




Statewide Wetlands Classification and Characterization

Natural Heritage Program
COLORADO

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Colorado State University
Knowledge to Go Places

Statewide Wetlands Classification and Characterization

WETLAND PLANT ASSOCIATIONS OF COLORADO

Prepared for:

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Front page photos (from top), HGM subclasses are discussed in the report:

1. Depressional (1) - Snow Mesa, Hinsdale Co. *Colorado Natural Areas Program file photo.*
2. Slope (1) - iron fen at Chattanooga, San Juan Co. *Colorado Natural Areas Program file photo.*
3. Flats (1) - Stinking Spring, Rio Blanco Co. *Colorado Natural Areas Program file photo.*
4. Riverine (3, 4) - North St. Vrain Creek, Boulder Co. *By Ron West.*
5. Riverine (5) - plains cottonwood riparian forest at Big Sandy Creek, Cheyenne Co. *By Gwen Kittel.*
6. Depressional (2, 3) - playa lake at Pawnee National Grasslands. *By Ric Hupalo.*

Background photo: Kettle Lakes Research Natural Area, Jackson Co. *By Janet Coles*

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Ric Hupalo managed Phase I of the project and wrote the Phase I report, from which much of the Methods section for this report is taken. We appreciate all that he did to establish, structure and organize the project.

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EXECUTIVE SUMMARY

The ***Comprehensive Statewide Wetlands Classification and Characterization*** (CSWCC) project is a three-year effort of the Colorado Natural Heritage Program (CNHP), in partnership with Colorado State University, and the Colorado Department of Natural Resources, Division of Wildlife (DOW) Wetlands Program to integrate previously collected data and develop a floristic classification for the wetlands of Colorado. Floristic classification and characterization of wetland types is an important step toward understanding the nature and dynamics of Colorado wetlands. It is an essential tool to help meet DOW Wetland Program goals for protecting wetland habitat and wetland-dependent wildlife. It also establishes a basis for focusing wetland research, land management, and conservation efforts where they will be most effective and beneficial.

The first phase of this project (1999-2000) integrated previously collected data, especially from the CNHP Statewide Riparian Classification (Kittel et al.1999a), CNHP wetland inventories (1995-present), and Colorado State University (Dr. David Cooper) and grouped over 4,500 stands by hydrogeomorphic class and subclass (Hupalo et al. 2000).

The second phase of the project (2000-01) defined plant associations within each of the hydrogeomorphic (HGM) subclasses (Colorado Geologic Survey et al. 1998) and classified them according to the National Vegetation Classification System (USNVC). Expanding on the *Classification of Riparian Wetland Plant Associations of Colorado* of Kittel et al. (1999), the second phase identifed and described wetland plant associations that occur outside riparian areas. The CSWCC includes both native and non-native vegetation from near- pristine sites and sites that have been altered by natural or anthropogenic disturbances.

In the third and final phase of the project (2001-2003) the results of the classification were compiled for public distribution in the form of a printed field guide to the wetland and riparian plant associations of Colorado and an accompanying CD-ROM which includes new or updated descriptions (Community Characterization Abstracts) for all described associations, as well as a user-friendly database of all plot data used in the classification.

One hundred and eighty-four plant associations in four HGM classes (Depressional, Flats, Riverine and Slope) and ten HGM subclasses (D1, D2/3, D4/5, F1, S1/2, S3/4, R1, R2, R3/4, R5) are described in the field guide. Fourty-four of the 184 associations included in the guide are newly described since the work of Kittel et al. (1999). Associations are arranged into forest, woodland, shrubland, and herbaceous types. Each plant association is ranked and prioritized in terms of imperilment and biodiversity significance with global and state ranks when available. The guide includes a dichotomous key which helps users to identify plant associations in the field.

This report also includes tables of associations by HGM group and a list of undescribed associations.

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INTRODUCTION

A critical first step in understanding and defining the nature and dynamics of habitats across the landscape is cataloging and describing types. In order to manage, restore and protect Colorado wetlands adequately, we must know which types exist, their functions and attributes, relative frequency or rarity, and distribution across the landscape. This information is crucial to efforts to prioritize allocation of limited conservation resources. Information collected for this classification indicates that between one-third and one-half of Colorado flora occurs in wetland and riparian habitats. Preventing the loss of this valuable biodiversity is critical, particularly in the arid western United States (Dahl 2000).

The U.S. Environmental Protection Agency (EPA), pursuant to section 104 (b)(3) of the Clean Water Act, has funded projects to assess, map, characterize and classify wetland and riparian habitats in Colorado in order to improve the management of Colorado wetland resources. One of those projects, the Statewide Wetlands Strategy, is a collaborative venture among the Colorado Department of Natural Resources Division of Wildlife (DOW), EPA Region VIII, and the Colorado Natural Heritage Program (CNHP) to provide a strategy for wetlands protection and to ensure the quality of life for Coloradans. As part of the Statewide Wetlands Strategy, this classification is intended to be a tool for community-based conservation and protection of Colorado wetlands and associated biodiversity.

