3	20
Saline Wetlands		10	2	1	13
Fens	6	4	1		11
Total	**30**	**64**	**27**	**16**	**137**
Biotic Condition Rank					
Wet Meadows	7	7	28	18	60
Riparian Areas	15	9	5	4	33
Freshwater Marshes			12	8	20
Saline Wetlands		1	5	7	13
Fens	7	4			11
Total	**29**	**21**	**50**	**37**	**137**
Abiotic Condition Rank (overall)					
Wet Meadows	11	29	16	4	60
Riparian Areas	12	16	5		33
Freshwater Marshes		6	14		20
Saline Wetlands		7		6	13
Fens	6	4	1		11
Total	**29**	**62**	**36**	**10**	**137**
Hydrology Rank (component of the Abiotic Condition Rank)					
Wet Meadows	12	13	25	10	60
Riparian Areas	14	13	3	3	33
Freshwater Marshes		2	9	9	20
Saline Wetlands		3	4	6	13
Fens	6	4	1		11
Total	**32**	**35**	**42**	**28**	**137**
Physiochemistry Rank (component of the Abiotic Condition Rank)					
Wet Meadows	13	40	7		60
Riparian Areas	18	13	2		33
Freshwater Marshes	6	12	2		20
Saline Wetlands	6	7			13
Fens	6	5			11
Total	**49**	**77**	**11**		**137**

3.3.6 Level 3 Assessment Results: Vegetation Index of Biotic Integrity

Level 3 condition scores were calculated for 62 out of 137 wetlands sampled. Vegetation data within these sites were collected using the more intensive Level 3 plot-based protocols. With more detailed vegetation data, we were able to calculate Vegetation Index of Biotic Integrity (VIBI) scores for these sites. Wetlands sampled with Level 3 protocols included 43 wet meadows, 15 riparian shrublands, and 4 fens. Given the sample sizes, more detailed analyses were possible for wet meadows and riparian shrublands than for fens.

<u>Wet Meadows:</u> Using metrics and scoring formulas from version 2.0 of the wet meadow VIBI model (Lemly and Rocchio 2009b), sites in the Rio Grande Headwaters basin scored between 0.39–8.85, with spike a in scores between >6.00–7.00 (Figure 3.25). The mean VIBI score was 5.42 with a standard deviation of 1.82. During calibration of the version 2.0 model, a threshold was set at 5.24 to distinguish between higher and lower integrity sites. Only two condition classes could be identified during the version 2.0 calibration based on the limited sample size of the development plots. Based on this threshold, 20 wet meadows in the Rio Grande Headwaters basin fall within the lower integrity class, while 23 fall within the higher integrity class.

However, there is a strong possibility that the version 2.0 wet meadow VIBI model is not fully calibrated and may not apply as accurately to the Rio Grande sites. During development and calibration of the VIBI models, wet meadows were the least well represented wetland type. Among the plots sampled in the Rio Grande Headwaters, several sites had component VIBI metric values outside the range of the development dataset. Because the scores are based on deviation from a given range, each model needs to be continually updated until the range accurately represents that expected range of all wetlands within the type. The high degree of value outside the range of the development plots means that the scoring formulas do not adequately capture the range of what is observed within the Rio Grande Headwaters. Before these scores can be taken with a high degree of confidence, the VIBI models should be again calibrated with additional plots. The Rio Grande plots and others recently sampled in the North Platte River basin would be ideal to use for this purpose.

To further test the effectiveness of the VIBI model for the Rio Grande Headwaters wet meadows, we plotted VIBI scores against the Human Disturbance Index, which was used to develop the original and calibrated model. Based on development and calibration plots, the wet meadow version 2.0 VIBI model had a strong correlation to the HDI (R^2 = 0.74 and correlation coefficient = -0.87: Lemly and Rocchio 2009b). For the Rio Grande plots, the relationship is significantly weaker (Figure 3.26). The correlation coefficient is only -0.22 and the R^2 is only 0.05. This clearly indicates that the model's performance was not very strong in the study area.

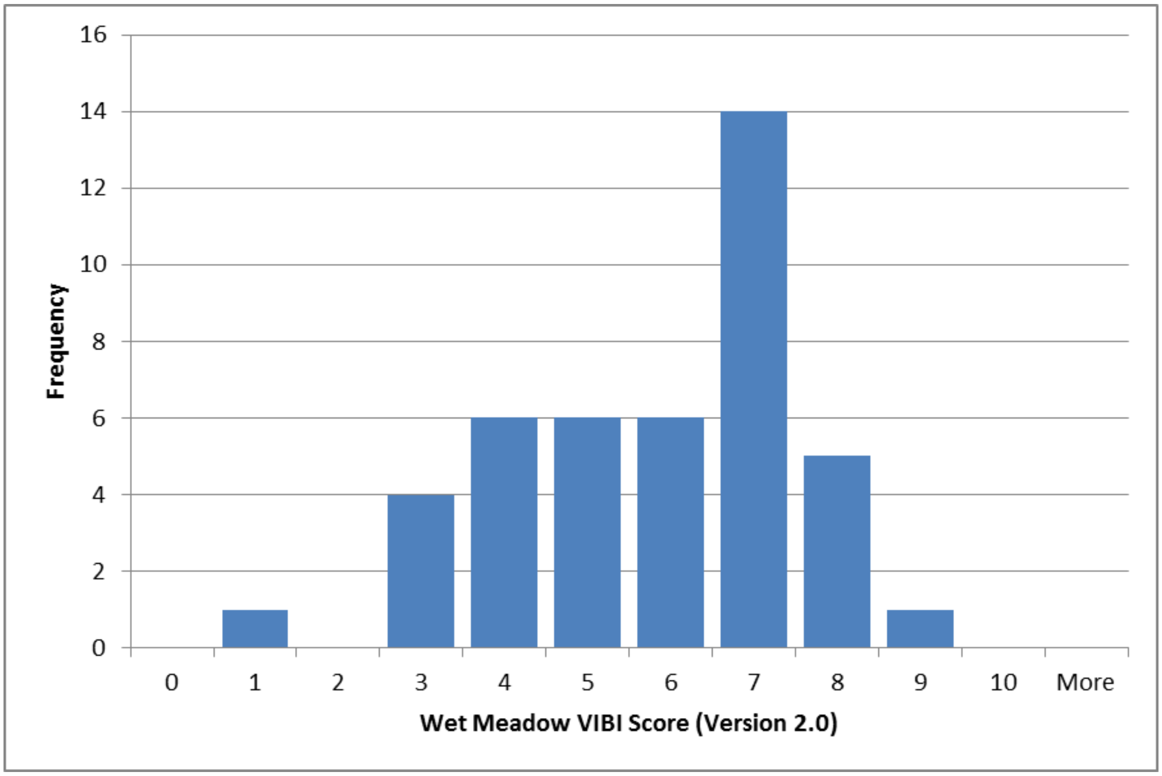

Figure 3.25. Frequency of Wet Meadow VIBI scores for all wet meadows sampled with Level 3 protocols. Numbers under each bar represents the upper bound of the bin.

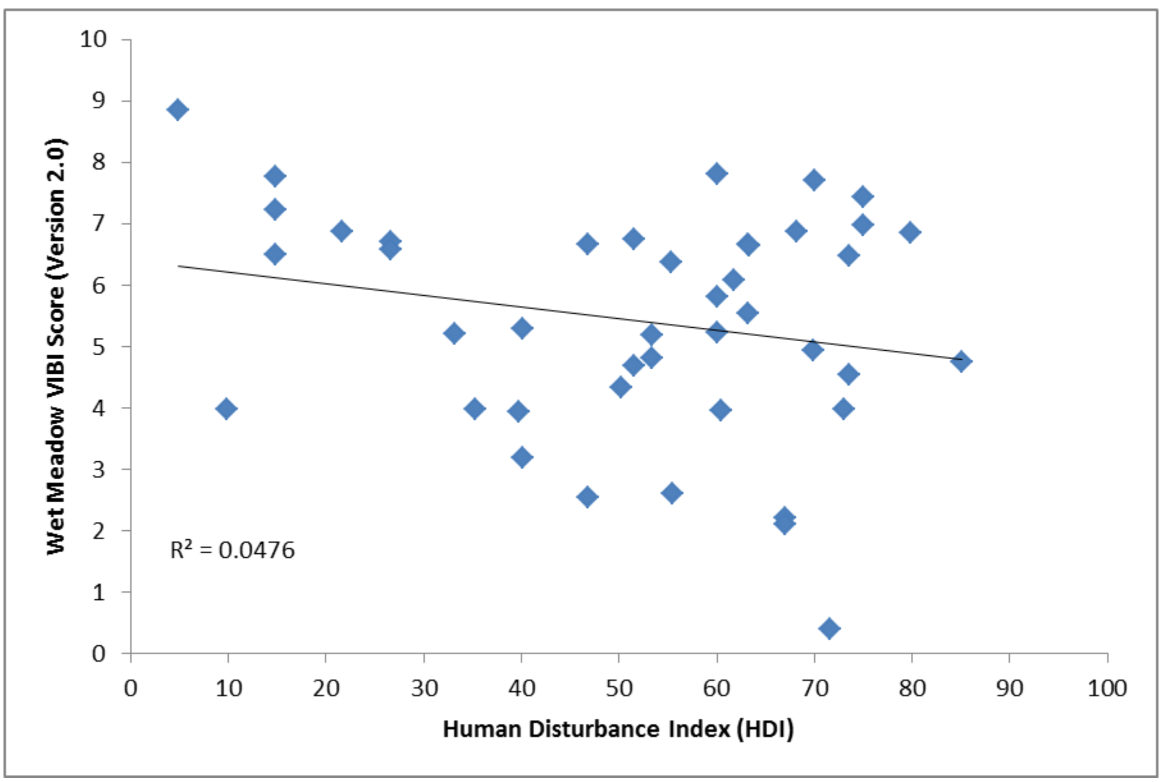

Figure 3.26. Correlation of Wet Meadow VIBI scores to the Human Disturbance Index (HDI).

Riparian Shrublands: Using metrics and scoring formulas from version 2.0 of the riparian shrubland VIBI model (Lemly and Rocchio 2009b), sites in the Rio Grande Headwaters basin scored between 1.33–8.90, with several sites scoring between >8.00–9.00 (Figure 3.27). The mean VIBI score for riparian shrublands was 5.63 with a standard deviation of 2.62. During calibration of the version 2.0 model, thresholds were set at 6.56 and 8.08 to distinguish between low, moderate, and high integrity sites. Based on these thresholds, eight riparian shrublands in the Rio Grande Headwaters basin fall within the low integrity class, three fall within the moderate integrity class, and four fall within the high integrity class.

In contrast to the wet meadow VIBI model, the riparian shrubland VIBI model was developed with a larger number of sites and with more confidence in the derived final scores. Among the Rio Grande plots, a handful of metric values were outside the range of the development plots, but far fewer than with the wet meadows. The correlation between Rio Grande riparian shrubland VIBI scores and the HDI was also closer to expected, with a $R^2 = 0.39$ and correlation coefficient = -0.63 (Figure 3.28). There were two outlier plots among the Rio Grande sites with high VIBI scores and high HDI scores that weaken this relationship. Otherwise, the model appears to be working well, though minor calibration of scoring thresholds could improve its effectiveness.

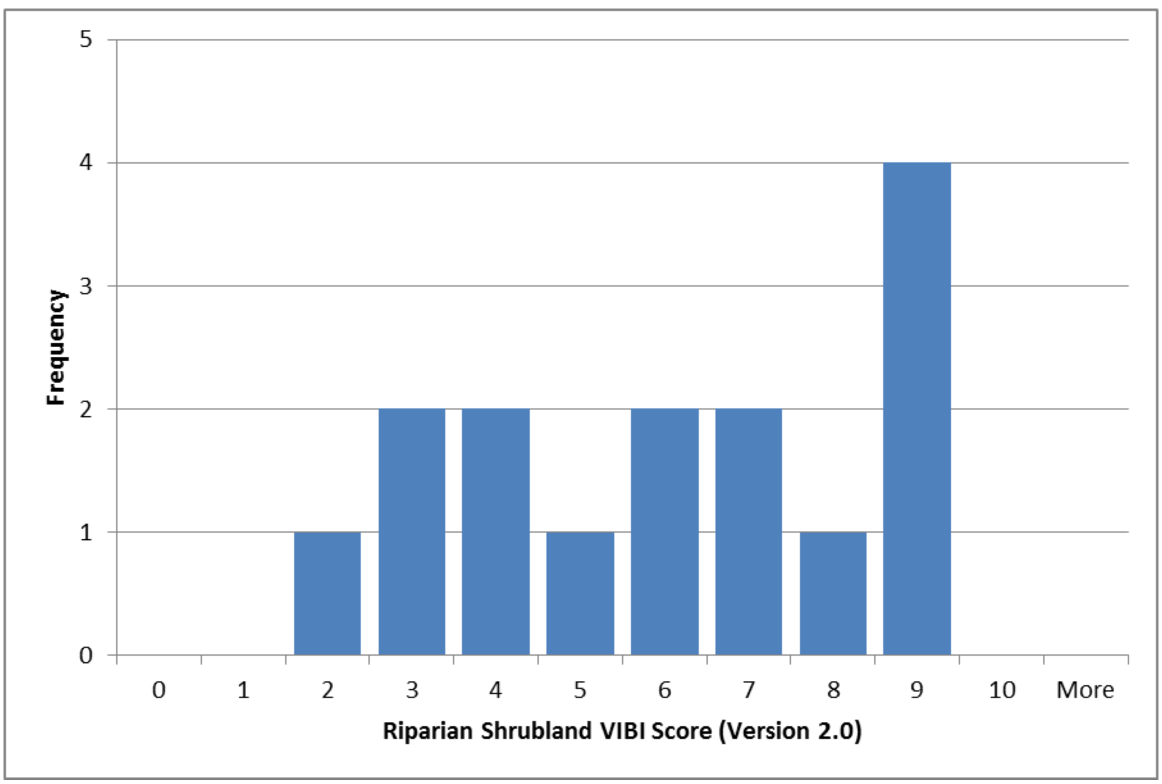

Figure 3.27. Frequency of Riparian Shrubland VIBI scores for all riparian shrublands sampled with Level 3 protocols. Numbers under each bar represents the upper bound of the bin.

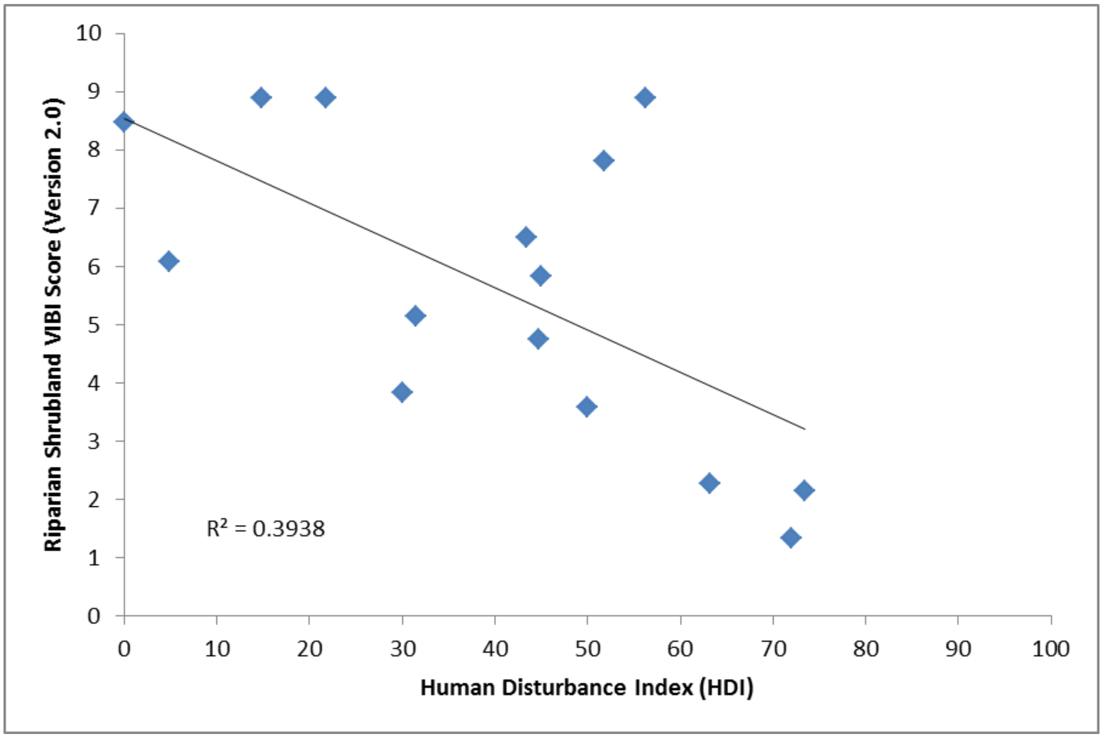

Figure 3.28. Correlation of Riparian Shrubland VIBI scores to the Human Disturbance Index (HDI).

Fens: Using metrics and scoring formulas from version 2.0 of the fen VIBI model (Lemly and Rocchio 2009b), sites in the Rio Grande Headwaters basin scored between 6.04–6.92, with a mean of 6.31 and standard deviation of 0.41. All four of the sites fall within or right at the threshold of the high integrity class based on the calibration of the fen model. With so few plots and such a tight range of scores, it is not meaningful to test the effectiveness of this model within the Rio Grande Headwaters basin. But it appears that the fens surveyed have high biotic integrity.

3.3.7 Comparison of Level 1, 2, 3 Results

Several methods were used in this project to estimate the condition of wetlands within the Rio Grande Headwaters river basin. At this point in time, all methods used are still under development and in need of refinement. One way to evaluate the effectiveness of each method is to compare the results between the various approaches. The first comparison presented is between the Level 1 Wetland Landscape Integrity Model (LIM) and field-based results.

