National Wetland Inventory Mapping of the Arkansas Headwaters Subbasin

March 2016

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 of the Arkansas Headwaters Subbasin

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EXECUTIVE SUMMARY

Wetlands are an integral component of Colorado's landscape and provide a host of beneficial services, such as wildlife habitat, flood abatement, storm water retention, groundwater recharge, and water quality improvement. Wetlands and riparian areas in the Arkansas Headwaters subbasin support biologically significant resources, including plants animals and natural communities. Decisions about wetland management should be based on a solid understanding of their extent and distribution. Yet for most of Colorado, including the Arkansas Headwaters subbasin, these data have historically been lacking because National Wetland Inventory (NWI) mapping by the U.S. Fish and Wildlife Service was available only on paper.

The goal of this project was to create an up-to-date digital map of wetlands in the Arkansas Headwaters subbasin to aid regulatory, conservation and management decisions. The *first* step was to digitize original 1970–80s NWI maps for areas of the basin lacking digital data. The *second* step was to create new, updated NWI maps for the subbasin. The *last* step was to compare the historical and contemporary mapping to evaluate trends in the extent and type of aquatic resources. From this analysis, we attempted to qualitatively distinguish what changes in the mapping represented true changes in the landscape and what changes came from updated mapping methodologies.

Updated NWI mapping of the Arkansas Headwaters subbasin contained 66,758 acres of aquatic resources, representing only 3.4% of the total land area. Areas mapped as wetlands accounted for 74% of the total acres (49,474 acres), waterbodies accounted for 17% (11,552 acres), and non-wetland riparian areas accounted for 8.6% (5,732 acres). Within the updated NWI mapping, herbaceous wetlands were the most abundant mapped type, with 27,860 acres. Following herbaceous wetlands, shrub wetlands were the second most abundant wetland type with 19,589 acres. Shrub wetlands in the subbasin support numerous significant plant communities and habitat for rare Colorado populations of the boreal toad.

Overall, the updated mapping contained 10,934 fewer acres than the original mapping, due to differences in mapping methodologies, better aerial imagery, and apparent change in the landscape. Herbaceous wetlands changed the most in terms of total area. The updated mapping contained 18,974 acres fewer acres of herbaceous wetlands than the original dataset, for a change of -41%. The biggest difference in the mapping of herbaceous wetlands was in the treatment of large wet meadow / hay field complexes in both the Arkansas River Valley and the Wet Mountain Valley. From conversations with local stakeholders and field visits to the areas, we do believe that irrigation was more extensive in the 1970-80s, which would have led to more acres of irrigated wetlands.

Through the NWI mapping and field excursions to the area, it is clear that water development projects over the past 100 years have had a profound and lasting impact on the wetland and aquatic resources of the Arkansas subbasin. With increasing population growth forecasted for the larger Arkansas Basin and the Front Range, and the potential for a warming and drying climate, action should be taken to conserve the important wetland resources of the Arkansas Headwaters subbasin.

ACKNOWLEDGMENTS

The authors at Colorado Natural Heritage Program (CNHP) would like to acknowledge the U.S. Environmental Protection Agency (EPA) Region 8 and Aurora Water for their financial support of this project. Without financial investment from these two entities, and several others in the past ten years, Colorado would lag well behind the rest of the nation in terms of digital wetland data.

We benefitted significantly from the knowledge and assistance of several stakeholders in the subbasin, including Bill Goosman, Chair of the Arkansas Headwaters Wetland Focus Area Committee, Dave Gilbert with the Bureau of Land Management, and Ben Lenth, of the San Isabel Land Protection Trust.

We also thank Rusty Griffin from U.S. Fish and Wildlife Services (USFWS)'s National Wetland Inventory (NWI) Program, who provided valuable assistance streamlining our NWI map conversion process and strongly supports our work in wetland mapping. Thanks also to James Dick, USFWS Regional Wetland Coordinator for Region 2, Albuquerque, New Mexico, who visited with our mapping team to discuss USFWS Riparian Mapping classification.

During the course of this project, we gained tremendous technical assistance, ideas and overall guidance from our colleagues at CNHP, especially Dave Anderson, Denise Culver and Laurie Gilligan. Finally, we would like to thank Mary Olivas and Carmen Morales with Colorado State University for logistical support and grant administration.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1.0 INTRODUCTION

Wetlands are an integral component of Colorado's landscape. They provide a host of beneficial services, such as flood abatement, storm water retention, groundwater recharge, and water quality improvement (Mitsch & Gosselink 2007; Millennium Ecosystem Assessment 2005). Wetlands are particularly important for wildlife because they are highly productive and diverse ecosystems, providing habitat for many of Colorado's species. In areas of the Intermountain West, more than 90% of wildlife species depend on wetland and riparian areas at some point in their lives (Redelfs 1980 as cited in McKinstry et al. 2004).

The relative importance of wetlands is underscored by the fact that they occupy a small fraction of the landscape. The total acreage of wetlands in Colorado is roughly 1.0 to 1.5 million acres or ~2% of Colorado's land area (Dahl 1990; USFWS 2016). Historically, Colorado likely supported twice the wetland acreage that exists today (Dahl 1990). Up to 50% of Colorado's original wetlands have been modified by agriculture 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 have been 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 making sound, watershed-based decisions about wetland regulation, conservation and management (Lemly et al. 2013).

Wetlands and riparian areas in the Arkansas Headwaters subbasin support a host of biologically significant resources, including plants animals and natural communities (Table 1; Culver et al. 2009; Neid 2006). In particular, drainages in Chaffee County historically supported some of the most successful breeding sites for the Southern Rocky Mountain population of the boreal toad (*Anaxyrus boreas boreas*). This rare amphibian was once common in the mountains of Colorado, but has declined precipitously during the last three decades (Carey 1993; Loeffler 2001) and is currently being considered for listing as an endangered species by the U.S. Fish and Wildlife Service. Along with habitat destruction and high alpine weather events, a major threat to the boreal toad is infection by the chytrid fungus *Batrachochytrium dendrobatidis* (Bd), which is easily spread and can cause a disease with very high mortality. Until recently, the Chaffee County populations were free of the chytrid fungus, though tests conducted in 2014 confirmed that the fungus has reached the county (Smith 2015; Lambert et al. *in review*). To protect the remaining boreal toads, and all other wetland species, greater attention should be paid to the wetland resources of this important area.

Decisions about wetlands should be based on a solid understanding of the extent and distribution of wetland resources. The U.S. Fish and Wildlife Service established the National Wetland Inventory (NWI) program in the 1970s in an effort to provide this information at a national scale. NWI is the most ambitious and comprehensive attempt to map wetlands in the country. All of Colorado was mapped on paper in the early years of the NWI program, but the majority of this mapping has been unavailable in a digital format until recently. With today's regular use of geographic information systems (GIS) to inform management decisions, digital data are necessary for any landscape-scale analyses.

Wetlands in the Arkansas Headwaters subbasin were mapped on paper by NWI between 1975–1987 using the best aerial imagery at the time, which was black and white photography at a scale of 1:80,000 in the 1970s and true color photography at a scale of 1:58,000 in the 1980s. Both the scale and type of imagery available limited the level of detail that could be photo-interpreted reliably. In addition, mapping within the study area was carried out in the early years of the NWI program, when the classification system used to attribute polygons was still in development. Several changes have been made to the mapping and classification standards since the 1980s that increase the accuracy of more recent NWI maps.

The goal of this project was to create an up-to-date digital map of wetlands in the Arkansas Headwaters subbasin to aid regulatory, conservation and management decisions. The *first* step was to digitize original 1970–80s NWI maps for areas of the basin lacking digital data. The *second* step was to create new, updated NWI maps for the subbasin. The *last* step was to compare the historical and contemporary mapping to evaluate trends in the extent and type of aquatic resources. From this analysis, we attempted to qualitatively distinguish what changes in the mapping represented true changes in the landscape and what changes came from updated mapping methodologies. While updating NWI maps for the Arkansas Headwaters is critical for understanding current conditions of wetlands in the sub basin, it is important to preserve the historical NWI data and to learn from these data how wetland resources may have changed.

Table 1. Significant wetland and riparian dependent elements of biodiversity found in the Arkansas Headwaters subbasin.[1]

Scientific Name	*Common Name*	*G Rank*	*S Rank*
Amphibians			
Anaxyrus boreas boreas	Boreal Toad (Southern Rocky Mountain Population)	G4T1Q	S1
Birds			
Cypseloides niger	Black Swift	G4	S3B
Melanerpes lewis	Lewis's Woodpecker	G4	S4
Fish			
Oncorhynchus clarkii stomias	Greenback Cutthroat Trout	G4T2T3	S2
Insects			
Ochrotrichia susanae	Susan's purse-making caddisfly	G2	S2
Mammals			
Sorex nanus	Dwarf Shrew	G4	S2
Mollusks			
Valvata sincera	Mossy Valvata	G5	S3
Vascular Plants			
Carex concinna	low northern sedge	G5	S1
Carex diandra	lesser panicled sedge	G5	S1
Carex oreocharis	a sedge	G3	S2
Carex scirpoidea	Canadian single-spike sedge	G5	S2
Carex stenoptila	small-winged sedge	G2	S2
Epipactis gigantea	giant helleborine	G4	S1S2
Eriophorum altaicum var. *neogaeum*	Altai cottongrass	G4?T3T4	S3
Eriophorum gracile	slender cottongrass	G5	S1S2
Eutrema penlandii	Mosquito Range mustard	G1G2	S1S2
Hypoxis hirsuta	yellow stargrass	G5	S1
Liatris ligulistylis	gay-feather	G5?	S2
Listera borealis	northern twayblade	G4	S2
Listera convallarioides	broad-leaved twayblade	G5	S2
Phippsia algida	snow grass	G5	S2
Ptilagrostis porteri	Porter feathergrass	G2	S2
Salix candida	hoary or silver willow	G5	S2
Salix serissima	autumn willow	G4	S1
Sisyrinchium pallidum	Pale blue-eyed grass	G3	S2
Utricularia minor	lesser bladderwort	G5	S2

Continued on next page.

[1] Significant elements are based on the Colorado Natural Heritage Program ranking system. More on this system, including G Rank and S Rank, can be found at: http://www.cnhp.colostate.edu/about/heritage.asp.

Scientific Name	***Common Name***	***G Rank***	***S Rank***
Natural Communities			
Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest	Montane Riparian Forest	G2	S2
Alnus incana - Salix drummondiana Shrubland	Montane Riparian Shrubland	G3	S3
Alnus incana / Mesic Forbs Shrubland	Montane Riparian Shrubland	G3	S3
Betula nana / Mesic Forbs - Mesic Graminoids Shrubland	Subalpine Riparian Shrubland	G3G4	S3
Betula occidentalis / Maianthemum stellatum Shrubland	Foothills Riparian Shrubland	G4?	S3
Betula occidentalis / Mesic Graminoids Shrubland	Lower Montane Riparian Shrubland	G3	S2
Eleocharis rostellata Herbaceous Vegetation	Emergent Wetland	G3	S2
Juniperus scopulorum / Cornus sericea Woodland	Lower Montane Riparian Woodland	G4	S2
Pascopyrum smithii - Eleocharis spp. Herbaceous Vegetation	Playa Grassland	G1	S1
Phippsia algida Herbaceous Vegetation	Alpine Wetland	GU	S1
Picea pungens / Alnus incana Woodland	Montane Riparian Forest	G3	S3
Picea pungens / Betula occidentalis Woodland	Montane Riparian Woodland	G2	S2
Picea pungens / Equisetum arvense Woodland	Montane Riparian Woodland	G3?	S1
Pinus ponderosa / Alnus incana Woodland	Montane Riparian Woodland	G2	S1
Populus angustifolia - Juniperus scopulorum Woodland	Montane Riparian Woodland	G2G3	S3
Populus angustifolia - Pseudotsuga menziesii Woodland	Montane Riparian Woodland	G3	S2
Populus angustifolia / Alnus incana Woodland	Montane Riparian Woodland	G3	S3
Populus angustifolia / Betula occidentalis Woodland	Montane Riparian Woodland	G3	S3
Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland	Montane Riparian Woodland	G3	S2
Populus tremuloides / Acer glabrum Forest	Montane Riparian Forest	G2	S2
Populus tremuloides / Alnus incana Forest	Montane Riparian Forest	G3	S3
Populus tremuloides / Betula occidentalis Forest	Montane Riparian Forest	G3	S2
Populus tremuloides / Salix drummondiana Forest	Montane Riparian Forest	G3G4	S1

Continued on next page.

