

# National Wetland Inventory Mapping for the Colorado Portion of the Southern Rockies Landscape Conservation Cooperative



January 2014

*CNHP's mission is to preserve the natural diversity of life by contributing the essential scientific foundation that leads to lasting conservation of Colorado's biological wealth.*

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# National Wetland Inventory Mapping for the Colorado Portion of the Southern Rockies Landscape Conservation Cooperative

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# EXECUTIVE SUMMARY

The Southern Rockies Landscape Conservation Cooperative (SRLCC) covers over 36 million acres in Colorado and spans a wide elevation gradient from high Rocky Mountain peaks to dry plateaus of the Colorado's west slope. Wetlands are similarly variable within this region and are particularly important for wildlife habitat, as they are often more productive than the surrounding uplands. In addition, wetlands are an integral component of regional hydrologic cycles through their role in flood abatement, storm water retention, groundwater recharge, and water quality improvement. Colorado's wetlands were mapped by the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) Program in the late 1970s and early 1980s. Though the maps existed, they were created as paper maps and most were not available digitally, limiting their effectiveness to support on-the-ground conservation efforts or to model potential impacts of drought and climate variation on these resources.

Without reliable spatial data for wetland and riparian areas, it is impossible for land managers to accurately assess the distribution of critical aquatic habitats and model potential impacts caused by climate change. At the outset of this project, digital wetland mapping from the NWI program was available for approximately 60% of the SRLCC in Colorado, though paper maps drawn between the late 1970s and early 1980s existed for the remaining area. To complete the digital mapping coverage and summarize wetland acreage for the area, the Colorado Natural Heritage Program converted scanned images of original NWI paper maps to geo-rectified digital polygons for all topographic quads lacking digital spatial data, producing a wall-to-wall map of wetlands within the SRLCC. The digital NWI polygons were used to summarize wetland acreage in a number of different ways, presented as the "wetland profile" for the Colorado portion of the SRLCC. Wetland profiles summarize the types, abundance, and distribution of wetlands among ecoregions and landownership within a given geographic area and can be used to establish baseline conditions, assess cumulative impacts, and inform conservation planning. The profile is for the entire SRLCC within Colorado, including quads funded through this project and mapping completed through other funding sources.

Based on digital NWI mapping, there are 1,249,610 acres of wetlands and water bodies within the Colorado portion of the SRLCC, representing approximately 3% of the total land area. Lakes, rivers and riparian areas comprise 218,413 of the total NWI acres. The majority (61%) of the NWI mapped acres are freshwater herbaceous wetlands. When lakes and rivers are excluded, herbaceous wetlands make up 73% of wetland acres. Shrub wetlands are the second most common class, making up 17% of all NWI acres and 20% of wetland acres. Within the region as a whole, 27% of wetland acres are mapped as irrigated and these acres are overwhelmingly (95%) freshwater herbaceous wetlands. Among all herbaceous wetlands, 35% are mapped as irrigated. Less than 10% of wetland acres were attributed as excavated or dammed. When broken down by major landowner, 61% of wetland acres are privately owned. Private landowners hold a far greater share of wetland acres than they do total area within the basin (34%) as the density of wetland acres is greater within the intermountain valleys and agricultural areas where private landownership is concentrated, than in the publically owned mountain areas.

# SIGNIFICANT FINDINGS

## Wetland quantity and types:

- There are 1,249,610 acres of wetlands and waterbodies in the SRLCC (1,031,197 wetland acres without lakes and rivers).
- Wetlands and waterbodies represent 3% of the total land area.
- Herbaceous wetlands represent 73% of all wetlands, of which 35% are mapped as irrigated.
- 27% of all wetlands (>78,000 acres) are mapped as irrigated.
- Beaver-influenced wetlands comprise only 4% of all mapped wetland acres.
- Only 29% of all mapped lakes are natural, without a modifier of dammed or excavated.

## Wetland distribution within the SRLCC:

- 74% of wetlands and water bodies are in the Southern Rockies Ecoregion.
- Though the Arizona/New Mexico Plateau Ecoregion only has 6% of the land area of the SRLCC, it contains 17% of all mapped wetlands.
- The Colorado Plateau Ecoregion contains 25% of the land area of the SRLCC, but only 8% of all mapped wetlands.

## Ownership of wetland acres:

- 34% of wetland acres are federally owned.
- 24% are owned by the U.S. Forest Service.
- 3% are owned by the U.S. Bureau of Land Management.
- Private land covers 34% of the entire SRLCC, but contains 61% of all mapped wetlands.

## ACKNOWLEDGEMENTS

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# 1.0 INTRODUCTION

Wetlands are an integral component of the Rocky Mountain landscape. They provide a host of beneficial services, such as flood abatement, storm water retention, groundwater recharge, and water quality improvement (Mitsch & Goselink 2007; Millennium Ecosystem Assessment 2005). Wetlands are particularly important for wildlife because they are highly productive and diverse ecosystems, providing habitat for many species. For example, in many parts of the Rocky Mountain West, over 90% of wildlife species depend on wetlands or riparian areas at some point in their life (McKinstry et al. 2004).

The relative importance of wetlands is underscored by the fact that they occupy a small fraction of the landscape. Though total acreage of wetlands in the Rocky Mountains is unknown, estimates exist on a state level. Estimates for Colorado place the extent at roughly 1 million acres or 1.5% of the land area (Dahl 1990). Historically, Colorado likely supported twice the wetland acreage that exists today. Up to 50% of Colorado's original wetlands have been drained, converted to farmland or urban development, or lost as a result of water diversion and storage. Wetlands in Colorado continue to be impacted by multiple human uses, but the magnitude of these impacts is difficult to quantify as data on the location, type, and condition of Colorado's wetlands are limited. To ensure the benefits Coloradoans receive from wetlands continue into the future, scientifically grounded information about the status and trends of Colorado's wetland resource is essential for wetland conservation and management.

In 2010, the Department of the Interior created a network of Landscape Conservation Cooperatives (LCCs) in an effort to integrate science and management to address landscape level impacts of climate change and other large scale issues. The collaborative nature of the LCCs ensures that resource managers and scientists are working towards the sustainability of the land. The 22 LCCs cover the United States and stretch into parts of Canada and Mexico. The Southern Rockies Landscape Conservation Cooperative (SRLCC) includes the western half of Colorado, the eastern half of Utah and the northern halves of both Arizona and New Mexico. The area encompasses a wide range of elevations from the highest peaks of Colorado to the cold deserts of Arizona and New Mexico. A particular emphasis of the SRLCC is the management and conservation of aquatic resources, including wetlands, in the arid, high desert climate of the Rocky Mountains. This report focuses solely on the Colorado portion of the SRLCC and any further mention of the SRLCC refers only to this Colorado portion.

## 1.1 Wetland Profile for the Colorado Portion of the SRLCC

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The initial step in the conservation, management, and restoration of wetlands across the SRLCC is to compile a "wetland profile" based on digital wetland mapping. Wetland profiles summarize the types, abundance, and distribution of wetlands within a given geographic area and can be used to establish baseline conditions, assess cumulative impacts, and inform strategic goals (Bedford 1996; Gwin et al. 1999; Johnson 2005).

Colorado's wetlands were mapped by the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) Program in the late 1970s and early 1980s. The NWI program's goal was to create a nationwide inventory of wetlands and waterbodies to aid conservation efforts. Though original NWI maps exist for all of Colorado, they were created as paper maps and most are not available as digital data, limiting their effectiveness to support on-the-ground conservation efforts or to model potential impacts of drought and climate variation on these resources. Since 2008, the Colorado Natural Heritage Program (CNHP) has partnered with the NWI program to significantly increase the amount of digital wetland data for Colorado from less than 15% of the state to well over 50% in 2012 by converting original paper maps into digital data. The vast majority of digital wetland data for Colorado as a whole and the Colorado portion of the SRLCC have been produced by CNHP and its partners. At the outset of this project, digital wetland mapping was available for approximately 60% of the SRLCC within Colorado. Grants from the U.S. Environmental Protection Agency (EPA) added another 408 quads of NWI mapping, including 95 in the SRLCC, during the same time period as this project. The overall goal of this project was to fill in the remaining gaps of digital wetland data within the Colorado portion of the SRLCC. Complete digital NWI data for SRLCC in Colorado will allow SRLCC science partners to better model and predict the potential effects of future climate scenarios on wetland and riparian habitats and the species that rely on them, as well as aid resource managers in on-the-ground conservation efforts.

## 1.2 Project Objectives

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The primary objective of this project was to complete the digital map coverage within the SRLCC boundaries of Colorado and develop a wetland profile for the entire SRLCC.

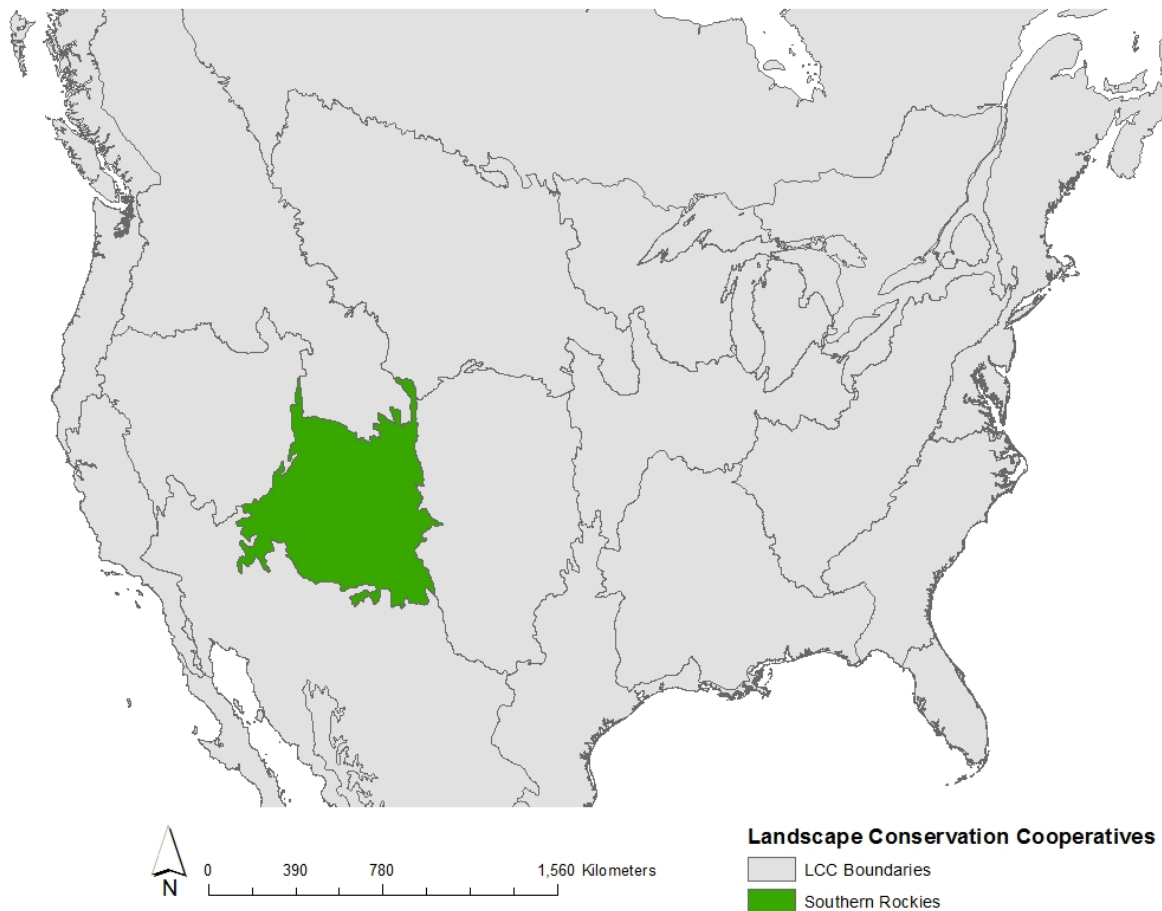
The project objective was implemented with the following tasks:

- Compile scanned wetland maps from NWI program for the area missing digital data.
- Digitize the scanned NWI maps.
- Compile previously created digital NWI wetland data for the SRLCC.
- Develop a detailed wetland profile based on digital NWI mapping summarizing the extent of wetland acreage throughout the basin by NWI system/class, hydrologic regime, extent modified, extent irrigated, land ownership, and Level IV Ecoregions.
- Update wetland mapping on selected State Land Board parcels using CNHP field notes.

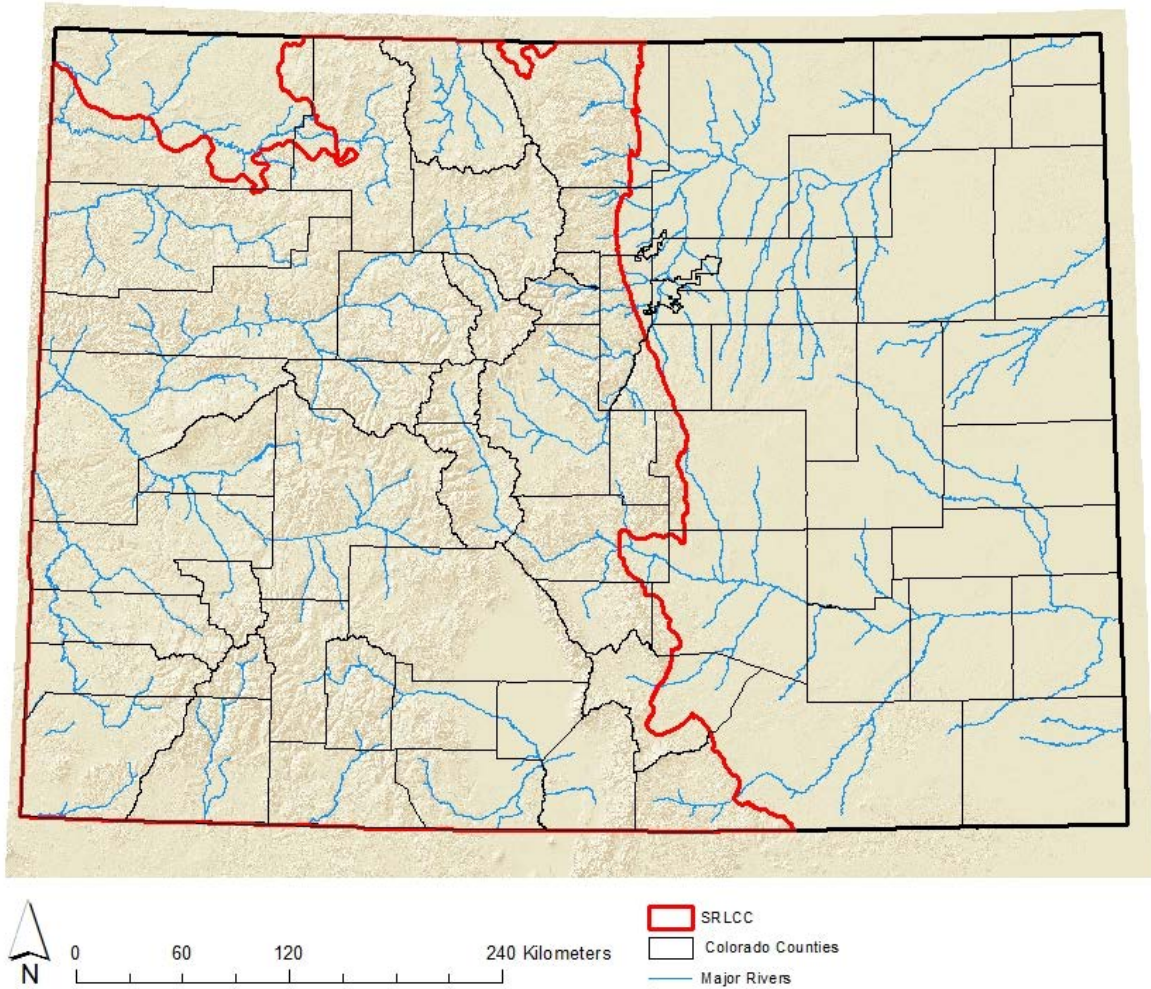
## 2.0 STUDY AREA

### 2.1 Geography

The SRLCC is located in the western half of North America (Fig. 1), though this study focused only on the Colorado portion of the SRLCC. The study area is bounded by the Colorado state line to the north, west, and south, the Great Northern LCC to the northwest, and the Great Plains LCC and encompasses 42 of the 77 counties in Colorado (Fig. 2). Within the study area there are 10 HUC6 river basins and 79 HUC8 river subbasins (Fig. 3).