Across all plots, the LIM showed relatively high correlation between all three primary Level 2 methods (Table 3.22). The relationship in all three cases moved in a predictable direction. The LIM and HDI both increase with increasing disturbance /stressors and the correlation between the two was 0.67 (Figure 3.29). While the LIM increases with increasing stressors, EIA scores should decrease. Accordingly, the correlation between these two measures was -0.69 (Figure 3.30). Similar to the EIA scores, Mean C scores also decrease with increasing stressors, and the correlation between LIM and Mean C was -0.71, the strongest among the measures (Figure 3.31). VIBI scores were only compared with LIM scores for wetland types with sufficient numbers of Level 3 sample sites, so a comparison across all sites is not possible.

Correlations calculated by Ecological System group provide insight into whether the LIM works better for certain wetland types (Table 3.22). Correlations were strongest for those wetland types with larger sample sizes and also wider spread of scores. Correlations are all strong and predictable for wet meadows and riparian areas, but the correlation between LIM and VIBI scores is not as strong for wet meadows. This reinforces the conclusion that the wet meadow VIBI model needs further calibration. Marshes show much weaker correlations and the relationship between LIM and Mean C scores is in the opposite direction predicted. The same is true for saline wetlands, though it is the relationship between LIM and EIA scores that trends in the opposite direction predicted. Correlations for fens are all weak.

In addition to the overall trends and correlations between the LIM and field based methods, the ranking thresholds that define stressor classes should also be evaluated. If LIM stressor classes 1 & 2 are combined, this created four classes similar to the four tiered EIA ranks. When LIM stressor class designations and EIA ranks are compared, it appears that the LIM accentuates high and low scores, while the EIA ranks include far more sites with middle scores (Table 3.23). The LIM stressor classes may need to be revised to better reflect on the ground evaluations.

Table 3.22. Correlations of LIM scores with Level 2 & 3 condition scores.

Ecological System Group	# of Sites	Method			
		HDI	EIA	Mean C	VIBI
Wet Meadows	60	0.72	-0.75	-0.72	-0.22 (N = 43)
Riparian Areas	33	0.65	-0.70	-0.68	-0.55 (N = 15)
Freshwater Marshes	20	0.37	-0.04	0.16	NA
Saline Wetlands	13	-0.36	0.49	-0.08	NA
Fens	11	0.20	-0.11	-0.20	NA
All Sites	**137**	**0.67**	**-0.69**	**-0.71**	**NA**

Table 3.23. Comparison of LIM stressor classes with EIA ranks.

EIA Rank	LIM Stressor Class				Total
	1+2	3	4	5	
A	23	3			26
B	15	8	6	8	37
C	1	7	15	30	53
D		5	3	13	21
Total	39	23	24	51	137

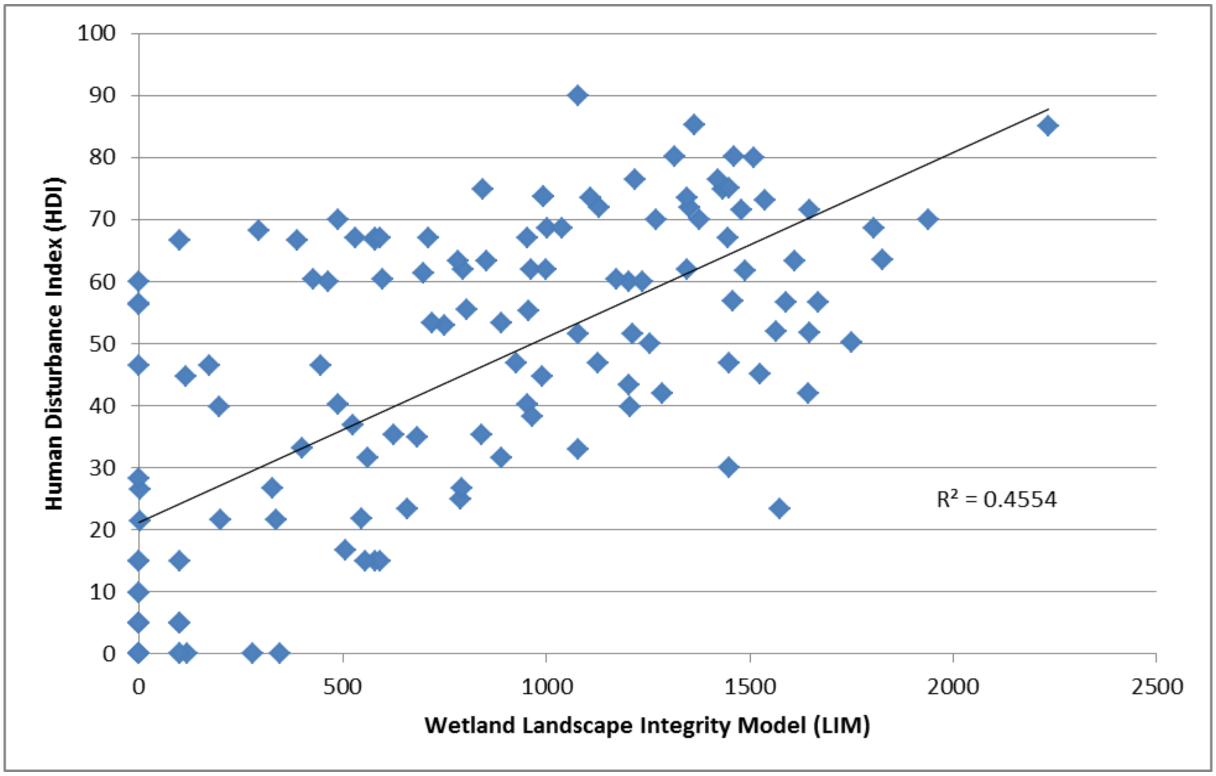

Figure 3.29. Correlation of Wetland LIM scores to the HDI.

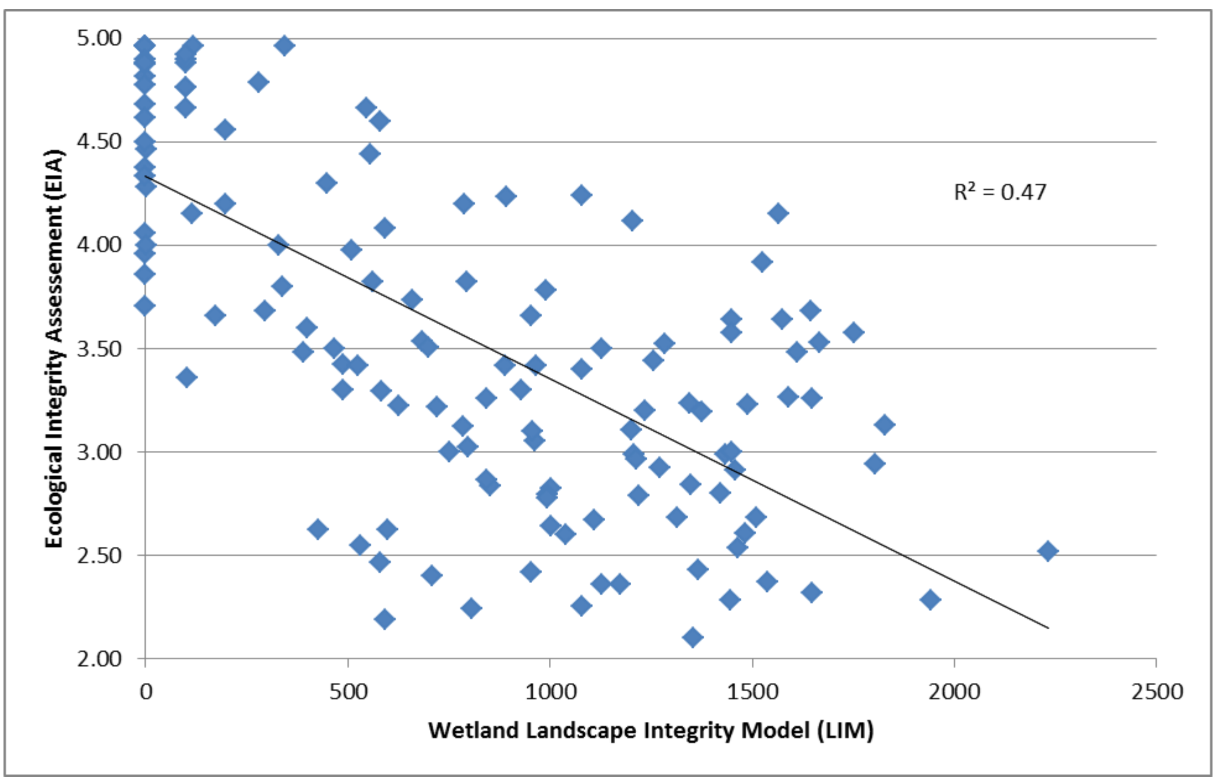

Figure 3.30. Correlation of Wetland LIM scores to EIA scores.

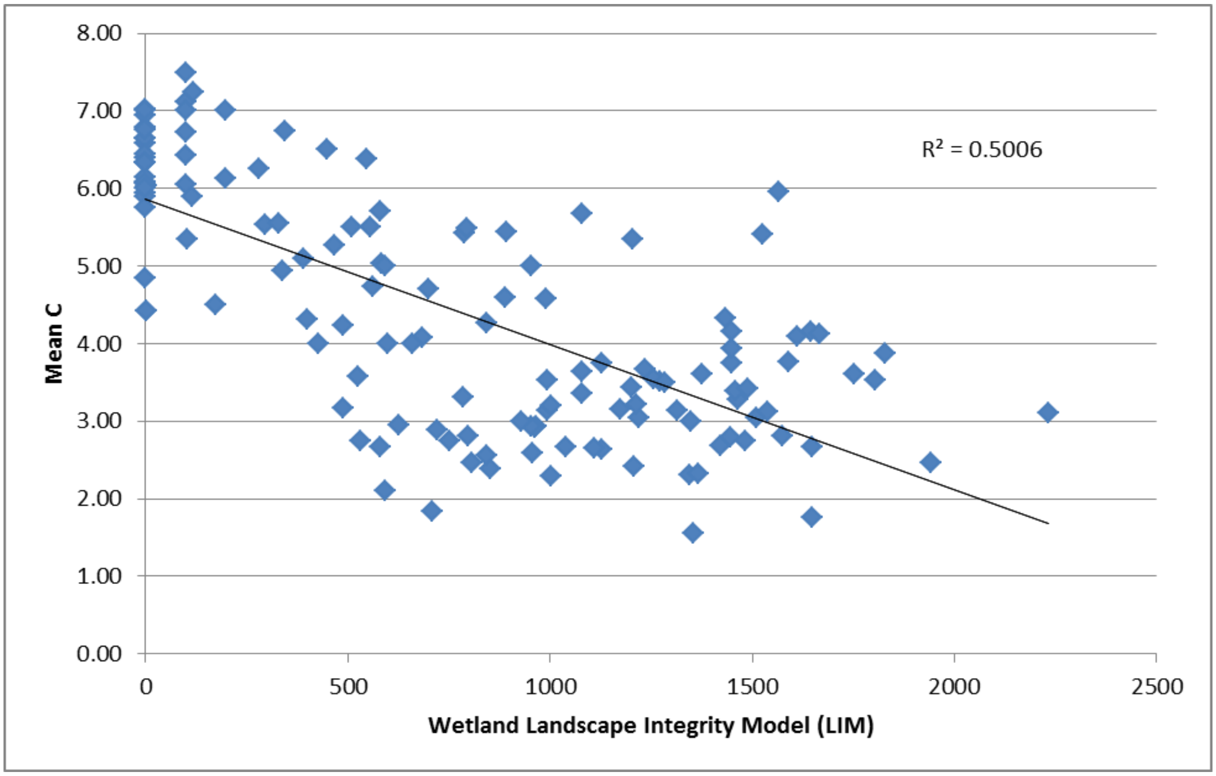

Figure 3.31. Correlation of Wetland LIM scores to Mean C scores.

The final comparison between methods is between Level 2 EIA scores and Level 3 VIBI scores for the two Ecological Systems that were sampled with sufficient numbers of Level 3 plots, wet meadows and riparian shrublands. To evaluate the strength of these methods, correlations between VIBI scores and each component of the EIA score were calculated (Table 3.24). Though more wet meadows were sampled with Level 3 protocols than riparian shrublands, the correlations are much stronger between VIBI scores and EIA components for riparian shrublands than for wet meadows. This is again most likely because the wet meadow VIBI model is in need of further calibration. Overall, the correlation for wet meadows between the VIBI score and EIA score is 0.53. For riparian shrublands, it is 0.91.

For both wetland types, the strongest correlations between VIBI scores and EIA components are with the biotic condition category. This is logical, as the VIBI is a measure of biotic integrity, so biotic component is the most parallel measure within the EIA. For wet meadows, the correlation between the VIBI and EIA biotic condition score is 0.51, while for riparian shrublands, it is a very high 0.99. For riparian shrublands, the biotic condition component of the EIA is relaying almost exactly the same signal as the VIBI score. For both wetland types, overall abiotic scores and hydrology scores are more strongly related to VIBI scores than landscape context and physiochemistry scores, the latter showing almost no correlation at all.

Table 3.24. Correlations of VIBI scores with each component of the EIA for wet meadows and riparian shrublands.

Ecological System	# of Sites	Component of the EIA					
		Final EIA	Landscape	Biotic	Abiotic	Hydrology	Physiochem
Wet Meadows	43	0.53	0.29	0.51	0.49	0.48	0.08
Riparian Shrublands	15	0.91	0.39	0.99	0.69	0.64	0.09

3.4 Discussion

The goals of the Rio Grande Headwaters pilot wetland assessment were two-fold: 1) to estimate the range wetland condition in the basin using principles developed by EPA for large scale assessments and methodology developed by CNHP and 2) to test the effectiveness of these techniques and make recommendations for future studies. Elements of this discussion are broken down by these two goals.

3.4.1 Rio Grande Headwaters Wetland Profile and Condition Assessment

There have been at least two previous estimates of wetland acreage in the San Luis Valley portion of the basin. In 1955, the USFWS estimated approximately 141,000 acres of wetlands on the valley floor (USFWS 1955). A decade later, Hopper (1968) estimated approximately 230,000 acres of wetland in the irrigated portion of the San Luis Valley. This acreage is thought to have declined significantly due to changes in irrigation practices (CDOW 1989). Current digital NWI mapping suggest that there are 282,804 acres of wetlands and waterbodies in the Rio Grande Headwaters basin, and 265,371 acres of wetlands excluding lakes and rivers. Of these 265,371 acres of wetlands, ~195,000 are located on the valley floor (Level 4 Ecoregions 22b, 22c, 22e: see Appendix G). Of all wetland acres, the vast majority are freshwater herbaceous wetlands, primarily with temporarily or seasonally flooded water regimes. Approximately one-third of wetland acres are irrigated, and these irrigated acres are concentrated within the San Luis Valley where the density of wetland acreage is greatest. The distribution of wetland types is closely tied to geography. Marshes and saline wetlands occur more frequently on the valley floor, while fens and riparian shrublands occur at higher elevations in the mountains. Wet meadows, however, span the elevation range, though species composition within meadows changes depending on location.

Level 1 analysis of wetland condition shows that geography affects condition as well as wetland extent and distribution. Across the basin, more than half of wetland acres fall into the severe stressor class of our Level 1 LIM for wetlands. These highly stressed wetlands are particularly concentrated on the valley floor. Level 2 & 3 analyses support trends shown by the Level 1 model. Marshes and saline wetlands had the lowest Level 2 scores, while fens and riparian shrublands had the highest. Wet meadows, which span the geographic range, also span the condition gradient. Hydrologic modification is a particular concern for many wetlands in the basin. Draw down of groundwater levels and drying of wetlands was observed within the San Luis Creek drainage at the base of the Sangres. In addition to groundwater draw down, many of the major rivers, including the Rio Grande River, are currently disconnected from their former floodplains and there was evidence of downcutting and bank erosion.

These findings provide an initial starting point from which the CPW Wetlands Program can begin to quantify the extent and condition of wetland habitat in the basin for targeted wetland dependent species. Through the Wetland Program's Strategic Plan (CPW 2011), rough population objectives have been identified for certain species groups. These population objectives are then tied to habitat objectives thought to support desired populations. Over the course of this project, CNHP and CPW identified a need for more rigorous methods to relate ecological integrity measures to habitat value. It has been shown in other parts of the state that floristic quality measures do not always translate into wildlife habitat quality, though they do consistently relate to the presence or absence of stressors (Cariveau and Pavlacky 2009). The presence of many waterfowl and other bird species is more strongly related to food resources, which may or may not be native plant species, than they are to the extent of human modification. For this reason, future collaborative studies between CNHP and CPW will seek to build on our field-based tools by incorporating direct measures of habitat quality.

3.4.2 Effectiveness of Pilot Project Methodology

Through this project, several lessons were learned about carrying out a river-basin scale wetland assessment. These lessons involved the study design, field methods, and metric scoring thresholds.

<u>Study Design:</u> The most significant lesson learned regarding the study design was that there were several real disadvantages to not having complete and consistent digital data at the start of the project. In order to make up for the lack of complete NWI, we integrated CPW's riparian mapping with the existing NWI. Though this did provide more coverage across the sample frame, the different definitions used by the two data sources led to too many target sites outside the target population. We found it was incredibly important that the sample frame matched the target population as closely as possible. Combining alternative data sources led to lost time in the field and confusion on the part of the field team. In addition, a clear definition of the target pollution was also imperative. For a significant portion of the 2008 field season, the team worked hard to clarify the target population definition and determine the best criteria to use to ensure that all members understood which points should be included and which should be excluded. In the future, we will only carry out wetland assessment projects in areas for which we have complete digital wetland data in advance.