Scientific Name	***Common Name***	***G Rank***	***S Rank***
Pseudotsuga menziesii / Betula occidentalis Woodland	Montane Riparian Woodland	G3?	S2
Pseudotsuga menziesii / Cornus sericea Woodland	Lower Montane Riparian Woodland	G4	S2
Salix drummondiana / Calamagrostis canadensis Shrubland	Lower Montane Willow Carr	G3	S3
Salix geyeriana - Salix monticola / Mesic Forbs Shrubland	Montane Willow Carr	G3	S3
Salix geyeriana / Carex aquatilis Shrubland	Montane Willow Carr	G3	S2
Salix geyeriana / Mesic Forbs Shrubland	Montane Willow Carr	G3	S2
Salix geyeriana / Mesic Graminoids Shrubland	Montane Willow Carr	G3?	S2
Salix ligulifolia Shrubland	Montane Willow Carr	G2G3	S3
Salix monticola / Carex aquatilis Shrubland	Montane Willow Carr	G3	S2
Salix monticola / Carex utriculata Shrubland	Montane Willow Carr	G3	S3
Salix planifolia / Deschampsia caespitosa Shrubland	Subalpine Willow Carr	G2G3	S2
Salix planifolia / Mesic Forbs Shrubland	Subalpine Willow Carr	G4	S2
Salix wolfii / Carex aquatilis Shrubland	Subalpine Willow Carr	G4	S3
Salix wolfii / Mesic Forbs Shrubland	Subalpine Willow Carr	G3	S3

2.0 Study Area

2.1 Geography

The Arkansas River Basin is the largest river basin in the state of Colorado and drains nearly a quarter of the state's land area. Our study area was specifically the Arkansas Headwaters subbasin (HUC8: 11020001), which includes the source of the Arkansas River and numerous high mountain tributaries. The Arkansas River begins in central Colorado (Figure 1), near the town of Leadville, at an elevation of over 14,000 ft. The Arkansas Headwaters subbasin covers 1,960,273 acres and is generally oriented northwest to southeast. To the northwest, the subbasin is bounded by the Sawatch Mountain Range, which includes the Continental Divide, as well as the three highest peaks in the Rocky Mountains. These mountains separate the Arkansas River from the western flowing rivers in Colorado. To the northeast, the subbasin is bound by the Mosquito Range, which separates the Arkansas from the headwaters of the South Platte and the broad open valleys of South Park. To the southwest, the subbasin is bound by the Sangre de Cristo Mountains, which separate the Arkansas from the Rio Grande headwaters and the San Luis Valley. To the southeast, the subbasin is bound by the Wet Mountains, past which the Arkansas River flows out onto the eastern plains.

The center of the basin is characterized by a high elevation valley bordered by steep mountains. Elevations in the subbasin range from about 7,000 ft on the valley floor to 14,439 ft at the top of Mt. Elbert. The Arkansas River flows almost due south from its northern origin above Turquoise Lake through a relatively narrow, high elevation valley. Two-thirds of the way through the subbasin, the river takes a turn to the east and flows through a rugged foothill zone out towards the eastern plains. The southern portion of the subbasin is known as the Wet Mountain Valley, which drains the eastern flank of the Sangre de Cristos and the western flank of the Wet Mountains. Grape Creek, the largest tributary in the subbasin, flows north through the Wet Mountain Valley to meet with the Arkansas River at the eastern edge of the subbasin.

Average mean annual flow of the Arkansas River in its upper reaches near Leadville is 73.1 cfs, but increases over ten-fold to 803.5 cfs at the downstream edge of the subbasin near Canyon City.[2] In part the increase in flow is due to several major trans-basin diversions which move water from the Colorado River basin to the Arkansas River basin, making use of reservoirs such as Twin Lakes and Turquoise Lake. Flows in the subbasin are natural driven by spring snowmelt, and peak flow occur in June, then level off towards the end of the summer and through the winter. Diversions and additions have altered the natural flows to some degree, though the late spring pulse remains.

Climate of the Arkansas Headwaters is characterized by warm summers and cold winters, though the sun often shines throughout the year. The valley between Leadville and Salida is referred to as Colorado's Banana Belt, because it is relatively warm and dry. In Salida, summer temperatures reach into the high 70s °F, while winter temperatures are often in the 40s during the day and below 20°F at night. Temperatures in Leadville are ~10°F cooler on average. Average annual precipitation

[2] Average mean annual flow calculated from for USGS Gage 07081200 Arkansas River near Leadville (period of record 1968-2015) and Gage 07094500 at Parkdale, CO (period of record 1946-1994). Data accessed from http://maps.waterdata.usgs.gov/.

is only 5.0 inches in Salida and 12.5 inches in Leadville. [3]. Snowfall in the highest mountains, however, is considerably more, up to 30 or more inches annually.

Figure 1. Arkansas Headwaters subbasin study area.

[3] Average climate data for Leadville (station #054884, period of record 1981-2010) and Salida (station #057371, period of record 1981-2010), accessed from Western Regional Climate Center (http://www.wrcc.dri.edu/).

2.2 Land Ownership and Land Use

The subbasin encompasses part or all of six counties: Lake, Chafee, Park, Fremont, and Custer (Figure 1). Notable municipalities in the basin include Salida (pop. 5,236) and Buena Vista (pop. 2,617) (U.S. Census Bureau 2015), with the remaining area being sparsely populated. The U.S. Forest Service (USFS) is the largest land owner in the basin (Figure 2). The San Isabel National Forest covers 42% of the subbasin, including the highest elevation mountains. Private landowners hold another 36%. Private land is concentrated in the valley bottoms, including the Arkansas River Valley and the Wet Mountain Valley, along with scattered foothill lands to the southeast. The Bureau of Land Management (BLM) owns another significant share of the subbasin, as does the State of Colorado, through both the State Land Board and Colorado Parks and Wildlife.

The economy of the basin is dominated by recreation and tourism. The river draws fisherman, boaters, and recreationalists of many type to the valley during the summer months. Hay fields on the valley floor also support local cattle operations. In the very upper reaches of the subbasin, mining historically played a major role in shaping the economy and the landscape. The Leadville mining district was the most productive silver mining areas in Colorado. At its peak in the 1880s, the city of Leadville had a population over 40,000 and was the second largest city in Colorado. Located northeast of Leadville, just over Freemont Pass and beyond the boundary of the Arkansas Headwaters subbasin, the Climax molybdenum mine is one of the few remaining active mines in the area. Most other mining operations have ceased today, but abandoned mining infrastructure is still visible throughout the mountains around Leadville.

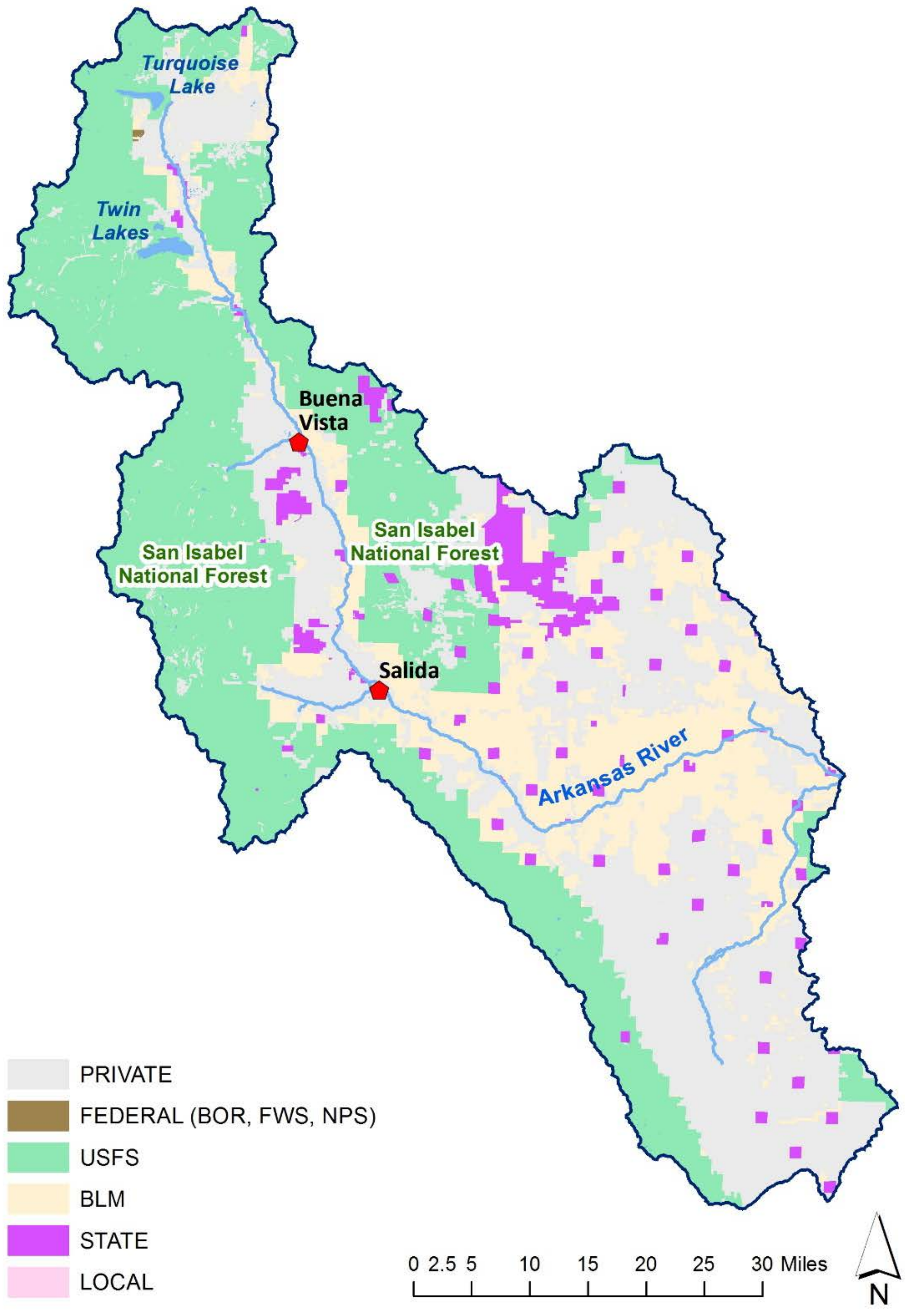

Figure 2. Land ownership of the Arkansas Headwaters subbasin.

2.3 Ecoregions and Vegetation

The subbasin falls entirely within the Southern Rockies Level III Ecoregion (Figure 3; Omernik 1987[4]). Level IV Ecoregions further divide the Southern Rockies landscape into finer units based on geology and dominant vegetation (Table 2; Figure 3). The Southern Rocky Mountains Ecoregion is characterized by steep, high elevation mountains. Vegetation cover is largely coniferous forests, but vegetation communities follow a strong elevational gradient, with lower elevations dominated by grass or shrub communities and often grazed. There are 11 Level IV Ecoregions within the subbasin, which we grouped in 5 ecoregion groups for further analysis: alpine zone, subalpine forests, mid-elevation forests, woodlands and foothills, and grassland and sagebrush parks.

Table 2. Level IV Ecoregions of the Arkansas Headwaters subbasin.

Name	*Description*
21a: Alpine Zone **Group:** Alpine Zone	The **Alpine Zone** occurs on mountain tops above treeline, beginning at about 10,500 to 11,000 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.
21b: Crystalline Subalpine Forests **Group:** Subalpine Forests	The **Crystalline Subalpine Forests** 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 8,500 to 12,000 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.
21c: Crystalline Mid-Elevation Forests **Group:** Mid-Elevation Forests	The **Crystalline Mid-Elevation Forests** are found mostly in the 7,000 to 9,000 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.

Continued on the next page.

[4] For more information on Omernik/EPA Ecoregions and to download GIS shapefiles, visit the following website: https://archive.epa.gov/wed/ecoregions/web/html/level_iii_iv-2.html.

Name	*Description*
21d: Foothill Shrublands **Group:** Woodlands and Foothills	The **Foothill Shrublands** 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 6,000 to 8,500 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.
21e: Sedimentary Subalpine Forests **Group:** Subalpine Forests	The **Sedimentary Subalpine Forests** 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.
21f: Sedimentary Mid-Elevation Forests **Group:** Mid-Elevation Forests	The **Sedimentary Mid-Elevation Forests** 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.
21g: Volcanic Subalpine Forests **Group:** Subalpine Forests	The steep, mountainous **Volcanic Subalpine Forests** 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.
21g: Volcanic Mid-elevation Forests **Group:** Mid-Elevation Forests	The **Volcanic Mid-Elevation Forests** ecoregion occurs at elevations of 7,000 to 9,000 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.

Continued on the next page.