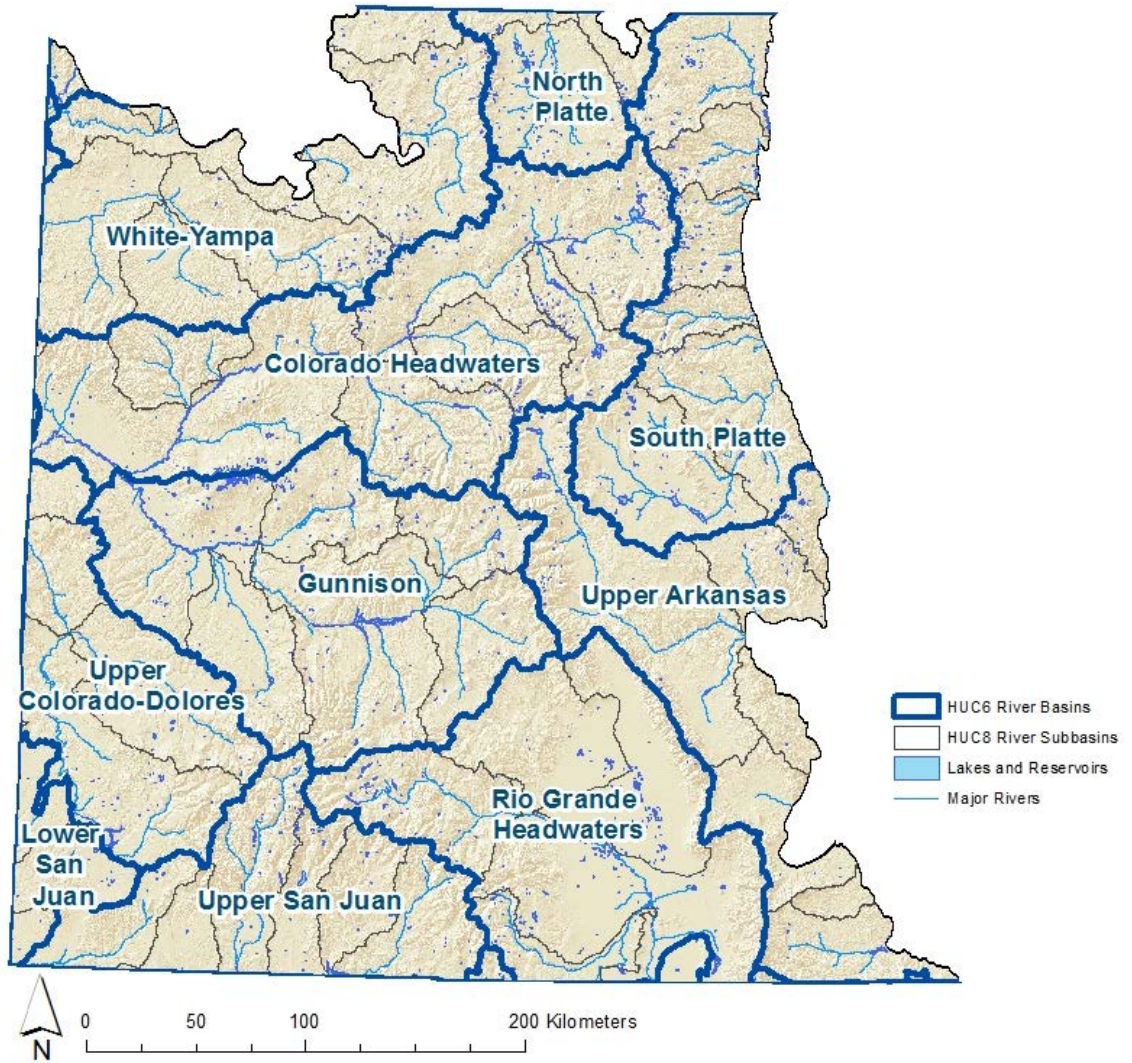


**Fig. 1. Landscape Conservation Cooperatives across North America. The Southern Rockies Landscape Conservation Cooperative is located in the western half of the continent.**



**Fig. 2. SRLCC boundary in Colorado. The study area is bounded by the Colorado state line to the north, south, and west, the Great Northern Landscape Conservation Cooperative to the northwest, and the Great Plains Landscape Conservation Cooperative to the east. Black lines show the various counties within Colorado and blue lines show major rivers across the state.**

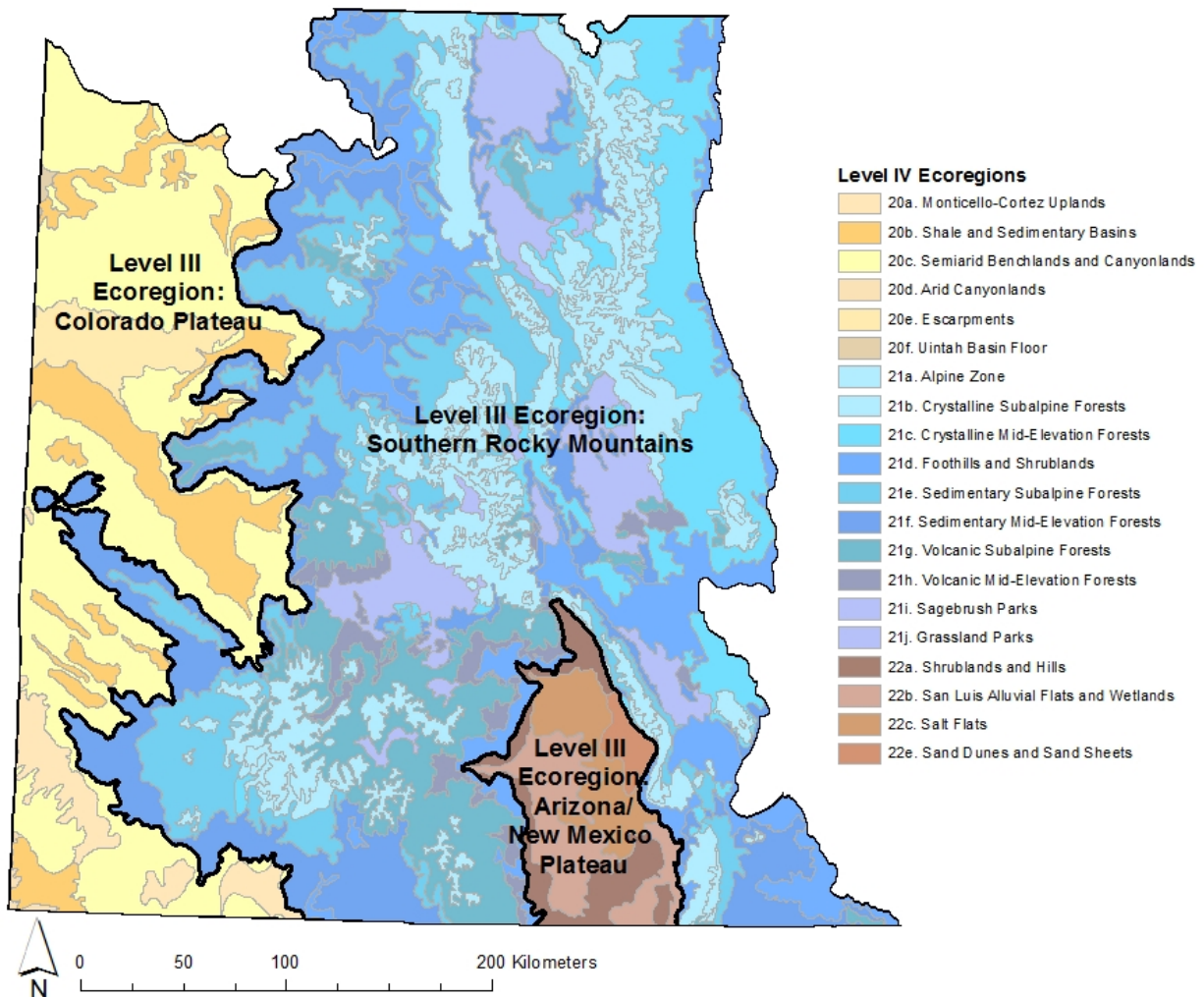
The area spans ~270 miles (435 km) from east to west and ~276 miles (445 km) from north to south, encompassing 36,521,296 acres (57,064 mile<sup>2</sup> or 146,703 km<sup>2</sup>). The Rocky Mountains dominate the center of the SRLCC and are characterized by steep subalpine and alpine zones surrounding high elevation valleys. Human activities in this high elevation zone include forestry, livestock grazing, mining, and tourism. The western part of the study area is characterized by dry, low elevation basins and canyons with dominant human activities including oil and gas production, livestock grazing, and recreation. Elevations in the SRLCC range from just under 5,000 ft. (1400 m) to a high of 14,440 ft. (4401 m) at Mount Elbert. A total of 53 peaks surpass 14,000 ft. (4,267 m).



**Fig. 3.** HUC6 river basins, HUC8 river subbasins, and major rivers, lakes, and reservoirs within the SRLCC in Colorado.

## 2.2 Ecoregions and Vegetation

Much of the SRLCC in Colorado falls within the Southern Rocky Mountains Level III Ecoregion<sup>1</sup> (Fig. 4; Table 1). The Colorado Plateau Ecoregion makes up the western part of the state, while the San Luis Valley to the south is included in the Arizona/New Mexico Plateau Ecoregion. Level IV Ecoregions further divide the SRLCC into finer units based on geology and dominant vegetation (Table 2).



**Fig. 4. Level III and IV Ecoregions within the SRLCC in Colorado. Level III Ecoregions demarcated by the black lines. See Table 2 for Level IV Ecoregion descriptions.**

The forests of the Southern Rockies Ecoregion are largely dominated by Engelmann spruce (*Picea engelmanni*), subalpine fir (*Abies lasiocarpa*), or lodgepole pine (*Pinus contorta*). Riparian floodplains fill the valleys and predominately contain mixed willow species, including *Salix*

<sup>1</sup> For more information on Omernik/EPA Ecoregions and to download GIS shapefiles, visit the following website:  
<http://www.epa.gov/wed/pages/ecoregions.htm>.



*monticola* and *Salix geyeriana*. The Colorado Plateau Ecoregion is predominantly Semiarid Benchlands and Canyonlands dominated by pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), sagebrush (*Artemisia* spp.), or Gamble’s oak (*Quercus gambelii*). The Arizona/New Mexico Plateau Ecoregion contains Sagebrush and Pinyon-Juniper communities on the hillsides, with much of the native vegetation in the valley removed for agricultural production on lower alkaline soils and sparsely vegetated salt flats in the higher alkaline areas.

**Table 1. Level III and IV Ecoregions within the SRLCC.**

<b>Level III / IV Ecoregion</b>		<b>Acres</b>	<b>% of SRLCC</b>
<b>20</b>	<b>Colorado Plateau</b>	<b>8,989,872</b>	<b>25%</b>
20a	Monticello-Cortez Uplands	601,834	2%
20b	Shale and Sedimentary Basins	1,868,820	5%
20c	Semiarid Benchlands and Canyonlands	5,805,426	16%
20d	Arid Canyonlands	42,032	0%
20e	Escarpments	647,298	2%
20f	Uintah Basin Floor	24,462	0%
<b>21</b>	<b>Southern Rockies</b>	<b>25,388,156</b>	<b>70%</b>
21a	Alpine Zone	2,368,455	6%
21b	Crystalline Subalpine Forests	3,050,030	8%
21c	Crystalline Mid-Elevation Forests	2,849,100	8%
21d	Foothill Shrublands	3,016,832	8%
21e	Sedimentary Subalpine Forests	3,940,871	11%
21f	Sedimentary Mid-Elevation Forests	4,832,185	13%
21g	Volcanic Subalpine Forests	2,519,757	7%
21h	Volcanic Mid-Elevation Forests	667,457	2%
21i	Sagebrush Parks	1,317,616	4%
21j	Grassland Parks	825,853	2%
<b>21</b>	<b>Arizona/New Mexico Plateau</b>	<b>2,126,399</b>	<b>6%</b>
22a	Shrublands and Hills	632,992	2%
22b	San Luis Alluvial Flats and Wetlands	776,520	2%
22c	Salt Flats	554,105	2%
22e	Sand Dunes and Sand Sheets	162,782	0%
<b>Total</b>		<b>36,504,427</b>	<b>100%</b>

**Table 2. Descriptions of Level IV Ecoregions within the SRLCC.**

NAME	DESCRIPTION
<p><b>20a: Monticello-Cortez Uplands</b></p>	<p>Parts of the gently sloping <b>Monticello-Cortez Uplands</b> and Sagebrush Valleys ecoregion are covered by eolian material. Deep, silty soils are typical and retain enough available moisture to naturally support Wyoming big sagebrush and associated grasses. These soils now sustain dryland farming, with more irrigated agriculture to the east. Crops include pinto beans, Anasazi beans, winter wheat, oats, and alfalfa. Shallow or stony soils occur along the rims of benches and minor escarpments and support pinyon-juniper woodland.</p>
<p><b>20b: Shale and Sedimentary Basins</b></p>	<p>The arid <b>Shale Deserts and Sedimentary Basins</b> ecoregion consists of nearly level basins and valleys, benches, low rounded hills, and badlands. Rock outcrops occur. It is sparsely vegetated with mat saltbush, bud sagebrush, galleta grass, and desert trumpet. Floodplains have alkaline soils that support greasewood, alkali sacaton, seepweed, and shadscale. Scattered, gravel-capped benches occur and protrude from the present denudational surface because they are more resistant to erosion than the surrounding shales. Soils are shallow and types range from clayey to silty. Soils that formed primarily on Mancos shale are found in the areas northwest of Ranglely, east of Meeker, in the Grand Valley, in Dry Creek Basin and Disappointment Valley southwest of the Uncompahgre Plateau, and in southwest Colorado near the Mancos River. The Mancos shale basins have the potential for high selenium levels, a particular problem in areas with irrigated agriculture. Soils formed from sandstone, limestone, shale, and gypsum are found in Paradox and Big Gypsum valleys southwest of the Uncompahgre Plateau. Soils formed from claystone, shale, sandstone, and mudstone are found west of Meeker, and in the Colorado River valley near Rifle. Land use includes rangeland, pastureland, and dryland and irrigated cropland, with winter wheat, small grains, forage crops, and pinto beans as major crops. The valleys of the Gunnison and Colorado rivers have areas favorable for growing apples, peaches, pears, and apricots. Shrublands provide important winter habitat for wildlife.</p>
<p><b>20c: Semiarid Benchlands and Canyonlands</b></p>	<p>Broad, grass-, shrub-, and woodland-covered benches and mesas characterize the <b>Semiarid Benchlands and Canyonlands</b> ecoregion. Areas of high relief alternate with areas of low relief. Low escarpments separate remnant mesa tops and narrow canyons from surrounding benches. Bedrock exposures (e.g., slickrock and fins) are common along rims, escarpments, and on steep dip slopes. Deep eolian soils are composed of fine sand and support warm season grasses, winterfat, Mormon tea, fourwing saltbush, and sagebrush. Two-needle pinyon and Utah juniper occur on shallow, stony soils. Scattered areas of Gambel oak occur at higher elevations. Fire suppression and erosion have allowed this woodland to expand beyond its original range. Overall, the vegetation is not as sparse as in drier areas such as Ecoregions 20b and 20d. Average annual precipitation in the Colorado portion of the region varies from 10 to 18 inches in lower areas; on the highest sites, such as Mesa Verde, 20 to 25 inches can occur. Livestock grazing is a dominant land use, although stock carrying capacity is limited. On floodplains and terraces, some irrigated cropland occurs, primarily hay and grain for livestock. Oil and natural gas wells, oil shale extraction, and coal mining are also present in the region.</p>