In part due to the lack of NWI data, we chose a two-stage survey design for this project with stage one based on HUC12 watersheds of similar characteristics. The two-stage design did turn out to be helpful for more efficient sampling within watersheds, particularly in mountain watersheds that required backpacking for access. Within these remote watersheds, teams were able to sample numerous sites on one trip. However, the HUC12 watershed unit did not always control for the range of variation within each watershed. This was particularly true at the interface between the mountain/foothills and the valley floor. Some individual HUC12 watersheds on the eastern edge of the basin (watershed stratum F) spanned the full range from >14,000 ft to the valley floor. Higher portions of these watershed shared more similar characteristics to the high San Juan Mountains in watershed stratum A, while the lower portions of the watersheds were more similar to watershed strata D and E. This confounds results complied by watershed strata.

Instead of clustered watersheds, we found dividing the landscape by Level 4 Ecoregions leads to much stronger and more cohesive units. Wetland profiles summarized by ecoregion show very clear patterns in wetland distribution, abundance, and characterization (see Appendix G). In the ordination of wetland vegetation, ecoregions were better able to distinguish vegetation patterns than were the watershed strata. Though we could not stratify by ecoregions in this study due to lack of NWI data, all future studies will use a one-stage design stratified by Level 4 Ecoregions.

Lastly, the target watersheds became a problem in certain areas of the basin where private landowners held large tracts of land, at times making up a significant portion of an individual watershed. In these cases, a few no responses meant that we were unable to survey most or all of the wetlands within a watershed, which hampered out ability to carry out some desired analyses. Instead of limiting the target wetland points to target watershed, drawing sample points from across all wetland area within a river basin ensures a better spread of points and alleviates the issue of undersampling in a given watershed.

<u>Field Methods and Metrics:</u> A couple significant changes were made to the methods either during the course of this study or as a result of this study. The first lesson learned was that defining the potential AA and a 100 m radius circle around the target point was simply too large for the crew to effectively work in. A full 100 m circle AA represents 7.75 acres or 3.14 hectares, which is a considerable area to assess in one visit. In most cases, the full 100 m radius circles often spilled well beyond the wetland boundary. Most AAs were than drawn based on the wetland boundary and ranged in size from 0.25–7.75 acres. The average AA was ~3 acres, less than half the potential size. This issue arose early in the first field season, but to keep the data consistent, we continued to use the 100 m radius circle to define the potential AA throughout this project. In all future projects, we will use a 40 m radius circle, which creates an AA that is 1.25 acres or 0.5 hectares.

One issue that we did address and change in the middle of this project was the intensiveness of the VIBI plot method. After the 2008 field season, it was decided that the nested corners in the vegetation plat did not provide significant enough information to warrant the extra time. It was important that a team of two people be able to carry out the methods in under 6 hours, including the site characterization, vegetation plot, soil pits, and EIA metric evaluation. Reducing the time needed to carry out the vegetation plat was an important decision and will be followed in all future basin studies.

The third important lesson learned regarding the field protocols was that EIA metrics with ambiguous narrative ratings were difficult for field crew to interpret consistently. Based on feedback from the field crew and analysis conducted during the field test of the Riparian Shrubland EIA (Lemly and Rocchio 2009a), several draft metrics were eliminated or refined. Future basin assessments will benefit greatly from these changes. The same issue of ambiguity also led to much more detailed descriptions of wetland and riparian Ecological Systems and the field key included as Appendix C of this report. This key was developed collaboratively between the Colorado and Montana Natural Heritage Program and benefited greatly from experiences and feedback form field crew members during the course of this project. It is also clear from the results of this study that more work is needed to refine the Level 3 assessment tools for Colorado. While the Level 2 EIA metrics have come a long way since their draft protocols, the VIBI model for wet meadows needs more calibration with data from this and other projects.

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APPENDIX A: Details on Stressors Included in the Wetland LIM

TNC Aquatic Measures
Title: Freshwater measures in Colorado
Originators: The Nature Conservancy and Colorado State University
Publication date: unpublished draft, date of dataset 10/2010
Data type: vector digital data
Other citation details: John Sanderson and Jan Koenig, The Nature Conservancy, Colorado Field Office.
Media: electronic mail system
Source contribution: Source of modeled mean annual flow, reservoir storage, altered annual flow, dams and diversions. Both local watershed values and upstream accumulated values.
Date: 2008
Currentness reference: ground condition

Permitted Mines
Title: Permitted Mines
Originators: Division of Reclamation, Mining and Safety, State of Colorado
Publication date: Summer 2008
Data type: vector digital data
Data location: http://mining.state.co.us/GIS 20Data.htm
Map scale denominator: statewide
Media: online
Source contribution: Source of mine locations and types.
Date: Summer 2008
Currentness reference: publication date

Well Applications
Title: Well application information for the Colorado Division of Water Resources
Originators: Data dump from HydroBase
Publication date: unpublished material
Data type: vector digital data
Data location: ftp://dwrftp.state.co.us/dwr/GIS/well_applications.zip
Other citation details: Spatial representation of well application data
Map scale denominator: statewide
Media: online
Source contribution: Source of well locations and types
Date: 04/15/2011
Currentness reference: downloaded

LandFire Current Veg
Title: LANDFIRE Current Vegetation for Colorado
Originators: United States Forest Service
Publication date: 2006
Data type: raster digital data
Data location: http://www.LANDFIRE.gov
Other citation details: Missoula MT
Media: online

Source contribution: Source of land-cover information. Used to derive levels of housing/commercial development, agriculture.
Date: 2006
Currentness reference: publication date

TIGER/Line 2006se
Title: TIGER/Line Files, 2006 Second Edition, Colorado
Originators: U.S. Department of Commerce, U.S. Census Bureau, Geography Division
Series name: TIGER/Line Files
Series identification: Each file contains a version code that uniquely identifies each specific release of a version of the TIGER/Line files. The version code (MMYY) represents the month and year that the data in the file was extracted from the TIGER database.
Publication date: 2006
Edition: 2006 Second Edition
Data type: vector digital data
Data location: http://www.census.gov/geo/www/tiger
Media: online
Source contribution: Source of roads data
Date: 2006
Currentness reference: publication date

Oil & Gas Wells
Title: Wells
Originators: Colorado Oil and Gas Conservation Commission
Publication date: Updated daily
Data type: vector digital data
Data location: http://oil-gas.state.co.us/
Map scale denominator: statewide
Media: online
Source contribution: Source of oil & gas well locations, type, & status
Date: 04/15/2011
Currentness reference: downloaded

Wind Turbines
Title: wind_farms
Originators: Colorado Natural Heritage Program
Publication date: July 15, 2008
Map scale denominator: statewide
Source contribution: Source of wind turbine locations
Date: July 15, 2008
Currentness reference: ground condition

Tamarisk
Title: Tamarisk
Originators: The Nature Conservancy and the Tamarisk Coalition
Publication date: unpublished material
Media: electronic mail system
Source contribution: Source of tamarisk infestation locations and density

APPENDIX B: Wetland LIM Stressor Classes by HUC8 River Subbasin and County

Appendix B.1. Wetland LIM stressor classes by HUC8 river subbasin. Subbasins are organized by major river basins for ease of interpretation.

HUC8 Code	HUC8 River Subbasin Name	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
North Platte River Basin						
10180001	North Platte Headwaters	9.69%	29.84%	21.18%	26.48%	12.81%
10180002	Upper North Platte	17.98%	48.45%	16.86%	11.22%	5.50%
10180010	Upper Laramie	22.76%	46.01%	16.11%	11.19%	3.92%
South Platte River Basin						
10190001	South Platte Headwater	9.46%	34.47%	23.49%	18.60%	13.99%
10190002	Upper South Platte	13.21%	30.69%	17.07%	13.08%	25.95%
10190003	Middle South Platte-Cherry Creek	0.78%	12.24%	16.63%	18.55%	51.80%
10190004	Clear Creek	4.61%	27.33%	20.51%	16.10%	31.45%
10190005	St. Vrain	3.47%	19.56%	14.19%	12.64%	50.14%
10190006	Big Thompson	12.20%	24.30%	14.38%	12.26%	36.86%
10190007	Cache La Poudre	13.77%	29.46%	14.68%	11.64%	30.46%
10190008	Lone Tree-Owl	5.36%	32.87%	17.36%	15.35%	29.06%
10190009	Crow	4.99%	44.42%	23.61%	14.37%	12.61%
10190010	Kiowa	0.03%	15.70%	33.03%	25.90%	25.34%
10190011	Bijou	1.34%	32.71%	29.18%	20.84%	15.93%
10190012	Middle South Platte-Sterling	0.93%	31.24%	21.42%	21.30%	25.11%
10190013	Beaver	3.73%	24.32%	30.67%	25.93%	15.35%
10190014	Pawnee	5.81%	42.52%	23.42%	16.75%	11.51%
10190015	Upper Lodgepole	2.07%	22.35%	39.61%	29.93%	6.03%
10190016	Lower Lodgepole	0.00%	8.56%	24.19%	42.11%	25.13%
10190017	Sidney Draw	2.16%	33.76%	33.21%	22.01%	8.87%
10190018	Lower South Platte	0.33%	23.22%	23.47%	23.41%	29.58%

HUC8 Code	HUC8 River Subbasin Name	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
Republican River Basin						
10250001	Arikaree	0.60%	17.50%	33.29%	31.76%	16.86%
10250002	North Fork Republican	0.13%	10.46%	27.12%	30.92%	31.37%
10250003	South Fork Republican	0.64%	14.09%	34.14%	34.17%	16.96%
10250005	Frenchman	0.00%	4.12%	26.37%	41.34%	28.17%
10250006	Stinking Water	0.00%	2.67%	28.32%	42.29%	26.72%
10250012	South Fork Beaver	0.05%	4.37%	22.93%	43.52%	29.13%
10250013	Little Beaver	0.00%	1.53%	21.00%	50.80%	26.67%
10260001	Smoky Hill Headwaters	2.10%	17.03%	43.82%	25.21%	11.84%
10260002	North Fork Smoky Hill	0.31%	6.69%	33.22%	39.64%	20.13%
10260004	Ladder	1.02%	10.73%	41.25%	29.50%	17.50%
Upper Arkansas River Basin						
11020001	Arkansas Headwaters	16.52%	43.14%	19.28%	10.66%	10.40%
11020002	Upper Arkansas	7.40%	41.11%	24.65%	13.23%	13.62%
11020003	Fountain	8.68%	33.64%	17.84%	13.09%	26.75%
11020004	Chico	8.50%	38.30%	36.52%	13.14%	3.55%
11020005	Upper Arkansas-Lake Meredith	10.00%	56.02%	17.40%	6.07%	10.51%
11020006	Huerfano	9.09%	49.13%	23.05%	11.02%	7.70%
11020007	Apishapa	25.37%	48.11%	13.36%	6.07%	7.10%
11020008	Horse	5.95%	57.69%	24.70%	8.09%	3.58%
11020009	Upper Arkansas-John Martin Reservoir	14.28%	39.86%	17.68%	16.64%	11.54%
11020010	Purgatorie	26.61%	45.84%	13.08%	7.87%	6.60%
11020011	Big Sandy	3.69%	43.69%	27.60%	19.82%	5.19%
11020012	Rush	2.53%	48.08%	27.23%	16.63%	5.54%
11020013	Two Butte	12.00%	57.06%	21.71%	7.76%	1.46%
11030001	Middle Arkansas-Lake McKinney	0.00%	8.33%	30.16%	47.67%	13.83%
11030002	Whitewoman	0.57%	6.90%	60.59%	22.72%	9.22%

HUC8 Code	HUC8 River Subbasin Name	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
11040001	Cimarron Headwaters	34.79%	53.07%	9.89%	1.85%	0.40%
11040002	Upper Cimarron	6.97%	49.64%	24.27%	14.78%	4.33%
11040003	North Fork Cimarron	0.03%	4.42%	33.39%	43.89%	18.27%
11040004	Sand Arroyo	0.26%	18.58%	24.58%	39.11%	17.46%
11040005	Bear	0.76%	12.08%	38.59%	32.49%	16.08%
11080001	Canadian Headwaters	42.96%	21.13%	22.38%	6.05%	7.48%
Rio Grande Headwaters River Basin						
13010001	Rio Grande Headwaters	33.55%	47.92%	9.37%	4.49%	4.67%
13010002	Alamosa-Trinchera	14.21%	32.88%	15.55%	10.17%	27.20%
13010003	San Luis	6.62%	27.31%	18.52%	14.23%	33.32%
13010004	Saguache	9.11%	44.06%	16.31%	10.25%	20.28%
13010005	Conejos	21.02%	41.47%	11.75%	8.03%	17.73%
13020101	Upper Rio Grande	2.63%	29.30%	26.31%	16.98%	24.77%
13020102	Rio Chama	44.05%	32.87%	17.10%	5.20%	0.78%
Colorado Headwaters River Basin						
14010001	Colorado Headwaters	16.99%	41.45%	18.03%	13.74%	9.80%
14010002	Blue	17.40%	43.76%	17.04%	10.36%	11.44%
14010003	Eagle	10.68%	47.20%	18.89%	10.98%	12.24%
14010004	Roaring Fork	14.41%	45.69%	15.81%	9.94%	14.16%
14010005	Colorado Headwaters-Plateau	11.78%	46.31%	16.09%	9.20%	16.62%
Gunnison River Basin						
14020001	East-Taylor	29.35%	46.84%	12.83%	5.44%	5.54%
14020002	Upper Gunnison	15.43%	51.80%	17.31%	7.73%	7.74%
14020003	Tomichi	20.62%	49.32%	16.30%	7.45%	6.30%
14020004	North Fork Gunnison	16.41%	35.85%	18.67%	13.63%	15.43%
14020005	Lower Gunnison	18.63%	46.28%	12.61%	6.98%	15.50%
14020006	Uncompahange	7.32%	34.67%	20.08%	10.87%	27.05%

HUC8 Code	HUC8 River Subbasin Name	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
Dolores River Basin						
14030001	Westwater Canyon	18.58%	60.19%	17.27%	3.49%	0.47%
14030002	Upper Dolores	27.78%	48.60%	12.98%	6.66%	3.98%
14030003	San Miguel	15.16%	44.88%	19.12%	10.39%	10.44%
14030004	Lower Dolores	30.41%	54.60%	9.59%	3.13%	2.27%
14030005	Upper Colorado-Kane Springs	1.56%	72.12%	18.73%	5.11%	2.49%
White-Yampa-Green River Basin						
14040106	Upper Green-Flaming Gorge Reservoir	19.62%	58.40%	17.60%	3.12%	1.27%
14040109	Vermilion	21.98%	55.42%	17.65%	3.68%	1.26%
14050001	Upper Yampa	8.68%	28.29%	20.17%	23.06%	19.80%
14050002	Lower Yampa	15.75%	55.19%	18.12%	7.05%	3.89%
14050003	Little Snake	19.22%	52.25%	16.26%	9.52%	2.75%
14050005	Upper White	19.78%	41.25%	18.30%	12.88%	7.78%
14050006	Piceance-Yellow	13.04%	58.91%	18.61%	6.39%	3.05%
14050007	Lower White	21.03%	55.40%	16.10%	5.05%	2.42%
14060001	Lower Green-Diamond	31.76%	51.97%	13.02%	2.05%	1.20%
Upper San Juan River Basin						
14080101	Upper San Juan	16.82%	34.79%	13.69%	12.68%	22.01%
14080102	Piedra	21.12%	39.66%	14.65%	13.18%	11.39%
14080104	Animas	22.61%	33.43%	11.48%	9.02%	23.46%
14080105	Middle San Juan	2.55%	14.30%	23.04%	30.64%	29.48%
14080107	Mancos	7.56%	39.03%	25.34%	18.97%	9.10%
14080201	Lower San Juan-Four Corners	13.97%	50.77%	20.69%	10.61%	3.97%
14080202	McElmo	5.95%	34.55%	17.03%	18.65%	23.83%
14080203	Montezuma	4.26%	30.54%	25.65%	24.22%	15.33%

Appendix B.2. Wetland LIM stressor classes by county.