Name	Description
21i: Sagebrush Parks **Group:** Grassland and Sagebrush Parks	The **Sagebrush Parks** 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.
21j: Grassland Parks **Group:** Grassland and Sagebrush Parks	The **Grassland Parks** 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.
26h Pinyon-Juniper Woodlands and Savannas **Group:** Woodlands and Foothills	The **Pinyon-Juniper Woodlands and Savannas** is characterized by scattered, dissected areas with pinyon and juniper woodlands on the uplands. Occurring in Colorado and New Mexico, the region is a continuation or an outlier of the pinyon-juniper woodlands found in Ecoregion 21d in the Southern Rockies (21). Soils tend to be thin, and for most of the region are formed in materials weathered from limestone, sandstone, and shale. Rock outcrops are common. In central New Mexico, much of the region is often associated with the Paleozoic Glorieta Sandstone and other limestone and shale rocks. In the north, the region includes a few hills and peaks of volcanic or mixed geology that have some small areas of montane coniferous forest. Annual precipitation in the New Mexico portion ranges from 12 to 16 inches, with the highest precipitation found in areas closest to the mountains. Land use is primarily wildlife habitat and rangeland

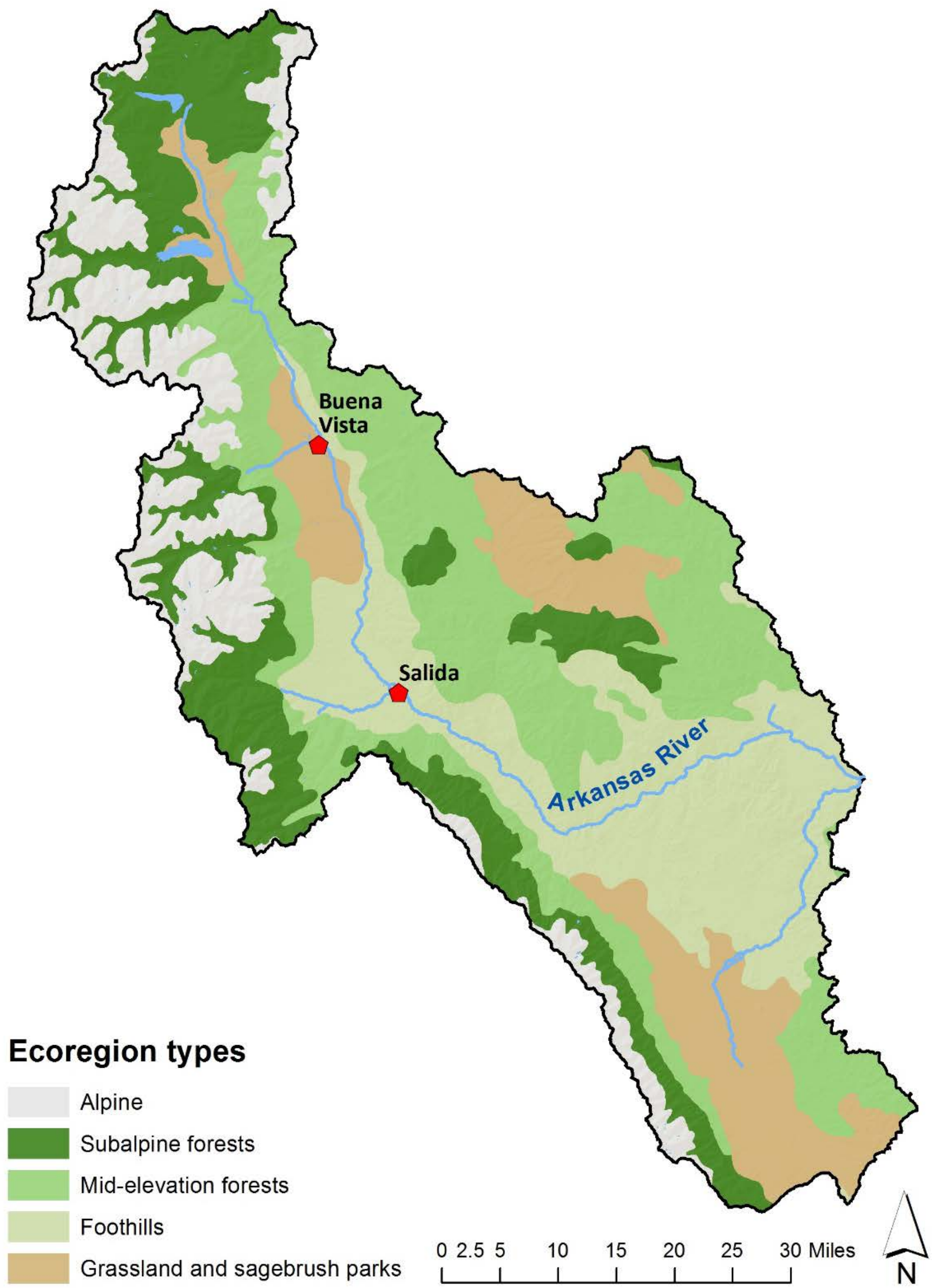

Figure 3. Ecoregion groups of the Arkansas Headwaters subbasin.

3.0 METHODS

3.1 National Wetland Inventory (NWI) Classification System

The NWI classification system was first described by Cowardin et al. in 1979 and has been updated periodically over time. The current NWI classification system, shown in brief in Appendix A, is now the federal standard for wetland mapping (FGDC 2013).[5] The basic structure of the classification system is the same for all mapping presented in this report. Codes used in the early 1970s mapping that are now obsolete (e.g., POW for Palustrine Open Water) have been replaced by their current equivalents (e.g., POW = PUB for Palustrine Unconsolidated Bottom). However, code interpretation and application in the 1970-80s was somewhat different than it is today. Issues with code interpretation are described in the results sections.

The NWI or Cowardin classification system 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"* (Cowardin et al. 1979).

NWI mapping includes both wetlands and deep waterbodies. Each mapped polygon is attributed by system, subsystem, class, hydrology, and optional special modifiers. The result is a 4–6 character alpha-numeric code. System divides mapped features into a handful of aquatic resource types and is followed (when appropriate) by a numeric subsystem code (Table 3). The three systems used for Colorado NWI mapping are Riverine (rivers / streams / canals), Lacustrine (lakes and lake shores), and Palustrine (vegetated wetlands). 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 (saturated) sites are rarely flooded, but have water at or very near the surface consistently. The J hydrologic regime of intermittently flooded refers to areas where the hydroperiod is driven by stochastic rainfall events and where surface water is present for variable periods without detectably seasonality.

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 in either the original 1970-80s mapping or any updates (Table 6). Though irrigation is known to influence Rocky Mountain wetlands (Peck & Lovvorn 2001; Sueltenfuss et al. 2013), it is not included in the list of modifiers because the type and extent of modification is difficult to identify from aerial

[5] For more information on the current NWI classification system, please visit: http://www.fws.gov/wetlands/data/wetland-codes.html.

images. The hydrologic regime code of 'K' or 'Artificially flooded' is occasionally used in NWI mapping for irrigated wetland, though its use has changed over time within the NWI mapping standards and it was not applied to irrigated acres in the Arkansas Headwaters subbasin. In the current NWI classification standards, the K hydrologic regime is now reserved for sites where the hydrology is controlled by pipes or siphons, such as a water treatment facility.

For summary purposes, NWI codes were lumped to create several reporting groups, called wetland and waterbody types throughout most of the results section (Table 7).

Table 3: NWI system and subsystem codes and interpretation.

System	*Subsystem*	*Code*	*Interpretation*
Riverine		**R**	**Rivers and streams**
	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 canals and ditches
Lacustrine		**L**	**Lakes (water bodies > 20 acres and/or > 2.5 m deep)**
	Limnetic	1	lake water > 2.5 m deep
	Littoral	2	lake water < 2.5 m deep along lake shores and margins
Palustrine		**P**	**Vegetated wetlands (marshes, swamps, bogs, etc.) even if associated with rivers or lakes**

Table 4: NWI class codes and interpretation.

Class	*Code*	*Interpretation*
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 hydrologic regime codes and interpretation.

Code	*Interpretation*
A	temporarily flooded
B	saturated
C	seasonally flooded
F	semi-permanently flooded
G	intermittently exposed
H	permanently flooded
J	Intermittently flooded
K	artificially flooded

Table 6: NWI special modifier codes and interpretation.

Code	*Interpretation*
b	Beaver
d	Drained
h	impounded
x	Excavated

Table 7: NWI attribute groups for summary tables.

NWI Group	*Codes*	*Interpretation*
Herbaceous Wetlands	PEM*	all herbaceous wetlands (e.g., marshes, wet meadows, fens, etc.)
Shrub Wetlands	PSS*	shrub dominated wetlands (e.g. willow stands)
Forested Wetlands	PFO*	tree dominated wetlands (e.g., wet cottonwood stands)
Ponds and Impoundments	PAB*/PUB*/ PUS*	ponds of all kinds, either vegetated or not, but with open water < 2 m (e.g. beaver ponds, stock ponds, golf ponds, etc.)
Farmed Wetlands	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, including reservoirs
Rivers	R2/R3*(not x)	river channels and their associated unvegetated shores (i.e., unvegetated sandbars)
Streams	R4*(not x)	smaller stream channels
Canals	R*(x)	excavated channels, specifically manmade ditches

In the years since the original NWI classification was introduced, USFWS realized the need to map riparian areas that may not meet the criteria used for mapping wetlands. This need is particularly great in the western U.S. where numerous wildlife species depend on riparian habitats in an otherwise arid landscape. These habitats are moist, can be flooded for short periods of time, and are commonly associated with flowing water. Riparian areas are "wetter" than uplands, but do not always meet the flooding, biological composition or soil criteria to be classified as a wetland. To identify, map, and classify a broad spectrum of non-wetland riparian areas, USFWS issued guidance in a document titled *A System for Mapping Riparian Areas in the Western United States* (USFWS 2009).

The definition of riparian used in the mapping guidance is:

> *"Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermitted lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one of both of the following characteristics: 1) distinctively different vegetation species than adjacent areas, and 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland."*

This USFWS riparian mapping classification system is fully integrated into the NWI classification scheme and also includes system, subsystem and class. The system is a single unit category of Rp (riparian vegetation) and subsystem defines the water source (lotic for flowing and lentic for standing water). Class denotes the dominant life form of riparian vegetation, similar to class within the primary NWI classification. No water regime or modifiers are applied.

It is important to note that most general definitions of riparian areas do include wetland habitats within the riparian zone. The wettest areas within riparian corridors can meet the wetland criteria, especially at higher elevations. However, riparian areas can include drier areas that are not wetland. The two concepts of wetland and riparian are best conceptualized as two overlapping spheres. There are wetlands within riparian areas, but not all wetlands are within riparian areas *and* not all riparian areas are wetlands. It is the drier, non-wetland riparian areas that are targeted with the supplemental USFWS riparian mapping standards.

The riparian mapping standard was not developed when the Arkansas Headwaters subbasin was mapped by NWI in the 1970-80s. Because of this, some areas dominated by cottonwood that would be mapped as riparian today were included in the original NWI mapping.

It is also important to note that the NWI or Cowardin definition of wetland is different than the definition used by the Army Corps of Engineers (ACOE) and the Environmental Protection Agency (EPA) for regulatory purposes under Section 404 of the Federal Clean Water Act:

> *"[Wetlands are] those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.* (ACOE 1987)"

The primary difference between the two definitions is that the Clean Water Act definition requires positive identification of all three wetland parameters (hydrology, vegetation, and soils) while the NWI definition requires only one to be present. Because it would be impossible to verify all three parameters through aerial photos interpretation, not all wetlands mapped by NWI would be considered jurisdictional wetlands under the Clean Water Act and NWI mapped boundaries should not be interpreted as wetland delineations.

3.2 Conversion of Original NWI Paper Maps to Digital Data

At the outset of this project, 57 topographic quadrangles within the study area lacked digital wetland mapping (Figure 2). Many quads on the edges of the study area had been converted to digital data prior to this project. To create a complete digital version of the original NWI mapping, scans of the paper maps were converted to digital data following CNHP's wetland mapping procedures (CNHP 2013) and adhering to the federal wetland mapping standard (FGDC 2009), to the extent possible. The mapping was clipped to the study area boundary and this clipped dataset was the basis of determining the extent of wetlands based on original NWI mapping. This dataset is referred to as the original mapping throughout this report.

Original wetland mapping data were not updated or corrected in this process, except in cases where the original code was no longer accepted by NWI. The purpose of the digital conversion was not to create an up-to-date map of wetlands, but to convert a large quantity of hard copy data into digital polygons in an efficient and cost effective manner. All newly converted digital data were submitted to the NWI program for incorporation into the national dataset as soon as it was converted to maximize the utility for potential users.

3.3 Creation of Updated Mapping

New, updated NWI mapping was created for all 69 USGS quads in the study area. Updated wetland mapping was conducted on screen in ESRI ArcGIS 10.2 at a scale of 1:4,500 and was based on photo-interpretation of 2011 NAIP color infrared (CIR) imagery. Procedures and methods for new photo-interpretation are documented in CNHP (2013) and follow the Federal Geographic Data Committee standards for wetland mapping (FGDC 2009). All source imagery followed the standards outlined in the federal wetland mapping standard. In addition to the 2013 NAIP imagery, multiple ancillary data sources were used to map wetlands. Older and newer NAIP image dates (2013, 2009 and 2005), USGS topographic maps, soil survey data, hydrography data, land use data, and other supplementary data sources were also used to aid interpretation.

The most recent coding rules of the NWI classification system were used to attribute the polygons (as of December 2015). Special modifiers were used more effectively in the new mapping compared to the original mapping. Polygons were also created for riparian features, following the USFWS riparian mapping classification (USFWS 2009).