In 1999, CNHP, in partnership with the Colorado Department of Natural Resources DOW Wetlands Program, initiated the Statewide Wetlands Classification and Characterization project (CSWCC) as a key component of the on-going effort to define a Statewide Wetlands Strategy model for Colorado. The CSWCC project was developed with advice from a Wetlands Task Force convened by CNHP in April 1999. Attendees included representatives of federal, state, county, and city agencies and academia (Hupalo et al. 2000). This classification is an extension of research conducted by wetland scientists over the past twenty years. That work is integrated here, and new analyses are presented.

The CSWCC was a three-phase project designed to develop a tool for community-based conservation and protection of Colorado wetlands and associated biodiversity. The three phases are described below.

1. Phase I (1999-2000)
    a. Collect and synthesize existing wetland data (4,511 plots).
    b. Identify data gaps and begin collection of data from underrepresented wetland types.
    c. Stratify the entire dataset into nine hydrogeomorphic (HGM) subclasses, based on hydrogeomorphic classification developed by David Cooper in 1998 (Colorado Geologic Survey et al. 1998, Hupalo et al. 2000).

2. Phase II (2000-2001)
    a. Classifiy wetland vegetation according to the Unites States National Vegetation Classification System (USNVC) standard.
    b. Identify plant associations within ten hydrogeomorphic (HGM) subclasses.
    c. Begin to compile or revise existing plant association descriptions (community characterization abstracts) with known ecological and environmental data.

3. Phase III (2001-2003)
    a. Complete the characterization of the wetland plant associations.
    b. Rank and prioritize wetland plant associations in terms of imperilment and biodiversity significance according to the USNVC.
    c. Complete revision of existing descriptions (community characterization abstracts) for previously identified associations and complete abstracts for newly described associations.
    d. Identify associations for which data is still lacking.
    e. Produce a key and field guide to wetland types.

Vegetation Classification Methods: The US National Vegetation Classification System (USNVC)

The CSWCC follows the format of the USNVC (Anderson et al. 1998), the accepted national standard for all federal agencies (Maybury 1999). The USNVC: 1) is vegetation-based, 2) uses a systematic approach, 3) emphasizes natural vegetation, 4) emphasizes existing vegetation, 5) uses a combined physiognomic-floristic hierarchy, identifying vegetation units at scales practical for conservation, and 6) is appropriate for mapping at multiple scales (Grossman et al. 1998). The upper levels of the USNVC (beginning with the most inclusive) including class, subclass, group, subgroup and formation are physiognomic, based on growth form characteristics and environmental factors. The lowest levels, alliance and association, are floristic, based on dominant or diagnostic species names. The association is considered the basic unit for vegetation classification, and is the focus of this project.
(These syntaxa, e.g. alliance, are not used in accordance with the same terms in the Braun-Blanquet system or other vegetation classification schemes used around the world.)

Although the terms plant association and community have been described by numerous ecologists, no general consensus of their meaning has developed. The terms are similar, somewhat overlapping, and are often used more or less interchangeably. The USNVC defines a community as an "assemblage of species that co-occur in defined areas at certain times and that have the potential to interact with one another" (The Nature Conservancy 1999), and a plant association as a type of plant community with "definite floristic composition, uniform habitat conditions, and uniform physiognomy" (Flahault and Schroter 1910).

Vegetation classifications are necessary simplifications of the natural world, developed to facilitate understanding, planning, management, and conservation. Classifications of wetlands can be based on factors (e.g., vegetation, hydrology, landform) that are used either singly or jointly. Single factor classification systems, such as those based on vegetation, are generally easier to develop since less information is required, characteristics are less complex, and they can be tailored to specific objectives (Anderson et al. 1998). Vegetation is often chosen as the basis of a single factor system for classifying ecological systems because it generally integrates the ecological processes operating on a site or landscape more reliably and visibly than any other factor or set of factors (Mueller-Dumbois and Ellenberg 1974); (Kimmins 1997).

Characterizing and tracking communities provides many potential benefits to conservation. Ecological communities represent unique sets of natural interactions among species and their environment (Costanza R./d'Arge 1997), (Daily 1997). Community description and classification can be important tools for systematically characterizing the current pattern and condition of ecosystems and landscapes (Grossman 1998). By protecting communities, many species not generally targeted for conservation, including those from poorly known groups such as bryophytes and invertebrates, are protected. Change over time may be more efficiently monitored in communities than in component species. Changes may be detected by monitoring composition (changes in species abundance, richness, proportions of endemics or exotics), structure (canopy features), and function (productivity, nutrient cycling, and patch dynamics) (Noss 1990), (Max 1996). Community classification also provides the basis for monitoring by providing a systematic means to break the landscape continuum into recognizable units.