NAME	DESCRIPTION
<b>20d: Arid Canyonlands</b>	<p>Occurring primarily in Utah, the <b>Arid Canyonlands</b> ecoregion includes the inner gorge of the Colorado River and its major tributaries. Much of this ecoregion is bounded by nearly vertical canyon walls that separate it from the adjacent, higher benchlands of Ecoregion 20c. Soils are shallower and have a drier moisture regime than those of Ecoregions 20a and 20c. Exposed bedrock is common. Blackbrush, shadscale, and drought-tolerant grasses including galleta grass and Indian ricegrass occur. Blackbrush is more common here than in Ecoregion 20c, where pinyon-juniper woodland and sagebrush dominate. Annual precipitation is lowest in the deepest canyons, mostly less than 10 inches. Land use is mostly livestock grazing and recreation.</p>
<b>20e: Escarpments</b>	<p>The <b>Escarpments</b> ecoregion is characterized by extensive, deeply-dissected, cliff-bench complexes that ascend dramatically from Ecoregions 20b or 20c to the forested mountain rim. Local relief can be as great as 3000 feet, and the region is prone to landslides. Ecoregion 20e includes major scarp slopes of the Book Cliffs and Roan Cliffs. Natural vegetation varies according to aspect and moisture availability, ranging from Douglas-fir forest on steep, north-facing slopes at higher elevations to desert and semidesert grassland or shrubland on lower, drier sites. Pinyon-juniper woodland often dominates escarpments and benches that are covered by shallow soils. This rugged, remote, and varied landscape provides habitat for wildlife.</p>
<b>20f: Uintah Basin Floor</b>	<p>Occurring primarily in Utah, the <b>Uinta Basin Floor</b> ecoregion lies in a large synclinal basin enclosed by the Uinta Mountains and Tavaputs Plateau. Precipitation is low and soils are arid. Winters are constantly cold and often foggy due to frigid, dense air draining from the adjacent uplands and resultant air temperature inversions. Saltbush-greasewood is the natural vegetation type. Ecoregion 20f is distinguished from other arid basins by the abundant stream runoff it receives from the mountains in Utah. Streams are often diverted for irrigation. Alfalfa, small grain, and corn are grown for silage on arable, gently-sloping terraces and valley floors. Stonier soils are irrigated for pasture where and when water is available. Non-irrigated areas are used for livestock grazing.</p>
<b>21a: Alpine Zone</b>	<p>The <b>Alpine Zone</b> occurs on mountain tops above treeline, beginning at about 10500 to 11000 feet. It includes alpine meadows as well as steep, exposed rock and glaciated peaks. Annual precipitation ranges from about 35 to greater than 70 inches, falling mostly as snow. Vegetation includes low shrubs, cushion plants and wildflowers and sedges in wet meadows. The forest-tundra interface is sparsely colonized by stunted, deformed Engelmann spruce, subalpine fir and limber pine (krummholz vegetation). Rocky Mountain bristlecone pines, some of the oldest recorded trees in North America, are also found here. Land use, limited by difficult access, is mostly wildlife habitat and recreation. Alpine is snow-free only 8 to 10 weeks annually. Snow cover is a major source of water for lower, more arid ecoregions.</p>

NAME	DESCRIPTION
<b>21b: Crystalline Subalpine Forests</b>	The <b>Crystalline Subalpine Forests</b> ecoregion occupies a narrow elevational band on the steep, forested slopes of the mountains, becoming more extensive on the north-facing slopes. The elevation range of the region is 8500 to 12000 feet, just below the Alpine Zone. The lower elevation limit is higher in the south, starting at 9000 to 9500 feet. The dense forests are dominated by Engelmann spruce and subalpine fir; aspen and pockets of lodgepole pine locally dominate some areas. Subalpine meadows also occur. Forest blowdown, insect outbreaks, fire and avalanches affect the vegetation mosaic. Soils are weathered from a variety of crystalline and metamorphic materials, such as gneiss, schist and granite, as well as some areas of igneous intrusive rocks. Recreation, logging, mining and wildlife habitat are the major land uses. Grazing is limited by climatic conditions, lack of forage and lingering snowpack.
<b>21c: Crystalline Mid-Elevation Forests</b>	The <b>Crystalline Mid-Elevation Forests</b> are found mostly in the 7000 to 9000 feet elevation range on crystalline and metamorphic substrates. Most of the region occurs in the eastern half of the Southern Rockies. Natural vegetation includes aspen, ponderosa pine, Douglas-fir and areas of lodgepole pine and limber pine. A diverse understory of shrubs, grasses and wildflowers occurs. The variety of food sources supports a diversity of bird and mammal species. Forest stands have become denser in many areas due to decades of fire suppression. Land use includes wildlife habitat, livestock grazing, logging, mineral extraction and recreation, with increasing residential subdivisions.
<b>21d: Foothill Shrublands</b>	The <b>Foothill Shrublands</b> ecoregion is a transition from the higher elevation forests to the drier and lower Great Plains to the east and to the Colorado Plateaus to the west. This semiarid region has rolling to irregular terrain of hills, ridges and foot slopes, with elevations generally 6000 to 8500 feet. Sagebrush and mountain mahogany shrubland, pinyon-juniper woodland and scattered oak shrublands occur. Other common low shrubs include serviceberry and skunkbush sumac. Interspersed are some grasslands of blue grama, june grass and western wheatgrass. Land use is mainly livestock grazing and some irrigated hayland adjacent to streams.
<b>21e: Sedimentary Subalpine Forests</b>	The <b>Sedimentary Subalpine Forests</b> ecoregion occupies much of the western half of the Southern Rockies, on sandstone, siltstone, shale and limestone substrates. The elevation limits of this region are similar to the crystalline and volcanic subalpine forests. Stream water quality, water availability and aquatic biota are affected in places by carbonate substrates that are soluble and nutrient rich. Soils are generally finer-textured than those found on crystalline or metamorphic substrates of crystalline subalpine zone and are also more alkaline where derived from carbonate-rich substrates. Subalpine forests dominated by Engelmann spruce and subalpine fir are typical, often interspersed with aspen groves or mountain meadows. Some Douglas-fir forests are at lower elevations.
<b>21f: Sedimentary Mid-Elevation Forests</b>	The <b>Sedimentary Mid-Elevation Forests</b> ecoregion occurs in the western and southern portions of the Southern Rockies, at elevations generally below sedimentary subalpine forest. The elevation limits and vegetation of this region are similar to the crystalline and volcanic mid-elevation forests; however, a larger area of Gambel oak woodlands and forest is found in this region. Carbonate substrates in some areas affect water quality, hydrology and biota. Soils are generally finer-textured than those found on crystalline and metamorphic substrates such as those in the crystalline mid-elevation forest.

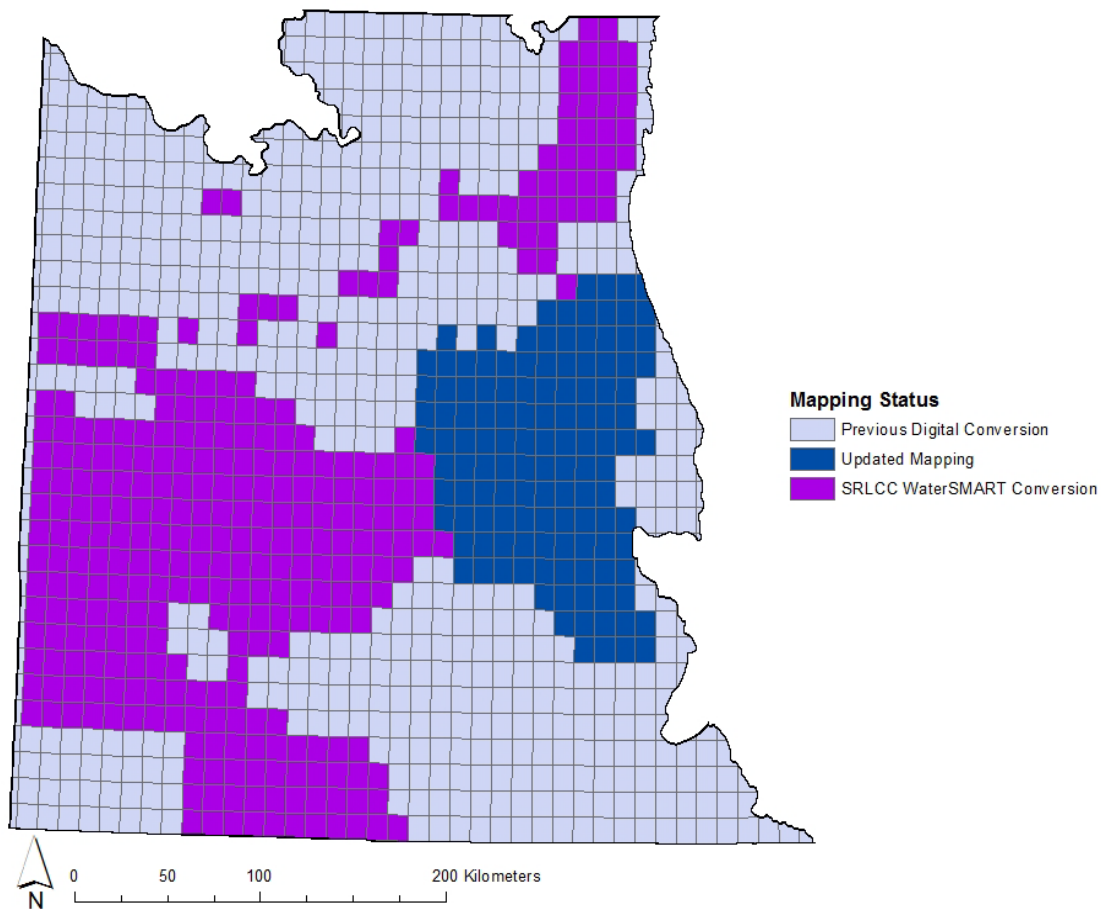
NAME	DESCRIPTION
<b>21g: Volcanic Subalpine Forests</b>	The steep, mountainous <b>Volcanic Subalpine Forests</b> ecoregion is composed of volcanic and igneous rocks, predominately andesitic with areas of basalt. The region is found mainly in the San Juan Mountains, which have the most rugged terrain and the harshest winters in the Southern Rockies of Colorado. Smaller areas are found in the West Elk Mountains, Grand Mesa, Flat Tops and in the Front Range. The area is highly mineralized and gold, silver, lead and copper have been mined. Relatively young geologically, the mountains are among the highest and most rugged of North America and still contain some large areas of intact habitat. Engelmann spruce, subalpine fir and aspen forests support a variety of wildlife.
<b>21h: Volc Mid-Elev Forests</b>	The <b>Volcanic Mid-Elevation Forests</b> ecoregion occurs at elevations of 7000 to 9000 feet and is composed of igneous rocks of andesite and basalt. The majority of the region is found in the San Juan Mountains, the West Elk Mountains, and in a small area of the Front Range. Forests of ponderosa pine, Douglas-fir, and aspen occur. Land use includes wildlife habitat, livestock grazing, logging, recreation, and mineral extraction of silver and gold.
<b>21i: Sagebrush Parks</b>	The <b>Sagebrush Parks</b> ecoregion contains the large, semiarid, high intermontane valleys that support sagebrush shrubland and steppe vegetation. The ecoregion includes North Park, Middle Park and the Gunnison Basin and is slightly drier than the Grassland Parks. Summers tend to be hot and winters very cold, with annual precipitation of 10-16 inches. Land use is mostly rangeland and wildlife habitat, with some hay production near streams. The sagebrush provides forage and habitat to many animals and birds. Sandy loam soils are typical, formed in residuum from crystalline and sedimentary rocks, glacial outwash and colluvial or alluvial materials.
<b>21j: Grassland Parks</b>	The <b>Grassland Parks</b> ecoregion also consists of high intermontane valleys similar in elevation to the drier Sagebrush Parks (21i); however, water availability is greater in 21j and the region supports grasslands rather than the sagebrush shrubland and steppe found in 21i. Grasslands with bunchgrasses are dominant, and include Arizona fescue, Idaho fescue, mountain muhly, bluebunch wheatgrass, needle-and-thread, Junegrass, and slender wheatgrass. Springs and wetlands may occur. Some subalpine/montane fens are found where groundwater seepage has persistently reached the surface and supported peatland development. There are only a few trees or shrubs, and if present, they are widely scattered and mature.
<b>22a: Shrublands and Hills</b>	The San Luis <b>Shrublands and Hills</b> ecoregion includes the higher relief foothill edges and low mountain areas within the basin. It includes the San Luis Hills in the southwest, a rugged mass of hills and tilted mesas. The hills are composed of andesitic volcanic rock and are 500 to 1000 feet higher than the adjacent ecoregions of 22. Vegetation communities represent a transition from the grassland and desert communities of the lower basin to the woodland species found in the surrounding foothills of the Southern Rockies (21). Big sagebrush, rabbitbrush, and winterfat occur, as well as grasslands of western wheatgrass, green needlegrass, blue grama, and needle-and-thread. Areas of pinyon-juniper are found on the tops of the San Luis Hills.

NAME	DESCRIPTION
<b>22b: San Luis Alluvial Flats and Wetlands</b>	Although precipitation in the <b>San Luis Alluvial Flats and Wetlands</b> ecoregion is low, less than 8 to 10 inches, water availability from mountain runoff, a high water table, and associated springs and wetlands have made cropland irrigation possible. The ecoregion was once dominated by shadscale, saltbush and greasewood, but most of the native vegetation has been removed for agriculture. Irrigated cropland is common, with barley malt, potatoes, alfalfa, small grains, and hay, and smaller areas of vegetables such as spinach, head lettuce, and carrots. Generally, the soils of this region tend to be less alkaline than the soils of 22c. The increasing demand for water throughout this region is an ongoing issue, exacerbated by recent droughts. Increased salt accumulation in soils and groundwater depletion are problems associated with irrigation and the competing uses of available water.
<b>22c: Salt Flats</b>	The <b>Salt Flats</b> ecoregion includes the alkaline basin that surrounds the San Luis Lakes. The smooth to irregular plains of low to moderate relief have elevations ranging from 7400 to 7700 feet, some of the lowest areas in the San Luis Valley. Vegetation is sparse, with greasewood and shadscale dominating along with scattered areas of horsebrush, spiny hopsage, rabbitbrush, saltgrass, alkali sacaton, and small areas of sagebrush at the eastern edges. Some areas are devoid of vegetation. Land use is limited to low density livestock grazing and wildlife habitat. Unlike 22b, cropland is more limited within this region due to the more alkaline soils. Precipitation ranges from 6 to 8 inches annually.
<b>22e: Sand Dunes and Sand Sheets</b>	Great Sand Dunes National Park and the outlying sand sheets are included in the <b>Sand Dunes and Sand Sheets</b> ecoregion. The sand sheets consist of low parabolic and longitudinal dunes that are largely stabilized by scrubby vegetation. The Great Sand Dunes rise up to 750 feet above the basin and are the tallest dunes in North America. The sand was derived mainly from volcanic rock sediments of the San Juan Mountains that were transported by the Rio Grande, and deposited on the alluvial fan on the west side of the valley. The sand was then blown by the prevailing southwesterly winds, piling up at the base of the mountains. The dunes are mostly bare, with patches of Indian ricegrass, blowout grass, or lemon scurfpea. Sand sheet plants include rabbitbrush, sand dropseed, spiny hopsage, sand verbena, and prairie sunflower. Land use in the region is mostly recreation and wildlife habitat, with some limited rangeland.

## 3.0 METHODS

### 3.1 Wetland Mapping and Wetland Profile

At the outset of this project, digital wetland mapping from the NWI program was available for approximately 60% of the SRLCC in Colorado (Fig. 5). A coincident EPA-funded project filled in another 95 quads, shown in blue in Fig 2 below. To complete the digital mapping coverage and create the SRLCC wetland profile, scanned original paper maps were converted to geo-rectified digital polygons for all remaining topographic quads lacking digital spatial data, producing a wall-to-wall map of wetlands within the SRLCC in Colorado (see Appendix A for detailed mapping methodologies). Though land use has likely changed wetland resources since the maps were first created in the 1980s, many locations within the SRLCC remain unchanged over the last 30 years. Original maps were created by using the best aerial imagery at the time, with each wetland attributed according to the NWI wetland classification system (Cowardin et al. 1979) which has become the federal standard for wetland classification.