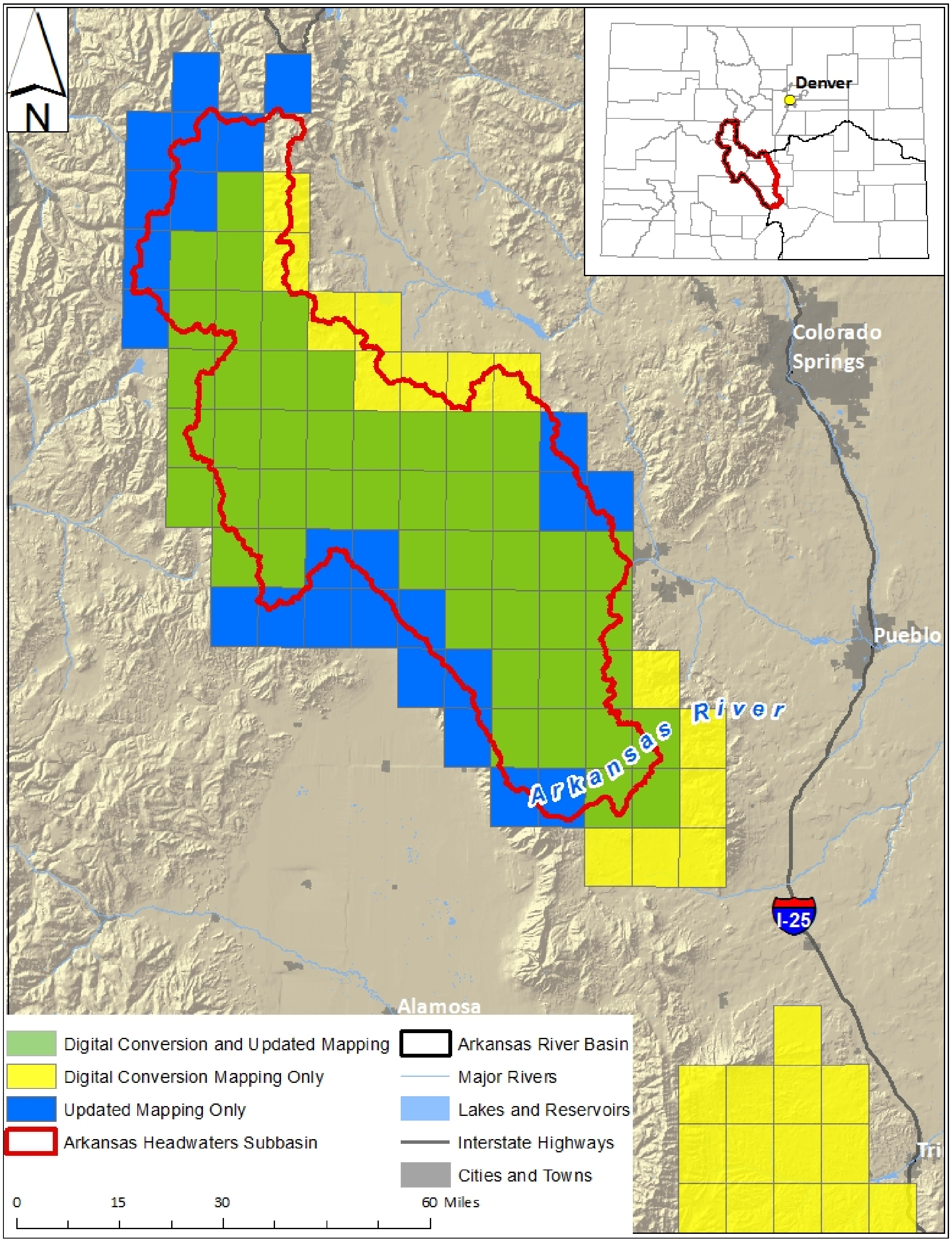

Figure 4. Arkansas Headwaters subbasin and the USGS 1:24,000 quadrangles mapped in this study. Green quads were designated for both digital conversion and updated mapping. Blue quadrangles were designated for updated mapping only. Yellow quadrangles are designated for digital conversion only. Yellow quads at the bottom of the map were digitized through this grant, but are are outside the Arkansas Headwaters subbasin and are not reported on in this report. The inset map shows the entire Arkansas basin (HUC 6) and the Arkansas Headwaters subbasin in the state of Colorado.

To ensure the photo interpreters were familiar with the landscape, field visits were conducted in the summer of 2013. Visits were made after a representative portion of the landscape had been mapped, providing the photo interpreters a chance to validate their understanding of certain signatures and to investigate areas that were less clear. The degree to which irrigation influenced the aerial photo signatures and whether irrigated fields should be included within the wetland mapping was a major emphasis in these visits. Many fields were visited that appeared wet in the imagery but did not appear to have the characteristics of wetlands once on the ground. In addition to field visits, the photo interpretation was checked by several interpreters throughout the process and coding and line changes were made where appropriate.

To ensure accuracy in coding, a final automated procedure checked the data layer for invalid wetland codes, size limitations and topological errors. Each error flagged was identified and carefully examined using multiple data layers to reconcile errors.[6]

3.4 Comparison of Original NWI Mapping to Updated NWI Mapping

Original and updated NWI mapping were compared in two ways: 1) the total acres mapped within each wetland and waterbody type (including riparian areas) was compared to determine which types had more or less acres overall between the two dataset, and 2) the two datasets were compared spatially to identify areas that were mapped with different codes between the two time periods and areas that were mapped in one time period and not the other. Because the original NWI mapping was created on paper first, and digitized many years later, some shifting of polygons from their originally intended location inevitably occurred. This resulted in acres that did not overlap exactly between original NWI mapping and updated NWI mapping, though the intended area mapped was the same. *It is important to note* that we did not examine historic aerial photography from the 1970-80s in order to determine the exact cause of change between the two datasets, but inferred dominant themes based on conversations with local stakeholders and common causes of discrepancy based on our previous work with original NWI mapping.

[6] For information on the NWI Data Verification Procedure, please visit: http://www.fws.gov/wetlands/Data/Tools-Forms.html.

4.0 RESULTS

4.1 Original Mapped Wetland Acreage

Once converted to digital data, original NWI mapping of the Arkansas Headwaters subbasin contained 77,692 acres (31,440 ha) of aquatic resources, including both wetlands and waterbodies (Table 8). This represents only 4.0% of the total land area. Area mapped as wetlands (classified within the Palustrine system) accounted for 85% of mapped aquatic resources (66,051 acres), while waterbodies (lakes, river, streams and canals) accounted for the remaining 15% (11,641 acres).

Within the original NWI mapping, herbaceous wetlands were the most abundant mapped type, with 46,834 acres or 61% of all mapped aquatic resources. With lakes and rivers removed to specifically highlight wetlands, herbaceous wetlands accounted for 71% of wetland acres. Areas mapped as herbaceous wetlands include marshes, wet meadows (including some fed by flood irrigation), fens, and mesic herbaceous areas along floodplains and riparian corridors.

Shrub wetlands were the next most abundant type of mapped acres at 15,995 acres. Shrub wetlands accounted for 20% of all aquatic resources and 24% of wetland acres. Shrub wetlands were mapped extensively in the upper reaches and tributaries of the basin, including many acres mapped as influenced by beaver. Forested wetlands were only 1,297 acres, and accounted for 1.9% of all aquatic resources and 2.2% of wetland acres. Forested wetlands were primarily mapped along floodplains and riparian corridors throughout the basin.

The final wetland type mapped by NWI was ponds and impoundments. Ponds and impoundments were mapped throughout the basin. Most were small in size and represented two different types of ponds. Just over half the mapped ponds were mapped as influenced by beaver, meaning they were natural ponds within beaver complexes. Another 13% were mapped with an excavated or damned/impounded modifier, representing small manmade ponds for stock watering or recreational purposes. As a category of mapped wetlands, ponds and impoundments made up 1,925 acres, or 2.5% of all aquatic resources and 2.9% of wetland acres.

Mapped lakes covered 5,828 acres across the basin and represented 7.3% of mapped aquatic resources. The biggest lakes, Turquoise Lake, Twin Lakes, and Clear Creek Reservoirs, are located just off the Arkansas River and are reservoirs used for storing water from trans-basin diversions. In addition, De Weese Reservoir is located in the Wet Mountain Valley along Grape Creek. Rivers, streams and artificially dug irrigation canals together made up another 5,813 acres across the basin (7.3% of mapped aquatic resources).

Table 8. Acres of wetlands and waterbodies in the Arkansas Headwaters subbasin, based on original NWI mapping.

Wetland and Waterbody Type		*Acres*	*% of Basin Area*	*% of NWI Acres*	*% of Wetland Acres*
Total Basin Area		1,960,273	100.0%	---	---
Upland Area (not mapped by NWI)		1,882,581	95.9%	---	---
Wetlands					
NWI Code	**Wetland Type**				
PEM	Herbaceous Wetlands	46,834	2.4%	60.8%	71.2%
PSS	Shrub Wetlands	15,995	0.8%	20.2%	23.7%
PFO	Forested Wetlands	1,297	<0.1%	1.9%	2.2%
PAB/PUB/ PUS	Ponds and Impoundments	1,925	0.1%	2.5%	2.9%
Total Area of Wetlands		**66,051**	**3.4%**	**85.4%**	**100.0%**
Waterbodies					
NWI Code	**Waterbody Type**				
L	Lakes and Shores	5,828	0.3%	7.3%	---
R3	Large Rivers	4,313	0.2%	5.4%	---
R4	Smaller Streams	1,378	<0.1%	1.7%	---
R*/x mod	Canals and Ditches	122	<0.1%	0.2%	---
Total Area of Waterbodies		**11,641**	**0.6%**	**14.6%**	**---**
Total Area of Wetlands and Waterbodies		**77,692**	**4.0%**	**100%**	**---**

4.2 Updated Mapped Wetland and Riparian Acreage

Updated NWI mapping of the Arkansas Headwaters subbasin contained 66,758 acres of wetlands, water bodies, and riparian areas, representing only 3.4% of the total land area (Table 8; Figure 6; Figure 7). The overall total was lower than the original NWI mapping efforts, due to differences in mapping methodologies and better aerial imagery, but also potential change in the landscape. In the updated mapping, areas mapped as wetlands accounted for 74% of the total acres, waterbodies accounted for 17%, and non-wetland riparian areas accounted for 8.6%.

Within the updated NWI mapping, herbaceous wetlands were still the most abundant mapped type, with 27,860 acres or 42% of all mapped aquatic resources. With lakes and rivers removed to specifically highlight wetlands, herbaceous wetlands accounted for 56% of wetland acres. Following herbaceous wetlands, shrub wetlands were the second most abundant wetland type. In the updated dataset, shrub wetlands made up 19,589 acres, or 30% of all aquatic resources and 40% of wetland acres. Forested wetlands were the smallest groups in the updated dataset. The final estimate for forested wetlands was only 352 acres, much lower than what was originally mapped by NWI.

Ponds and impoundments made up 1,672 acres in the updated mapping, or 2.5% of all aquatic resources and 3.4% of wetland acres. A smaller share of ponds were mapped with the beaver modifier in the updated mapping (21%), but a larger share were mapped as excavated or impounded (47%).

Mapped lakes in the final dataset made up 6,050 acres across the basin and represented 9.1% of mapped aquatic resources. The majority of mapped lakes are still reservoirs, as in the old mapping. Rivers, streams and artificially dug irrigation canals together make up another 5,503 acres across the basin (11% of mapped aquatic resources).

In addition to mapped wetlands and waterbodies, the updated mapping also contains riparian areas, which are drier than true wetlands, but still influenced by water movement. The riparian mapping classification and guidance was not in place at the time the original mapping was carried out. The updated mapping includes 5,732 acres of riparian areas, or 8.6% of all mapped aquatic resources.

Table 9. Acres of wetlands and waterbodies in the Arkansas Headwaters subbasin, based on updated NWI mapping.

Wetland and Waterbody Type		*Acres*	*% of Basin Area*	*% of NWI Acres*	*% of Wetland Acres*
Total Basin Area		1,960,273	100.0%	---	---
Upland Area (not mapped by NWI)		1,893,515	96.6%	---	---
Wetlands					
NWI Code	**Wetland Type**				
PEM	Herbaceous Wetlands	27,860	1.4%	41.7%	56.3%
PSS	Shrub Wetlands	19,589	1.0%	29.3%	39.6%
PFO	Forested Wetland	352	<0.1%	0.5%	0.7%
PAB, PUB, PUS	Ponds and Impoundments	1,672	<0.1%	2.5%	3.4%
Total Area of Wetlands		**49,474**	**2.5%**	**74.1%**	**100.0%**
Waterbodies					
NWI Code	**Waterbody Type**				
L	Lakes and Shores	6,050	0.3%	9.1%	---
R3	Larger Rivers	2,866	0.15%	4.3%	---
R4	Smaller Streams	2,273	0.12%	3.4%	---
R*/x mod	Canals and Ditches	364	<0.1%	0.5%	---
Total Area of Waterbodies		**11,552**	**0.6%**	**17.3%**	**---**
Riparian Areas					
NWI Code	**Riparian Type**				
Rp	All Riparian	5,732	0.3%	8.6%	---
Total Area of Riparian		**5,732**	**0.3%**	**8.6%**	**---**
Total Area Wetlands, Waterbodies, Riparian		**66,758**	**3.4%**	**100.0%**	**---**