County	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
ADAMS	0.07%	5.21%	19.34%	28.52%	46.86%
ALAMOSA	1.70%	11.31%	14.42%	16.90%	55.67%
ARAPAHOE	1.37%	12.37%	25.05%	25.20%	36.02%
ARCHULETA	16.06%	34.69%	18.80%	16.80%	13.65%
BACA	4.53%	27.26%	28.16%	27.69%	12.35%
BENT	23.08%	52.15%	10.42%	5.96%	8.39%
BOULDER	3.97%	21.23%	15.52%	14.58%	44.70%
BROOMFIELD	0.00%	0.03%	2.21%	4.22%	93.54%
CHAFFEE	23.56%	45.41%	12.58%	7.23%	11.22%
CHEYENNE	2.41%	29.84%	36.50%	22.40%	8.85%
CLEAR CREEK	12.97%	40.83%	22.17%	12.38%	11.65%
CONEJOS	17.84%	39.22%	11.54%	8.59%	22.81%
COSTILLA	14.53%	33.65%	23.70%	12.38%	15.73%
CROWLEY	7.35%	60.79%	19.17%	6.94%	5.75%
CUSTER	10.57%	34.38%	25.23%	15.53%	14.28%
DELTA	7.24%	29.60%	17.17%	13.85%	32.15%
DENVER	0.00%	0.21%	1.32%	7.46%	91.01%
DOLORES	28.17%	41.12%	15.64%	9.95%	5.12%
DOUGLAS	5.27%	25.11%	26.94%	21.45%	21.23%
EAGLE	9.97%	44.38%	20.07%	14.21%	11.36%
EL PASO	4.85%	37.08%	31.10%	14.22%	12.75%
ELBERT	2.84%	41.63%	34.57%	15.56%	5.40%
FREMONT	8.58%	45.66%	23.69%	12.36%	9.71%
GARFIELD	14.47%	45.49%	16.64%	9.82%	13.58%

County	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
GILPIN	2.81%	32.64%	23.38%	19.52%	21.65%
GRAND	19.27%	40.39%	17.21%	11.92%	11.21%
GUNNISON	19.52%	47.47%	17.37%	8.37%	7.27%
HINSDALE	31.65%	54.75%	8.09%	3.41%	2.10%
HUERFANO	7.65%	47.98%	24.40%	11.80%	8.16%
JACKSON	10.70%	32.09%	20.65%	24.63%	11.92%
JEFFERSON	4.29%	19.20%	14.71%	16.00%	45.80%
KIOWA	2.31%	33.12%	29.00%	27.24%	8.32%
KIT CARSON	0.40%	11.32%	32.52%	37.28%	18.48%
LA PLATA	12.38%	22.30%	13.28%	15.25%	36.79%
LAKE	19.26%	46.79%	16.22%	8.37%	9.37%
LARIMER	16.63%	34.41%	16.11%	11.64%	21.21%
LAS ANIMAS	28.53%	45.87%	12.85%	6.86%	5.90%
LINCOLN	5.53%	41.42%	29.08%	18.06%	5.92%
LOGAN	0.52%	23.69%	23.04%	26.94%	25.82%
MESA	20.15%	49.21%	12.97%	6.16%	11.51%
MINERAL	37.78%	46.18%	8.35%	4.36%	3.32%
MOFFAT	17.88%	52.75%	17.24%	7.34%	4.80%
MONTEZUMA	11.97%	39.13%	19.50%	16.23%	13.18%
MONTROSE	13.35%	48.14%	15.98%	7.21%	15.31%
MORGAN	0.99%	27.89%	17.38%	19.21%	34.54%
OTERO	6.57%	59.13%	15.43%	5.68%	13.19%
OURAY	9.87%	36.89%	25.24%	13.06%	14.94%
PARK	13.47%	36.41%	21.73%	16.14%	12.25%
PHILLIPS	0.00%	3.29%	24.98%	39.10%	32.63%
PITKIN	16.35%	52.51%	14.71%	7.29%	9.13%
PROWERS	5.36%	28.20%	26.87%	23.13%	16.43%

County	No Discernable Stress	Low Stress	Moderate Stress	High Stress	Severe Stress
PUEBLO	14.84%	47.07%	20.20%	7.75%	10.14%
RIO BLANCO	15.98%	50.39%	18.59%	9.68%	5.36%
RIO GRANDE	17.51%	33.12%	9.78%	6.20%	33.39%
ROUTT	8.04%	28.97%	20.19%	24.82%	17.97%
SAGUACHE	13.85%	44.58%	16.72%	9.99%	14.86%
SAN JUAN	30.55%	52.60%	11.17%	4.13%	1.56%
SAN MIGUEL	14.35%	45.52%	19.22%	12.16%	8.75%
SEDGWICK	0.93%	13.68%	24.15%	33.01%	28.22%
SUMMIT	18.79%	44.71%	16.54%	9.12%	10.84%
TELLER	8.01%	36.31%	25.56%	16.73%	13.40%
WASHINGTON	0.66%	17.43%	33.07%	32.03%	16.80%
WELD	3.09%	28.07%	18.03%	14.78%	36.03%
YUMA	0.41%	18.19%	20.80%	27.16%	33.44%

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

1a. Wetland defined by groundwater inflows and peat (organic soil) accumulation of at least 40 cm. Vegetation can be woody or herbaceous. If the wetland occurs within a mosaic of non-peat forming wetland or riparian systems, then the patch must be at least 0.1 hectares (0.25 acres). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criteria. .... **Rocky Mountain Subalpine-Montane Fen**

1b. Wetland does not have at least 40 cm of peat (organic soil) accumulation or occupies an area less than 0.1 hectares (0.25 acres) within a mosaic of other non-peat forming wetland or riparian systems **2**

2a. Total woody canopy cover generally 25% or more within the overall wetland/riparian area. Any purely herbaceous patches are less than 0.5 hectares and occur within a matrix of woody vegetation. Note: Relictual woody vegetation such as standing dead trees and shrubs are included here............................ **GO TO KEY A: Woodland and Shrubland Ecological Systems**

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

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

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

KEY A: Woodland and Shrubland Ecological Systems

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

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

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

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

3a. Montane or subalpine riparian woodlands (canopy dominated by trees). This system occurs as a narrow streamside forest lining small, confined low- to mid-order streams. Common tree species include *Abies lasiocarpa*, *Picea engelmannii*, *Pseudotsuga menziesii*, and *Populus tremuloides*.. **Rocky Mountain Subalpine-Montane Riparian Woodland**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

11a. Subalpine to montane shrubby wetlands that occur around seeps, fens, lakes, and isolated springs on slopes away from valley bottoms. This system can also occur within a mosaic of multiple shrub- and herb-dominated communities within snowmelt-fed basins. Vegetation dominated by species of *Salix*, *Alnus*, or *Betula.* Within Slope, Flat, Lacustrine, or Depressional HGM Classes, this system has a similar species composition as occurrences within the Riverine HGM Class, but occurs in different landscape settings .... **Rocky Mountain Subalpine-Montane Riparian Shrubland**

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

KEY B: Herbaceous Wetland Ecological Systems

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

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

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

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

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

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

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

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

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

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

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

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

7a. Wetlands with a permanent water source throughout all or most of the year. Water is at or above the surface throughout the growing season, except in drought years. This system can occur around ponds, as fringes around lakes and along slow-moving streams and rivers. The vegetation is dominated by common emergent and floating leaved species including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Juncus*, *Carex*, *Potamogeton*, *Polygonum*, and *Nuphar*. .... **Western North American Emergent Marsh**

7b. Herbaceous wetlands associated with a high water table or overland flow, but typically lacking standing water. Sites with *no channel formation* are typically associated with snowmelt and not subjected to high disturbance events such as flooding (Slope HGM Class). Sites *associated with a stream channel* are more tightly connected to overbank flooding from the stream channel than with snowmelt and groundwater discharge and may be subjected to high disturbance events such as flooding (Riverine HGM Class). Vegetation is dominated by herbaceous species; typically graminoids have the highest canopy cover including *Carex* spp., *Calamagrostis* spp., and *Deschampsia caespitosa* .... **Rocky Mountain Alpine-Montane Wet Meadow**

KEY C: Sparsely Vegetated Ecological Systems

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

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

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

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

APPENDIX D: NWI Codes and CPW Wetland and Riparian Mapping Categories Included in the Rio Grande Headwaters Sample Frame

Appendix D.1: NWI Codes included in the Rio Grande Headwaters sample frame.

CODE	SYSTEM	SUBSYS	CLASS	REGIME	SPC_MOD	INCLUDE?
L2ABC	Lacustrine	Littoral	Aquatic Bed	Seasonally Flooded		Yes
L2ABF	Lacustrine	Littoral	Aquatic Bed	Semipermanently Flooded		Yes
L2ABFh	Lacustrine	Littoral	Aquatic Bed	Semipermanently Flooded	Diked / Impounded	Yes
L2ABG	Lacustrine	Littoral	Aquatic Bed	Intermittently Exposed		Yes
L2ABGh	Lacustrine	Littoral	Aquatic Bed	Intermittently Exposed	Diked / Impounded	Yes
PABF	Palustrine		Aquatic Bed	Semipermanently Flooded		Yes
PABFb	Palustrine		Aquatic Bed	Semipermanently Flooded	Beaver	Yes
PABFh	Palustrine		Aquatic Bed	Semipermanently Flooded	Diked / Impounded	Yes
PABG	Palustrine		Aquatic Bed	Intermittently Exposed		Yes
PABGb	Palustrine		Aquatic Bed	Intermittently Exposed	Beaver	Yes
PABGd	Palustrine		Aquatic Bed	Intermittently Exposed	Partially Drained / Ditched	Yes
PABGh	Palustrine		Aquatic Bed	Intermittently Exposed	Diked / Impounded	Yes
PABH	Palustrine		Aquatic Bed	Permanently Flooded		Yes
PEM / SSA	Palustrine		Emergent / Scrub-Shrub	Temporarily Flooded		Yes
PEM / USW	Palustrine		Emergent / Unconsolidated Shore	Intermittently Flooded / Temporary		Yes
PEM1A	Palustrine		Emergent	Temporarily Flooded		Yes
PEM1C	Palustrine		Emergent	Seasonally Flooded		Yes
PEM1Ch	Palustrine		Emergent	Seasonally Flooded	Diked / Impounded	Yes
PEMA	Palustrine		Emergent	Temporarily Flooded		Yes
PEMAd	Palustrine		Emergent	Temporarily Flooded	Partially Drained / Ditched	Yes
PEMAh	Palustrine		Emergent	Temporarily Flooded	Diked / Impounded	Yes
PEMB	Palustrine		Emergent	Saturated		Yes
PEMBb	Palustrine		Emergent	Saturated	Beaver	Yes
PEMC	Palustrine		Emergent	Seasonally Flooded		Yes
PEMCb	Palustrine		Emergent	Seasonally Flooded	Beaver	Yes
PEMCd	Palustrine		Emergent	Seasonally Flooded	Partially Drained / Ditched	Yes
PEMCh	Palustrine		Emergent	Seasonally Flooded	Diked / Impounded	Yes

CODE	SYSTEM	SUBSYS	CLASS	REGIME	SPC_MOD	INCLUDE?
PEMF	Palustrine		Emergent	Semipermanently Flooded		Yes
PEMFb	Palustrine		Emergent	Semipermanently Flooded	Beaver	Yes
PEMFd	Palustrine		Emergent	Semipermanently Flooded	Partially Drained / Ditched	Yes
PEMFh	Palustrine		Emergent	Semipermanently Flooded	Diked / Impounded	Yes
PEMJ	Palustrine		Emergent	Intermittently Flooded		Yes
PEMJh	Palustrine		Emergent	Intermittently Flooded	Diked / Impounded	Yes
PEMW	Palustrine		Emergent	Intermittently Flooded / Temporary		Yes
PEMY	Palustrine		Emergent	Saturated / Semipermanent / Seasonal		Yes
PFLY	Palustrine		Flat	Saturated / Semipermanent / Seasonal		Yes
PFO / EMW	Palustrine		Forested / Emergent	Intermittently Flooded / Temporary		Yes
PFO / SSJ	Palustrine		Forested / Scrub-Shrub	Intermittently Flooded		Yes
PFO / SSW	Palustrine		Forested / Scrub-Shrub	Intermittently Flooded / Temporary		Yes
PFO / SSY	Palustrine		Forested / Scrub-Shrub	Saturated / Semipermanent / Seasonal		Yes
PFO / USW	Palustrine		Forested / Unconsolidated Shore	Intermittently Flooded / Temporary		Yes
PFOA	Palustrine		Forested	Temporarily Flooded		Yes
PFOAb	Palustrine		Forested	Temporarily Flooded	Beaver	Yes
PFOAd	Palustrine		Forested	Temporarily Flooded	Partially Drained / Ditched	Yes
PFOAh	Palustrine		Forested	Temporarily Flooded	Diked / Impounded	Yes
PFOB	Palustrine		Forested	Saturated		Yes
PFOC	Palustrine		Forested	Seasonally Flooded		Yes
PFOHh	Palustrine		Forested	Permanently Flooded	Diked / Impounded	Yes
PFOJ	Palustrine		Forested	Intermittently Flooded		Yes
PFOW	Palustrine		Forested	Intermittently Flooded / Temporary		Yes
PSS / EMB	Palustrine		Scrub-Shrub / Emergent	Saturated		Yes
PSS / EMC	Palustrine		Scrub-Shrub / Emergent	Seasonally Flooded		Yes
PSS / EMW	Palustrine		Scrub-Shrub / Emergent	Intermittently Flooded / Temporary		Yes
PSS / EMY	Palustrine		Scrub-Shrub / Emergent	Saturated / Semipermanent / Seasonal		Yes
PSS / FLW	Palustrine		Scrub-Shrub / Flat	Intermittently Flooded / Temporary		Yes
PSS / USW	Palustrine		Scrub-Shrub / Unconsolidated Shore	Intermittently Flooded / Temporary		Yes
PSS1Ch	Palustrine		Scrub-Shrub	Seasonally Flooded	Diked / Impounded	Yes

CODE	SYSTEM	SUBSYS	CLASS	REGIME	SPC_MOD	INCLUDE?
PSSA	Palustrine		Scrub-Shrub	Temporarily Flooded		Yes
PSSAb	Palustrine		Scrub-Shrub	Temporarily Flooded	Beaver	Yes
PSSAd	Palustrine		Scrub-Shrub	Temporarily Flooded	Partially Drained / Ditched	Yes
PSSAh	Palustrine		Scrub-Shrub	Temporarily Flooded	Diked / Impounded	Yes
PSSB	Palustrine		Scrub-Shrub	Saturated		Yes
PSSBb	Palustrine		Scrub-Shrub	Saturated	Beaver	Yes
PSSBd	Palustrine		Scrub-Shrub	Saturated	Partially Drained / Ditched	Yes
PSSC	Palustrine		Scrub-Shrub	Seasonally Flooded		Yes
PSSCb	Palustrine		Scrub-Shrub	Seasonally Flooded	Beaver	Yes
PSSCd	Palustrine		Scrub-Shrub	Seasonally Flooded	Partially Drained / Ditched	Yes
PSSCh	Palustrine		Scrub-Shrub	Seasonally Flooded	Diked / Impounded	Yes
PSSF	Palustrine		Scrub-Shrub	Semipermanently Flooded		Yes
PSSJ	Palustrine		Scrub-Shrub	Intermittently Flooded		Yes
PSSW	Palustrine		Scrub-Shrub	Intermittently Flooded / Temporary		Yes
R2ABF	Riverine	Lower Perennial	Aquatic Bed	Semipermanently Flooded		Yes

Appendix D.2: CPW wetland and riparian mapping categories included in the Rio Grande Headwaters sample frame.

Dominant Vegetation	Subdominant Vegetation	Class Area (m^2)	% of Basin	Include?
Herbaceous-General	Irrigated Agriculture*	583,720,722	53.00	No
Open Water-Canal		354,547	0.03	No
Open Water-Canal	Deciduous-Cottonwood	11,592	0.00	No
Open Water-Canal	Herbaceous-Sedges / Rushes-Moist Soils	27,628	0.00	No
Open Water-General	Unvegetated	391,781	0.04	No
Open Water-General	Upland Grass	3,555	0.00	No
Open Water-Riverine		7,167,701	0.65	No
Open Water-Riverine	Unvegetated	2,269,645	0.21	No
Open Water-Riverine	Upland Grass	41,925	0.00	No
Open Water-Riverine	Upland Shrub	116,679	0.01	No
Open Water-Standing		19,027,569	1.73	No
Open Water-Standing	Unvegetated	121,502	0.01	No
Open Water-Standing	Upland Grass	11,643	0.00	No
Shrub-Gambel Oak		26,166	0.00	No
Shrub-Gambel Oak	Deciduous-Aspen	70,676	0.01	No
Shrub-Gambel Oak	Herbaceous-Sedges / Rushes-Moist Soils	21,220	0.00	No
Shrub-Gambel Oak	Shrub-Willow	44,841	0.00	No
Shrub-Gambel Oak	Unvegetated	3,654	0.00	No
Shrub-Gambel Oak	Upland Grass	34,630	0.00	No
Unvegetated		4,322,889	0.39	No
Unvegetated	Open Water-Canal	3,469	0.00	No
Unvegetated	Open Water-Riverine	1,471,510	0.13	No
Unvegetated	Open Water-Standing	292,685	0.03	No
Unvegetated	Upland Grass	21,149,759	1.92	No
Unvegetated	Upland Shrub	673,279	0.06	No
Upland Grass		46,187,768	4.19	No
Upland Grass	Open Water-Riverine	103,269	0.01	No

*This class is not always irrigated agriculture and includes some acreage that looks like wetland. However, it was removed from dataset regardless because NWI polygons overlap most of what is incorrectly classified.