The Nature Conservancy and the Natural Heritage Program Network, including CNHP, use a coarse filter/fine filter approach to prioritize management and conservation efforts (The Nature Conservancy 1996). This approach involves identification and protection of plant communities (coarse filter) and rare species (fine filter). Identifying and protecting representative examples of plant communities ensures conservation of a greater number of species, biotic interactions, and ecological processes. Using communities as a coarse filter has ensured that conservation efforts are working to protect a more complete spectrum of biological diversity.

This project followed the quantitative analysis methods for classification suggested in Grossman et al. 1998. Data were stratified by hydrogeomorphic type. Ordination and cluster analysis were used to summarize the data in major groups. The summary also included the exploration of vegetation-environment relationships where such data were available. Tabular analysis was used to assign samples to plant associations. This process resulted in a floristic classification of Colorado wetland communities.

Wetland definitions

The CSWCC follows the U.S. Fish and Wildlife Service (USFWS) definition of wetlands (Cowardin et al. 1979). According to that definition 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." USFWS-defined wetlands must have *one or more* of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (wetland plants); (2) the substrate is predominantly undrained hydric soil; and/or (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. The U. S. Army Corps of Engineers definition (US Army Corps of Engineers 1987), developed to define "jurisdictional" wetlands for the Clean Water Act permitting process, requires that a site have all three wetland attributes (vegetation, soil, and hydrology) to be classified as a jurisdictional wetland.

For this classification, we use the USFWS definition because it recognizes that not all wetlands are "jurisdictional" wetlands. Riparian areas in particular often do not meet all three of the wetland criteria, but should be included in wetland classification and conservation programs. Riparian areas perform many of the same functions as do wetlands, including maintenance of water quality, storage of floodwaters, and enhancement of biodiversity, especially in the western United States (National Research Council 1995).

Previous wetland and riparian classification work in Colorado

Researchers using a variety of methodologies have conducted wetland studies in scattered areas throughout Colorado and neighboring states (see summary in Kittel et al. 1999a). Dr. David Cooper has collected wetland plot data and classified wetland plant associations throughout the state for more than 15 years and contributed much of the data used for the CSWCC. Since 1994, CNHP, in cooperation with the DOW Wetlands Program, has systematically inventoried wetlands within Larimer, Routt, Summit, portions of Park, Pueblo, El Paso, Mesa, and Garfield, Rio Grande, and Conejos counties, as well as wetlands in broader watershed areas such as the San Luis Valley (Saguache and northern Alamosa counties) and the Uncompahgre River Basin (eastern Montrose and Ouray counties). Sanderson and Kettler (1996) produced a preliminary wetland vegetation classification for a portion of Colorado's western slope (based on 152 plots). Kittel et al. (1999a) completed a separate classification for riparian wetland plant associations of all major drainage basins, two National Forests, and one National Grassland. Kittel and others (1999a). analyzed research data by drainage basin rather than on a statewide basis; the report includes summaries for each basin.

Although wetlands have been studied in Colorado for many years, there has been no systematic inventory or comprehensive classification. In the absence of a comprehensive classification of Colorado wetlands, the CSWCC builds on previous studies and inventories of riparian and wetland plant associations in the state, especially those of Cooper and Kittel. Cooper has identified, described, and classified all wetland types of several regions or local areas of the state. His descriptions and classifications provide valuable resources for regional and local planners as well as conservation organizations. Kittel's (1999a) focus was on riparian sites that were "relatively undisturbed by human activity, thereby limiting the classification to plant associations native to Colorado" with the hope that these areas would serve as reference areas for management and restoration activities, as well as potential sites for land conservation.

The CSWCC is comprehensive in the sense of considering pristine and disturbed, riparian and non-riparian wetlands, and wetlands dominated by native and non-native plants. The CSWCC, however, must be considered preliminary. Although this project combines an unprecedented quantity of data from previous studies into a single, statewide classification, it should not be considered a final description of Colorado wetlands. The datasets used here do not constitute a comprehensive sample of Colorado geography or ecology. It is clear that many Colorado wetland types and localities still have not been adequately sampled. As a consequence, there are probably many plant associations that have yet to be described. In addition, some of the associations listed here will require further refinement and reclassification in order to accurately and completely describe Colorado wetlands. Therefore, this classification should be updated as more information becomes available.

STUDY AREA

The state of Colorado forms a nearly perfect rectangle, roughly between 37° and 41° north latitude and 102° and 109° west longitude. The boundaries encompass 104,247 square miles (over 66.7 million acres or 27 million hectares) of plains, foothills, mountains, plateaus and canyons. Colorado's average elevation is 6,800 feet (2,073 m). The lowest point is 3,315 feet (1,011 m) on the Arikaree River at the Kansas border, and the highest point is Mt. Elbert at 14,431 feet (4,400 m)(Colorado State Archives 2001).