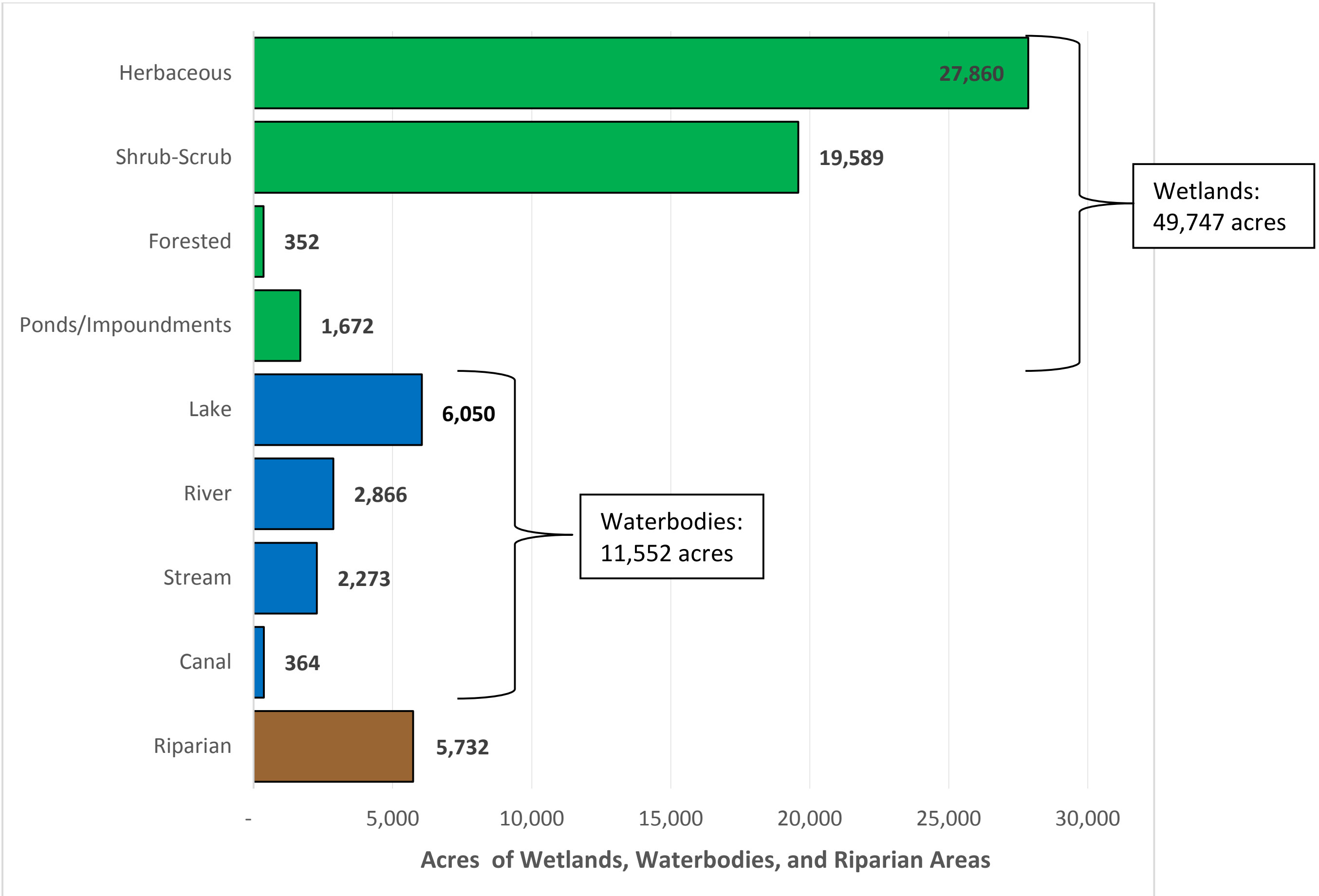

Figure 5. Acres of wetlands and waterbodies in the Arkansas Headwaters subbasin, based on updated NWI mapping.

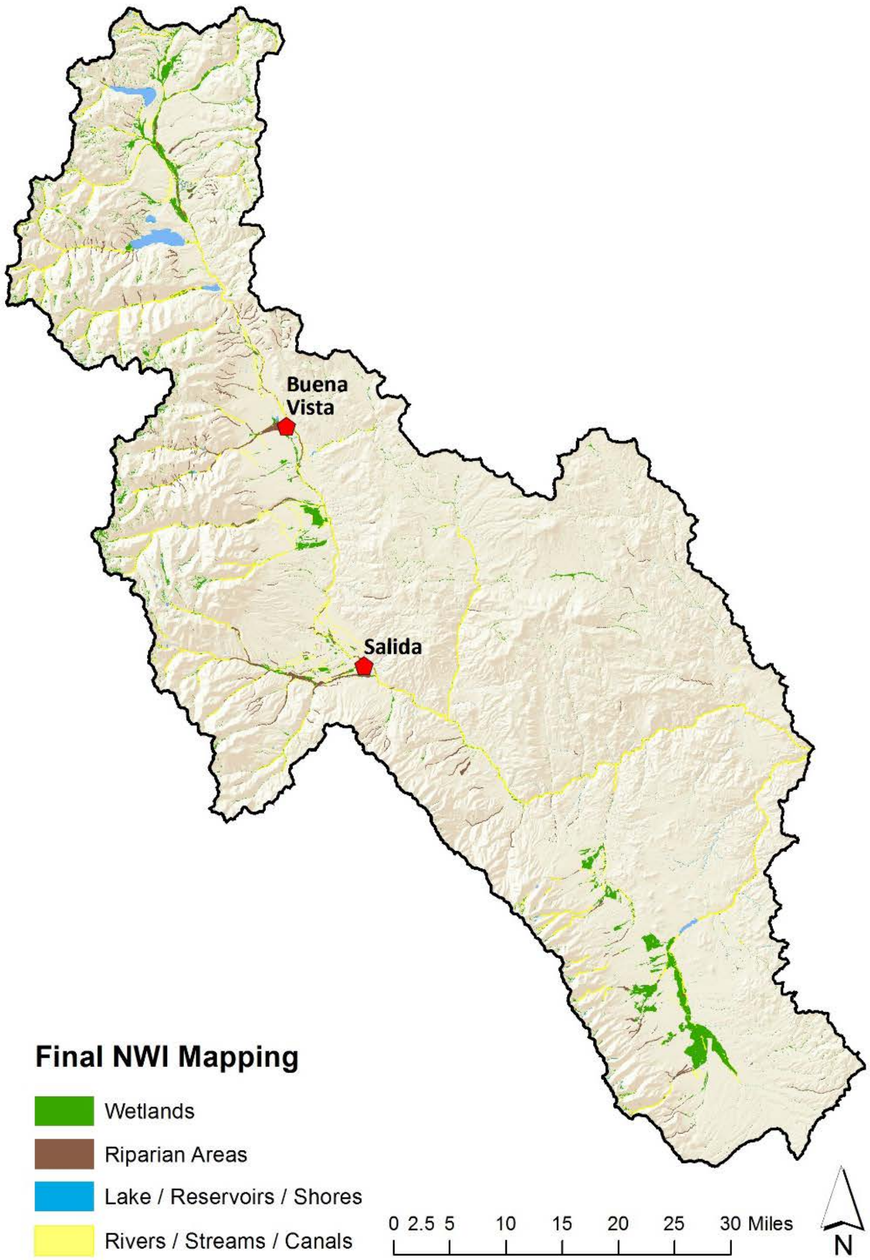

Figure 6. Updated NWI mapping of the Arkansas Headwaters subbasin.

4.3 Comparison of Original NWI Mapping to Updated NWI Mapping

Overall, the updated mapping contained 10,934 fewer acres of wetlands and waterbodies (including newly mapped riparian areas) than the original mapping (Table 10). This represents 14% fewer acres in total. The updated mapping contains 16,577 fewer acres wetland only (not including waterbodies or riparian areas), which represents 25% fewer. Waterbody acres barely changed at all. The updated waterbody total is only 89 acres less than the original mapping, for a decrease of only 1%. Waterbodies are more straightforward to map, as they boundaries are more stable and easier to interpret, at least in this landscape. In addition to wetlands and waterbodies, the updated mapping contains 5,732 acres of riparian areas, which is included in the overall total.

Table 10. Comparison of total acres within the original NWI mapping vs. updated NWI mapping.

Wetland and Waterbody Type	*Mapped Acres*			*% Change from Original*
	Original	*Updated*	*Difference*	
Herbaceous Wetlands	46,834	27,860	-18,974	-41%
Shrub Wetlands	15,995	19,589	3,594	+22%
Forested Wetland	1,297	352	-945	-73%
Ponds and Impoundments	1,925	1,672	-253	-13%
All Wetland Acres	**66,051**	**49,474**	**-16,577**	**-25%**
Lakes and Shores	5,828	6,050	222	+4%
Large Rivers	4,313	2,866	-1,447	-34%
Smaller Streams	1,378	2,273	895	65%
Canals	122	364	242	+198%
All Waterbody Acres	**11,641**	**11,552**	**-89**	**-1%**
Riparian	--	5,732	5,732	--
All NWI Acres	**77,692**	**66,758**	**-10,934**	**-14%**

Herbaceous wetlands changed the most in terms of total area. The updated mapping contains 18,974 acres fewer acres of herbaceous wetlands than the original dataset, for a change of -41%. The biggest difference in the mapping of herbaceous wetlands between the two datasets was in the treatment of large wet meadow / hay field complexes in both the Arkansas River Valley and the Wet Mountain Valley. In these areas, generations of ranchers have taken advantage of natural groundwater seeps and natural stream flow to create large fields of irrigated hay. In many areas, small, localized canals draw water out from the Arkansas itself or tributary streams and spread it over fields immediately adjacent to the floodplain or on open toeslopes. The relationship between natural water and irrigation is complex and makes the exact mapping of wetland boundaries in these areas difficult, especially without spatial data depicting the current and historic extent of irrigation. [7] Some irrigated meadows are indeed wet enough to be mapped as wetlands. Others are

[7] Irrigated lands data over multiple time periods are available for most areas of the state through the Colorado Decision Support System (http://cdss.state.co.us/GIS/Pages/GISDataHome.aspx). However, the data for the Arkansas River Basin do not include the Arkansas Headwaters subbasin.

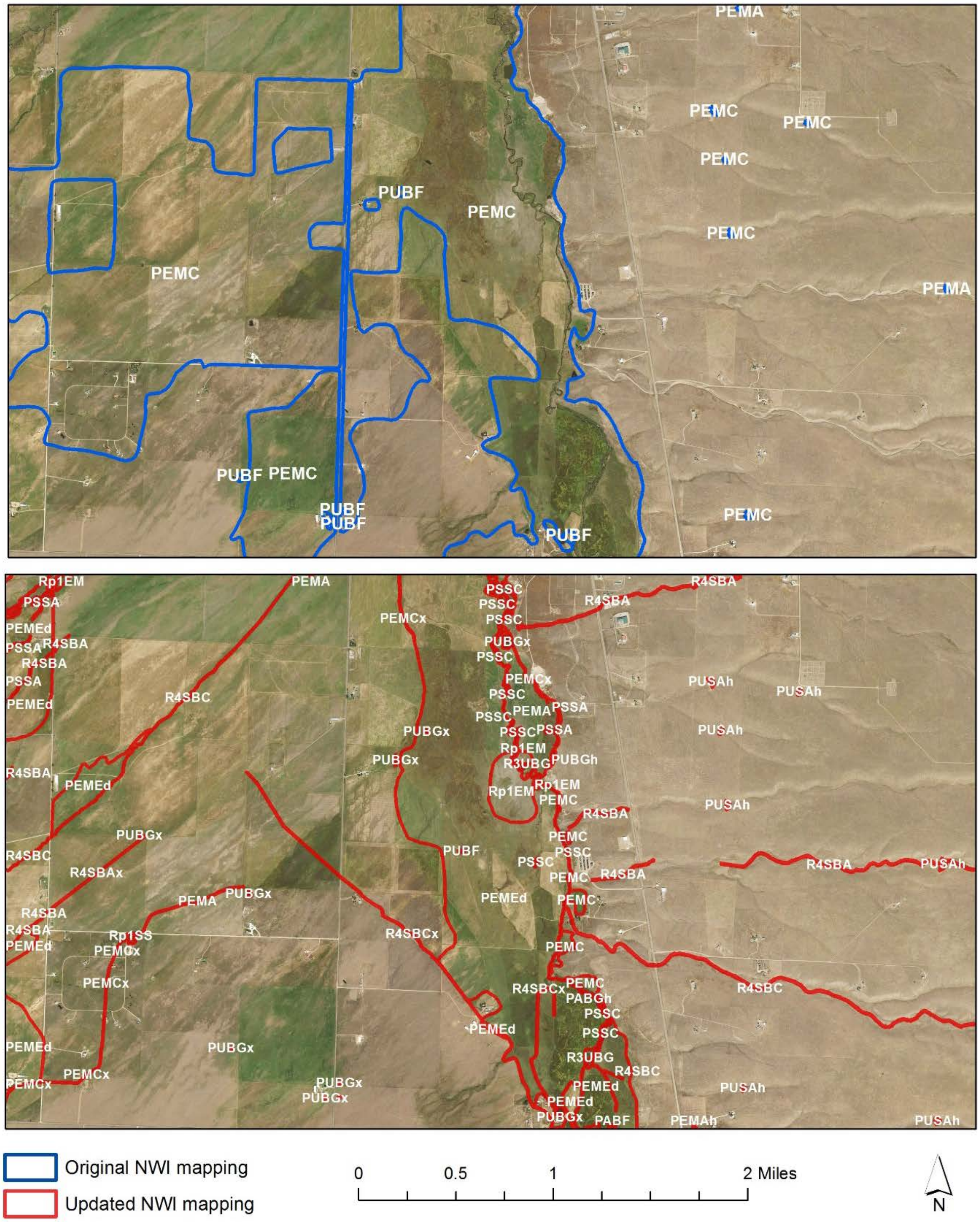

Figure 7. Comparison of original NWI mapping to updated NWI mapping in an herbaceous area. Specifically note the areas to the left in the upper map, which contains a large polygon mapped as herbaceous wetland. This same area was not mapped in the updated NWI, as it does not appear to receive enough flooding or saturation to be considered a true wetland. The updated mapping does include herbaceous wetlands along the floodplain. Also not he increased resolution of the updated mapping, which contains more polygons than the old mapping.

wetter than the surrounding landscape, but not wet enough to form true wetland characteristics. In the 1970-80s, NWI mappers included far more acres of irrigation-influenced meadows. In the updated mapping, we focused on the wettest areas that are most likely to be considered true wetlands (Figure 7). From conversations with local stakeholders and field visits to the areas, we do believe that irrigation was more extensive in the 1970-80s, which would have led to more acres of irrigated wetlands.