Dominant Vegetation	Subdominant Vegetation	Class Area (m^2)	% of Basin	Include?
Upland Grass	Open Water-Standing	20,414	0.00	No
Upland Grass	Shrub-Gambel Oak	63,628	0.01	No
Upland Grass	Unvegetated	33,628,517	3.05	No
Upland Grass	Upland Shrub	12,419,400	1.13	No
Upland Shrub		155,223	0.01	No
Upland Shrub	Unvegetated	317,583	0.03	No
Upland Shrub	Upland Grass	1,642,921	0.15	No
		Total percent of area removed	**66.80**	
Deciduous-Aspen		12,321,014	1.12	Yes
Deciduous-Aspen	Deciduous-Cottonwood	3,051	0.00	Yes
Deciduous-Aspen	Evergreen-General	7,484,039	0.68	Yes
Deciduous-Aspen	Herbaceous-Cattails / Sedges / Rushes-Standing Water	11,440	0.00	Yes
Deciduous-Aspen	Herbaceous-Sedges / Rushes-Moist Soils	2,530,183	0.23	Yes
Deciduous-Aspen	Open Water-Riverine	12,545	0.00	Yes
Deciduous-Aspen	Open Water-Standing	40,791	0.00	Yes
Deciduous-Aspen	Shrub-Gambel Oak	64,773	0.01	Yes
Deciduous-Aspen	Shrub-General	68,421	0.01	Yes
Deciduous-Aspen	Shrub-Willow	781,219	0.07	Yes
Deciduous-Aspen	Unvegetated	4,821	0.00	Yes
Deciduous-Aspen	Upland Grass	2,096,571	0.19	Yes
Deciduous-Aspen	Upland Shrub	115,069	0.01	Yes
Deciduous-Cottonwood		5,104,594	0.46	Yes
Deciduous-Cottonwood	Deciduous-Aspen	37,671	0.00	Yes
Deciduous-Cottonwood	Evergreen-General	612,498	0.06	Yes
Deciduous-Cottonwood	Herbaceous-Cattails / Sedges / Rushes-Standing Water	311,925	0.03	Yes
Deciduous-Cottonwood	Herbaceous-Sedges / Rushes-Moist Soils	6,844,356	0.62	Yes
Deciduous-Cottonwood	Open Water-Canal	111,848	0.01	Yes
Deciduous-Cottonwood	Open Water-Riverine	283,626	0.03	Yes
Deciduous-Cottonwood	Open Water-Standing	60,646	0.01	Yes
Deciduous-Cottonwood	Shrub-General	1,275,402	0.12	Yes

Dominant Vegetation	Subdominant Vegetation	Class Area (m^2)	% of Basin	Include?
Deciduous-Cottonwood	Shrub-Tamarisk	24,317	0.00	Yes
Deciduous-Cottonwood	Shrub-Willow	1,950,109	0.18	Yes
Deciduous-Cottonwood	Unvegetated	3,352,242	0.30	Yes
Deciduous-Cottonwood	Upland Grass	5,903,548	0.54	Yes
Deciduous-General		21,848	0.00	Yes
Deciduous-General	Shrub-Willow	18,261	0.00	Yes
Deciduous-General	Unvegetated	50,086	0.00	Yes
Deciduous-General	Upland Grass	1,347,119	0.12	Yes
Evergreen-General		5,131,559	0.47	Yes
Evergreen-General	Deciduous-Aspen	4,458,272	0.40	Yes
Evergreen-General	Deciduous-Cottonwood	509,789	0.05	Yes
Evergreen-General	Herbaceous-Cattails / Sedges / Rushes-Standing Water	11,813	0.00	Yes
Evergreen-General	Herbaceous-Sedges / Rushes-Moist Soils	2,628,743	0.24	Yes
Evergreen-General	Open Water-Riverine	330,026	0.03	Yes
Evergreen-General	Open Water-Standing	14,152	0.00	Yes
Evergreen-General	Shrub-Gambel Oak	10,050	0.00	Yes
Evergreen-General	Shrub-General	196,907	0.02	Yes
Evergreen-General	Shrub-Willow	1,896,857	0.17	Yes
Evergreen-General	Unvegetated	474,431	0.04	Yes
Evergreen-General	Upland Grass	2,823,387	0.26	Yes
Evergreen-General	Upland Shrub	112,976	0.01	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water		23,368,693	2.12	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Deciduous-Aspen	31,306	0.00	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Deciduous-Cottonwood	141,473	0.01	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Evergreen-General	144,723	0.01	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Herbaceous-Sedges / Rushes-Moist Soils	12,713,594	1.15	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Open Water-Riverine	217,588	0.02	Yes

Dominant Vegetation	Subdominant Vegetation	Class Area (m^2)	% of Basin	Include?
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Open Water-Standing	7,986,472	0.73	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Shrub-General	485,421	0.04	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Shrub-Willow	1,768,012	0.16	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Unvegetated	281,197	0.03	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Upland Grass	30,753	0.00	Yes
Herbaceous-Cattails / Sedges / Rushes-Standing Water	Upland Shrub	1,879	0.00	Yes
Herbaceous-General		3,703	0.00	Yes
Herbaceous-General	Shrub-General	1,515	0.00	Yes
Herbaceous-General	Unvegetated	543,708	0.05	Yes
Herbaceous-General	Upland Grass	4,649,263	0.42	Yes
Herbaceous-General	Upland Shrub	1,934	0.00	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Deciduous-Aspen	1,059,582	0.10	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Deciduous-Cottonwood	1,555,990	0.14	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Evergreen-General	2,671,576	0.24	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Herbaceous-Cattails / Sedges / Rushes-Standing Water	31,450,604	2.86	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Open Water-Canal	66,755	0.01	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Open Water-Riverine	2,608,577	0.24	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Open Water-Standing	781,772	0.07	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Shrub-Alpine Willow	64,683	0.01	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Shrub-General	2,520,775	0.23	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Shrub-Willow	11,682,280	1.06	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Unvegetated	13,681,048	1.24	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Upland Grass	45,037,432	4.09	Yes
Herbaceous-Sedges / Rushes-Moist Soils	Upland Shrub	100,993	0.01	Yes
Mesic Meadow		49,101	0.00	Yes
Open Water-Riverine	Deciduous-Cottonwood	94,900	0.01	Yes
Open Water-Riverine	Evergreen-General	104,519	0.01	Yes

Dominant Vegetation	Subdominant Vegetation	Class Area (m^2)	% of Basin	Include?
Open Water-Riverine	Herbaceous-Cattails / Sedges / Rushes-Standing Water	470,872	0.04	Yes
Open Water-Riverine	Herbaceous-Sedges / Rushes-Moist Soils	1,516,695	0.14	Yes
Open Water-Riverine	Shrub-General	24,568	0.00	Yes
Open Water-Riverine	Shrub-Willow	1,176,055	0.11	Yes
Open Water-Standing	Deciduous-Aspen	6,479	0.00	Yes
Open Water-Standing	Deciduous-Cottonwood	83,964	0.01	Yes
Open Water-Standing	Evergreen-General	20,068	0.00	Yes
Open Water-Standing	Herbaceous-Cattails / Sedges / Rushes-Standing Water	6,198,338	0.56	Yes
Open Water-Standing	Herbaceous-Sedges / Rushes-Moist Soils	901,637	0.08	Yes
Open Water-Standing	Shrub-General	71,346	0.01	Yes
Open Water-Standing	Shrub-Willow	876,123	0.08	Yes
Shrub-Alpine Willow		60,059	0.01	Yes
Shrub-Alpine Willow	Herbaceous-Sedges / Rushes-Moist Soils	134,669	0.01	Yes
Shrub-Alpine Willow	Open Water-Standing	22,955	0.00	Yes
Shrub-Alpine Willow	Upland Grass	6,785	0.00	Yes
Shrub-General		597,116	0.05	Yes
Shrub-General	Deciduous-Aspen	34,643	0.00	Yes
Shrub-General	Deciduous-Cottonwood	324,822	0.03	Yes
Shrub-General	Evergreen-General	121,154	0.01	Yes
Shrub-General	Herbaceous-Cattails / Sedges / Rushes-Standing Water	571,551	0.05	Yes
Shrub-General	Herbaceous-Sedges / Rushes-Moist Soils	1,580,217	0.14	Yes
Shrub-General	Open Water-Riverine	178,038	0.02	Yes
Shrub-General	Open Water-Standing	192,512	0.02	Yes
Shrub-General	Unvegetated	680,891	0.06	Yes
Shrub-General	Upland Grass	497,745	0.05	Yes
Shrub-General	Upland Shrub	14,304	0.00	Yes
Shrub-Willow		7,741,527	0.70	Yes
Shrub-Willow	Deciduous-Aspen	265,282	0.02	Yes
Shrub-Willow	Deciduous-Cottonwood	921,009	0.08	Yes
Shrub-Willow	Evergreen-General	965,743	0.09	Yes

Dominant Vegetation	Subdominant Vegetation	Class Area (m^2)	% of Basin	Include?
Shrub-Willow	Herbaceous-Cattails / Sedges / Rushes-Standing Water	2,300,440	0.21	Yes
Shrub-Willow	Herbaceous-Sedges / Rushes-Moist Soils	11,938,065	1.08	Yes
Shrub-Willow	Open Water-Riverine	2,370,946	0.22	Yes
Shrub-Willow	Open Water-Standing	488,730	0.04	Yes
Shrub-Willow	Unvegetated	401,759	0.04	Yes
Shrub-Willow	Upland Grass	1,347,811	0.12	Yes
Shrub-Willow	Upland Shrub	83,051	0.01	Yes
Unvegetated	Deciduous-Aspen	11,739	0.00	Yes
Unvegetated	Deciduous-Cottonwood	8,285,233	0.75	Yes
Unvegetated	Evergreen-General	295,099	0.03	Yes
Unvegetated	Herbaceous-Cattails / Sedges / Rushes-Standing Water	66,937	0.01	Yes
Unvegetated	Herbaceous-Sedges / Rushes-Moist Soils	6,585,944	0.60	Yes
Unvegetated	Shrub-General	658,881	0.06	Yes
Unvegetated	Shrub-Willow	349,365	0.03	Yes
Upland Grass	Deciduous-Aspen	596,533	0.05	Yes
Upland Grass	Deciduous-Cottonwood	529,634	0.05	Yes
Upland Grass	Evergreen-General	2,142,031	0.19	Yes
Upland Grass	Herbaceous-Cattails / Sedges / Rushes-Standing Water	54,323	0.00	Yes
Upland Grass	Herbaceous-Sedges / Rushes-Moist Soils	62,129,113	5.64	Yes
Upland Grass	Shrub-Alpine Willow	11,963	0.00	Yes
Upland Grass	Shrub-General	421,355	0.04	Yes
Upland Grass	Shrub-Willow	568,108	0.05	Yes
Upland Shrub	Deciduous-Cottonwood	7,752	0.00	Yes
Upland Shrub	Evergreen-General	42,801	0.00	Yes
Upland Shrub	Herbaceous-Sedges / Rushes-Moist Soils	35,977	0.00	Yes
Upland Shrub	Shrub-General	177,256	0.02	Yes
		Total percent of area remaining	**33.16**	

APPENDIX E: Rio Grande Pilot Wetland Condition Assessment Field Forms and Example Field Maps

APPENDIX F: Ecological Integrity Assessment (EIA) Metric Rating Criteria and Scoring Formulas for the Rio Grande Headwaters Pilot

Appendix G: EIA metric rating criteria for the Rio Grande Headwaters pilot wetland condition assessment, by ecological category.

	Key Ecological Attribute	Indicator / Metric	Metric Rating Criteria			
		Rank / Score	**A / 5**	**B / 4**	**C / 3**	**D / 1**
		Interpretation	**Reference (No or Minimal Human Impact)**	**Slight Deviation from Reference**	**Moderate Deviation from Reference**	**Significant Deviation from Reference**
LANDSCAPE CONTEXT	**Buffer**	*1a. Average Buffer Width*	Average buffer width is ≥100 m	Average buffer width is 50 to <100 m	Average buffer width is 25 to <50 m	Average buffer width is <25 m or no buffer exists
		1b. Buffer Condition	Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND little or no trash or refuse.	Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils, moderate or lesser amounts of trash or refuse, OR minor intensity of human visitation or recreation.	Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption, moderate or greater amounts of trash or refuse, OR moderate intensity of human visitation or recreation.	Dominant (>50%) cover of non-native plants, barren ground and highly compacted or otherwise disrupted soils, moderate or greater amounts of trash or refuse, moderate or greater intensity of human visitation or recreation, OR no buffer at all.
	Landscape Connectivity	*1c. Percent Unfragmented Landscape*	Embedded in 90–100% unfragmented, natural landscape.	Embedded in 60–90% unfragmented, natural landscape.	Embedded in 20–60% unfragmented, natural landscape.	Embedded in <20% unfragmented, natural landscape.
		1d. Riparian Corridor Continuity[1] *RIVERINE ONLY*	<5% of the riparian corridor with anthropogenic patches.	5–20% of the riparian corridor with anthropogenic patches.	20–50% of the riparian corridor with anthropogenic patches.	>50% of the riparian corridor with anthropogenic patches.

[1] Metric used for Riverine HGM wetlands only

	Key Ecological Attribute	Indicator / Metric	Metric Rating Criteria				
		Rank / Score	A / 5	B / 4	C / 3	D / 1 –OR– D / 2 and E / 1	
		Interpretation	Reference (No or Minimal Human Impact)	Slight Deviation from Reference	Moderate Deviation from Reference	Significant or Severe Deviation from Reference	
BIOTIC CONDITION	**Community Composition**[1]	*2a. Relative Cover Native Plant Species*	Relative cover native plants > 99%	Relative cover native plants >95-99%	Relative cover native plants >80-95%	Relative cover native plants >50-80%	Relative cover native plants <50%
		2b. Absolute Cover Noxious Weeds	Absolute cover noxious weeds = 0%	Absolute cover noxious weeds >0-3%	Absolute cover noxious weeds >3-10%	Absolute cover noxious weeds >10% noxious	
		2c. Absolute Cover Aggressive Native Species	<10% cattail or <5% reed canary grass or giant reed grass	10-25% cattail or 5-10% reed canary grass or giant reed grass	>25-50% cattail or 10-25% reed canary grass or giant reed grass	>50% cattail or >25% reed canary grass or giant reed grass	
		2d. Mean C[2]					
		Riparian Areas and Fens	Mean C > 6.0	Mean C > 5.5-6.0	Mean C >5.0-5.5	Mean C >4.5-5.0	Mean C ≤ 4.0
		Wet Meadows	Mean C > 6.0	Mean C > 5.5-6.0	Mean C >4.0-5.5	Mean C >3.0-4.0	Mean C ≤ 3.0
		Saline Wetlands & Marshes	Mean C > 4.5	Mean C > 4.0-4.5	Mean C >3.0-4.0	Mean C >2.0-3.0	Mean C ≤ 2.0
	Community Structure	*2e. Native Sapling and Seedling*[2]	Saplings and/or seedlings present in expected amounts; obvious regeneration; >15% of cottonwood cover and/or >5% of willow cover is established saplings and/or seedlings.	Saplings and/or seedlings present but less than expected; 5–15% of cottonwood cover and/or 1–5% of willow cover is established saplings and/or seedlings.	Saplings and/or seedling present but low amounts; little regeneration; >5% of cottonwood cover and/or >1% of willow cover is established saplings and/or seedlings.	No reproduction of woody species.	
		2f. Interspersion of Patches	Horizontal structure consists of a very complex array of nested and/or interspersed, irregular biotic and abiotic patches with no single dominant patch type.	Horizontal structure consists of a moderate array of biotic and abiotic patches with no single dominant patch type.	Horizontal structure consists of a simple array of biotic and abiotic patches.	Horizontal structure consists of one dominant patch type and thus has relatively no interspersion.	

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

	Key Ecological Attribute	Indicator / Metric	Metric Rating Criteria			
		Rank / Score	**A / 5**	**B / 4**	**C / 3**	**D / 1**
		Interpretation	**Reference (No or Minimal Human Impact)**	**Slight Deviation from Reference**	**Moderate Deviation from Reference**	**Significant Deviation from Reference**
ABIOTIC CONDITION	**Hydrology**[1]	*3a. Hydrologic Alteration* *NON-RIVERINE ONLY*	No alterations. No dikes, diversions, ditches, flow additions, pugging (hummocking from livestock hooves), or fill present in the assessment area that restricts flow.	Low intensity alterations such as roads at/near grade, pugging, small diversions or ditches (<1 ft deep), or minor flow additions.	Moderate intensity alterations such as 2-lane road, roads w/ culverts adequate for stream flow, moderate pugging, low dikes, medium diversions or ditches (1–3 ft deep), or moderate flow additions.	High intensity alteration such as 4-lane highway, large dikes, diversions or ditches (>3 ft deeper) capable of lowering the water table, large amount of fill, artificial groundwater pumping, or high amounts of flow additions.
		3b. Upstream Water Retention *RIVERINE ONLY*	<5% of watershed drains to water storage facility.	5–20% of watershed drains to water storage facility.	20–50% of watershed drains to water storage facility.	>50% of watershed drains to water storage facility.
		3c. Water Diversions and/or Additions *RIVERINE ONLY*	No upstream or onsite water diversions or additions present.	Few diversions/additions present or impacts minor relative to contributing watershed size. Minor impact to local hydrology.	Many diversions/additions present or impact moderate relative to contributing watershed size. Major impact to local hydrology.	Diversions/additions very numerous or impacts high relative to contributing watershed size. Local hydrology drastically altered.
		3d. Floodplain Interaction *RIVERINE ONLY*	Floodplain interaction is within natural range of variability. There are no geomorphic modifications (incised channel, dikes, levees, riprap, bridges, road beds, etc.) made to contemporary floodplain.	Floodplain interaction is disrupted due to the presence of a few geomorphic modifications. Up to 20% of streambanks are affected.	Floodplain interaction is highly disrupted due to multiple geomorphic modifications. Between 20 – 50% of streambanks are affected.	Complete geomorphic modification along river channel. The channel occurs in a steep, incised gulley due to anthropogenic impacts. More than 50% of streambanks are affected.
		3e. Bank Stability *RIVERINE ONLY*	Banks stable; evidence of erosion or bank failure absent or minimal; < 5% of bank affected. Streambanks dominated (> 90% cover) by stabilizing plant species (OBL & FACW).	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 (OBL & FACW).	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. Streambanks have 60-75% cover of stabilizing plant species (OBL & FACW).	Unstable; many eroded areas; "raw". Areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. Streambanks have < 60% cover of stabilizing plant species (OBL & FACW).
		3f. Beaver Activity[2] *RIVERINE ONLY*	Active or recent beaver sign present. Beaver currently active within the area.	Recent or old beaver sign present. Beaver may not be currently active, but have been within the past 10 years.	Only old beaver sign present. No evidence of recent or new beaver activity despite available food resources and habitat.	No beaver sign present.

ABIOTIC CONDITION	**Physio-chemistry**	*3g. Water Quality – Sediment and Turbidity*	No evidence of excessive sediment in assessment area due to human activities (bare ground, row crops, erosion, etc.); AND water is not turbid.	Slight evidence of excessive sediment in assessment area due to human activities, OR water is slightly turbid.	Moderate evidence of excessive sediment in assessment area due to human activities, OR water is moderately turbid.	High evidence of excessive sediment in assessment area due to human activities (bare ground, row crops, erosion, etc.); OR water is highly turbid.
		3h. Water Quality – Algal Growth	Algae growth is minimal.	Algae growth in small patches.	Algae growth in large patches.	Algae growth in continuous mats.
		3i. Substrate / Soil Disturbance	No apparent modifications.	Past modifications, but recovered; OR recent but minor modifications.	Recovering OR recent and moderate modifications.	Recent and severe modifications.