**Fig. 5.** NWI mapping status for the SRLCC in Colorado. Digital wetland data were available for 60% of the project area prior to this project. EPA funds were used for updated mapping in the blue quads. BOR WaterSMART funds were used for digital conversion of original paper maps in the remaining purple quads.

The NWI wetland classification system (Cowardin et al. 1979) is based on the following definition of wetlands:

*“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.”*

The classification is a hierarchical system that describes wetlands at varying scales of specificity. All mapped polygons are attributed using the NWI hierarchy of system, subsystem, class, hydrology, and special modifiers. The result is a 4–6 character alpha-numeric code (see Appendix B for the full classification system).

System is the primary division in the classification and divides mapped features into a handful of aquatic resource types and is followed (when appropriate) by a numeric subsystem code. The four systems used for Colorado NWI mapping are Riverine (rivers), Lacustrine (lakes), Palustrine (vegetated wetlands) and Riparian (non-wetland vegetated areas adjacent to waterbodies) (Table 3). The Riparian system was developed following the initial mapping in the 70s and 80s (USFWS 2009). As the majority of the study area was digitally converted from 1980’s NWI mapping, only those areas with updated mapping include riparian features.

After system and subsystem, class identifies the dominate substrate or vegetation structure present and is represented by a two letter code (Table 4). Hydrologic regimes describe the duration and timing of flooding and is represented by a single letter character (Table 5). Duration increases from A-H, though B sites are rarely flooded, but have water at or very near the surface consistently. Areas mapped as Riparian do not receive a hydrologic regime code. The final component of the code is an optional special modifier, represented by a lowercase letter. Many modifiers are possible, though only a handful of codes were applied in the study area (Table 6). To facilitate generalizations about the mapping data, Cowardin codes were combined into eight broad groups (Table 7), of which five are considered true wetlands and the remaining three are lakes, rivers/streams and riparian.



**Table 3: NWI Cowardin system and subsystem codes and interpretation.**

<i>System</i>	<i>Subsystem</i>	<i>Code</i>	<i>Interpretation</i>
<b>Riverine</b>		<b>R</b>	<b>Rivers and streams</b>
	Lower Perennial	2	low gradient, slow moving channels
	Upper Perennial	3	steep, fast moving channels
	Intermittent	4	channels that do not flow year round, including manmade ditches
<b>Lacustrine</b>		<b>L</b>	<b>Lakes (water bodies &gt;20 acres and/or &gt; 2 m deep)</b>
	Limnetic	1	lake water > 2 m deep
	Littoral	2	lake water < 2 m deep along lake margins
<b>Palustrine</b>		<b>P</b>	<b>Vegetated wetlands (marshes, swamps, bogs, etc.) even if associated with rivers or lakes</b>
<b>Riparian</b>		<b>Rp</b>	<b>Non-wetland areas adjacent to waterbodies with vegetation distinct from surrounding uplands</b>

**Table 4: NWI Cowardin class codes and interpretation.**

<i>Class</i>	<i>Code</i>	<i>Interpretation</i>
Aquatic Bed	AB	aquatic rooted or floating vegetation
Emergent	EM	herbaceous, non-woody vegetation
Scrub-shrub	SS	low woody vegetation
Forested	FO	trees
Unconsolidated Bottom	UB	habitats with at least 25% cover of particles smaller than stones and less than 30% areal cover of vegetation
Unconsolidated Shore	US	unconsolidated substrates with less than 75% areal cover of stones, boulders or bedrock and less than 30% areal cover of vegetation
Stream Bed	SB	unvegetated surfaces with variable substrate sizes within stream channels

**Table 5: NWI Cowardin hydrologic regime codes and interpretation.**

<i>Code</i>	<i>Interpretation</i>
A	temporarily flooded
B	saturated
C	seasonally flooded
F	semi-permanently flooded
G	intermittently exposed
H	permanently flooded
K	artificially flooded

**Table 6: NWI Cowardin special modifier codes and interpretation.**

<i>Code</i>	<i>Interpretation</i>
x	Excavated
h	Dammed/impounded
b	Beaver

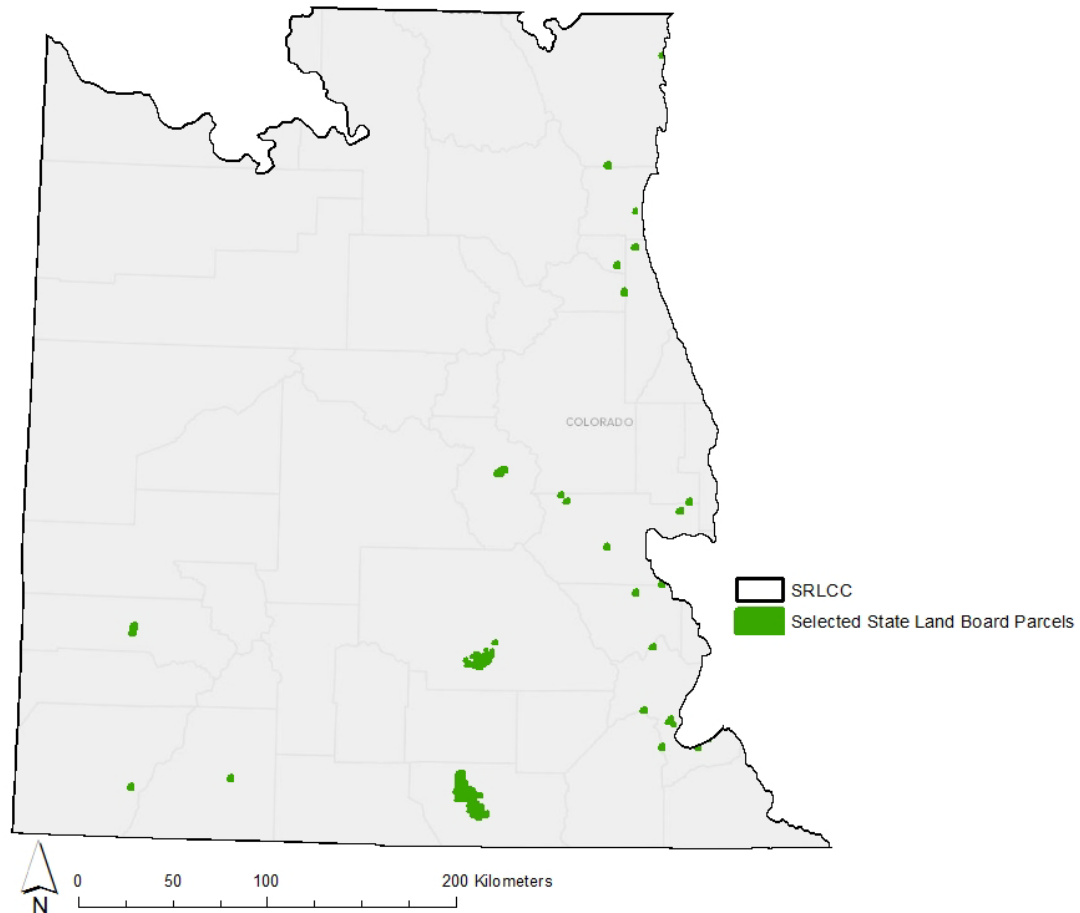
**Table 7: NWI attribute groups for summary tables.**

<i>NWI Group</i>	<i>Codes</i>	<i>Interpretation</i>
Herbaceous Wetlands	PEM*	all herbaceous wetlands (e.g., marshes, wet meadows, playas, etc.)
Shrub Wetlands	PSS*	shrub dominated wetlands (e.g. willow stands)
Forested Wetlands	PFO*	tree dominated wetlands (e.g., wet cottonwood stands)
Ponds	PAB*/PUB*	ponds of all kinds, either vegetated or not, but with open water < 2 m (e.g. beaver ponds, stock ponds, golf ponds, etc.)
Other Wetlands	PUS*/Pf	misc. other classes, primarily unvegetated surface (i.e. sparsely vegetated salt flats) and some farmed wetlands (used only rarely)
Lakes and Shores	L*	all lakes and unvegetated lake shores
Rivers / Streams / Canals	R*	all river and stream channels, including manmade ditches, and their associated unvegetated shores (i.e., unvegetated sandbars)
Riparian	Rp*	Non-wetland areas adjacent to waterbodies with vegetation distinct from surrounding uplands

Though irrigation is known to influence Rocky Mountain wetlands through various mechanisms (Peck and Lovvorn 2001; Sueltenfuss et al. 2013), it is not included in the list of modifiers because the type and extent of modification is impossible to identify from aerial images. “Artificially flooded” is a hydrologic regime codes used in the Cowardin classification, though its use has changed over time within the NWI mapping standards, is not consistently applied to all irrigated acres, and is not reliable. Wetlands can be recharged from irrigation water through a number of mechanisms, including leakage from canals, overflow from adjacent irrigated fields, and through direct application of irrigation water. It is not practical to identify wetlands receiving leakage from canals or overflow from adjacent fields, but it is possible to estimate the area of wetlands directly receiving irrigation water by overlaying the final layer of mapped wetland with a statewide layer of irrigated parcels (CDSS 2013). This analysis provides a conservative estimate for the influence of irrigation on wetlands as it underestimates the total impact of irrigation by addressing only one of the possible wetland recharge mechanism.

### 3.2 Updated Wetland Mapping on State Land Board Parcels

In concert with the digital conversion of existing NWI paper maps, CNHP sought to improve the wetland mapping available on certain lands within the SRLCC. Between 2011 and 2013, CNHP ecologists conducted vegetation inventories on select State Land Board parcels within the SRLCC (Fig. 6). Their field notes and findings, along with recent aerial imagery, were used to update NWI wetland mapping on these State Land Board parcels.



**Fig. 6. State Land Board Parcels selected for vegetation surveys by CNHP ecologists within the Colorado portion of the SRLCC. Surveys informed wetland mapping to create updated wetland maps for these parcels within the study area.**

# 4.0 RESULTS

## 4.1 Wetland Profile of the SRLCC

Results of the complete SRLCC wetland profile, including the extent of wetland acreage by NWI system/class, hydrologic regime, extent modified, extent irrigated, land ownership, and Level IV Ecoregions, provide a coarse quantification of wetland resources in the SRLCC study area. The study area itself covers 36,521,296 acres. Original NWI mapping contained 1,249,610 acres of wetlands and water bodies, representing approximately 3% of the total land area (Fig. 7; Table 8).

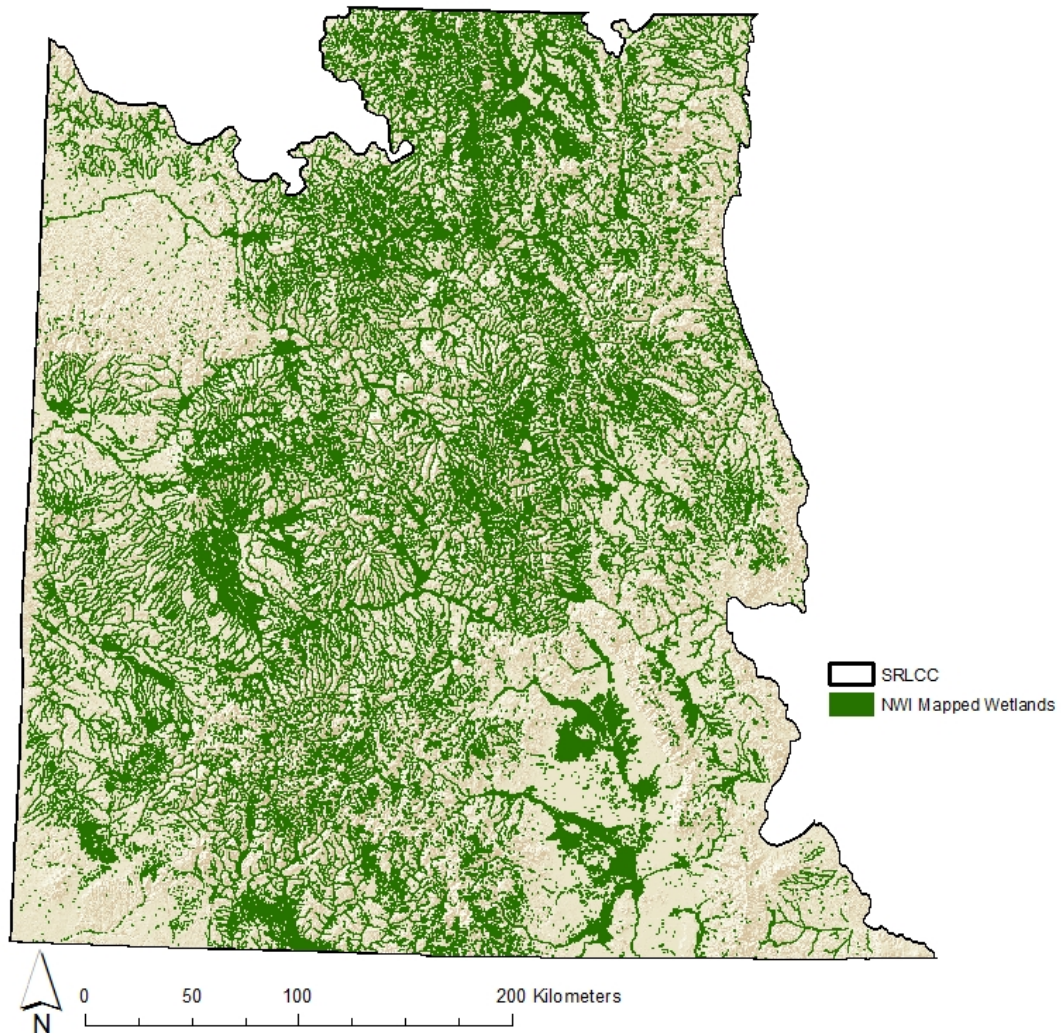


Fig. 7. Digital NWI wetlands mapped in the SRLCC in Colorado.

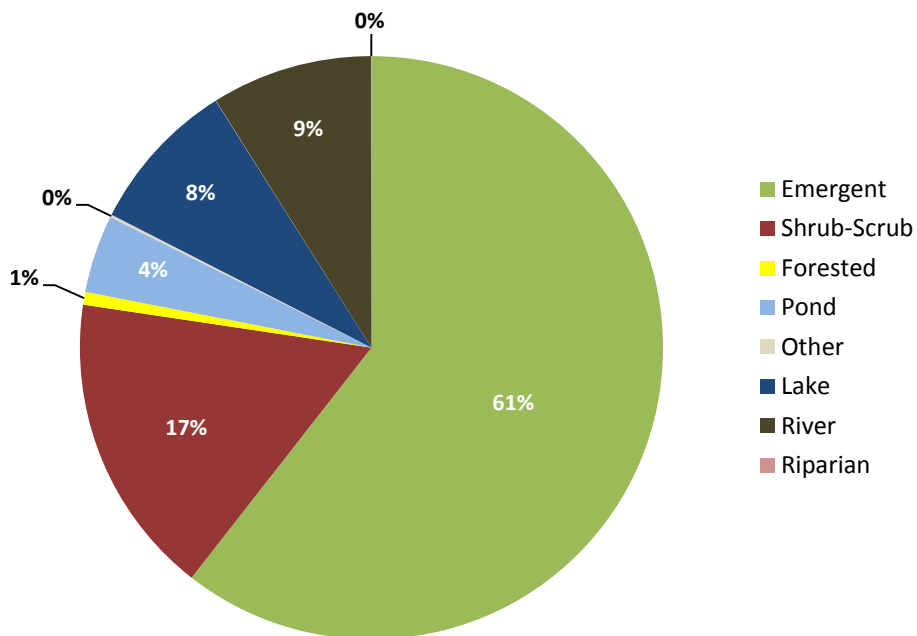
### **Wetland Acres by NWI Group**

Within the entire SRLCC area of Colorado, herbaceous wetlands were overwhelmingly the largest mapped group at 756,704 acres, representing 61% of the total mapped features (Table 8; Fig. 8). The second largest group was shrub wetlands at 210,022 acres (17%). Lakes, both natural and manmade, were 9% of all mapped NWI acres. Many of the lakes in the study area are artificially created reservoirs, primarily used for water storage. Though the majority of the rivers in the area are within their natural channels, the 111,679 acres of river is artificially elevated due to the extensive network of artificially dug irrigation canals found in the valleys and lower elevation agricultural areas. Only 189 acres of riparian areas were mapped in the study area, though this number is dramatically lower than the actual amount of riparian area in the SRLCC, as this is a new type of mapped polygon and has only been used in a small fraction of the area.