While the majority of change between herbaceous wetlands mapped in the two datasets appeared to be from the interpretation of irrigated meadows, additional change came from changing codes and shifting polygons. By intersecting the original mapping with the updated mapping, we compared the original attribution of specific areas on the ground to the updated attribution (Table 11). In this comparison, 1,713 acres mapped as herbaceous in the original mapping were mapped as shrub wetlands in the updated mapping. The majority of these acres were small patches in the landscape that may be the result of changes in interpretation rather than changes in vegetation, though some may represent vegetation change. Another small share of originally mapped herbaceous wetlands along streams (592 acres) was classified as non-wetland riparian areas in the new mapping, as they were too dry to be considered wetlands.

The wetland type that changed the most proportionally was forested wetlands. While the original mapping contained 1,297 acres of forested wetlands, the updated mapping included only 352 acres that appeared to truly be forested wetland. This represented a decrease of 73% of forested wetland acres. This was likely a change in coding rather than a change in vegetation composition. The original mapping included several swaths of cottonwood and aspen at the base of the Sangre do Cristo Mountains. Parts of these stands were better classified as non-wetland riparian areas (Figure 8). Other parts of the polygons appeared to be upland areas incorporated into the larger polygons. Of the 1,297 acres originally mapped as forested wetlands, most (898 acres) were not mapped at all in the updated mapping. Of the 398 acres that did overlap between the old and new mapping, most common class transitions in the new mapping were shrub wetlands (133 acres), to non-wetland riparian areas (119 acres), and to emergent wetlands (85 acres). Only 36 of the original mapped acres remained as forested wetlands. However, the updated mapping did contain and additional 317 acres of forested wetlands not in the original mapping. In many cases, these new acres were in close proximity to old mapping of forested or shrub wetlands.

While herbaceous and forested wetland acreage decreased in the updated dataset, the updated mapping included an increase in shrub wetlands, from 15,995 acres in the original mapping to 19,589 acres in the updated mapping. Of those acres 9,455 were mapped in the shrub class in both the original and updated datasets. There was a good deal of shifting between herbaceous and shrub classification, due either to changes in the vegetation or differences in interpretation, and the net result was an increase of 3,496 acres of mapped shrub wetlands. This included some large shrubby complexes in the subalpine and alpine zones that were not included by the original mappers (Figure 9). These alpine shrub zones are fed by snowmelt and have shallow soils, but are dominated by wetland species. We do not believe this is a change in the landscape, but a different interpretation of the vegetation.

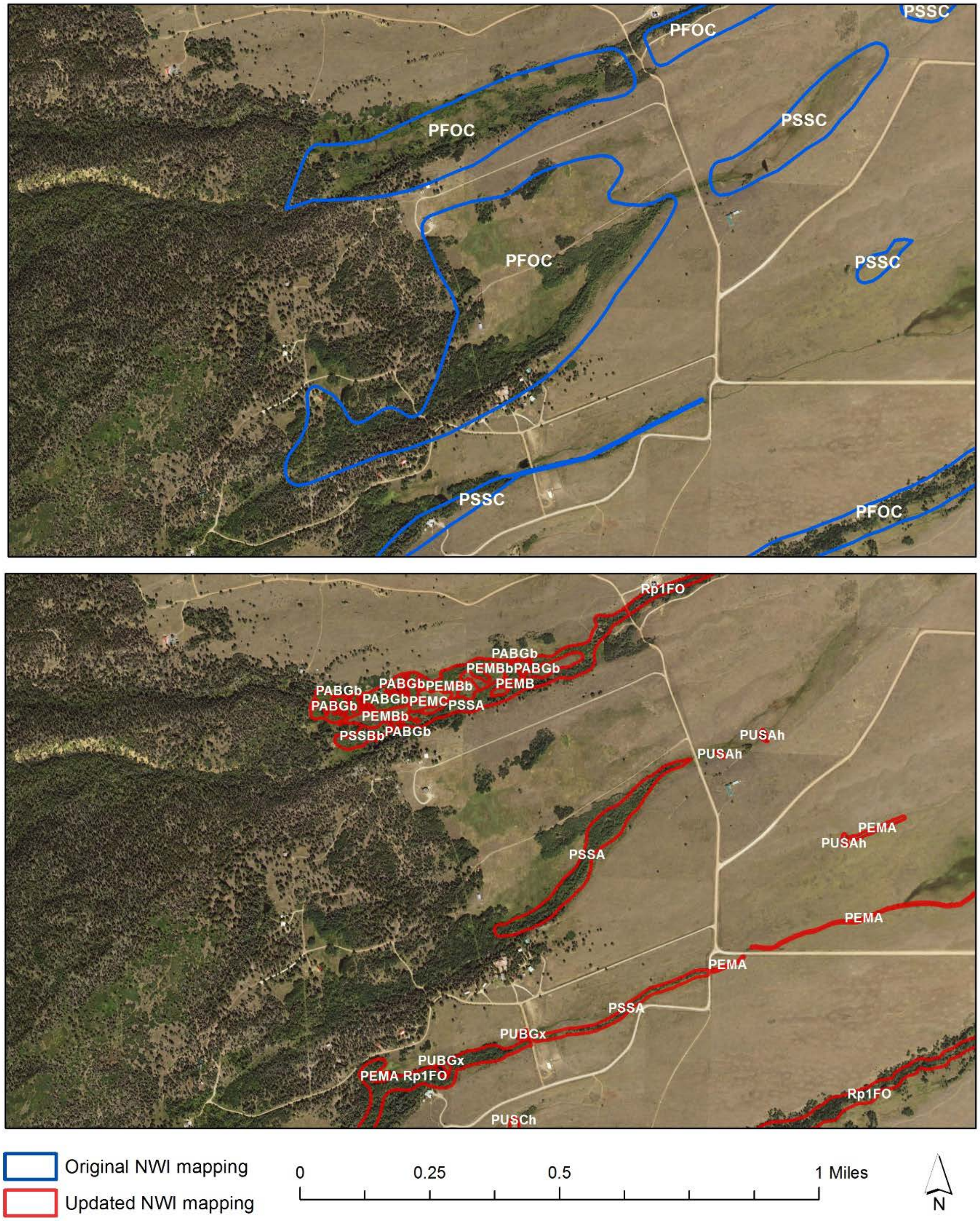

Figure 8. Comparison of original NWI mapping to updated NWI mapping in a forested area. This area was mapped as forested wetland (PFOC) in the original mapping, but was mapped as a combination of types in the updated mapping.

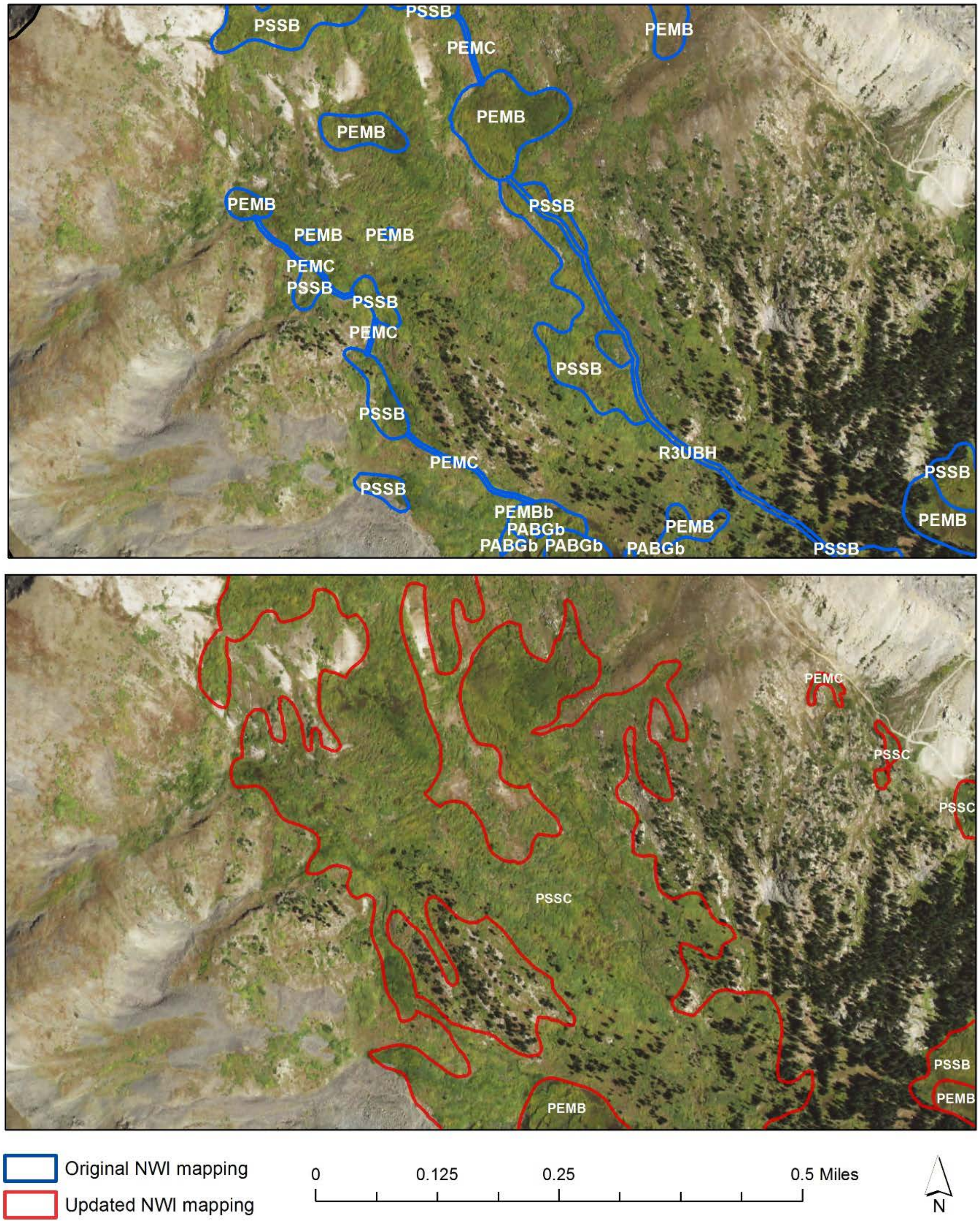

Figure 9. Comparison of original NWI mapping to updated NWI mapping in an alpine shrub area. In the original mapping there is a large section that is not mapped, but is mapped as shrub wetlands (PSSC) in the updated mapping.

The mapping of waterbodies between the two datasets resulted in very similar overall total acres (Table 10). Lakes and shores were mapped almost exactly the same in the two datasets, with a minor increase in the updated mapping (4%). However, there were some important differences in the interpretation of rivers, streams, and canals. As narrow features, there was significant shifting between the two datasets. In many areas, the same stream or canal was mapped just meters away in the updated mapping, but there was little overlap because each feature was so narrow. This resulted in few overlapping acres when the two datasets were compared (Table 11), though the resource mapped was the same. In addition, the old mapping was not consistent in its application of the codes that differentiate rivers (R2/R3) from streams (R4). The original mapping coded many of the tributary streams as rivers, even far into the headwaters. In the updated mapping, we restricted the coding of river to the Arkansas itself and the largest tributaries. This meant the total acres of rivers went down in the updated mapping and the acres of streams went up. In addition, the updated mapping was more precise with the coding of canals, leading to a doubling of the total canal acres (122 acres in the original mapping and 364 acres in the updated mapping). Those changes aside, the total acres of linear waterbodies (rivers, streams and canals together) changed little between the two datasets (5,813 acres in the original mapping and 5,503 in the updated mapping).

Table 11. Overlap between original NWI mapping (1970-80s image years) vs. updated NWI mapping (2011 image year) by wetland and waterbody type. Results are shown as acres within each class. Shaded boxes represent acres mapped the same in both years. Acres mapped in both years, but given a different classification, are in boxes that are not shaded. Acres mapped in one time period and not the other are shown at the far right (for acres not in updated mapping) and the bottom (for acres not in original mapping).

Acres Mapped in Both Datasets		Updated Mapping										Acres Not in Updated Mapping	Original Grand Total
		Herb	Shrub	Forest	Pond / Impound	Lake	River	Stream	Canal	Riparian	Intersect Total		
Original Mapping	Herbaceous	18,159	1,704	27	182	44	163	180	110	592	**21,160**	25,684	**48,834**
	Shrub	864	9,455	17	164	56	240	29	13	400	**11,239**	4,762	**15,995**
	Forested	85	133	36	4	3	11	7	1	119	**398**	898	**1,297**
	Pond / Impound	140	224	1	682	97	12	2	1	19	**1,178**	752	**1,925**
	Lake	48	18	--	73	5,506	6	--	--	--	**5,650**	184	**5,828**
	River	168	576	9	16	26	1,228	33	6	201	**2,264**	2,059	**4,313**
	Stream	23	16	--	2	--	3	252	--	9	**306**	1,073	**1,378**
	Canal	5	5	--	--	--	--	3	16	7	**36**	86	**122**
	Intersect Total	**19,493**	**12,139**	**92**	**1,125**	**5,732**	**1,665**	**507**	**146**	**1,347**	**42,246**	**37,793**	**77,692**
Acres Not in Original Mapping		8,368	7,450	261	549	317	1,203	1,766	218	4,384	**24,529**		
Updated Grand Total		**27,860**	**19,589**	**352**	**1,672**	**6,050**	**2,866**	**2,273**	**364**	**5,732**	**66,758**		

4.4 Further Details on the Updated Mapping

The NWI Cowardin coding system includes several supplementary details beyond wetland class that can shed more light on the types of wetlands within an area. In addition, the mapping can be intersected with ancillary datasets to provide context for wetland distribution and management. To provide a richer understanding of wetlands in the Arkansas Headwaters subbasin, the following sections break down the updated wetland mapping by hydrologic regime, modifier, geographic spread, and land ownership.