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

Scoring Formulas:

Non-Riverine HGM Wetlands

Landscape Context Score: ([(1a*1b)$^{1/2}$] * 0.6) + (1c * 0.4)
Biotic Condition Score: (2a * 0.2) + [(2b OR 2c[1]) * 0.2] + (2d * 0.4) + (2e[2] * 0.1) + [2f[2] * (0.1 OR 0.2)]
Abiotic Condition Score: (Hydrology Sub-score * 0.6) + (Physiochemistry Sub-score * 0.4)
Hydrology Sub-Score: (3a * 1.0)
Physiochemistry Sub-Score: (3g * 0.25) + (3h * 0.25) + (3i * 0.5)

Riverine HGM Wetlands

Landscape Context Score: ([(1a*1b)$^{1/2}$] * 0.6) + (1c * 0.3) + (1d * 0.1)
Biotic Condition Score: (2a * 0.2) + [(2b OR 2c[1]) * 0.2] + (2d * 0.4) + (2e[2] * 0.1) + [2f[2] *(0.1 OR 0.2)]
Abiotic Condition Score: (Hydrology Sub-score * 0.6) + (Physiochemistry Sub-score * 0.4)
Hydrology Sub-Score: ([(3b*3c)$^{1/2}$] * 0.5) + (3d * 0.3) + [3e[3] *(0.1 OR 0.2)] + (3f[3] * 0.1)
Physiochemistry Sub-Score: (3g * 0.25) + (3h * 0.25) + (3i * 0.5)

Overall EIA Score

(Landscape Context Score * 0.2) + (Biotic Condition Score * 0.4) + (Abiotic Score * 0.4)

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

Overall Score to Rank Conversion:

A = 4.5 – 5.0
B = 3.5 – <4.5
C = 2.5 – <3.5
D = 1.0 – <2.5

APPENDIX G: Wetland Acres by Class, Hydrologic Regime, and Land Ownership for HUC8 River Subbasins, Watershed Strata, and Ecoregions within the Rio Grande Headwaters Basin

HUC8 River Subbasin	Total Area within the Basin		Wetland and Waterbodies Area		Percent Wetlands by NWI System / Class						
	Acres	%	Acres	%	L1/L2	R2/3/4	UB/US	PAB	PEM	PSS	PFO
13010001: Rio Grande Headwaters	883,507	18%	33,965	12%	11%	5%	1%	3%	52%	29%	< 1%
13010002: Alamosa-Trinchera	1,577,461	33%	88,580	31%	5%	3%	1%	3%	84%	5%	< 1%
13010003: San Luis	1,011,949	21%	48,155	17%	4%	2%	1%	2%	90%	1%	< 1%
13010004: Saguache	859,078	18%	79,630	28%	< 1%	< 1%	< 1%	1%	95%	3%	< 1%
13010005: Conejos	342,486	7%	30,543	11%	4%	3%	< 1%	2%	78%	9%	4%
13020101: Upper Rio Grande	103,401	2%	565	< 1%	33%	14%	5%	18%	29%	1%	< 1%
13020102: Rio Chama	52,119	1%	1,364	< 1%	2%	2%	3%	9%	67%	16%	1%

HUC8 River Subbasin	Wetland Acres	Percent Wetlands by NWI Hydrologic Regime								Altered	Irrigated
		A	B	C	F	G	H	J	K		
13010001: Rio Grande Headwaters	33,965	8%	57%	20%	1%	3%	11%	--	< 1%	12%	2%
13010002: Alamosa-Trinchera	88,580	46%	5%	32%	7%	1%	6%	1%	2%	9%	42%
13010003: San Luis	48,155	64%	1%	17%	3%	3%	< 1%	12%	< 1%	2%	40%
13010004: Saguache	79,630	51%	6%	10%	1%	1%	< 1%	32%	--	1%	37%
13010005: Conejos	30,543	33%	18%	40%	2%	2%	6%	< 1%	--	4%	25%
13020101: Upper Rio Grande	565	35%	4%	10%	18%	--	33%	--	--	68%	5%
13020102: Rio Chama	1,364	2%	58%	25%	4%	9%	2%	--	--	1%	--

HUC8 River Subbasin	Wetland Acres	Percent Wetlands by Grouped Land Owners										
		USFS	BLM	NPS	FWS	BOR	SLB	CPW	STPARKS	PRIVATE	LAND TRUST	COUNTY
13010001: Rio Grande Headwaters	33,965	69%	< 1%	--	--	--	< 1%	1%	--	29%	--	--
13010002: Alamosa-Trinchera	88,580	4%	1%	--	18%	--	3%	2%	--	72%	--	< 1%
13010003: San Luis	48,155	1%	3%	5%	25%	--	4%	< 1%	1%	50%	11%	--
13010004: Saguache	79,630	8%	1%	--	< 1%	3%	4%	1%	--	82%	1%	--
13010005: Conejos	30,543	26%	< 1%	--	--	--	1%	--	--	73%	--	--
13020101: Upper Rio Grande	565	--	< 1%	--	--	--	--	--	--	100%	--	--
13020102: Rio Chama	1,364	61%	--	--	--	--	--	--	--	39%	--	--

Watershed Strata	Total Area within the Basin		Wetland and Waterbodies Area		Percent Wetlands by NWI System / Class						
	Acres	%	Acres	%	L1/L2	R2/3/4	UB/US	PAB	PEM	PSS	PFO
A: Upper San Juan Mtns	1,257,948	26%	50,554	18%	11%	2%	1%	4%	55%	26%	< 1%
B: Mid-Elevation Forests	1,110,312	23%	17,927	6%	3%	7%	1%	2%	71%	15%	1%
C: Foothill Shrublands	851,607	18%	57,037	20%	3%	3%	< 1%	2%	86%	4%	1%
D: Alluvial Fans, Valley Floor	362,805	8%	31,868	11%	1%	2%	1%	3%	89%	3%	2%
E: Salt Flats, Valley Floor	598,161	12%	105,576	37%	1%	< 1%	1%	1%	97%	< 1%	< 1%
F: Sangre de Cristo Mtns	649,246	13%	19,835	7%	12%	4%	1%	1%	80%	2%	< 1%

Watershed Strata	Wetland Acres	Percent Wetlands by NWI Hydrologic Regime								Altered	Irrigated
		A	B	C	F	G	H	J	K		
A: Upper San Juan Mtns	50,554	6%	62%	18%	1%	4%	11%	--	--	12%	< 1%
B: Mid-Elevation Forests	17,927	36%	18%	36%	2%	1%	8%	1%	< 1%	6%	25%
C: Foothill Shrublands	57,037	52%	< 1%	33%	4%	2%	2%	3%	3%	6%	49%
D: Alluvial Fans, Valley Floor	31,868	59%	< 1%	30%	7%	< 1%	2%	1%	< 1%	3%	40%
E: Salt Flats, Valley Floor	105,576	52%	< 1%	16%	4%	< 1%	< 1%	28%	< 1%	2%	39%
F: Sangre de Cristo Mtns	19,835	63%	3%	17%	2%	1%	10%	3%	< 1%	11%	39%

Watershed Strata	Wetland Acres	Percent Wetlands by Grouped Land Owners										
		USFS	BLM	NPS	FWS	BOR	SLB	CPW	STPARKS	PRIVATE	LAND TRUST	COUNTY
A: Upper San Juan Mtns	50,554	77%	--	--	--	--	3%	1%	--	19%	--	--
B: Mid-Elevation Forests	17,927	20%	2%	--	--	--	2%	1%	--	75%	--	--
C: Foothill Shrublands	57,037	< 1%	1%	2%	12%	--	2%	1%	1%	74%	6%	< 1%
D: Alluvial Fans, Valley Floor	31,868	--	--	--	< 1%	--	1%	5%	--	94%	--	--
E: Salt Flats, Valley Floor	105,576	--	< 1%	< 1%	17%	3%	4%	1%	--	74%	1%	--
F: Sangre de Cristo Mtns	19,835	2%	6%	5%	12%	--	2%	< 1%	--	67%	5%	--

Level 3 / 4 Ecoregion	Total Area within the Basin		Wetland and Waterbodies Area		Percent Wetlands by NWI System / Class						
	Acres	%	Acres	%	L1/L2	R2/3/4	UB/US	PAB	PEM	PSS	PFO
21: Southern Rockies	**2,704,962**	**56%**	**65,473**	**23%**	**10%**	**3%**	**1%**	**3%**	**58%**	**24%**	< 1 %
21a: Alpine Zone	380,869	8%	12,723	4%	5%	< 1 %	1%	4%	53%	37%	< 1 %
21b: Crystalline Subalpine Forests	236,309	5%	561	< 1 %	< 1 %	-	2%	5%	32%	56%	4%
21c: Crystalline Mid-Elevation Forests and Shrublands	29,815	1%	84	< 1 %	-	-	-	2%	1%	88%	8%
21d: Foothills and Shrublands	440,707	9%	7,323	3%	6%	2%	< 1 %	1%	76%	14%	1%
21e: Sedimentary Subalpine Forests	68,970	1%	561	< 1 %	1%	-	1%	5%	77%	12%	3%
21f: Sedimentary Mid-Elevation Forests and Shrublands	45,058	1%	242	< 1 %	-	1%	4%	3%	11%	81%	-
21g: Volcanic Subalpine Forests	1,135,558	24%	34,195	12%	13%	2%	1%	4%	56%	24%	< 1 %
21h: Volcanic Mid-Elevation Forests and Shrublands	297,984	6%	3,938	1%	7%	14%	< 1 %	3%	57%	17%	1%
21j: Grassland Parks	69,693	1%	5,845	2%	12%	9%	1%	2%	65%	11%	< 1 %
22: Arizona/New Mexico Plateau	**2,125,039**	**44%**	**217,331**	**77%**	**2%**	**2%**	**1%**	**2%**	**91%**	**2%**	**1%**
22a: Shrublands and Hills	632,606	13%	15,515	5%	4%	4%	1%	2%	85%	5%	< 1 %
22b: San Luis Alluvial Flats and Wetlands	776,027	16%	83,661	30%	3%	2%	1%	2%	87%	3%	1%
22c: Salt Flats	553,740	11%	113,105	40%	2%	< 1 %	1%	1%	96%	< 1 %	< 1 %
22e: Sand Dunes and Sand Sheets	162,665	3%	5,050	2%	< 1 %	17%	1%	< 1 %	81%	< 1 %	< 1 %

Level 3 / 4 Ecoregion	Wetland Acres	Percent Wetlands by NWI Hydrologic Regime								Altered	Irrigated
		A	B	C	F	G	H	J	K		
21: Southern Rockies	**65,473**	**11%**	**53%**	**21%**	**1%**	**3%**	**10%**	**-**	**< 1%**	**11%**	**4%**
21a: Alpine Zone	12,723	1%	87%	3%	1%	4%	4%	-	-	< 1%	-
21b: Crystalline Subalpine Forests	561	56%	29%	9%	2%	4%	0%	-	-	1%	-
21c: Crystalline Mid-Elevation Forests and Shrublands	84	87%	1%	9%	2%	< 1%	-	-	-	2%	-
21d: Foothills and Shrublands	7,323	50%	9%	34%	1%	< 1%	7%	-	-	9%	31%
21e: Sedimentary Subalpine Forests	561	32%	5%	56%	6%	< 1%	1%	-	-	< 1%	-
21f: Sedimentary Mid-Elevation Forests and Shrublands	242	2%	1%	90%	6%	2%	-	-	-	13%	-
21g: Volcanic Subalpine Forests	34,195	3%	62%	18%	1%	4%	12%	-	-	14%	-

Level 3 / 4 Ecoregion	Wetland Acres	Percent Wetlands by NWI Hydrologic Regime								Altered	Irrigated
		A	B	C	F	G	H	J	K		
21h: Volcanic Mid-Elevation Forests and Shrublands	3,938	7%	28%	47%	2%	2%	14%	-	< 1%	10%	3%
21j: Grassland Parks	5,845	27%	11%	41%	1%	2%	18%	-	-	16%	-
22: Arizona/New Mexico Plateau	**217,331**	**54%**	**< 1%**	**23%**	**4%**	**1%**	**2%**	**15%**	**1%**	**4%**	**42%**
22a: Shrublands and Hills	15,515	69%	< 1%	21%	2%	< 1%	6%	2%	-	7%	39%
22b: San Luis Alluvial Flats and Wetlands	83,661	52%	< 1%	35%	6%	< 1%	4%	1%	2%	7%	45%
22c: Salt Flats	113,105	53%	< 1%	15%	3%	2%	< 1%	27%	< 1%	1%	41%
22e: Sand Dunes and Sand Sheets	5,050	66%	< 1%	11%	2%	< 1%	< 1%	21%	< 1%	1%	41%

Level 3 / 4 Ecoregion	Wetland Acres	Percent Wetlands by Grouped Land Owners										
		USFS	BLM	NPS	FWS	BOR	SLB	CPW	STPARKS	PRIVATE	LAND TRUST	COUNTY
21: Southern Rockies	**65,473**	**65%**	**< 1%**	**< 1%**	**-**	**-**	**3%**	**1%**	**-**	**30%**	**< 1%**	**-**
21a: Alpine Zone	12,723	96%	< 1%	1%	-	-	-	-	-	3%	-	-
21b: Crystalline Subalpine Forests	561	3%	-	6%	-	-	-	-	-	92%	-	-
21c: Crystalline Mid-Elevation Forests and Shrublands	84	1%	< 1%	1%	-	-	-	-	-	98%	-	-
21d: Foothills and Shrublands	7,323	3%	2%	< 1%	-	-	5%	1%	-	89%	-	-
21e: Sedimentary Subalpine Forests	561	18%	-	-	-	-	-	-	-	82%	-	-
21f: Sedimentary Mid-Elevation Forests and Shrublands	242	1%	< 1%	-	-	-	-	-	-	99%	< 1%	-
21g: Volcanic Subalpine Forests	34,195	80%	< 1%	-	-	-	4%	2%	-	14%	-	-
21h: Volcanic Mid-Elevation Forests and Shrublands	3,938	38%	2%	-	-	-	2%	4%	-	55%	-	-
21j: Grassland Parks	5,845	23%	-	-	-	-	-	1%	-	76%	-	-
22: Arizona/New Mexico Plateau	**217,331**	**< 1%**	**1%**	**1%**	**13%**	**1%**	**3%**	**1%**	**< 1%**	**77%**	**3%**	**< 1%**
22a: Shrublands and Hills	15,515	< 1%	4%	-	-	-	3%	< 1%	-	91%	1%	-
22b: San Luis Alluvial Flats and Wetlands	83,661	-	< 1%	-	10%	-	1%	2%	-	88%	< 1%	< 1%
22c: Salt Flats	113,105	-	2%	< 1%	17%	2%	4%	1%	< 1%	70%	3%	-
22e: Sand Dunes and Sand Sheets	5,050	-	-	36%	15%	-	-	-	-	2%	47%	-

APPENDIX H: Wetland LIM Stressor Classes by HUC8 River Subbasins, Watershed Strata, and Ecoregions within the Rio Grande Headwaters Basin

HUC8 River Subbasin	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
13010001: Rio Grande Headwaters	25%	34%	8%	14%	18%
13010002: Alamosa-Trinchera	2%	4%	3%	22%	68%
13010003: San Luis	1%	4%	12%	32%	51%
13010004: Saguache	2%	6%	7%	21%	65%
13010005: Conejos	9%	11%	5%	24%	51%
13020101: Upper Rio Grande	4%	8%	13%	25%	50%
13020102: Rio Chama	27%	17%	24%	25%	6%
All Wetlands & Waterbodies	6%	9%	7%	23%	56%
Entire Basin	16%	37%	15%	10%	22%

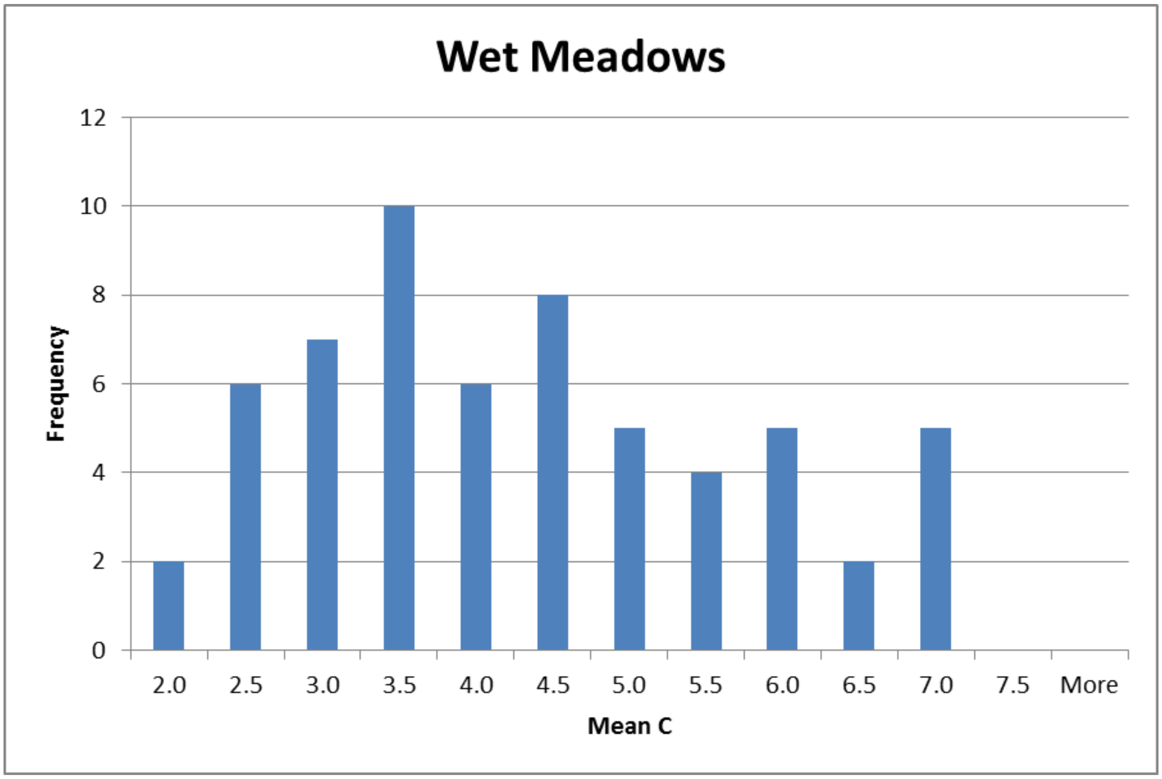
Watershed Strata	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
A: Upper San Juan Mtns	29%	37%	11%	13%	10%
B: Mid-Elevation Forests	2%	12%	7%	25%	54%
C: Foothill Shrublands	< 1%	2%	5%	25%	69%
D: Alluvial Fans, Valley Floor	-	< 1%	< 1%	19%	81%
E: Salt Flats, Valley Floor	-	2%	7%	24%	67%
F: Sangre de Cristo Mtns	2%	9%	7%	40%	41%
All Wetlands & Waterbodies	6%	9%	7%	23%	56%
Entire Basin	16%	37%	15%	10%	22%