Geology and geomorphology

The following description of the geologic history of Colorado is adapted from: Benedict 1991, Mutel and Emerick 1984, and Tweto 1979. The modern landforms of Colorado are the result of millions of years of geologic processes. The products of both gradual and cataclysmic events are evident throughout the state. Colorado's oldest rocks, the Precambrian "basement" of metamorphic gneiss and schist, represent the base of long-vanished mountain ranges. Igneous intrusives such as granite and gabbro are visible in northern and central parts of Colorado. Following the Precambrian, mountain building ceased and erosion was widespread. As a result, rocks from certain geologic time periods are scarce in Colorado. The only period completely missing from the geologic record is the Silurian (410-440 million years ago). The upper Precambrian erosional surface in Colorado is generally overlain by much younger sediments.

Paleozoic era geology in Colorado is represented primarily by sedimentary formations, now exposed throughout the central and western portions of the state. Some 300 million years ago during the Pennsylvanian period, renewed tectonic activity leading to the rise of the Ancestral Rocky Mountains produced block-fault mountains and adjacent basin subsidence. Basin-deposited sediments of this period include extensive "red beds" such as the Boulder Flatirons. By the end of the Paleozoic, the Ancestral Rocky Mountains had been almost completely buried in their own erosional debris.

Beginning approximately 230 million years ago, the gradual breakup of the supercontinent of Pangaea led to renewed mountain building and the cyclic advance and retreat of inland seas. Sedimentary deposits of alluvial plains, sand dunes and both shallow and deep marine environments from this time are found throughout Colorado. The Cretaceous Pierre and Mancos formations in particular are widespread in the eastern and western non-mountain areas. Toward the end of the Mesozoic, some 70 million years ago, the Laramide Orogeny began the uplift that would result in the formation of the Southern Rocky Mountains.

Most of Colorado's current mountain ranges and drainages are a result of geologic activity during the Tertiary period, which began about 65 million years ago. The early or Paleocene part of the period witnessed the continued uplift of the Rocky Mountains as a result of the Laramide Orogeny, the emplacement of large igneous intrusions in what would become the Colorado Mineral Belt, as well as continued erosion and basin development. As Laramide activity subsided, the uplifted surface continued to erode, and extensive volcanic activity shaped the southern mountains. As the Tertiary period drew to a close, regional uplift accompanied by erosion and canyon cutting by rivers continued, and the Rio Grande Rift developed. In the last two million years, glacial cycles of the Quaternary period have further sculpted the landscape of the Southern Rocky Mountains through erosion and wind-borne deposits.

Much of Colorado falls into three primary physiographic regions: the Great Plains, Southern Rocky Mountains, and Colorado Plateau. The eastern forty percent of the state belongs to the Great Plains region, characterized by flat, high plains and rolling grasslands, rising gradually to the west to meet the foothills of the Southern Rocky Mountain ranges. The level plains are occasionally interrupted by buttes, escarpments, and larger remnants of the Eocene high plains surface, while in the southwest parts of the region, mesas and buttes of volcanic origin mark the border with New Mexico. Stretching from the mountain foothills to the high plains escarpment between Denver and Greeley, the Colorado piedmont has been extensively eroded by the South Platte River. The highland of the Palmer Divide south of Denver separates the South Platte drainage from the other major prairie river, the Arkansas. Where the Great Plains meet the mountain front, tilted sedimentary beds form a series of hogbacks and ridges, and in the northern part of state, the mountains beyond rise quickly to the continental divide. Surface geology is largely sedimentary rocks and unconsolidated deposits including Quaternary eolian dune fields and loess, Tertiary sandstones and basalt fields, and Cretaceous shales and limestones.

The central mountainous portion of Colorado is part of the Southern Rocky Mountain region and contains a complex group of fairly well defined ranges, with more than fifty peaks greater than 14,000 feet (4,268 m) in elevation. Here the Continental Divide traces a winding path through west central Colorado, separating the state into eastern and western slopes. The northern end of the Rio Grande Rift cuts through the Southern Rocky Mountains, creating a series of large intermountain valleys. The Southern Rocky Mountains include the oldest rocks in the state, as well as extensive volcanic and sedimentary features, and are the result of alternating periods of mountain uplift and erosion during the past several hundred million years. Much of the topography we see today was formed within the last 70 million years by the most recent episodes of uplift, volcanism, erosion, and sedimentation. Mountain terrain above about 8,500 feet (2,591 m) has also been shaped by glacial activity of the past two million years.

The western-most portions of the state in the Colorado Plateau region are characterized by high plateaus, wide valleys, and rugged canyons. The Colorado River and its tributaries have carved numerous scenic canyons through a variety of sedimentary formations. Elevations range from 5,000 feet to 10,000 feet (1,524 – 3,049 m). Major features of the region include the high elevation Uncompahgre Plateau, the basalt-capped Battlement Mesa and Grand Mesa, the eroded sandstone canyons of the Paradox and San Juan Basins, and the extensive Tertiary shales of the Piceance Basin and Roan Plateau. Extreme northwestern Colorado also includes a portion of the Wyoming Basin region where ancient tributaries of the Yampa River have deeply dissected much of the high elevation terrain.