4.4.1 Mapped Wetland Acres by Hydrologic Regime

The most prevalent hydrologic regime used in the study area was C: seasonally flooded (30% of all acres, 38% of wetland acres, 13% of waterbody acres) (Table 12). This water regime was used for polygons in every wetland and waterbody type mapped in the basin, except for non-wetland riparian areas, which do not have a hydrologic regime (Table 13). Most of the seasonally flooded wetlands were shrub wetlands, followed by herbaceous wetlands. Seasonally flooded wetlands rely on seasonal precipitation, overbank flooding from adjacent rivers and streams, or direct or indirect addition of irrigation water. These wetlands are wet from a few weeks to a few months a year, typically in the beginning of the growing season, and may be dry towards the end of the growing season. This regime is also used for some of the lake shore, stream, and canal acres.

The next most common hydrologic regime was E: seasonally flooded/saturated (22% of all acres, 30% of wetland acres, no waterbody acres). The seasonally flooded/saturated water regime was primarily used for herbaceous wetlands (14,572 acres), and a small amount in shrub wetlands (40 acres). The hydrology of seasonally saturated wetlands is driven primarily by groundwater discharge or subsurface irrigation. These areas have high groundwater tables for much of the growing season, but are rarely flooded. Water tables may draw down by the end of the summer. This hydrologic regime was used for many of the groundwater-fed wet meadow complexes at the base of the Sawatch and Sangre de Cristo Mountains, in both the Arkansas Valley and the Wet Mountain Valley. The hydrology of most of these meadows is influenced by local irrigation practices, but they appear to have a strong natural groundwater influence as well.

The third most common hydrologic regime was B: saturated (14% of all acres, 19% of wetland acres, no waterbody acres). Shrub wetlands made up most wetlands under the saturated hydrologic regime (6,980 acres), followed by herbaceous wetlands (2,268 acres). A few acres of forested wetlands fell under the saturated regime. Saturated wetlands have high groundwater tables, often at the surface, throughout the growing season, but standing surface water is rarely present. There are two kinds of wetlands that are typically mapped with the B water regime, groundwater-fed fens and beaver-influenced complexes. In both cases, water tables are very high throughout the growing season. In the Arkansas Headwaters subbasin, 68% of saturated shrub wetlands and 16% of herbaceous wetlands (~5,000 acres total) were mapped with a beaver modifier and are likely beaver complexes. The remaining ~4,000 acres are likely fens.

The water regime A: temporarily flooded made up 11% of all acres, 11% of wetland acres, and 14% of waterbody acres. The temporarily flooded regime is the driest regime included in the Cowardin classification system. It refers to sites that are wet for less than two weeks during the growing season; a hydroperiod that is barely wet enough for true wetland formation.

The most common hydrologic regime for waterbodies was H: permanently flooded (11% all acres, no wetland acres, 62% of waterbody acres). This regime is not used for vegetated wetlands, only for deepwater lakes and rivers. Most lake and river acres fell under this regime.

Water regimes F: semi-permanently flooded and G: intermittently exposed made up the smallest portion of acres. Semi-permanently exposed wetlands have surface water present throughout the growing season in most years. This regime was used for a small number of herbaceous acres (often marshes) and some ponds, as well as some river acres. Intermittently exposed wetlands are one step wetter than semi-permanently flooded. These sites have surface water present throughout the year, except in years of extreme drought. The regime was used for most pond acres and many lake and river acres.

Table 12. NWI acres by hydrologic regime code.

Code	*Hydrologic Regime*	*All NWI Acres*	*% of NWI Acres*	*Wetland Acres*	*% of Wetland Acres*	*Waterbody Acres*	*% of Waterbody Acres*
A	Temporarily flooded	7,174	11%	5,580	11%	1,595	14%
B	Saturated	9,252	14%	9,252	19%	--	--
C	Seasonally flooded	20,036	30%	18,527	37%	1,509	13%
E	Seasonally flooded/ saturated	14,612	22%	14,612	30%	--	--
F	Semi-permanently flooded	540	1%	221	< 0.1%	319	3%
G	Intermittently exposed	2,308	3%	1,303	3%	1,005	9%
H	Permanently flooded	7,125	11%	--	--	7,125	62%
None	No hydrologic regime (Riparian)	5,711	9%	--	--	--	--
Total		**66,758**	**100%**	**49,495**	**100%**	**11,553**	**100%**

Table 13. NWI acres by hydrologic regime code and wetland / waterbody type.

Wetland and Waterbody Type	Hydrologic Regime Code, in acres								Total
	A	B	C	E	F	G	H	None	
Herbaceous	3,696	2,268	7,291	14,572	33	--	--	--	27,677
Shrub	1,535	6,980	11,055	40	--	--	--	--	19,589
Forested	253	4	95	--	--	--	--	--	352
Pond / Impound	96	--	85	--	188	1,303	--	--	1,672
Wetland Acres	**5,580**	**9,252**	**18,527**	**14,612**	**221**	**1,303**	**--**	**--**	**49,495**
Lakes / Shores	--	--	238	--	--	388	5,424	--	6,050
Rivers	51	--	177	--	319	617	1,701	--	2,866
Streams	1,544	--	729	--	--	--	--	--	2,273
Canals	--	--	364	--	--	--	--	--	364
Waterbody Acres	**1,595**	**--**	**1,509**	**--**	**319**	**1,005**	**7,125**	**--**	**11,553**
Riparian	--	--	--	--	--	--	--	5,711	5,711
All NWI Acres	**7,174**	**9,252**	**20,036**	**14,612**	**540**	**2,308**	**7,125**	**5,711**	**66,758**

4.4.2 Mapped Wetland Acres by Extent Modified

The NWI classification includes several modifiers that describe alteration from both human and natural causes. The four NWI modifications mapped in the Upper Arkansas basin are: 1) b: beaver influenced, 2) d: drained, 3) h: impounded, and 4) x: excavated. Among those four official modifiers, a polygon can only be attributed with one of the four. While many lakes and ponds are both excavated and impounded, they are mapped with one or the other depending on which modifier is dominant.

In total, 41% of total acres and wetlands and waterbodies were mapped with an official NWI modifier (Table 14). Eighty-four percent of lake acres were classified as either excavated or impounded. Many lakes within the study area are reservoirs created for water storage and are either impounded, excavated, or both. Canals were the other significant group mapped with an NWI modifier. All canal acres were, by definition, mapped with an excavated modifier. However, while rivers and streams were not mapped as modified, the NWI modifiers do not account for hydrologic modification, such as ditches and diversions that either take or add water to the Arkansas River and its largest tributaries.

Within wetland acres, ponds were often mapped as excavated (15%) or impounded (32%). These represent stock ponds, small water storage ponds, recreational ponds, and even some water treatment ponds. Another 21% of ponds are mapped with a beaver modifier, meaning they are natural ponds part of beaver complexes. Beaver also influence 24% of shrub wetlands.

A sizable share of herbaceous wetlands (55%) were mapped as ditched. These represent the natural groundwater-fed wetlands at the base of the Sawatch and Sangre de Cristo Mountains that have been ditched to spread water more effectively for hay grass production.

Table 14. NWI acres by modifiers.

Final NWI Reporting Group	Modifier, in acres					Total
	Beaver	Ditched	Impounded	Excavated	No Modifier	
Herbaceous	366	15,267	240	99	11,888	27,860
Shrub	4,774	--	49	51	14,737	19,610
Forested	--	--	--	3	349	352
Pond / Impoundment	357	--	529	255	532	1,672
All Wetland Acres	**366**	**15,267**	**240**	**99**	**11,888**	**27,860**
Lakes / Shores	--	--	5,020	30	999	6,050
Rivers	--	--	--	--	2,866	2,866
Streams	--	--	--	--	2,254	2,254
Canals	--	--	--	383	--	383
All Waterbody Acres	**--**	**--**	**5,020**	**413**	**6,119**	**11,552**
Riparian	--	--	--	--	5,711	5,711
All NWI Acres	**5,496**	**15,267**	**5,838**	**821**	**39,335**	**66,758**

4.4.3 Mapped Wetland Acres by Ecoregion Group

To understand the distribution of wetlands across the basin, it is helpful to look at regional patterns in the mapping. To do this, we divided the basin into five zones or regional strata based on ecoregion composition: 1) the alpine zone; 2) subalpine forests; 3) mid-elevation forests; 4) foothills and shrublands; and 5) grassland and sagebrush parks (Table 15). The Arkansas Headwaters subbasin is fairly evenly divided between the five major ecoregion zones, with mid-elevation forests being the largest share (29%), followed by foothills and shrublands (23%), subalpine forests (19%), grassland parks (16%), and the alpine zone (13%).

While only 16% of the landscape is grassland and sagebrush parks, this lower elevation zone contained 38% of all NWI acres. Herbaceous wetlands were the most common mapped wetland type, and 70% of all mapped herbaceous wetlands (19,287 acres) were in the grassland and sagebrush parks zone. These are primarily the large wet meadow / hay pasture complexes at the base of the mountains slopes, as well large swaths along the Arkansas and Grape Creek floodplains, many of which are influenced by irrigation. This zone also contained 33% of all waterbody acres, including 43% of the lake acres (Twin Lakes are in this zone) and 61% of all canal acres.

Subalpine forests makes up 19% of the subbasin, and contained 20% of NWI acres. Shrub wetlands were the most prominent wetland type in the subalpine forest zone, with 33% of all shrub wetlands acres occurring in the subalpine forest zone (6,492 acres). In the subalpine zone, natural shrub-dominated, beaver-influenced riparian corridors are common along the many tributary streams. Shrub-dominated fens are also common within this zone. Herbaceous wetlands were the next most common wetland type in the subalpine forest zone (2,769 acres), though this only represented 10% of all herbaceous wetlands. Additionally, 41% of mapped lakes and shores occurred in the subalpine forest zone, including the Turquoise Lake reservoir.

The alpine zone is 13% of the subbasin, and contained 15% of all NWI acres. Shrub wetlands were also the most common wetland type in the alpine zone, with 38% of all shrub wetlands occurring in the alpine zone (7,460 acres). Large snowmelt-fed shrub wetland complexes form within the alpine zone. Most have shallow soil development and low-stature shrubs. These complexes are often just above and grade into headwaters streams. A portion of lake acres (10%, 538 acres) also occurred in the alpine zone. These are natural, high alpine lakes.

The mid-elevation forest and foothill zones have comparatively fewer wetland and waterbody acres. The mid-elevation zone is relatively steep and less conducive for wetland development. This zone is characterized by riparian shrublands and stream channels. The foothill zone is dry and open, but does contain many acres of rivers and streams.

Table 15. Updated NWI mapping acres by five ecoregion groups.

Final NWI Reporting Group	*Alpine Zone*		*Subalpine Forests*		*Mid-Elevation Forests*		*Foothills and Shrublands*		*Grassland Parks*		*Total*
	Acres	*% of Class*	*Acres*	*% of Class*	*Acres*	*% of Class*	*Acres*	*% of Class*	*Acres*	*% of Class*	
Total Ecoregion Area / Percent of Basin	263,418	13%	374,071	19%	566,418	29%	445,881	23%	310,486	16%	1,960,274
Herbaceous	1,211	4%	2,769	10%	2,388	9%	2,205	8%	19,287	70%	27,860
Shrub	7,460	38%	6,492	33%	2,660	14%	876	4%	2,102	11%	19,589
Forested	21	6%	72	20%	111	32%	55	16%	95	27%	352
Pond / Impoundment	327	20%	437	26%	304	18%	197	12%	--	--	1,672
All Wetland Acres	**9,019**	**18%**	**9,770**	**20%**	**5,463**	**11%**	**3,333**	**7%**	**21,484**	**44%**	**49,474**
Lakes / Shores	583	10%	2,471	41%	407	7%	13	<1%	2,575	43%	6,050
Rivers	110	4%	634	22%	316	11%	1,306	46%	499	17%	2,866
Streams	55	2%	82	4%	358	16%	1,270	56%	508	22%	2,273
Canals	--	--	11	3%	14	4%	116	23%	223	61%	364
All Waterbody Acres	**748**	**6%**	**3,198**	**28%**	**1,095**	**9%**	**2,705**	**23%**	**3,805**	**33%**	**11,552**
Riparian	20	< 1%	985	17%	1,448	25%	1,332	22%	1,947	34%	5,732
All NWI Acres	**9,767**	**15%**	**12,968**	**20%**	**6,558**	**10%**	**6,038**	**9%**	**25,289**	**38%**	**66,758**

4.2.5 Mapped Wetland Acres by Land Ownership

Management decisions are ultimately made by those who own the land. As a final pieces of our analysis, we calculated the distribution of wetlands by landowner in the Arkansas Headwaters subbasin. This analysis highlights the importance of private lands for the wetland resources in the Upper Arkansas basin. The majority of land in the subbasin (65%) is publically owned by either federal or state agencies. Although only 35% of land is privately owned, these areas contain 58% of NWI acres and 63% of wetlands acres (Table 16). Most of the large wet meadow / hay pasture complexes are privately owned.