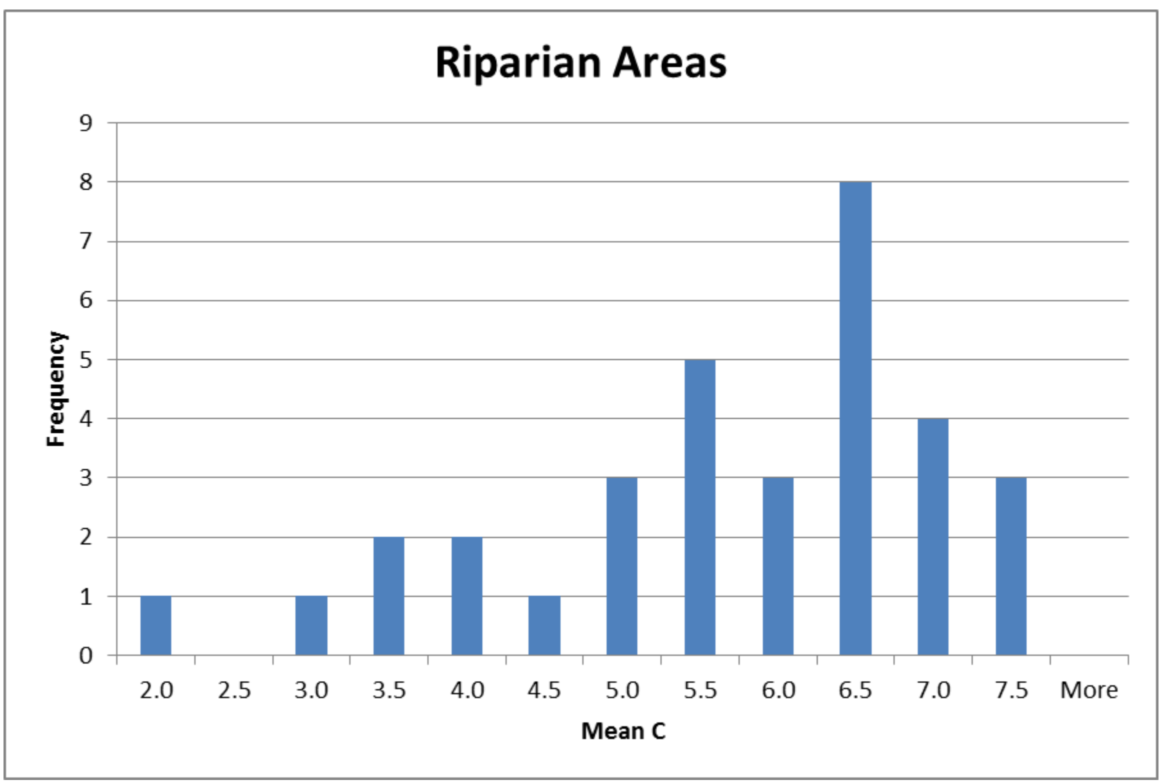
Level 3 / 4 Ecoregion	1: No stress	2: Low Stress	3: Moderate Stress	4: High Stress	5: Severe Stress
21: Southern Rockies	**24%**	**32%**	**10%**	**17%**	**17%**
21a: Alpine Zone	63%	34%	3%	< 1%	< 1%
21b: Crystalline Subalpine Forests	8%	25%	31%	30%	6%
21c: Crystalline Mid-Elevation Forests and Shrublands	-	< 1%	11%	29%	59%
21d: Foothills and Shrublands	< 1%	6%	4%	38%	52%
21e: Sedimentary Subalpine Forests	14%	8%	5%	38%	36%
21f: Sedimentary Mid-Elevation Forests and Shrublands	-	9%	13%	25%	53%
21g: Volcanic Subalpine Forests	22%	44%	14%	12%	8%
21h: Volcanic Mid-Elevation Forests and Shrublands	1%	10%	15%	29%	45%
21j: Grassland Parks	1%	14%	6%	40%	39%
22: Arizona/New Mexico Plateau	**< 1%**	**2%**	**5%**	**25%**	**68%**
22a: Shrublands and Hills	< 1%	3%	7%	38%	53%
22b: San Luis Alluvial Flats and Wetlands	< 1%	1%	2%	22%	75%
22c: Salt Flats	-	3%	8%	24%	65%
22e: Sand Dunes and Sand Sheets	< 1%	11%	13%	34%	42%
All Wetlands & Waterbodies	6%	9%	7%	23%	56%
Entire Basin	16%	37%	15%	10%	22%

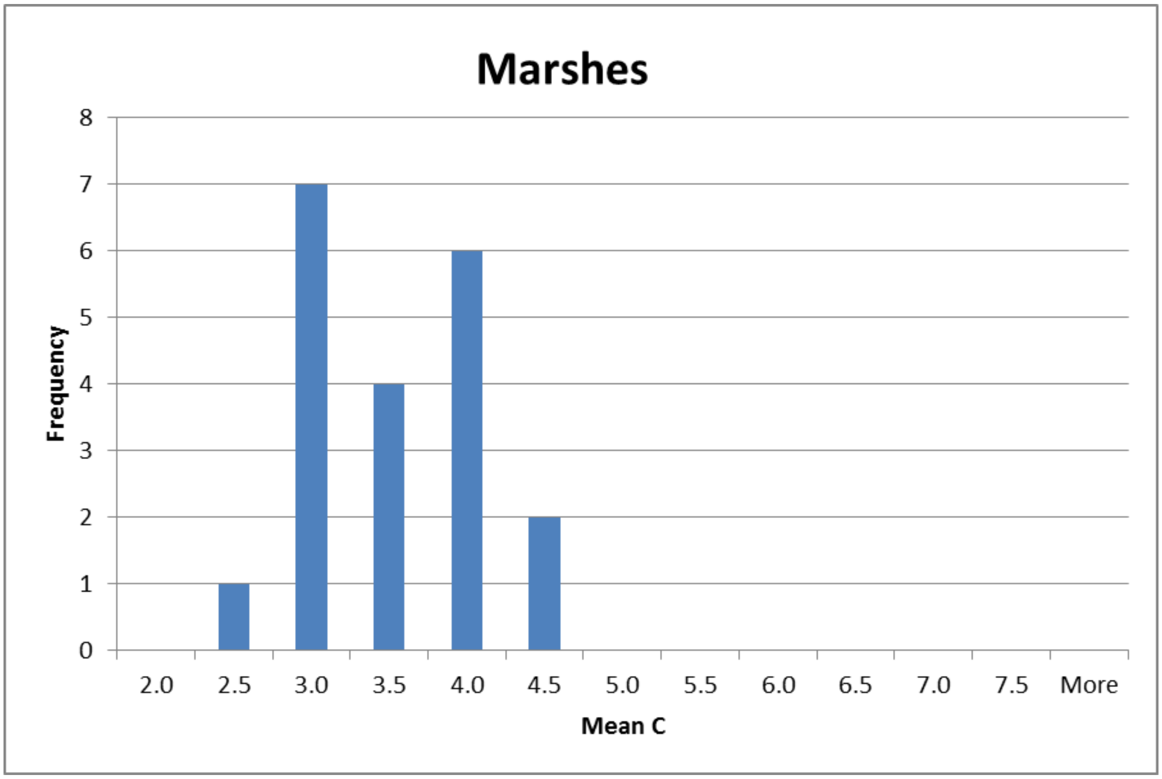
APPENDIX I: Most Common Species Encountered In the Rio Grande Headwaters Basin by Watershed Strata

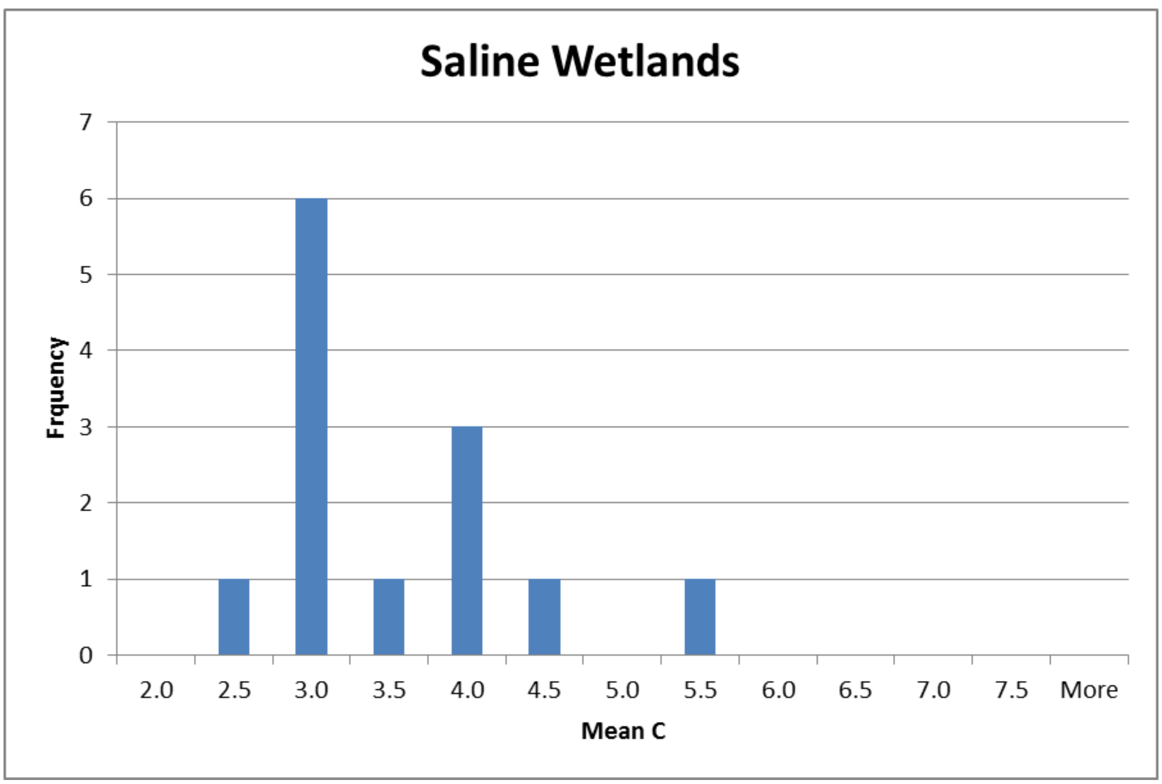
Rank	Watershed Strata					
	A	**B**	**C**	**D**	**E**	**F**
1	*Deschampsia cespitosa*	*Juncus arcticus* ssp. *ater*	*Carex praegracilis*	*Critesion jubatum*	*Juncus arcticus* ssp. *ater*	*Eleocharis macrostachya*
2	*Phleum commutatum*	*Taraxacum officinale*	*Juncus arcticus* ssp. *ater*	*Eleocharis macrostachya*	*Critesion jubatum*	*Halerpestes cymbalaria* ssp. *saximontana*
3	*Psychrophila leptosepala*	*Achillea lanulosa*	*Taraxacum officinale*	*Beckmannia syzigachne* ssp. *baicalensis*	*Breea arvensis*	*Juncus arcticus* ssp. *ater*
4	*Taraxacum officinale*	*Iris missouriensis*	*Muhlenbergia asperifolia*	*Juncus arcticus* ssp. *ater*	*Eleocharis macrostachya*	*Poaceae*
5	*Carex aquatilis*	*Poa palustris*	*Halerpestes cymbalaria* ssp. *saximontana*	*Almutaster pauciflorus*	*Muhlenbergia asperifolia*	*Breea arvensis*
6	*Salix planifolia*	*Poa pratensis*	*Iris missouriensis*	*Persicaria amphibia*	*Distichlis stricta*	*Critesion jubatum*
7	*Veronica nutans*	*Allium geyeri*	*Mentha arvensis*	*Polygonum douglasii*	*Cardaria pubescens*	*Bassia hyssopifolia*
8	*Pedicularis groenlandica*	*Equisetum arvense*	*Potentilla plattensis*	*Schoenoplectus lacustris* ssp. *acutus*	*Halerpestes cymbalaria* ssp. *saximontana*	*Schoenoplectus lacustris* ssp. *acutus*
9	*Achillea lanulosa*	*Trifolium longipes*	*Eleocharis macrostachya*	*Typha latifolia*	*Sarcobatus vermiculatus*	*Taraxacum officinale*
10	*Carex utriculata*	*Carex praegracilis*	*Bassia hyssopifolia*	*Carex utriculata*	*Schoenoplectus lacustris* ssp. *acutus*	*Trifolium longipes*

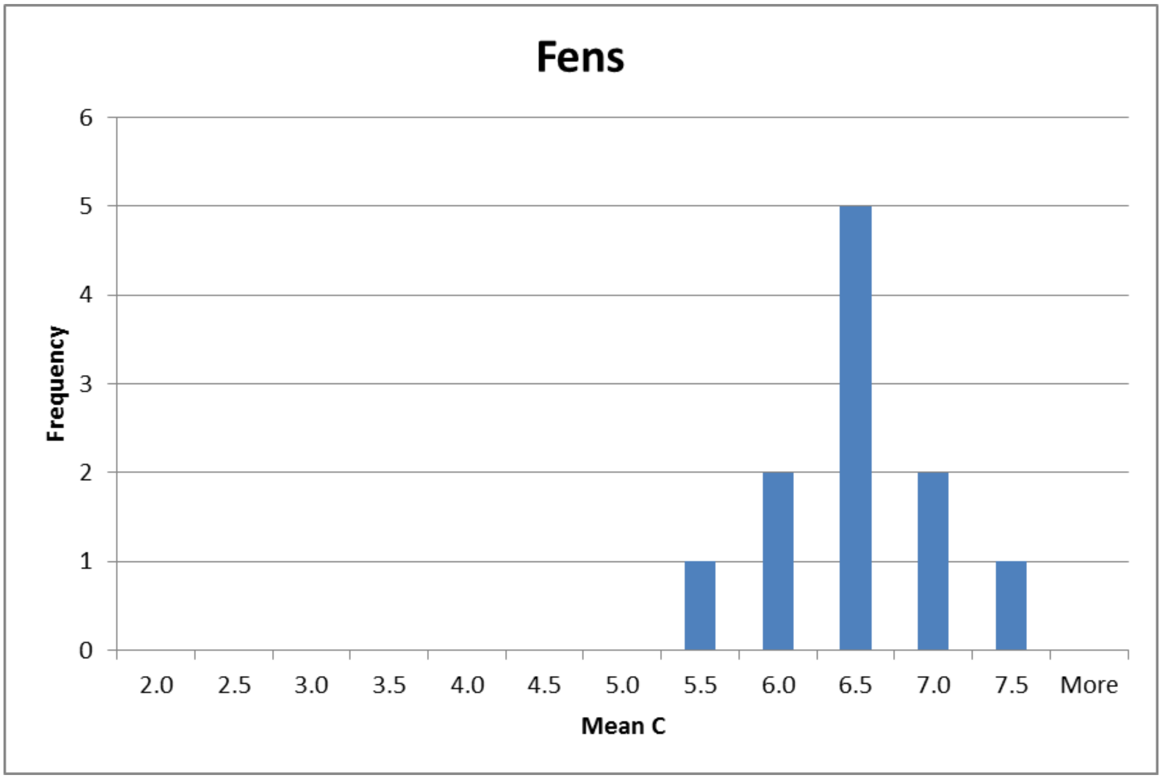
APPENDIX J: Frequency of Mean C Values by Ecological System Group


Wet Meadows
Frequency
Mean C
12
10
8
6
4
2
0
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
More


Riparian Areas
Frequency
Mean C
9
8
7
6
5
4
3
2
1
0
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
More


Marshes
Frequency
8
7
6
5
4
3
2
1
0
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
More
Mean C


Saline Wetlands
Frquency
7
6
5
4
3
2
1
0
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
More
Mean C


Fens
6
5
4
3
2
1
0
Frequency
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
More
Mean C

APPENDIX K: Wetland Acres by Land Ownership and Management Unit within the Rio Grande Headwaters Basin