Climate

Elevation and topography are major factors influencing climate in Colorado. The climate is generally dry, due in part to the mid-latitude position in the continental interior. Annual precipitation in Colorado ranges from eight inches to over 60 inches (20 – 152 cm) with a statewide average of around 17 inches (43cm) (Daly and Taylor 1998). The San Luis Valley is the driest area of the state; areas receiving the most precipitation are the higher elevations of the Front Range, Park Range, West Elk, and San Juan Mountains. There are several different patterns of annual precipitation influencing the development of native vegetation. The eastern plains area tends to receive the majority of precipitation in the spring. The northern mountains have the heaviest precipitation in the winter months. For the southern mountains, the monsoons of late summer also provide a large portion of annual precipitation. Much of the remainder of the state lacks a dominant precipitation season.

Hydrology

Six major rivers have headwaters in the mountains of Colorado. On the western slope, the Colorado River and the major tributaries the White, Yampa, Gunnison, Dolores and San Juan flow toward the Gulf of California. On the eastern slope, the North Platte, South Platte, Arkansas, and Republican rivers are part of the Mississippi drainage which, with the Rio Grande River, eventually empties into the Gulf of Mexico.

All or part of four major aquifer systems are present in Colorado: the Colorado Plateau, Rio Grande, High Plains, and Denver Basin. Precipitation falling on the land surface in Colorado either flows directly into streams and rivers as runoff, or infiltrates the soil and underlying aquifers and moves laterally to discharge into rivers and streams as baseflow. Surficial aquifers occur primarily at shallow depth in unconsolidated sediments along parts of major river valleys. With the exception of the South Platte and Arkansas River drainages, individual stream-valley aquifers are usually small and unconnected to aquifers in other valleys or to distant aquifers in the same valley. Only in the valleys of eastern Colorado are the aquifers large and continuous enough to form a major aquifer. For a detailed description of the hydrology of Colorado, see the U. S. Geologic Survey Ground Water Atlas of the United States for Arizona, Colorado, New Mexico and Utah (Robson and Banta 1995).

Although there are few large natural lakes in Colorado, there are numerous small bodies of water in mountain areas. Many small natural lakes have been augmented by dams or diversions. Reservoirs and irrigation ditches are also common, especially on the eastern plains and in the San Luis Valley. Streams originating in the Southern Rockies usually flow year-round. Lower order streams in the non-mountainous areas of the state are often intermittent, flowing only during spring snowmelt or with local direct run-off.

On the predominantly dry eastern plains, wetlands occur along drainages and in shallow depressions with at least periodically wet soils. Most naturally-occurring wetlands are in the Southern Rocky Mountain region where higher precipitation and varied geomorphology support a wide variety of wetlands on slopes, in ponds and shallow depressions, and along streams. The often saline or alkaline wetlands of the western plateaus and canyons occur along river terraces and floodplains, or in a variety of seeps, springs, and marshes.

Vegetation

The eastern plains are dominated by grasslands, primarily shortgrass prairie. Especially in the northern plains, many native grasslands have been replaced by cereal crops. Large areas of stabilized sand dunes support shrubby grasslands. Trees are fairly rare on the plains, and in pre-settlement times would have been confined to riparian corridors, mesic draws, and higher buttes. The highly variable topography of the Southern Rocky Mountains supports a diversity of vegetation. Mountainous areas are chiefly characterized by coniferous woodlands and forests of ponderosa pine, Douglas-fir, Englemann spruce, and subalpine fir, interspersed with stands of aspen, grasslands and meadows, and mountain shrublands. The highest elevations are dominated by a variety of alpine tundra communities. The western plateaus and canyons are characterized by shrublands of sagebrush and saltbush. Bunchgrass grasslands and piñon-juniper woodlands are also common.

Land ownership, management and uses

More than 27 million acres (10.9 million hectares, or approximately 40%) of the 66.7 million acres within Colorado borders are in public ownership (Colorado GAP Project 1993). Public lands are concentrated in the western half of the state. Primary land managers for public lands in Colorado are the USDA Forest Service, administering more than 14 million acres (5.7 million hectares), the U. S. Bureau of Land Management administering more than eight million acres (3.2 million hectares), and the State of Colorado, with more than three million acres (1.2 million hectares) (Colorado GAP Project 1993). Throughout Colorado, valley bottoms and riparian areas are likely to be privately owned except at higher elevations.

The availability of water is often the driving factor in determining land use. Most relatively flat areas in the state are used for agriculture. The Great Plains are dominated by dry and irrigated farming and livestock grazing. In the mountains and western plateaus ranching, mining, timber harvest, and irrigated crops in valleys are common land uses.