With lakes and rivers removed to highlight wetlands specifically, herbaceous wetlands accounted for 73% of wetlands, with shrub wetlands making up 20%. Herbaceous wetlands primarily represent fens in the higher elevations, wet meadows in mountain valleys, and marshes in depressional areas. There are more shrub wetlands than in other parts of the state due to the lush stream corridors in the high elevations of the Rocky Mountains. The extent of forested wetlands and wetlands in the “other” category were much smaller, 1% and 0%, respectively. Forested wetlands are not as common in Colorado as they are in other parts of the country as our tree species are not adapted to large expanses of wet ground. Ponds made up 4% of the overall mapped area and 5% of the mapped wetlands specifically, which is higher than would be expected naturally due to the creation of berms in drainages and artificially dug irrigation and stock ponds.

**Table 8. NWI acreage mapped in the SRLCC in Colorado.**

<i>Wetland Type</i>	<i>All Acres</i>	<i>% Wetlands and Water</i>	<i>% Wetlands</i>
Herbaceous	756,704	61%	73%
Shrub	210,022	17%	20%
Forested	8,818	1%	1%
Ponds	54,008	4%	5%
Other Wetlands	1,645	0%	0%
<b>Total Wetlands (excl. Lakes &amp; Rivers)</b>	<b>1,031,197</b>	<b>82%</b>	<b>100%</b>
Lakes and Shores	106,546	9%	-
Rivers/Streams/Canals	111,679	9%	-
Riparian	189	0%	-
<b>Total Wetlands &amp; Waterbodies</b>	<b>1,249,610</b>	<b>100%</b>	<b>NA</b>



**Fig. 8. Percent of mapped NWI acres by group.**

### ***Wetland Acres by Extent Modified and Irrigated***

The NWI classification includes several modifiers that describe alteration from human and beaver activity. The three modifications mapped in the SRLCC boundary were 1) excavated wetlands, 2) dammed and impounded wetlands, and 3) beaver influenced wetlands. Though wetland modification is not distributed evenly across the landscape, with increased levels of beaver modification in higher elevations and greater amounts of human modification in lower elevation valleys, only 13% of the total mapped acres were modified and 8% of wetlands were modified (Table 9). Of all NWI groups, lakes were influenced by modification the most, with more than 70% of lakes modified by impoundments or excavations. Ponds were also heavily modified with more than 50% mapped as modified. Many ponds in agricultural areas were either dammed (29%) or excavated (10%), and 18% of mapped ponds were modified by beaver activity. Beavers also influenced 18% of the mapped shrub wetlands, while 0% of mapped shrub wetlands were influenced by either excavation or damming. Rivers were primarily un-modified, with a small portion modified by excavation (7%) due to the creation of irrigation canals.

Though 92% of wetlands were not coded with a modifier for excavation, damming, or beavers, irrigation (not captured in the mapping attribution) has a large influence on wetlands in Colorado. Within the SRLCC area, 23% of all mapped NWI features and 27% of mapped wetlands were located on irrigated lands. Herbaceous wetlands were the most common wetland type on irrigated lands, making up 35% of all mapped herbaceous wetlands and 95% of all irrigated wetlands. Shrub wetlands accounted for 3% of all irrigated wetlands. Though ponds accounted for only 1% of irrigated wetlands, it is reasonable to assume that a large portion of the 39% modified ponds were created for irrigation and agricultural purposes.

**Table 9. SRLCC NWI acres mapped by modifier and extent irrigated.**

Wetland Type	No Modifier		Excavated		Dammed / Impounded		Beaver Influenced		Irrigated Wetlands <sup>1</sup>		
	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	% of Irrigated Wetlands
Herbaceous	739,246	98%	3,583	0%	8,946	1%	4,929	1%	267,455	35%	95%
Shrub	182,552	87%	175	0%	952	0%	26,343	13%	8,819	4%	3%
Forested	8,687	99%	40	0%	58	1%	33	0%	431	5%	0%
Ponds	23,119	43%	5,493	10%	15,929	29%	9,468	18%	2,317	4%	1%
<b>Wetlands (excl. Lakes &amp; Rivers)</b>	<b>953,604</b>	<b>92%</b>	<b>9,291</b>	<b>1%</b>	<b>25,885</b>	<b>3%</b>	<b>40,773</b>	<b>4%</b>	<b>279,022</b>	<b>27%</b>	<b>99%</b>
Lakes and Shores	31,430	29%	2,303	2%	72,812	68%	-	-	187	0%	0%
Rivers/Streams/Canals	103,797	93%	7,882	7%	-	-	-	-	3,150	3%	1%
Riparian	189	100%	-	-	-	-	-	-	-	-	-
<b>Wetlands &amp; Waterbodies</b>	<b>1,088,831</b>	<b>87%</b>	<b>19,476</b>	<b>2%</b>	<b>98,697</b>	<b>8%</b>	<b>40,773</b>	<b>3%</b>	<b>282,359</b>	<b>23%</b>	<b>100%</b>

<sup>1</sup> Irrigated lands from the Colorado Decision Support System (CDSS 2013).

### ***Wetland Acres by Hydrologic Regime***

The most prevalent wetland hydrologic regimes of the NWI mapped acres were seasonally flooded (36%), temporarily flooded (23%), and saturated (19%) (Table 10). Both temporarily flooded and seasonally flooded wetlands rely on overbank flooding from adjacent rivers and streams, accumulation of storm runoff in drainages, or flood irrigation to deliver water to the wetlands. These wetlands are only wet from a few weeks to a few months a year, and may be dry towards the end of the growing season. Saturated wetlands rely on groundwater discharge or the backup of river water from beaver activity to keep the soil saturated throughout the entire year. Saturated wetlands are generally only found in higher elevations and are associated with fens and beaver complexes. Permanently flooded wetlands were 11% of the total mapped area, but a negligible percent of mapped wetlands. Generally, the permanently flooded, intermittently exposed, and semi permanently flooded regimes are associated with waterbodies rather than wetlands. Though artificially flooded wetlands were 1% of mapped wetlands, this figure is lower than in reality due to the difficulty of identifying specific water sources as entirely natural or entirely artificial from aerial images.

**Table 10. NWI Wetland and waterbody acreage mapped in the SRLCC by hydrologic regime code.**

<i>NWI Code</i>	<i>Hydrologic Regime</i>	<i>All NWI Acres</i>	<i>% All Acres</i>	<i>Wetland Acres Only</i>	<i>% Wetland Acres</i>
A	Temporarily Flooded	284,076	23%	264,708	26%
B	Saturated	239,982	19%	239,979	23%
C	Seasonally Flooded	450,756	36%	427,880	41%
F	Semipermanently Flooded	43,601	3%	34,875	3%
G	Intermittently Exposed	44,698	4%	24,845	2%
H	Permanently Flooded	135,082	11%	98	0%
J	Intermittently Flooded	32,805	3%	32,710	3%
K	Artificially Flooded	18,422	1%	6,102	1%
<b>Total</b>		<b>1,249,610</b>	<b>100%</b>	<b>1,031,197</b>	<b>100%</b>

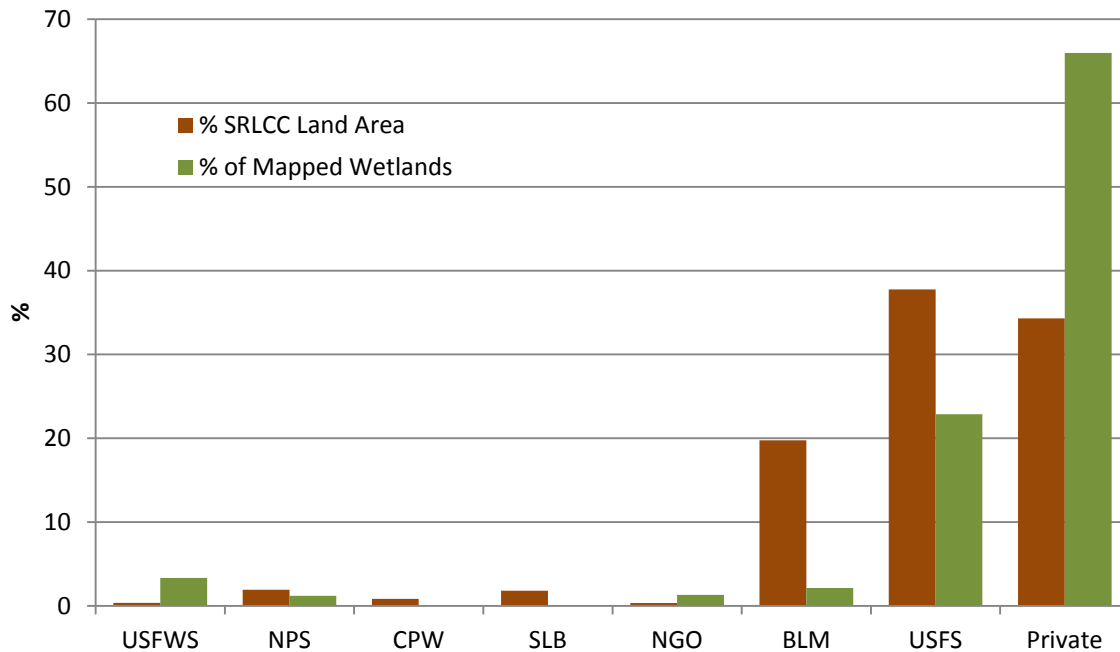
### ***Wetland Acres by Landownership***

The distribution of wetlands by landowner highlights the importance of private lands for the wetland resources in the SRLCC. Though private lands make up only 34% of the entire SRLCC area in Colorado, 61% of all NWI acres and 66% of wetlands were located on private land (Table 11; Fig. 9). The majority of land in the area is federally owned (60%), with the U.S. Forest Service owning 38% and the Bureau of Land Management owning 20%. Federal lands contained 34% of mapped NWI acres and 40% of mapped wetlands. Of the federally owned land, the U.S. Forest Service had the most mapped NWI acres, with 24% of all NWI acres and 23% of mapped wetlands. Other ownership groups were small in both the percent of study area owned as well as mapped wetlands, though non-governmental organizations, such as The Nature Conservancy and other land conservation groups, own 2% of all mapped NWI acres and 1% of mapped wetlands.



**Table 11. NWI Wetland and waterbody acreage mapped in the SRLCC by grouped land owner.**

<i>Grouped Owner<sup>1,2</sup></i>	<i>Total Land Area within SRLCC</i>		<i>Total NWI Acres within SRLCC</i>		<i>Wetland Acres Only</i>	
	<i>Acres</i>	<i>% of SRLCC</i>	<i>Acres</i>	<i>% of NWI Acres</i>	<i>Acres</i>	<i>% of Wetlands</i>
<b>Federal Lands</b>	<b>21,922,903</b>	<b>60%</b>	<b>421,069</b>	<b>34%</b>	<b>308,402</b>	<b>30%</b>
Bureau of Land Management	7,215,444	20%	43,115	3%	22,168	2%
Bureau of Reclamation	17,458	0%	7,226	1%	3,108	0%
Misc. Federal	60,304	0%	1,866	0%	336	0%
U.S. Fish and Wildlife Service	137,040	0%	35,131	3%	34,479	3%
National Park Service	704,858	2%	27,645	2%	12,500	1%
U.S. Forest Service	13,787,797	38%	306,086	24%	235,812	23%
<b>Tribal Lands</b>	<b>768,120</b>	<b>2%</b>	<b>4,368</b>	<b>0%</b>	<b>2,323</b>	<b>0%</b>
<b>State Lands</b>	<b>990,594</b>	<b>3%</b>	<b>33,342</b>	<b>3%</b>	<b>23,727</b>	<b>0%</b>
Colorado Parks and Wildlife	311,335	1%	15,455	1%	8,808	0%
State Land Board	667,832	2%	17,728	1%	14,785	0%
Misc. State	11,426	0%	159	0%	134	0%
<b>Other</b>						
Cities	70,299	0%	5,551	0%	1,521	0%
Counties	104,480	0%	2,999	0%	999	0%
Joint City / County	5,700	0%	856	0%	267	0%
Spec / Metro / School Districts	2,983	0%	80	0%	49	0%
Non-Govern. Organizations	128,971	0%	25,045	2%	13,616	1%
Private	12,527,245	34%	756,300	61%	680,293	66%
<b>Total</b>	<b>36,521,296</b>	<b>100%</b>	<b>1,249,610</b>	<b>100%</b>	<b>1,031,197</b>	<b>100%</b>



**Fig. 9. Percent of mapped wetlands and percent SRLCC land area by owner.**

### ***Wetland Acres by Ecoregion***

Analyzing mapped wetlands by ecoregion shows the spatial distribution of wetlands within the SRLCC in Colorado. The Southern Rockies Ecoregion had the most mapped NWI acres (74%), but this share is very similar to the total amount of land area within the Southern Rockies Ecoregion (70%) (Table 12). That more wetlands were mapped in the Southern Rockies Ecoregion is expected, as it has more available water than the other ecoregions due to the large amounts of snowfall at high elevations. Within the Southern Rockies Ecoregion, herbaceous wetlands were primarily mapped in the intermountain valleys of the Sagebrush and Grassland Parks and are likely tied to land use patterns of flood irrigation on private lands. Shrub wetlands were highest in Subalpine Forests. Ninety percent of all lakes and 64% of all rivers were mapped in the Southern Rockies Ecoregion.

The Colorado Plateau Ecoregion is a drier ecoregion and has less NWI acres (8% of basin) than its total land area (25%). Of these mapped acres, most were rivers and ponds. In the Arizona/New Mexico Plateau Ecoregion, primarily the San Luis Valley, there were more NWI acres (17%) than total land area (6%). The dominant type of wetland in the San Luis Valley was herbaceous wetlands (26% of all herbaceous). Herbaceous wetlands in the San Luis Valley were largely influenced by flood irrigation on private lands. The San Luis Valley also contained 14% of all mapped forested wetlands, though it is important to note that forested wetlands mapped in both the Colorado Plateau and the San Luis Valley may better fit with the new Riparian system, if they were mapped with the updated classification system. The Riparian system was only included in a small subset of the study area, all within the Southern Rockies Ecoregion.