Federal lands make up the largest share of land ownership in the Upper Arkansas, with 42% owned by the U.S. Forest Service (USFS) and 18% by the Bureau of Land Management (BLM). USFS lands contain 36% of all NWI acres and 33% of wetland acres. In contrast, drier BLM lands contain only 4% of NWI acres and 3% of wetland acres.

Table 16. NWI acres by grouped land owner.

Grouped Owner[1]	*Total Land Area within Basin*		*All NWI Acres*		*Wetland Acres Only*	
	Acres	*% of Basin*	*Acres*	*% of NWI Acres*	*Acres*	*% of Wet Acres*
Federal Lands	**1,179,858**	**60%**	**26,524**	**39%**	**16,321**	**36%**
U.S. Forest Service	822,495	42%	23,687	35%	15,087	33%
Bureau of Land Management	356,937	18%	2,785	4%	1,193	3%
Misc. Federal (USFWS)	426	< 1%	52	< 1%	41	< 1%
State Lands	**81,970**	**4%**	**1,534**	**2%**	**924**	**1%**
State Land Board	79,994	4%	742	1%	425	< 1%
Colorado Parks and Wildlife	1,976	< 1%	792	1%	517	1 %
Local Government	**269**	**< 1%**	**74**	**< 1%**	**5**	**< 1%**
Cities	269	< 1%	74	< 1%	5	< 1%
Other	**698,176**	**36%**	**38,599**	**58%**	**29,819**	**63%**
Private	698,176	36%	38,599	58%	29,819	63%
Total	**1,960,273**	**100%**	**66,758**	**100%**	**49,474**	**100%**

[1] Many properties in the basin are owned by one agency but managed by another agency through inter-agency agreements or are owned by private land owners but managed by an agency through easements. Therefore, the numbers of acres owned by a given agency is different than the number of acres managed by that agency.

5.0 Discussion

Wetlands of the Arkansas River subbasin are an important ecological resource for the state of Colorado and local citizens of the area. Based on updated National Wetland Inventory (NWI) mapping, the subbasin contains 66,758 acres of aquatic resources, including 49,474 acres of wetlands; 11,552 acres of lakes, river, streams and canals; and 5,732 acres of non-wetland riparian areas. While these resources represent only 3.4% of the landscape in the subbasin, their importance cannot be overstated. Wetlands provide valuable wildlife habitat, including habitat for the rare Colorado populations of boreal toad. They are critical for watershed hydrology, as they absorb and buffer excess runoff in the lower reaches and help maintain base flows in the upper reaches by storing and slowly releasing water throughout the growing season. Wetlands play a pivotal role is filtering pollutants, and may be particularly important in a watershed like the Arkansas Headwaters with a history of mining activities. Within the grassland parks ecoregion, at the base of the mountain slopes, groundwater-fed wetlands have also long been integrated into the regional economy as prime location for hay production.

The updated mapping provides important information for understanding wetland distribution. These results can aid wetland regulation, conservation and management within the subbasin by providing the context for decisions to be made using the watershed approach (Lemly et al 2013).

The mapping data revealed several main wetland and riparian types in the subbasin. The most expansive type includes woody wetland / riparian stands along the subbasin's rivers and streams. In total, the basin contains ~20,000 acres of shrub and forested wetlands along with ~6,000 acres of non-wetland riparian areas. Many of the Potential Conservation Areas identified by Colorado Natural Heritage Program in previous field studies in the area are for the protection of woody wetland and riparian communities (Culver et al 2009; Neid 2006). At higher elevations, shrub wetlands form large snowmelt-fed stands that grade into stream corridors. These alpine shrublands account for ~7,500 acres. In the subalpine, riparian shrublands are often influenced by beaver and form mosaics interspersed with herbaceous patches and small ponds. The subalpine also contains groundwater-fed fens that are a mix of woody and herbaceous vegetation. Subalpine shrublands and woody fens account for ~6,500 acres. At lower elevations, woody vegetation forms in narrower drainages and is a mix of wetland and non-wetland riparian species. These systems account for the remaining ~6,000 acres.

The subbasin contains ~5,000 acres of beaver influenced wetlands, which include shrub, herbaceous and pond complexes. The number of streams influenced by beaver may be lower than in recent past, however. Reports from stakeholders in the subbasin indicate that there has been a recent trend toward beaver removal (D. Gilbert, Bureau of Land Management, *personal communication)*, and the mapping comparison did show far fewer shrub acres modified by beaver. It is certainly true that there are fewer beaver than there were prior to fur trading and European settlement, as beaver once inhabited all of Colorado with much higher numbers than today (Baker & Hill 2003). Beaver are a critical component of wetland formation in the Rocky Mountains and should be encouraged and maintained where the landscape and land use practices can support them.

Second to woody wetland and riparian areas, the wet meadow / hay pasture complexes at the base of slopes grading into floodplains are the next most prevalent type (~15,000 acres). Many of these areas are influenced by long-standing irrigation practices, though also appear to have a strong connection to groundwater discharge, based on their landscape position. The prevalence of irrigation-influenced meadows in the subbasin is similar to other high mountain valleys in Colorado, where irrigation-influenced wet meadows comprise a major component of wetlands mapped by NWI (Lemly and Gilligan 2012; Lemly et al. 2011). The vegetation composition in these sites is largely dominated by non-native pasture grasses, though patches of native vegetation likely do occur and should be sought out and conserved. Even though they are modified by irrigation, they can provide incredibly important wildlife habitat in an otherwise arid region.

Strong regional and land ownership patterns are also evident across the subbasin. The greatest amount of wetlands occur in the grassland parks ecoregion, which also contains the largest amount of private land. This highlights the importance of working with private land owners in the management and conservations of wetland resources. While only 35% of land is privately owned, these lands contain 63% of wetland acres. This represents an important opportunity for collaborative conservation efforts between the private landowners who own and manage wetland acres and federal and state agencies with resources and technical assistance.

This project compared original 1970-80s era NWI mapping to more precise, updated NWI mapping based on 2011 aerial imagery. Changes in wetland acreage between the two datasets appear to be related to the scale of imagery, a tighter interpretation of wetland signatures, and potential change in the landscape. The biggest difference revealed in the comparison of the two datasets was a decrease in herbaceous acres, mostly at the base of the mountain slopes. We believe this was from both a stricter interpretation of wetlands and changes in irrigation practices. Without both current and historical data on irrigated acres, however, it is difficult to know exactly how changing irrigation practices have effected wetland distribution in the subbasin. Conversation with local stakeholders do indicate that flood irrigation has decreased over the years. Field visits also indicated that some previously irrigated areas of the valleys are drying. Soils in certain areas included significant organic matter content, typical of high elevation wetlands with saturated conditions, and these soils were dry and decomposing.

Though NWI mapping tries to incorporate impacts to wetlands, it was clear from field excursions that various water development projects over the past 100 years have had a profound and lasting impact on the wetland and aquatic resources of the Arkansas subbasin. Comparing the 1970-80s mapping to updated mapping does not capture the changes that have occurred since European settlement. Throughout the arid west, reservoir creation has changed many wetland and stream features into large open water features. Water development in the Front Range has also impacted the Arkansas Headwaters subbasin in other ways. The increasing population along Colorado's Front Range has led to an increase in the need for water for these growing urban centers. This water often comes from high elevation mountain watersheds, as well as trans-basin diversions from the west slope, both of which alter the aquatic systems within the Arkansas headwater watershed. The purchase of water rights from the Arkansas headwaters watershed has led to a drying up of irrigated land in the valley bottoms. Water rights transfers force the draining of the wetlands to send water to lower elevation municipalities. Along with wetland drainage projects, trans-basin diversions have significantly altered the discharge amount and timing of the Arkansas River itself. While these impacts have decreased the water in valley wetlands and increased the water in the Arkansas River, neither is adequately captured in NWI mapping, though should be noted in characterizing the rivers and wetlands of this high elevation Colorado watershed.

With increasing population growth forecasted for the larger Arkansas Basin and the Front Range (Arkansas Basin Roundtable 2015), and the potential for a warming and drying climate (Decker & Fink 2014), action should be taken to conserve the important wetland resources of the Arkansas Headwaters subbasin.

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Appendix 1: NWI Classification Chart

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

System: M - Marine

- **Subsystem: 1 - Subtidal**
  - Class: RB – Rock Bottom
    - Subclass: 1 Bedrock; 2 Rubble
  - Class: UB – Unconsolidated Bottom
    - Subclass: 1 Cobble-Gravel; 2 Sand; 3 Mud
  - Class: AB – Aquatic Bed
    - Subclass: 1 Algal; 3 Rooted Vascular
  - Class: RF – Reef
    - Subclass: 1 Coral; 3 Worm
- **Subsystem: 2 - Intertidal**
  - Class: AB – Aquatic Bed
    - Subclass: 1 Algal; 3 Rooted Vascular
  - Class: RF – Reef
    - Subclass: 1 Coral; 3 Worm
  - Class: RS – Rocky Shore
    - Subclass: 1 Bedrock; 2 Rubble
  - Class: US – Unconsolidated Shore
    - Subclass: 1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic

System: E - Estuarine

- **Subsystem: 1 - Subtidal**
  - Class: RB – Rock Bottom
    - Subclass: 1 Bedrock; 2 Rubble
  - Class: UB – Unconsolidated Bottom
    - Subclass: 1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic
  - Class: AB – Aquatic Bed
    - Subclass: 1 Algal; 3 Rooted Vascular; 4 Floating Vascular
  - Class: RF – Reef
    - Subclass: 2 Mollusk; 3 Worm
- **Subsystem: 2 - Intertidal**
  - Class: AB – Aquatic Bed
    - Subclass: 1 Algal; 3 Rooted Vascular; 4 Floating Vascular
  - Class: RF – Reef
    - Subclass: 2 Mollusk; 3 Worm
  - Class: SB – Streambed
    - Subclass: 1 Bedrock; 2 Rubble; 3 Cobble-Gravel; 4 Sand; 5 Mud; 6 Organic
  - Class: RS – Rocky Shore
    - Subclass: 1 Bedrock; 2 Rubble
  - Class: US – Unconsolidated Shore
    - Subclass: 1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic
  - Class: EM – Emergent
    - Subclass: 1 Persistent; 2 Non-persistent; 5 *Phragmites australis*
  - Class: SS – Scrub-Shrub
    - Subclass: 1 Broad-Leaved Deciduous; 2 Needle-Leaved Deciduous; 3 Broad-Leaved Evergreen; 4 Needle-Leaved Evergreen; 5 Dead; 6 Deciduous; 7 Evergreen
  - Class: FO – Forested
    - Subclass: 1 Broad-Leaved Deciduous; 2 Needle-Leaved Deciduous; 3 Broad-Leaved Evergreen; 4 Needle-Leaved Evergreen; 5 Dead; 6 Deciduous; 7 Evergreen

System: R - Riverine

- **Subsystem:** 1 - Tidal; 2 – Lower Perennial; 3 – Upper Perennial; 4* - Intermittent; 5* – Unknown Perennial
  - Class: RB** – Rock Bottom
    - Subclass: 1 Bedrock; 2 Rubble
  - Class: UB – Unconsolidated Bottom
    - Subclass: 1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic
  - Class: SB** – Streambed
    - Subclass: 1 Bedrock; 2 Rubble; 3 Cobble-Gravel; 4 Sand; 5 Mud; 6 Organic; 7 Vegetated
  - Class: AB – Aquatic Bed
    - Subclass: 1 Algal; 2 Aquatic Moss; 3 Rooted Vascular; 4 Floating Vascular
  - Class: RS – Rocky Shore
    - Subclass: 1 Bedrock; 2 Rubble
  - Class: US – Unconsolidated Shore
    - Subclass: 1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic; 5 Vegetated
  - Class: EM – Emergent
    - Subclass: 2 Nonpersistent

* **Intermittent** is limited to the **Streambed** Class;
Unknown Perennial is limited to **Unconsolidated Bottom** Class code **R5UB** only
** **Rock Bottom** is not permitted for the **Lower Perennial** Subsystem;
Streambed is limited to **Tidal** and **Intermittent** Subsystems

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

System: L - Lacustrine

Subsystem: 1 - Limnetic

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular

Subsystem: 2 - Littoral

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	RS – Rocky Shore	US – Unconsolidated Shore	EM – Emergent
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent

System: P - Palustrine

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	US – Unconsolidated Shore	ML – Moss-Lichen	EM – Emergent	SS – Scrub-Shrub	FO – Forested
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent 5 *Phragmites australis*	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen

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 farmed modifier may also be applied to the ecological system.

Water Regime			Special Modifiers	Water Chemistry			Soil
Nontidal	**Saltwater Tidal**	**Freshwater Tidal**		**Coastal Halinity**	**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	g Organic
B Saturated	M Irregularly Exposed	R Seasonally Flooded-Tidal	d Partly Drained/Ditched	2 Euhaline	8 Eusaline	t Circumneutral	n Mineral
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							