CLASSIFICATION METHODS

Data sources and preparation

This classification is based on floristic data from samples collected in 4,527 vegetation stands throughout Colorado (Appendix A). All researchers who contributed data had the common goal of sampling homogenous stands of vegetation for the purpose of community classification. However, the scope of sampling and sampling methodology varied between researchers. Studies ranged from extensive inventories of primary watersheds to intensive studies of particular wetland complexes, and plot size and species abundance scales differed among studies. Although the lack of standardized field methods may contribute to unexplainable variation in the data, the additional error is an acceptable trade-off for the greatly increased representation of vegetation samples.

Taxa not identified to species were removed from the dataset. Each species was assigned a unique code. Species nomenclature (with the exception of willows) follows Kartesz (Kartesz and Kartesz 1980), as reported and updated in the PLANTS database (U.S.D.A. NRCS). The nomenclature of willows follows (Dorn 1997). The binomial names are cross-referenced in the database to the nomenclature of the regional floras (Weber and Wittman 1996; Weber and Wittmann 1996; Weber and Wittmann 1996; Weber and Wittman 1996). In some cases, common names are regionally recognized names rather than Kartesz and Kartesz names.

The final combined data matrix was 4,527 sampling units by 1,269 species. Species abundance is represented by percent cover, ranging from zero to 100 percent. Accidental species, defined as species occurring in only one sampling unit and having a cover value of less than ten percent, were considered ecological noise and were removed from the data prior to analyses. This strategy avoided removing species that were rare but contributed significant cover in at least one sampling unit, this type of outlier may constitute unusual associations and were inspected in subsequent analyses.

A relational database (Access 97 Relational Database) was created to relate the stand data to environmental data (e.g. elevation) and to provide summary statistics. This database was used to generate datasets for analyses.

Treatment of large datasets

Large datasets are usually heterogeneous if they represent large geographic areas or many types of vegetation. In such cases, treatment of all the data in a single ordination or in classification can be ineffective since many calculations would be based on sampling units sharing no species (Van der Maarel et al. 1987). It is not always apparent which hierarchical clustering or ordination program options provide optimum (ecologically interpretable) results when dealing with thousands of sampling units (Van der Maarel et al. 1987). Local communities, represented by a small number of sampling units, may be masked by the greater variation occurring across a geographic region (Van der Maarel et al. 1987).

With large sets of floristic data, it is often necessary to break the analysis into several stages to produce satisfactory results (Kent and Coker 1992). Van der Maarel et al. (1987) suggest stratification prior to ordination or hierarchical clustering of large datasets to increase interpretability of the results. They suggest two ways of stratifying datasets. If clear local subsets of large heterogeneous areas exist, they can be used as grouping units. Allen and Peet (1990). Alternatively, if all or most of the plant communities of an area are included, samples may be grouped by vegetation type. In some circumstances, another alternative to stratification is to sub-sample the data to produce an initial classification and allocate the remaining sampling units to these groups (Kent and Coker 1992).

For this classification, a variation of the first approach was used. The dependence of wetland types upon hydrologic regime and geomorphic setting and processes suggested the use of hydrogeomorphic (HGM) classes as a means of stratification. A framework of regional hydrogeomorphic subclasses proposed by Cooper (Colorado Geologic Survey et al. 1998) was used for data stratification. The HGM approach focuses on geomorphic, physical, and chemical features of wetland ecosystems, and acknowledges that plant communities are often indicative of the hydrogeomorphic forces affecting an ecosystem (Brinson 1993).

HGM as a basis for stratification

As part of a multi-discipline collaboration to characterize wetlands of Colorado, Cooper (Colorado Geologic Survey et al. 1998) investigated the relationship between hydrogeomorphic attributes and the wetland vegetation of Colorado. His work synthesized environmental data derived from field data sheets and various USGS resource maps, based on location, for 3,625 sampling units within Colorado. The variables coarsely described elevation, latitude, longitude, soil texture, soil organic content, channel gradient, type of bedrock, surficial geology, stream order, inundation frequency, soil moisture, water source, and hydrologic disturbance.

The environmental and floristic datasets were analyzed together using the direct gradient analysis technique of Canonical Correspondence Analysis (CCA) (ter Braak 1986). CCA results in the simultaneous ordination of samples and species in the same space, as well as allowing the direct plotting of the environmental variables as vectors in the ordination diagram. Because this technique requires that ordination axes be expressed in terms of the environmental variables used, meaningful interpretation of CCA plots depends upon the assumption that those environmental variables included are, in fact, ecologically important. For a useful discussion of Correspondence Analysis methods see Palmer 1993.

Cooper concluded that the first axis represented a gradient from high elevation, glaciated landscapes and peat soils to coarse-textured soils, alluvial landscapes with high stream order. The second axis was interpreted as an inundation duration gradient. This work resulted in the definition of 15 preliminary HGM subclasses in four classes (River, Slope, Depression, and Flat) and common or diagnostic plant species for each subclass (Table 1). The 99 plant species associated with the HGM subclasses formed the basis for stratifying the sampling units (Appendix B).