**Table 12. Wetland acreage in SRLCC by ecoregion and NWI system / class.**

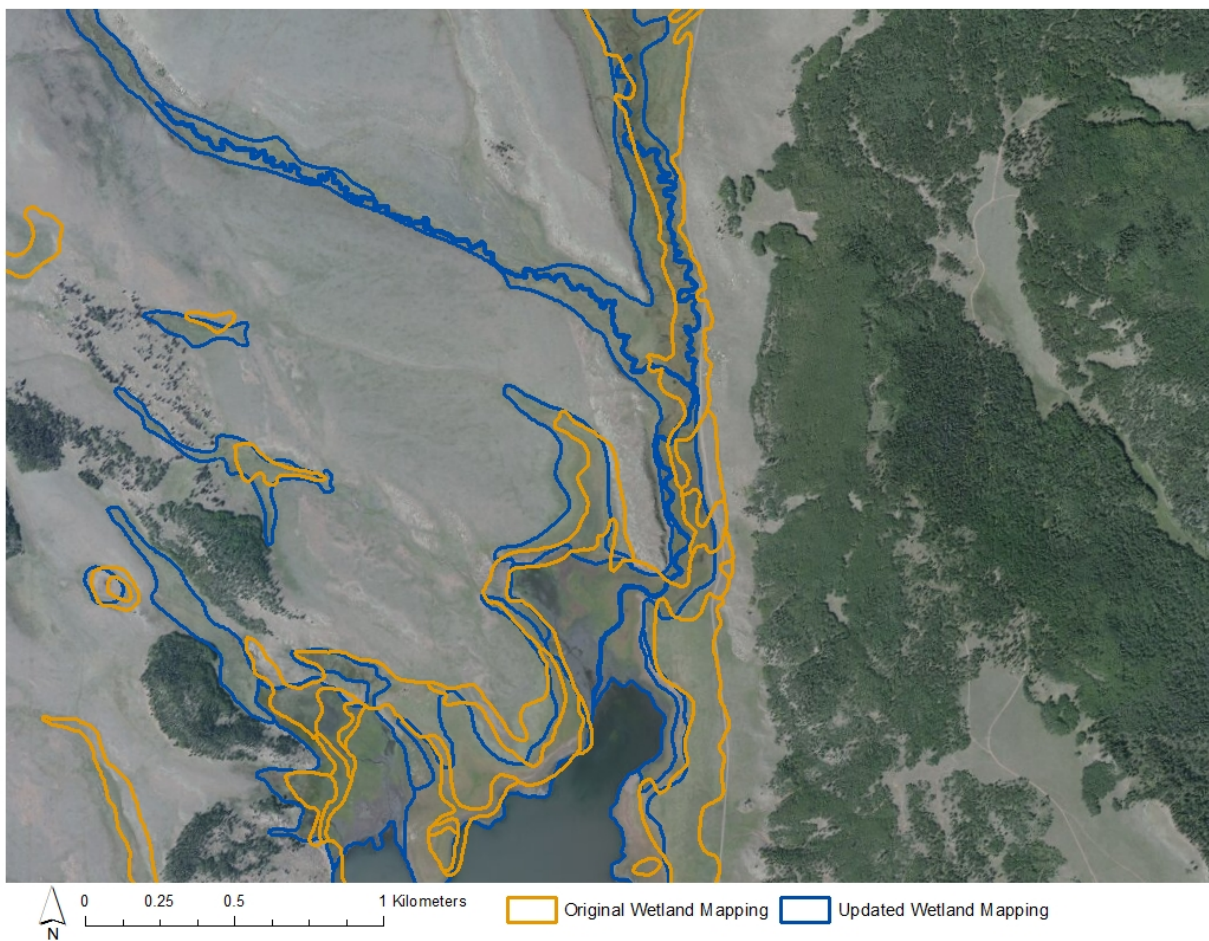
Level III / IV Ecoregion	SRLCC Land Area		SRLCC NWI Acres		Percent of SRLCC Wetlands within Ecoregion by NWI System / Class						
	Acres	%	Acres	%	Herb	Shrub	Forest	Pond	Lakes	Rivers	Riparian
<b>20: Colorado Plateaus</b>	<b>8,989,872</b>	<b>25%</b>	<b>102,786</b>	<b>8%</b>	<b>6%</b>	<b>4%</b>	<b>5%</b>	<b>14%</b>	<b>6%</b>	<b>34%</b>	<b>0%</b>
20a: Monticello-Cortez Uplands	601,834	2%	16,080	1%	1%	0%	0%	3%	1%	2%	0%
20b: Shale and Sedimentary Basins	1,868,820	5%	41,533	3%	2%	2%	2%	6%	1%	14%	0%
20c: Semiarid Bench/Canyonlands	5,805,426	16%	42,659	3%	2%	2%	3%	5%	4%	17%	0%
20d: Arid Canyonlands	42,032	0%	374	0%	0%	0%	0%	0%	0%	0%	0%
20e: Escarpments	647,298	2%	2,106	0%	0%	0%	0%	0%	0%	1%	0%
20f: Uintah Basin Floor	24,462	0%	33	0%	0%	0%	0%	0%	0%	0%	0%
<b>21: Southern Rockies</b>	<b>25,388,156</b>	<b>70%</b>	<b>929,354</b>	<b>74%</b>	<b>68%</b>	<b>94%</b>	<b>81%</b>	<b>79%</b>	<b>90%</b>	<b>62%</b>	<b>100%</b>
21a: Alpine Zone	2,368,455	6%	61,718	5%	2%	14%	1%	8%	6%	3%	0%
21b: Cryst Subalpine Forests	3,050,030	8%	91,494	7%	4%	21%	8%	8%	6%	6%	5%
21c: Cryst Mid-Elev Forests	2,849,100	8%	83,760	7%	6%	11%	7%	6%	5%	4%	69%
21d: Foothill Shrublands	3,016,832	8%	97,147	8%	8%	4%	21%	6%	7%	11%	26%
21e: Sed Subalpine Forests	3,940,871	11%	95,736	8%	4%	15%	6%	15%	12%	12%	0%
21f: Sedi Mid-Elev Forests	4,832,185	13%	114,322	9%	6%	11%	20%	18%	17%	14%	0%
21g: Volc Subalpine Forests	2,519,757	7%	64,579	5%	4%	8%	1%	7%	8%	4%	0%
21h: Volc Mid-Elev Forests	667,457	2%	50,013	4%	6%	1%	1%	1%	1%	1%	0%
21i: Sagebrush Parks	1,317,616	4%	174,086	14%	17%	7%	5%	6%	19%	5%	0%
21j: Grassland Parks	825,853	2%	96,498	8%	10%	2%	11%	3%	9%	2%	0%
<b>22: Arizona/New Mexico Plateau</b>	<b>2,126,399</b>	<b>6%</b>	<b>217,470</b>	<b>17%</b>	<b>26%</b>	<b>2%</b>	<b>14%</b>	<b>6%</b>	<b>5%</b>	<b>3%</b>	<b>0%</b>
22a: Shrublands and Hills	632,992	2%	15,525	1%	2%	0%	1%	0%	1%	0%	0%
22b: San Luis Alluvial Flats/Wetlands	776,520	2%	83,715	7%	10%	1%	14%	4%	2%	2%	0%
22c: Salt Flats	554,105	2%	113,177	9%	14%	0%	0%	2%	2%	0%	0%
22e: Sand Dunes and Sand Sheets	162,782	0%	5,053	0%	1%	0%	0%	0%	0%	1%	0%

## 4.2 Updated Wetland Mapping for State Land Board Study Area

On the State Land Board parcels that CNHP inventoried from 2011 through 2013, a total of 1,930 NWI acres were originally mapped (Table 13). Of these, 1,185 represented wetlands. With the updated field notes from inventories and new aerial imagery, these figures declined to 1,682 total NWI acres and 903 wetland acres. The largest decrease was from the herbaceous wetland type, which declined by 278 acres. Though only 3 acres has originally been mapped as forested wetland, zero acres were mapped in the updated version. Both of these declines can partially be attributed to the addition of the Riparian attribute in the updated mapping as some areas adjacent to rivers had originally been mapped as herbaceous or forested wetlands, but were changed to riparian features in the updated version (Fig. 10). Acreage from ponds and lakes also declined, though by relatively small amounts that can likely be attributed to changes in the quality of aerial imagery from the 1980s to today.

**Table 13. Comparison of wetland acreage on State Land Board parcels of the SRLCC mapped in 1980 and updated in 2013.**

NWI Group	1980 NWI Mapping			Updated SLB Mapping			Change in Acres from Original
	All Acres	% Wetlands and Water	% Wetlands	All Acres	% Wetlands and Water	% Wetlands	
Herbaceous	1,115	58%	94%	838	50%	93%	-278
Shrub	28	1%	2%	32	2%	3%	3
Forested	3	0%	0%	0	0%	0%	-3
Ponds	37	2%	3%	18	1%	2%	-19
Other	2	0%	0%	16	1%	2%	14
<b>Total Wetlands (excl. Lakes &amp; Rivers)</b>	<b>1,185</b>	<b>61%</b>	<b>1%</b>	<b>903</b>	<b>54%</b>	<b>1%</b>	<b>-282</b>
Lakes and Shores	701	36%	-	683	41%	-	-18
Rivers/Streams/Canals	45	2%	-	60	4%	-	15
Riparian	0	0%	-	36	2%	-	36
<b>Total Wetlands &amp; Waterbodies</b>	<b>1,930</b>	<b>100%</b>	<b>NA</b>	<b>1,682</b>	<b>100%</b>	<b>NA</b>	<b>-249</b>



**Fig. 10. State Land Board Parcel in the San Luis Valley Showing original wetland mapping in orange and updated mapping using CNHP field notes in blue. Note the blue mapping extending towards the upper left. This represents the Riparian attribution not included in the original mapping as well as more fine scale mapping of streams.**

## 5.0 DISCUSSION

The SRLCC wetland profile reveals an intriguing and optimistic look at the wetland and water resources of the Colorado portion of the SRLCC and has significant implications for wetland conservation across the landscape. Wetlands are known for their importance, which is often underscored by the small amount of total land area they occupy. Within the SRLCC, wetlands and waterbodies represent just over 3% of the land surface, with wetlands specifically occupying 2.8% of the landscape. While this is a small percentage of the overall land surface, the 1 million acres of wetlands mapped within the Colorado portion of the SRLCC alone equals previous estimates of 1 million acres for the entire state of Colorado, indicating that the state wide figure is likely well above these previous estimates (Dahl 1990).

Though the condition of wetlands across Colorado is actively being studied by CNHP and Colorado Parks and Wildlife through a long term effort called the Statewide Strategies for Colorado Wetlands (Lemly et al. 2011), the analysis of modifiers within the mapped wetlands shows that a vast majority of wetlands are not modified. While this figure might be lower than in reality, and represents wetland mapping from 30 years ago, limited human development in many areas of the Southern Rockies Ecoregion has likely preserved intact riparian corridors through valleys and wetland complexes at higher elevations. Water development and hydrologic alteration is a continual process in Colorado, and the west in general, but in the SRLCC only 4% of mapped wetlands were either dammed or excavated (though this figure is 70% for lakes). Non-modified wetlands and wetlands naturally modified by beavers represent over 95% of mapped wetlands in the area. This should be viewed as good news and approached as an opportunity to conserve wetlands of high biodiversity value across the area.

It is important to note the influence of irrigation on Colorado's wetlands, though this does not adequately show up in the attributing of mapped wetlands. Within agricultural areas of the SRLCC, irrigation augments water that naturally flows to some wetlands, and brings water to other areas that historically never had access to water at all. Wetland extent can be increased due to this augmentation, and other wetlands can be entirely created by the introduction of water from direct flood irrigation, tail water from irrigated fields, or seepage through irrigation ditches (Peck & Lovvorn 2001; Sueltenfuss et al. 2013). This is a different story than is generally reported in other areas of the country where wetlands are drained for agricultural purposes (de Voogt et al. 2000).

Augmentation by irrigation water may also offset hydrologic alterations that have occurred from the loss of beaver activity in some areas (Lemly and Gilligan 2012). Beavers (*Castor canadensis*) were historically abundant throughout Colorado. By the 1850s, fur trapping had dramatically reduced their populations and today their numbers are primarily concentrated in higher elevations. Through their extensive networks of dams, beavers help retain water within riparian floodplains (Westbrook et al. 2010). Without them, valleys are drained much faster and streams can run dry. As irrigation in higher elevation valleys generally takes river water and distributes it across historic floodplains, it is conceivable that some of the lost functions from beaver activity are augmented by current irrigation practices.

Irrigation plays an important role in maintaining wetlands in some areas and has likely added considerable wetland area above what would have been found prior to settlement. Understanding this dynamic is key for conservation efforts. As municipal and industrial water demand grows in Colorado, many irrigated acres are being removed from agricultural production. This may have dramatic implications for the acreage of herbaceous wetlands in the mountain valleys.

The evaluation of wetland resources by land owner throughout the SRLCC highlights opportunities for effective wetland conservation efforts. Though a majority of the SRLCC is federally owned, only 30% of mapped wetlands were located on federal land. Conversely, only 34% of the SRLCC is privately owned, but has 66% of mapped wetlands. Because wetlands on federally owned land are generally not threatened similarly to private land, much of the wetland conservation efforts are already aimed at private lands. Results from this mapping underscore the importance of ongoing conservation efforts.

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# **APPENDIX A: CNHP WETLAND MAPPING PROCEDURES**



# COLORADO NATURAL HERITAGE PROGRAM WETLAND MAPPING PROCEDURES

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**Version Date: March 29, 2013**

## Scope of Document

This document was prepared by the Colorado Natural Heritage Program (CNHP), a research unit of the Warner College of Natural Resources and Colorado State University. It describes procedures used by CNHP to map wetlands in Colorado. All wetland mapping conducted by CNHP is in collaboration with the U.S. Fish and Wildlife Service (USFWS)'s National Wetlands Inventory (NWI) Program and follows the Federal Geographic Data Committee (FGDC)'s most recent standards for wetland mapping (FGDC 2009).

There are two primary types of wetland mapping carried out by CNHP:

- 1) Conversion of original NWI paper maps to digital polygonal data. The original NWI paper maps were produced in the 1970s and 1980s and are currently available as either hard copy paper maps or scanned images, but are not available as digital polygonal data. CNHP works in partnership with the NWI program to convert these hard copy maps to geo-referenced digital polygonal data. Polygons and attributes are not updated or corrected in this process, except in cases where the original attribute is now considered an invalid code. When converting original NWI mapping, CNHP is responsible for the accurate representation of the original mapping in a digital form, but not for the accuracy of how well the data represent wetlands on the ground.
- 2) Creation of new, updated digital NWI maps delineated in ArcGIS and based on the most recent aerial photography available. When delineating newly updated NWI maps, CNHP is responsible for all aspects of accuracy and precision.

This document is primarily intended as an internal communication tool for CNHP's Wetland Mapping Specialists. Certain sections, therefore, may lack background information of interest to external readers. More information is available upon request.

Funding for CNHP's wetland mapping projects has come from a variety of partners, including U.S. Environmental Protection Agency (EPA), U.S. Forest Service (USFS), Bureau of Land Management (BLM), and National Academy of Science (NAS)'s Transportation Research Board (TRB). Non-Federal matching support has come from Colorado Parks and Wildlife (CPW), Great Outdoor Colorado (GOCO), Colorado Department of Transportation (CDOT), and Colorado Water Conservation Board (CWCB).

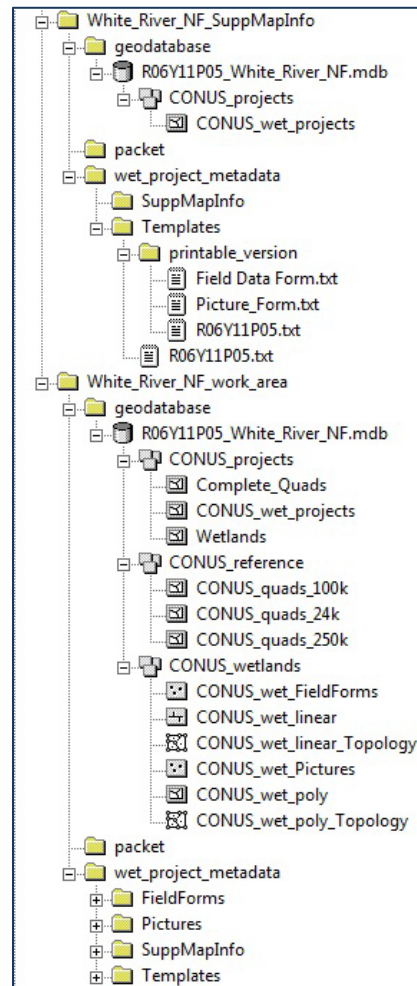


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## A. Project Check-out/Prep Work

- 1. Checkout Project Area from NWI:** Choose the quads in the project area. Merge and dissolve into a single polygon shape. Submit to Regional NWI Coordinator Kevin Bon ([Kevin\\_Bon@fws.gov](mailto:Kevin_Bon@fws.gov)). Kevin will reply with a “Checkout Packet” which will include documentation, a database with the checkout area, any existing wetland shapes and supplemental layers. Below is a view of the file structure in ArcCatalog.