Owner and Specific Management Unit	Basin Area by Owner		Wetland Area by Owner		Wetland Area in Acres by NWI System/Class						
	Acres	% of Basin	Acres	% of Total	L1/2	R2/3/4	PUB/US	PAB	PEM	PSS	PFO
BLM	**498,004**	**10.31%**	**2,711**	**0.96%**	**293**	**296**	**218**	**192**	**1,628**	**83**	**-**
Black Canyon WSA	1,149	0.02%	0	0.00%	-	-	-	0	-	-	-
Blanca Wildlife Habitat Area ACEC	7,824	0.16%	1,276	0.45%	293	-	117	172	695	-	-
Cumbres and Toltec Scenic Railroad Corridor ACEC	2,230	0.05%	1	0.00%	-	-	1	-	1	-	-
Elephant Rocks ACEC	1,766	0.04%	-	0.00%	-	-	-	-	-	-	-
Los Mogotes ACEC	30,610	0.63%	12	0.00%	-	-	7	1	4		
Ra Jadero Canyon ACEC	3,657	0.08%	1	0.00%	-	-	0	1	-	-	-
Rio Grande River Corridor ACEC	4,467	0.09%	416	0.15%	-	277	-	-	108	30	-
San Luis Hills/Flattop ACEC	25,559	0.53%	25	0.01%	-	-	11	1	13	-	-
San Luis Hills/Flattop ACEC & San Luis Hills WSA	10,893	0.23%	4	0.00%	-	-	1	-	3	-	-
Trickle Mountain ACEC	39,670	0.82%	87	0.03%	-	-	6	4	59	18	-
BLM Other	370,181	7.66%	888	0.31%	1	19	75	14	744	35	-
BOR	**3,065**	**0.06%**	**2,675**	**0.95%**	**299**	**-**	**40**	**44**	**2,293**	**-**	**-**
Russell Lakes SWA	3,065	0.06%	2,675	0.95%	299	-	40	44	2,293	-	-
CPW	**13,761**	**0.28%**	**3,409**	**1.21%**	**596**	**152**	**19**	**115**	**2,320**	**201**	**7**
Beaver Creek Reservoir SWA	102	0.00%	81	0.03%	81	-	-	-	0	-	-
Blanca SWA	40	0.00%	4	0.00%	-	-	-	-	4	-	-
Brown Lakes SWA	525	0.01%	278	0.10%	160	-	-	7	94	16	-
Coller SWA	747	0.02%	62	0.02%	-	62	-	-	1	-	-
Creede SAA	19	0.00%	7	0.00%	-	4	-	0	0	2	-
Frisco Creek SAA	138	0.00%	2	0.00%	-	-	-	-	-	2	-
Higel SWA	1,124	0.02%	842	0.30%	-	20	3	11	758	48	2
Home Lake SWA	324	0.01%	155	0.05%	57	7	-	3	83	5	-
Hot Creek SWA	3,467	0.07%	107	0.04%	-	-	-	4	66	37	-

John Mumma Native Aquatic Species Restoration Facility SFU	38	0.00%	-	0.00%	-	-	-	-	-	-	-
La Jara Reservoir SWA	684	0.01%	360	0.13%	275	-	-	1	84	-	-
La Jara SWA	3,089	0.06%	8	0.00%	-	-	-	-	7	0	-
Monte Vista - Area 17 Office SAA	29	0.00%	4	0.00%	-	-	-	-	4	-	-
Playa Blanca SWA	711	0.01%	182	0.06%	23	-	10	11	138	-	-
Rio Grande SWA	939	0.02%	520	0.18%	-	59	3	64	323	66	4
Russel Lakes SWA	1,195	0.02%	493	0.17%	-	1	-	3	489	-	-
Russell Lakes SWA	319	0.01%	271	0.10%	-	-	3	11	258	-	-
Saguache Park SAA	269	0.01%	34	0.01%	-	-	-	-	11	23	-
COUNTY	**1,309**	**0.03%**	**62**	**0.02%**	**-**	**-**	**1**	**-**	**61**	**-**	**-**
FWS	**111,734**	**2.31%**	**27,598**	**9.76%**	**446**	**150**	**324**	**538**	**25,988**	**148**	**4**
Alamosa National Wildlife Refuge	12,094	0.25%	6,836	2.42%	77	132	7	262	6,221	134	4
Baca National Wildlife Refuge	31,847	0.66%	2,763	0.98%	81	-	135	41	2,506	-	-
Baca National Wildlife Refuge / Baca Ranch	52,977	1.10%	9,313	3.29%	126	-	120	92	8,963	14	-
Monte Vista National Wildlife Refuge	14,817	0.31%	8,685	3.07%	162	19	62	144	8,299	-	-
LAND TRUST	**56,754**	**1.18%**	**6,059**	**2.14%**	**24**	**74**	**25**	**43**	**5,891**	**3**	**-**
Blair Parcel - Mishak Lakes / Colorado Wetlands Initiative Legacy	796	0.02%	24	0.01%	-	-	-	-	24	-	-
Cottonwood Creek Conservation Easements	108	0.00%	0	0.00%	-	-	-	-	0	-	-
Johnson - TNC	307	0.01%	73	0.03%	-	-	-	-	73	-	-
McClure - TNC	286	0.01%	1	0.00%	-	-	-	-	1	-	-
Medano/Zapata Ranch	40	0.00%	39	0.01%	-	-	-	-	39	-	-
Medano/Zapata Ranch Fee Acquisition	51,825	1.07%	5,164	1.83%	2	74	24	32	5,029	3	-
Met Fed Bank - TNC	273	0.01%	9	0.00%	-	-	-	-	9	-	-
Off Ranches - TNC	155	0.00%	112	0.04%	-	-	-	-	112	-	-
ROBINSON-MISHAK	167	0.00%	0	0.00%	-	-	-	-	0	-	-
Slane 1A - TNC	412	0.01%	267	0.09%	-	-	-	-	267	-	-

Slane 1B - TNC	186	0.00%	33	0.01%	-	-	-	0	33	-	-
Slane 2 - TNC	155	0.00%	6	0.00%	-	-	-	-	6	-	-
Stoddart - TNC	692	0.01%	238	0.08%	22	-	1	10	205	-	-
Valley View Hot Springs/Orient Land Trust	1,352	0.03%	94	0.03%	-	-	0	-	94	-	-
NPS	**136,976**	**2.84%**	**2,462**	**0.87%**	**66**	**817**	**6**	**22**	**1,541**	**10**	**-**
Great Sand Dunes National Park	7,758	0.16%	54	0.02%	-	48	-	0	6	-	-
Great Sand Dunes National Park - Great Sand Dunes Wilderness	32,654	0.68%	564	0.20%	-	548	1	-	15	-	-
Great Sand Dunes National Park / Baca Ranch	31,409	0.65%	79	0.03%	-	63	0	4	11	-	-
Great Sand Dunes National Preserve	1,098	0.02%	17	0.01%	-	-	-	-	13	4	-
Great Sand Dunes National Preserve - Sangre de Cristo Wilderness	40,484	0.84%	150	0.05%	66	-	3	4	70	6	-
Medano/Zapata Ranch	19,606	0.41%	1,467	0.52%	-	147	1	11	1,308	-	-
NPS Other	3,967	0.08%	130	0.05%	-	12	0	2	117	-	-
PRIVATE	**2,045,526**	**42.35%**	**186,650**	**66.00%**	**4,734**	**3,607**	**779**	**2,874**	**166,355**	**6,895**	**1,405**
Carson Public Fishing Easement	-	0.00%	-	0.00%	-	-	-	-	-	-	-
Coller SWA	163	0.00%	8	0.00%	-	8	-	-	-	0	-
Creede SAA	5	0.00%	4	0.00%	-	4	-	-	-	0	-
Frohn Public Fishing Easement	8	0.00%	3	0.00%	-	3	-	-	-	-	-
Gilmore Ranch SHA	1,017	0.02%	274	0.10%	-	24	-	38	186	26	-
Haugen SHA	341	0.01%	0	0.00%	-	-	-	-	0	-	-
Hayes/CAH	190	0.00%	30	0.01%	-	26	-	2	2	1	-
Higel SWA - Seasonal Access	349	0.01%	121	0.04%	-	-	1	0	120	-	-
Knoblach Ranch	119	0.00%	16	0.01%	-	-	-	2	13	-	-
Mountain Home Reservoir SWA	715	0.01%	435	0.15%	370	-	-	-	62	3	-
Poage Lake SWA	21	0.00%	21	0.01%	21	-	-	-	-	-	-
Quarter Circle U Ranch	1,535	0.03%	598	0.21%	-	-	-	-	499	100	-
Rio Grande River SWA (Del Norte Fishing Easements)	124	0.00%	93	0.03%	-	86	-	0	0	6	1
Rio Oxbow	525	0.01%	394	0.14%	-	22	-	2	349	21	-

Rio Oxbow, Phase II	569	0.01%	362	0.13%	-	67	-	6	237	50	-
River Valley Ranch SHA	556	0.01%	434	0.15%	-	2	-	8	400	14	10
Sanchez Reservoir SWA	3,058	0.06%	2,066	0.73%	1,792	3	1	0	269	-	-
Sego Springs SWA	642	0.01%	61	0.02%	-	22	5	9	12	12	-
Smith Reservoir SWA	956	0.02%	685	0.24%	557	-	-	-	49	80	-
Spicer SFU	1	0.00%	-	0.00%	-	-	-	-	-	-	-
Terrance Reservoir SWA	240	0.00%	177	0.06%	175	-	-	-	2	-	-
Vermejo Park SHA	15	0.00%	-	0.00%	-	-	-	-	-	-	-
Private Other	2,034,377	42.12%	180,867	63.95%	1,819	3,340	772	2,807	164,152	6,582	1,394
SLB	**147,165**	**3.05%**	**8,070**	**2.85%**	**1,008**	**0**	**89**	**188**	**6,733**	**50**	**2**
Alamoditos Mesa (SLB Pub. Access)	703	0.01%	-	0.00%	-	-	-	-	-	-	-
Alamosa Canyon (SLB Pub. Access)	242	0.01%	0	0.00%	-	-	-	-	0	-	-
Baca National Wildlife Refuge	310	0.01%	9	0.00%	-	-	-	-	9	-	-
Biedell Creek	11,605	0.24%	-	0.00%	-	-	-	-	-	-	-
Burro Springs (SLB Pub. Access)	7,932	0.16%	4	0.00%	-	-	-	-	4	-	-
Carnero (SLB Pub. Access)	1,712	0.04%	0	0.00%	-	-	-	0	0	-	-
Dry Creek (SLB Pub. Access)	1,291	0.03%	-	0.00%	-	-	-	-	-	-	-
Gerrard East (SLB Pub. Access)	304	0.01%	-	0.00%	-	-	-	-	-	-	-
Gerrard West (SLB Pub. Access)	481	0.01%	-	0.00%	-	-	-	-	-	-	-
La Jara Reservoir (SLB Pub. Access)	36,776	0.76%	1,207	0.43%	29	-	1	116	1,037	24	-
La Jara Reservoir Acquisition	4,780	0.10%	36	0.01%	-	-	1	0	35	-	-
La Jara Reservoir SWA	1,928	0.04%	646	0.23%	434	-	-	-	212	-	-
Little La Garita Creek (SLB Pub. Access)	662	0.01%	7	0.00%	-	-	-	-	2	5	-
Los Mogotes Peak (SLB Pub. Access)	644	0.01%	0	0.00%	-	-	0	-	-	-	-
Medano (SLB) Public Access Program	4,159	0.09%	316	0.11%	50	-	51	6	209	-	-
Medano/Zapata Ranch	39	0.00%	0	0.00%	-	-	-	-	0	-	-
Middle Creek (SLB Pub. Access)	629	0.01%	-	0.00%	-	-	-	-	-	-	-
Mineral Hot Springs (SLB Pub. Access)	643	0.01%	-	0.00%	-	-	-	-	-	-	-
Mishak Lakes (SLB Pub. Access)	2,591	0.05%	266	0.09%	-	-	14	8	245	-	-
Mogotos Arroyo (SLB Pub. Access)	318	0.01%	-	0.00%	-	-	-	-	-	-	-
Old Woman Creek (SLB Pub. Access)	663	0.01%	0	0.00%	-	-	-	-	0	-	-
Pinon Hills (SLB Pub. Access)	638	0.01%	-	0.00%	-	-	-	-	-	-	-

Rajadero Canyon (SLB Pub. Access)	672	0.01%	-	0.00%	-	-	-	-	-	-	-
Saguache Creek (SLB Pub. Access)	3,418	0.07%	136	0.05%	-	-	7	-	129	-	-
San Juan Creek (SLB Pub. Access)	3,192	0.07%	3	0.00%	-	-	-	-	3	-	-
San Luis Creek (SLB Pub. Access)	637	0.01%	297	0.10%	-	-	-	0	297	-	-
San Luis Hills (SLB Pub. Access)	655	0.01%	-	0.00%	-	-	-	-	-	-	-
San Luis Lakes SWA	1,652	0.03%	409	0.14%	71	-	1	18	319	-	-
San Luis State Park	944	0.02%	414	0.15%	403	-	-	-	10	-	-
Sanderson Gulch (SLB Pub. Access)	1,506	0.03%	21	0.01%	-	-	-	-	21	-	-
South Middle Creek (SLB Pub. Access)	7	0.00%	-	0.00%	-	-	-	-	-	-	-
Steel Canyon (SLB Pub. Access)	660	0.01%	1	0.00%	-	-	-	-	1	0	-
Stonehouse Gulch (SLB Pub. Access)	565	0.01%	-	0.00%	-	-	-	-	-	-	-
Valley View Hot Springs/Orient Land Trust	484	0.01%	-	0.00%	-	-	-	-	-	-	-
Villa Grove (SLB Pub. Access)	884	0.02%	41	0.01%	-	-	-	-	35	6	-
Vincente Canyon (SLB Pub. Access)	651	0.01%	8	0.00%	-	-	-	0	6	0	2
Werner Arroyo (SLB Pub. Access)	318	0.01%	6	0.00%	-	-	-	-	6	-	-
Zapata Falls	628	0.01%	-	0.00%	-	-		-	-	-	-
SLB Other	51,244	1.06%	4,240	1.50%	20	0	14	39	4,153	14	-
STPARKS	**340**	**0.01%**	**309**	**0.11%**	**307**	**-**	**-**	**-**	**2**	**-**	**-**
San Luis State Park	340	0.01%	309	0.11%	307	-	-	-	2	-	-
USFS - RIO GRANDE	**1,813,976**	**37.56%**	**42,768**	**15.12%**	**3,834**	**730**	**238**	**1,475**	**23,711**	**12,721**	**60**
Alberta Park Reservoir SWA	37	0.00%	34	0.01%	34	-	-	-	1	-	-
Big Meadows Reservoir SWA	117	0.00%	113	0.04%	113	-	-	-	0	-	-
Finger Mesa RNA	3,406	0.07%	125	0.04%	-	-	-	1	21	103	-
Frisco Creek SAA	22	0.00%	-	0.00%	-	-	-	-	-	-	-
Goose Lake SWA	34	0.00%	32	0.01%	32	-	-	-	-	-	-
Hay Press Lake SHA	25	0.00%	24	0.01%	24	-	-	-	1	-	-
Hot Creek RNA	1,858	0.04%	1	0.00%	-	-	-	-	1	-	-
La Garita Wilderness Area	49,459	1.02%	1,602	0.57%	25	-	1	55	670	851	-
Mill Creek RNA	1,595	0.03%	-	0.00%	-	-	-	-	-	-	-
Regan Lake SWA	76	0.00%	73	0.03%	73	-	-	-	0	-	-
Rio Grande National Forest	1,413,677	29.27%	30,199	10.68%	2,751	593	82	862	16,733	9,142	36

Rito Hondo Reservoir SWA	42	0.00%	41	0.01%	41	-	-	-	0	-	-
Road Canyon Reservoir SWA	169	0.00%	165	0.06%	164	-	-	-	1	0	-
Sangre De Cristo Wilderness Area	68,875	1.43%	384	0.14%	68	-	25	3	250	15	23
Sangre De Cristo Wilderness Area/Deadman Creek RNA	4,778	0.10%	47	0.02%	23	-	-	3	21	-	-
Sangre De Cristo Wilderness Area/Mill Creek RNA	962	0.02%	-	0.00%	-	-	-	-	-	-	-
Sangre De Cristo Wilderness Area/North Zapata RNA	6,092	0.13%	1	0.00%	-	-	-	-	1	-	-
South San Juan Wilderness Area	87,603	1.81%	4,247	1.50%	229	15	46	367	3,255	336	-
Spring Branch RNA	4,006	0.08%	4	0.00%	-	2	-	-	2	-	-
Tewksberry OCD	5	0.00%	-	0.00%	-	-	-	-	-	-	-
Trout Lake SWA	26	0.00%	24	0.01%	24	-	-	-	0	0	-
Trout Mountain/Elk Mountain OCD	1,382	0.03%	23	0.01%	-	-	-	-	21	1	1
Trujillo Meadows Reservoir SWA SWA	72	0.00%	71	0.03%	70	-	-	-	1	-	-
Weminuche Wilderness Area	169,659	3.51%	5,558	1.97%	164	120	84	185	2,733	2,273	-
USFS - GMUG	**943**	**0.02%**	**31**	**0.01%**	**-**	**-**	**-**	**-**	**30**	**1**	**-**
Gunnison National Forest	898	0.02%	31	0.01%	-	-	-	-	30	1	-
La Garita Wilderness Area	45	0.00%	-	0.00%	-	-	-	-	-	-	-
USFS - PIKE	**168**	**0.00%**	**0**	**0.00%**	-	-	-	-	0	-	-
San Isabel National Forest	108	0.00%	-	0.00%	-	-	-	-	-	-	-
Sangre De Cristo Wilderness Area	60	0.00%	0	0.00%	-	-	-	-	0	-	-
USFS - SAN JUAN	**280**	**0.01%**	**1**	**0.00%**	**-**	**-**	**1**	**0**	**1**	**-**	**-**
San Juan National Forest	19	0.00%	0	0.00%	-	-	-	-	0	-	-
South San Juan Wilderness Area	45	0.00%	0	0.00%	-	-	-	-	0	-	-
Weminuche Wilderness Area	216	0.00%	1	0.00%	-	-	1	0	0	-	-
Grand Total	**4,830,001**	**100.00%**	**282,804**	**100.00%**	**11,607**	**5,826**	**1,738**	**5,490**	**236,553**	**20,111**	**1,478**