Table 1. Preliminary HGM subclasses as described by Cooper (Colorado Geologic Survey et al. 1998).

HGM Subclass	Description	Common Species
Depressional 1	Mid-to-high elevation basins with peat soils and lake fringes with or without peat soils.	*Carex utriculata*
Depressional 2	Permanently or semi-permanently flooded low elevation basins, including reservoir and pond margin wetlands as well as marshes.	*Typha* spp., *Scirpus* spp.
Depressional 3	Seasonally flooded low elevation basins that are dry for long periods.	*Eleocharis palustris*
Depressional 4	Temporarily flooded low elevation basins flooded for short periods in the spring and early summer.	*Polygonum lapathifolium*
Depressional 5	Intermittently flooded low elevation basins that are not flooded annually or are largely barren of vegetation.	*Xanthium strumarium*
Flats 1	Middle to low elevation sites on mineral saline soil (due to evaporation) with a seasonal high water table near the ground surface and occasionally shallow standing water.	*Suaeda calceoliformis, Puccinellia nuttalliana, Sarcobatus vermiculatus*
Riverine 1	Steep gradient low order streams and springs on coarse-textured substrate. Very common in the subalpine zone.	*Mertensia ciliata, Senecio triangularis, Glyceria striata*
Riverine 2	Moderate gradient, low to middle order streams on coarse and fine-textured substrates. Typically dominated by willow thickets and may contain beaver pond complexes.	Salix *monticola, Salix boothii, Heracleum maximum*
Riverine 3	Moderate gradient, middle elevation reaches of small and mid-order streams.	*Picea pungens, Populus angustifolia, Alnus incana* ssp. *tenuifolia*
Riverine 4	Stream reaches on larger rivers in low elevation canyons in the foothills and plateaus. Generally steep gradient and coarse soils.	*Acer negundo* var. *interius*
Riverine 5	Low elevation floodplains on mid-to-high order streams with fine-textured substrate and usually a perennial flow.	*Populus deltoides, Salix amygdaloides*
Slope 1	Alpine and subalpine fens and wet meadows on saturated non-calcareous substrates.	*Carex aquatilis* var. *stans, Carex scopulorum*
Slope 2	Subalpine and montane fens and wet meadows on saturated calcareous substrates.	*Eleocharis quinqueflora, Kobresia simpliciuscula, Carex simulata*
Slope 3	Wet meadows at middle elevations in the mountain ecoregion with a seasonal high water table near the ground surface.	*Juncus balticus* var. *montanus*
Slope 4	Low elevation meadows with a seasonal high water table near the ground surface. May occur on floodplains or near springs.	*Carex nebrascensis*

Stratification: Methods for assignment of sampling units to HGM subclasses

Several HGM subclasses from Cooper's CCA analysis (Colorado Geologic Survey et al. 1998) were grouped to simplify the stratification of the comprehensive classification dataset. These were subclasses that had few diagnostic species, or cases where the subclass boundaries were not necessarily clear. The stratification framework is based on nine HGM subclasses, which stratifies the data into groups associated with nine broad ecological settings: Depressional 1, Depressional 2/3, Depressional 4/5, Flat 1, Riverine 1/2, Riverine 3/4, Riverine 5, Slope 1/2, and Slope 3/4. A combination of classification and ordination techniques was used to assign sampling units to the nine hydrogeomorphic subclasses representing the range of hydrogeomorphic conditions in wetlands of Colorado (Figure 1, page 15). Stratification was based on the 99 plant species Cooper (Colorado Geologic Survey et al.1998) reported as common or diagnostic of the HGM subclasses (Appendix B).

Cluster analysis was used to aggregate the sampling units into floristically similar groups. Indicator Species Analysis (ISA) (Dufrêne and Legendre 1997) was applied to the clustering results to identify species indicative of the clustering hierarchy. This information was in turn compared with the 99 characteristic species identified by Cooper (Colorado Geologic Survey et al. 1998) and allocations to the nine HGM groups were made accordingly.

Cluster analysis is a method of identifying groups of samples in a dataset. For this classification the groups are floristically similar assemblages of plots. The clustering method used works in an agglomerative manner, initially treating each sample unit as its own group, and proceeding to combine samples into larger and larger groups. This joining method produces a hierarchy of groups which contain smaller groups and are in turn part of larger groups.

Ward's method of minimum variance joining, as implemented in PC-ORD 4 (McCune and Mefford 1999) was used to cluster the sampling units. Euclidean distance, the default distance measure for Ward's method in PC-ORD, was used for the analysis. In this algorithm, joining is based on the two cluster groups whose fusion results in the smallest increase in variance, relative to the variances within each cluster taken separately (Ludwig and Reynolds 1988).