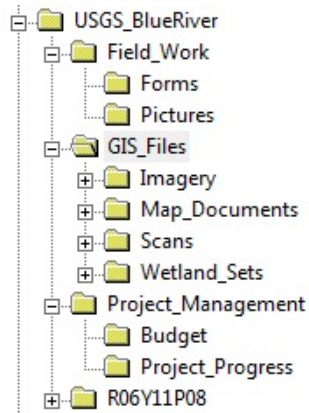
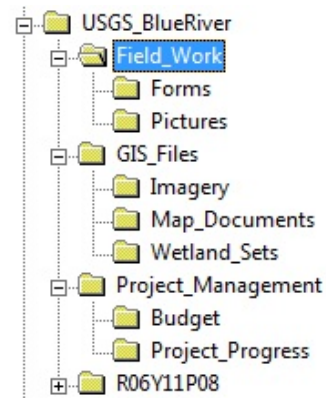


- 2. Identifying Priorities/Intermediate Deadlines:** These must be known early in the planning stages before mapping begins. Once the project area is divided into sets (see below) it can be very confusing to split sets or complete single quads for an intermediate data request. If priority areas or intermediate deadline exist (i.e., if the sponsor requests a certain set of the data before the entire project is complete) these should be flagged and the project area should be divided accordingly.
- 3. Aerial Imagery for New Mapping Updates:** New mapping updates will be based on the most current digital aerial photography available. In most cases, this imagery will be obtained from the USDA Farm Service Agency, Aerial Photography Field Office in Salt Lake



City, Utah (<http://www.apfo.usda.gov>). In special circumstances, imagery may be provided by a project sponsor for a specific project area. The imagery used must be color infra-red (CIR) and must meet all requirements stated in the FGDC standard for wetland mapping (FGDC 2009). The minimum imagery needed to perform new mapping updates is CIR imagery for the year the wetland mapping is being updated to, and CIR imagery for one other year. Two or more additional years is preferable, as having multiple years available (such as a drought year and wet year) supports more accurate water regime determination.

4. **Tracking Project Progress:** Progress on each mapping project is tracked in an Excel spreadsheet. Several template versions are located on the CNHP Server at [P:\Wetland\\_Mapping\SupportFiles\Project\\_Progress\\_Templates](P:\Wetland_Mapping\SupportFiles\Project_Progress_Templates). Three types exist: 1) Double\_Scan\_Quads, 2) Single\_Scan\_Quads and 3) New\_Mapping\_Updates. Slightly different intermediate steps warrant multiple versions. Projects with quads in more than one of these statuses should have the quads broken up and worked on separately and progress recorded in each respective spreadsheet. An additional, Full Project Progress spreadsheet should be created to track overall progress.
5. **Dividing Project Area:** It is usually not feasible to work continuously on a single feature class for a project area; therefore, the quads within the project area are divided into “sets”.
  - a. When converting original NWI maps to digital polygons, blocks can be made up of four quads in a 2x2 square. A 4x1 linear set can also be created. There is no difference between the two and often the overall project area will determine the correct set structure. Working with more than 4 quads can be very cumbersome and more densely populated quads may want to be divided into smaller sets.
  - b. When delineating new wetland features, quads should be dealt with singularly.
6. **Naming Conventions/File Structure:** The standard file structure below shows an Old-Digital Conversion project and a New Mapping Update project. The only difference between these two structures is the addition of a “GIS\_Files/Scans” folder to hold rasters of NWI maps, if available.

**Old-Digital Conversion****New Mapping Update**

Daily work should be complete on a local drive (C:\temp) and copied back to the proper location on the P:\ drive at the end of the day. Additional daily or AT LEAST weekly backups should be completed to a third (external) drive. Backup files should be named explicitly with a date (e.g., "Backup\USGS\_BlueRiver\7\_17\_2011"). Naming conventions for the wetland files produced during the procedure:

"ProjectCode"_Set_"#"_wetlands_pre_attribution.shp (after Step 3)
"ProjectCode"_Set_"#"_wetlands_post_attribution.shp
"ProjectCode"_Set_"#"_wetlands_qaqced.shp (ready to be merged)
"Project"_merged_wetlands (post merging)
"Project"_checked_wetlands (after topology and script run)

" " are values that change with the set or project.

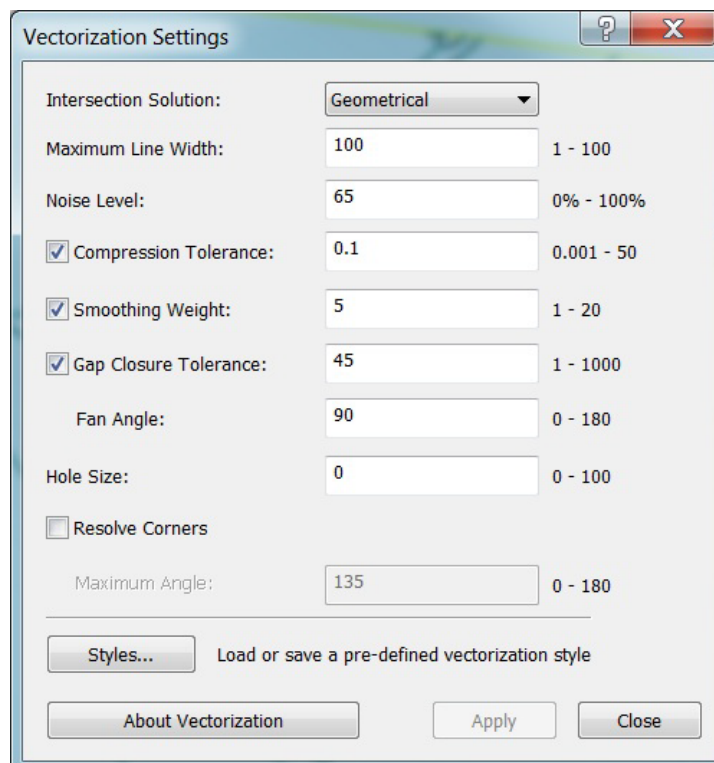
## **B. Overview of CNHP ArcGIS Method for Digital Conversion**

CNHP uses the ArcScan extension for ArcGIS 10.x to convert rasters (scanned data) into digital vector data. The steps below represent the conceptual process taken to convert raster NWI data into vector data. More detail on each step is spelled out in the following section.

1. Project rasters into NAD83: Albers projection. Extract the data within each individual quad and mosaic 4 to 6 quads worth of data into a set.
2. Use the ArcScan extension to generate vector lines on all the visible lines on the mosaicked raster.
3. Inspect lines that represent linear features (rivers and streams) and merge line segments into complete continuous lines that accurately represent linear wetland features.
4. Attribute the linear features with their NWI wetland code, and populate a field with buffer distance values that correspond to the desired width of linear features.
5. Convert all enclosed features into polygons.
6. Buffer the linear features using the values in the Buffer Distance field.
7. Copy the buffered lines into the feature class created in step 5.
8. Attribute all features with NWI wetland codes.
9. Run topology and QAQC tests as described in Section F and make necessary changes.

## C. Work Flow for Digital Conversion of Original NWI Mapping, using ArcScan extension

1. Copy the GDB "Wetlands\_Domain.gdb" from P:\Wetland\_Mapping > SupportFiles into the appropriate set folder.
2. Load quad TIFFs for the defined set to your map document.
3. For each TIFF:
  - Project in Albers (Data Management Tools > Projections and Transformations > Raster > Project Raster) with the output landing in the geodatabase in the set folder mentioned in step 1.
  - Extract each Tiff individually by highlight the quad boundary and extracting by mask (Spatial Analyst Tools > Extraction > Extract by mask).
4. Mosaic rasters together (Data Management > Raster > Raster Dataset > Mosaic to New Raster). Output location should be the GDB in the set folder. Number of bands = 1.
5. Add the 'Lines' blank linear feature class from the GDB to the map.
6. Start an editing session on the linear feature class created in the previous step.
7. Enter the following "vectorization settings" In the ArcScan toolbar drop down menu:



8. Select “Generate Features” under the Vectorization dropdown. Uncheck the box that says “Generate polygons where the maximum line width setting is exceeded.” Make sure the mosaic raster is in the ArcScan Raster selection.
9. Examine all linear features to ensure they are smooth and continuous. Manually draw or correct any linears missed or misrepresented during automated processing and merge necessary segments. Once a linear is merged and correct, enter the corresponding code into the “Attribute” attribute field.
10. Close any open polygon lines within the feature class or along the edges.
11. Once you are confident the feature line work is correct, use it to create polygons (Data Management > Features > FeaturetoPolygon). Save the feature class as “ProjectCode\_set\_XX\_pre\_attribution” in the GDB.
12. Export all attributed linears to the GDB. Name the output “linears\_for\_buff\_set\_X”.
13. Enter the correct buffer width for the following categories in the “Buff\_Dist” field:
  - Palustrines = 3m (6m)
  - Riverine Perennial (R2/3) = 4m (8m)
  - Riverine Intermittent (R4) = 3m (6m)
  - Lacustrine = 4m (8m)
14. Buffer the “linears\_for\_buff\_set\_X” using the “Buffer\_Width” field (Analysis > Proximity > Buffer). Name the output ‘Linears\_Buffered\_set\_X’.
15. Copy and paste ‘linears\_buffered\_set\_X’ into the ‘ProjectCode\_set\_XX\_pre\_attribution’ feature class.
16. Add, merge, and correct all polygons.
17. After saving edits and closing your map document, copy your geodatabase to the appropriate folder in P:Wetland\_Mapping and name it (ex. ‘SRLCC\_set\_28\_wetlands\_pre\_attribution’)
18. In ArcCatalog, apply the domain “Attribute” to the “ProjectCode\_set\_XX\_pre\_attribution” feature class. If you notice any common attributes that exist in the current set but are not included in the attribute domain, add those values to the domain.
19. Attribute polygons.
20. QAQC data as outlined in Section F.

## D. Process for Attributing Digitally Converted Data

CNHP often uses the help of student work studies, interns and volunteers to attribute the digitally converted original NWI data. The following steps should be taken to ensure correct attribution.

1. Navigate the map document (.mxd) that has been prepared for you and open it. In the table of contents, locate the shapefile you will be editing. It will be named something similar to: "SP\_set\_32\_pre\_attribution.shp"
2. Check to make sure the attribution table of this item is ready to be edited. Depending on the project you are working on, you will need either a field named Attribute (text, 20 characters) or Old\_Code (text, 20 characters). If the field you need is not in the shapefile's table, you can add it by clicking "Adding Field" in the table window's dropdown list.
3. Click on the editor toolbar dropdown list and choose "Start Editing." The next dialog box prompts you to indicate which layer you will be editing, choose the shapefile identified in step 1. If the editor toolbar is not already displayed in your ArcMap, you can add it using Customize > Toolbars > Editor.
4. Check to be sure that snapping is turned on for the layer you are editing. (Editor > Snapping > Snapping window). You may need to check the "use old style snapping" in the editor options if the snapping window is not an available choice.
5. Make sure your display properties are set up to make editing easy. You want the field you are editing to be the displayed label field, and layer visibility should be at about 35% transparency so you can see the raster layer underneath the shapefile you are editing. For symbology I usually go with "Lake" colored because the outline provides nice contrast.
6. Start filling in the "Attribute" (or Old\_Code) field. You can type this into the table directly, or open the attributing window by clicking "Attribute" on the editor toolbar. You can use the wetland code handout to understand what the codes mean. All codes are letters, with the exception that riverine and lacustrine systems have a number after their first letter (ie R4SBC).
7. An important rule of wetland mapping is that **no two features with the same attribute can touch each other**. Sometimes a single feature will be incorrectly split by the automated processes that we use to create them – in that case the appropriate solution is to merge the pieces. I set my merge function to Insert as a hotkey, but it can be set to any key, or chosen from the editor dropdown menu. Sometimes the solution to this problem is not so simple – perhaps a linear feature splits a polygon, but that linear feature was overlooked.  
  
\*\*When in doubt, just attribute a polygon with "???" so it can be reviewed later.
8. Reshape polygons that do not accurately represent the shape on the CONUS scan vectors.
9. When done attributing a shapefile, save edits and stop editing. Save and close the map document, and let me know that set is done.

## D. Work Flow for New Mapping Updates

1. Prepare ¼ quad images with mosaic method of choice.
2. Create a line shapefile to add features to.
3. Map smaller streams, channel, canals and linear features, then buffer to the appropriate amount.
4. Create a polygon shapefile to add features to.
5. Begin mapping large water bodies and rivers.
6. Attribute NWI wetland codes (Cowardin et al., 1979) as you go, keeping the following in mind:
  - Map to the image, not historic or predicted.
  - Be conscious of mowing changing the intensity of vegetation signatures.
  - Be conscious of haying changing the texture and color.
  - “Farmed” modifier describes tiled agriculture, not pastureland or mowed areas.
7. Use the Montana Natural Heritage Program’s method of applying LLWW descriptors in a semi-automated fashion to areas of 8-12 quads at a time. The application of LLWW descriptors will be done in a manner consistent with Ralph Tiner’s 2003 *Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors* (Tiner, 2003).
8. Once finished, save as quad name, copy to the project folder on P: and turn over to other mapper for QAQC’ing.
9. Important things to keep in mind:
  - Examine the wetlands for consistent alignment with features on the imagery.
  - Examine for correct System/Subsystem (mostly lakes and rivers).
  - Examine for correct Class (look for shadows denoting trees and shrubs, look carefully at smaller ponds for aquatic vegetation, and larger lakes for rings of aquatic vegetation).
  - Examine for correct Water Regime (use several dates if possible) compare with reference sites of field visits.
  - Examine for correct Modifiers (only put modifier if confident).
  - Look at large riparian systems carefully for matrix and isolated wetland pockets.

## E. Riparian Classification Information Sheet

**Riparian Features** – Riparian features are mapped at the same time as wetland features. The USFWS defines riparian features as “contiguous to and affected by... lotic and lentic water bodies (rivers, streams, lakes or drainage ways)”. They have either distinctly different vegetation (species) or significantly more robust growth. These areas are transitional between uplands and wetlands and can be considered to have a less predictable flooding regime and is often drier than an “A” water regime from NWI.

It is important to consider subsurface flow as well. Sandy washes, wooded draws, etc are affected by collection of water during storm events and/or water tables closer to the surface.

Residential areas can be trickier, as runoff from lawn watering, impervious surfaces, etc often elevate water tables in these areas. Look at the type of tree and proximity to water feature. Golf courses contain many trees and well watered vegetation but are not likely Rp.

**Coding:** Class is defined by the tallest life form that composes at least 30% of the area. No modifiers are applied to the riparian code. Tilled fields, even those close to rivers and streams are not mapped as riparian.

<b>System</b>	<b>Rp</b> (Riparian)		
<b>SubSystem</b>	<b>1</b> (lotic-flowing)	<b>2</b> (lentic – standing)	
<b>Class</b>	<b>EM</b> (emergent)	<b>SS</b> (scrub-shrub)	<b>FO</b> (forested)

**Examples:** Rp1FO, Rp1SS, Rp2FO

**Common settings:** *Rp1SS* – shrubby draw or drainage, often interrupted with drier herbaceous patches or by locations of incision. Shrubs can be dense or not. Often very narrow and linear in appearance. These will often be mapped as a linear feature then buffered out to the appropriate width.

*Rp1EM* – often along larger R4's with terraces. Often the same type of vegetation as the surround area, but much more robust. Channel scars and swales will usually be and NWI wetland code PEMA or PEMC, so one needs to look broadly.

*Rp1EM/Rp1FO* – matrix of herb/tree pockets in a larger floodplain. Look closely at denser pockets and the overall % cover to decide a class. Must choose one, DO NOT USE MIXED CODE.

*Rp2FO* – a ring of trees along a lake with a waterlevel that appears to fluctuate. Look closely at the understory (if visible) to determine if it's really Rp or NWI code PFOA.



## F. QA/QC Procedures

CNHP uses the Wetland Data Verification Toolset developed by the U.S. Fish and Wildlife Service National Wetlands Inventory. The tool and its supporting document is available at:

<http://www.fws.gov/wetlands/Data/Tools-Forms.html>

This toolset contains an ArcGIS 10 toolbox with 6 QAQC tests, a geodatabase containing a complete list of all currently valid NWI wetland codes and a PDF set of instructions. All data must clear these tests (or have justifications provided for records that get flagged as errors but are in fact correct) to be accepted by the NWI.

### F1. QAQC Work Flow for All Mapping Projects

1. **Run topology (rule: features must not overlap), correct all errors**
2. **Run the “NWI Wetlands Data Verification Toolset version 1206, database version 1110” tool in a custom toolbox:**

<http://www.fws.gov/wetlands/Data/tools/Wetlands-Data-Verification-Toolset-Installation-Instructions-and-User-Information.pdf>

3. **QAQC Code description:** Shows up in the form “NNNNNN”. “N” means no error.
  - C – incorrect wetland code
  - U – sliver uplands\*
  - A – adjacent polygons with same attribute, this test also catches multipart features
  - S – sliver wetlands, less than 0.1 acres \*
  - L – L1 or L2 < 20 acres \*
  - P – PUB or PAB > 20 acres \*
  - O – overlapping polygons (topology should render this test moot)

*\* indicates this test is “optional” in the sense that there can be polygons that are correct but not slivers, there can be Lakes less than 20 acres, etc.*

4. **Visual Scan** - new mapping only, see following section F5 for procedure.

## ***F2. Description of the Verification Tests***

A brief description of each of the verification functions is provided below.

***Code "C" - Incorrect Wetland Codes:*** This model identifies wetland polygons with incorrect wetland codes, or null or blank values in the 'attribute' field. Bad wetland code and wetland code synonym summary tables are created and stored with your wetlands file geodatabase. The model changes the first character of QAQC\_Code = 'C' if the wetland code is bad.

***Code "U" - Sliver Uplands:*** This model identifies upland islands or holes in wetlands that are less than 0.01 acres. These may be actual upland features but are identified as errors as they are typically errors in wetland delineation. The model changes the fourth character of QAQC\_Code = 'U', in wetland polygons adjacent to the upland sliver.

***Code "A" - Adjacent Wetlands:*** This model identifies wetland polygons that are adjacent to other wetland polygons with the same 'attribute' and changes the second character of QAQC\_Code = 'A'. Adjacent wetlands with the same attribute are not allowed and need to be corrected. This test also highlights multi-part features, which need to be corrected.

***Code "S" Sliver Wetlands:*** This model identifies wetland polygons less than 0.01 acres and changes the third character of QAQC\_Code = 'S'. These wetland features exceed the minimum mapping standard for wetlands and should be reviewed. Actual wetland features flagged as sliver wetlands can be justified as correct in the comments field of the QAQC\_Summary table.

***Code "L" or "P" - Lake and Pond Size:*** This model identifies Lakes that are less than 20 acres in size and Ponds that are greater or equal to 20 acres in size. It changes the fifth character of QAQC\_Code = 'L' for small lakes or 'P' for large ponds. These may or may not be errors and can be justified based on water depth of the identified waterbody or small lake portions on the edge of the mapping project area. Comments can be added to the 'comments' field of the QAQC\_Summary table for those wetland features flagged that are valid based on depth requirements outlined in the wetlands mapping standards.

***Code "O" - Overlapping Wetlands:*** This model identifies overlapping wetland polygons and changes the sixth character of QAQC\_Code = 'O'. The overlapping portions of these polygons are stored in your wetlands file geodatabase as an Overlapping\_Polygons feature class to assist in locating these features. This model does not validate topology of the wetlands file geodatabase. The CONUS\_wet\_poly\_Topology layer in your wetlands file geodatabase can be validated using the topology toolbar in ArcMap and also to view the errors. This model and the wet\_poly\_topology identify the same errors and either can be used. Overlapping wetland features are not allowed in the dataset.

### ***F3. Code Updates***

Some wetland codes were used in the original NWI maps that are no longer considered valid. These out of date codes are found on Colorado NWI maps uncommonly, but often enough that CNHP developed a standardized method for conversion. Codes can be checked for validity using the Wetland Code Interpreter available here: <http://www.fws.gov/wetlands/Data/Wetland-Codes.html>

The following rules have been used to update these out of date codes to valid codes:

#### Old Classes:

OW = UB  
BB or FL = US

#### Old Water Regimes

D = C  
W = A  
Y = B, C, or A (usually C)  
Z = G, H (P usually gets G, L usually gets H)

### ***F4. QAQC Notes***

#### Water Regimes Available for Each Class (red = default for P systems):

EM – Emergent	Water Regimes = A, B, <b>C</b> , F, G, H, or J
SS – Shrub/Scrub	Water Regimes = A, B, <b>C</b> , F, G, H, or J
FO – Forested	Water Regimes = A, B, <b>C</b> , F, G, H, or J
UB – Unconsolidated Bottom	Water Regimes = H, <b>G</b> , or F
AB – Aquatic Bed	Water Regimes = H, <b>G</b> , F or C
US – Unconsolidated Shore	Water Regimes = <b>C</b> , B, A or J

**PAB/PUB and LAB/LUB:** Ensure that only lakes and ponds with “apparent” aquatic vegetation are labeled as PAB. Be aware that flooded shrubs can look like aquatic vegetation. Be sure to examine both 2005 and 2009 images.

**PEMC/PEMF:** Can be confusing in that some PEMF (especially bulrush) can look pale. Examine 2005 true color image. PEMF’s are usually very dark.

**Rp1SS/PSSA:** PSSA needs to be wet and should be in proximity to other wet areas. Along streams Rp1SS is most common unless back channels, etc. suggest wetter conditions.

**CANALS:** Be aware of the 10m minimum distance. Larger canals can be labeled R4SB but smaller ones not. If a canal is shallow and significantly vegetated at a swath of 10m and appears to be significantly wet, it could be labeled as a PEM.

**DONUTS:** Be aware for areas where wetlands form inset, concentric circles to ensure that the inner polygon is “clipped” to remove that area from the larger polygon when analysis is completed.

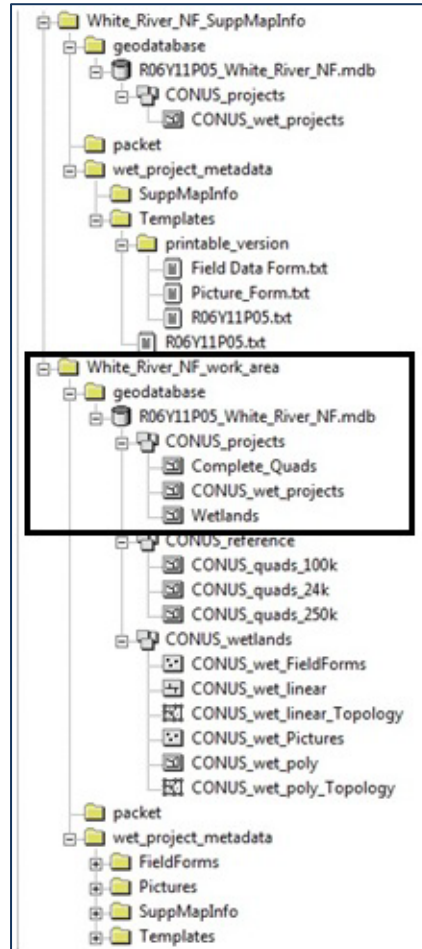
### ***F5. QA/QC Procedures: Visual Inspection on New Mapping***

**Goal: 100% of features visually inspected by a wetland mapper who did not create the dataset.**

1. Examine the wetlands for consistent alignment with features on the imagery.
2. Examine for correct System/Subsystem (mostly lakes and rivers).
3. Examine for correct Class (look for shadows denoting trees and shrubs, look carefully at smaller ponds for aquatic vegetation, and larger lakes for rings of aquatic vegetation).
4. Examine for correct Regime (use several dates if possible) compare with reference sites of field visits.
5. Examine for correct Modifiers (only put modifier if confident).
6. Look at large riparian systems carefully for matrix and isolated wetland pockets.

## G. Project Check-in/Data Storage

1. **Check in Project Area to NWI** – Import the files properly into the geodatabase provided in the materials originally received from the NWI. The created data should be submitted in the part of the file structure indicated below by the black box. “Complete\_Quads” indicates the actually area that was mapped as a feature class of the quads. “Wetlands” is the feature class that contains the attributed wetland polygons. A third feature class could be added for New Mapping Updates if riparian features were mapped. This would be called “Riparian” and be located in the same subfolder.



2. **Internal CNHP Wetlands Database** – For data sharing on relevant projects, an internal geodatabase of wetlands for the State of Colorado will be maintained. After wetland mapping projects are delivered to the client and delivered to the NWI, they will be imported into the Colorado\_Wetlands.gdb. The imported wetlands will need to be merged with the existing wetlands. If the imported data is an update, any existing wetland polygons should be clipped by quad boundary and exported with a logical file name. We do not want to delete older mapping, but it should not be included in the internally distributed layer. This dataset will be located at G:\Colorado\Wetlands. The date will be in the file or folder name

such that the most current data can be accessed. No more than 3 copies will exist at any given time in the folder, older copies will be deleted.

## **H. References**

Tiner, R.W. 2003. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. 44 pp.

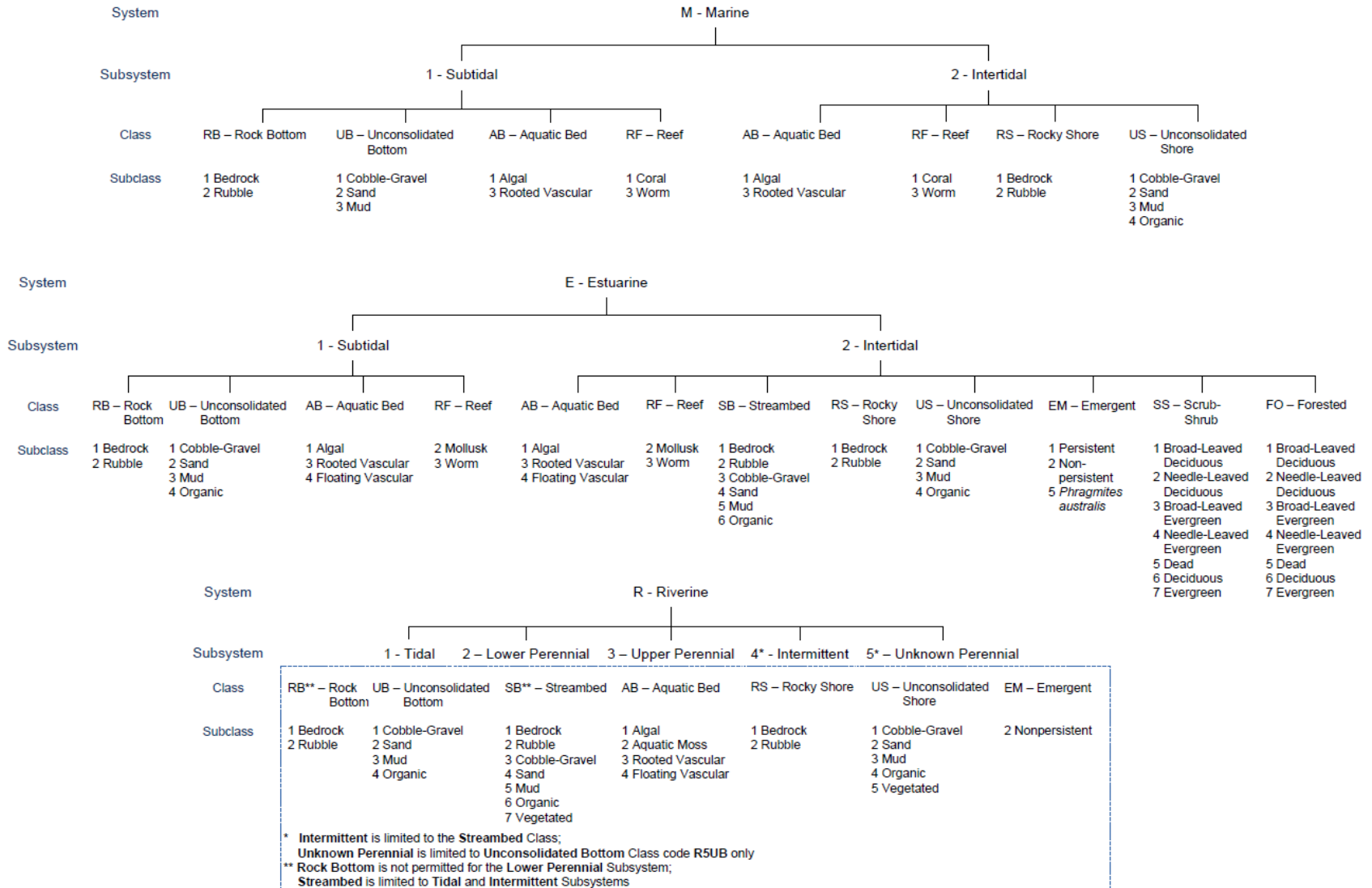
Cowardin et al. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Washington D.C.

## **APPENDIX B: NWI COWARDIN CODE HIERARCHY**

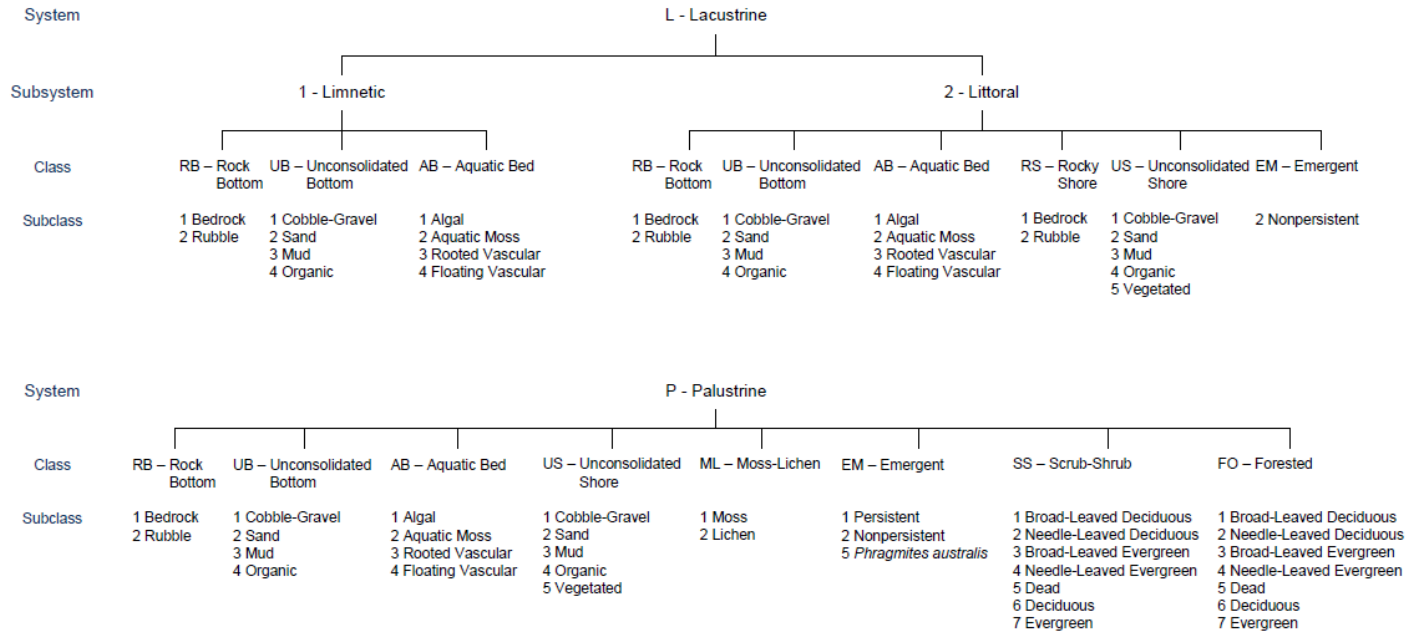




## WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



## WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



MODIFIERS						
In order to more adequately describe the wetland and deepwater habitats, one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The former modifier may also be applied to the ecological system.						
Water Regime			Special Modifiers	Water Chemistry	Soil	
Nontidal	Saltwater Tidal	Freshwater Tidal		Coastal Salinity	Inland Salinity	pH Modifiers for all Fresh Water
A Temporarily Flooded	L Subtidal	S Temporarily Flooded-Tidal	b Beaver	1 Hyperhaline	7 Hypersaline	a Acid
B Saturated	M Irregularly Exposed	R Seasonally Flooded-Tidal	d Partly Drained/Ditched	2 Euhaline	8 Eusaline	t Circumneutral
C Seasonally Flooded	N Regularly Flooded	T Semipermanently Flooded-Tidal	f Farmed	3 Mixohaline (Brackish)	9 Mixosaline	i Alkaline
E Seasonally Flooded/ Saturated	P Irregularly Flooded	V Permanently Flooded-Tidal	h Diked/Impounded	4 Polyhaline	0 Fresh	
F Semipermanently Flooded			r Artificial	5 Mesohaline		
G Intermittently Exposed			s Spoil	6 Oligohaline		
H Permanently Flooded			x Excavated	0 Fresh		
J Intermittently Flooded						
K Artificially Flooded						