An output option of the clustering program provided a record of group membership for each sampling unit in the upper 200 levels of clustering. This information was then used to create the group membership matrix necessary for Indicator Species Analysis (ISA). Indicator Species Analysis was applied to only the first 90 levels of the clustering (see Hupalo et al. 2000 for further details).

Once group membership has been determined, the next step is to characterize the differences between groups in an ecologically meaningful way, such as by species composition. In order to assign the groups produced by the cluster analysis to the correct HGM subclasses, species characteristic of those groups must be identified. Indicator Species Analysis (Dufrêne and Legendre 1997) is a technique to identify the species or species assemblage that characterize a group of sampling units. The objective of ISA is to identify species that have high fidelity to a particular group and thus are good indicators of that group. A good indicator species occurs with high relative abundance and high frequency in its own group, and at the same time does not occur in other groups. The indicator species identified by ISA were used as an aid to assigning a group of plots to an HGM group with the same characteristic species.

ISA (McCune and Mefford 1999) was conducted on all clusters for each of the upper 90 levels of the cluster analysis, and mass assignments of sampling units to HGM subclasses were based on the results. Following the work of Dufrêne and Legendre (1997), species having an Indicator Value (IV) of 25 or greater and a p-value of 0.05 or less were retained. This selected species present in at least 50% of the sampling units in one subclass and with relative abundance in that subclass (average percent cover) of 50% or greater. Assignments were made by comparing (visually matching species names) the Indicator Species of a group at a given cluster level with the HGM subclass diagnostic and common species identified by CCA analysis in Cooper (Colorado Geologic Survey et al. 1998).

After the assignment of groups to HGM subclasses, the subclasses were inspected for obviously misclassified plots. These types of outliers are not necessarily poor data, but they may have an extreme influence on multivariate analyses. Misclassification may result from sampling units which cross ecotones and therefore have non-homogenous vegetation. Sampling units from semiaquatic communities (e.g. dominated by *Nuphar luteum* and some *Potamogeton* and

Sparganium species) or regionally isolated, monocultural species (*Carex vesicaria*) were also outliers. Some plots were permanently removed (poor sampling units) and others were temporarily removed (unusual communities) from the data. The stand composition of each questionable plot, or group of plots, was evaluated by querying the relational database. Then a decision was made to leave the sampling unit(s), move the sampling unit(s) to a different HGM subclass, or remove the sampling unit(s) from the dataset.

Verification: Assessing the effectiveness of stratification

Once groups have been identified, the next step is to determine their validity. Two questions are of interest: 1) Are the groups significantly different? and 2) if so, how are they different? In order to address the first question, the non-parametric Multi-response Permutation Procedure (MRPP) comparison test was used. This procedure gives an indication of how clumped the original groups are compared to arbitrary groups produced by reassigning the samples. To address the second question, Indicator Species Analysis was reapplied to the sampling units, now grouped by nine HGM subclasses. This was done to determine whether the new set of Indicator Species made sense from ecological and hydrogeomorphic points of view, had good separation between groups, and compared well with the characteristic species that Cooper (Colorado Geologic Survey et al. 1998) identified.

MRPP tests the hypothesis that samples within a group are clumped in multivariate space. This hypothesis is evaluated by reassigning the original group memberships (permutation), and calculating the degree to which the original group is more clumped than groups of randomly assigned samples. MRPP detects concentration within *a priori* groups, a similar purpose to the one-way analysis of variance *F* test, but with fewer statistical assumptions about the data (Zimmerman et al. 1985). The test was applied to the subclasses as an overall comparison, rather than as pair-wise comparisons. The test statistic “T” is a descriptor of the within-group homogeneity of the real data compared to the amount of homogeneity expected by chance, indicating the degree of separation between the groups.

MRPP was implemented in PC-ORD 4 (McCune and Mefford 1999), using rank transformed Sorensen distances. The Sorensen distance metric was chosen for MRPP because it retains more sensitivity in heterogeneous datasets and gives less weight to outliers, compared to Euclidean distance (McCune and Mefford 1999). A rank transformation was applied to help correct the loss of sensitivity of distance measures as community heterogeneity increases (McCune and Mefford 1999). Applying the test to rank transformed distances changes the null hypothesis from "average within-group distance no smaller than expected by chance" to "no difference in average within-group rank of distances" (McCune and Mefford 1999).

Indicator Species Analysis was used to evaluate the degree of separation of characteristic species between the individual HGM subclasses. Group membership was according to one of nine HGM subclasses (Subclass R1/2 was later divided, resulting in a total of ten subclasses). In some respects this provides more ecological insight than conducting pair-wise comparisons with MRPP and avoids Type I error and test power issues associated with non-independent multiple comparisons. If good separation existed between the nine groups, then a species maximum Indicator Value would be expected to be statistically significant and have a considerably higher value than in the other subclasses. Secondly, subclass Indicator Species should agree with the characteristic species of Cooper (Colorado Geologic Survey et al. 1998).

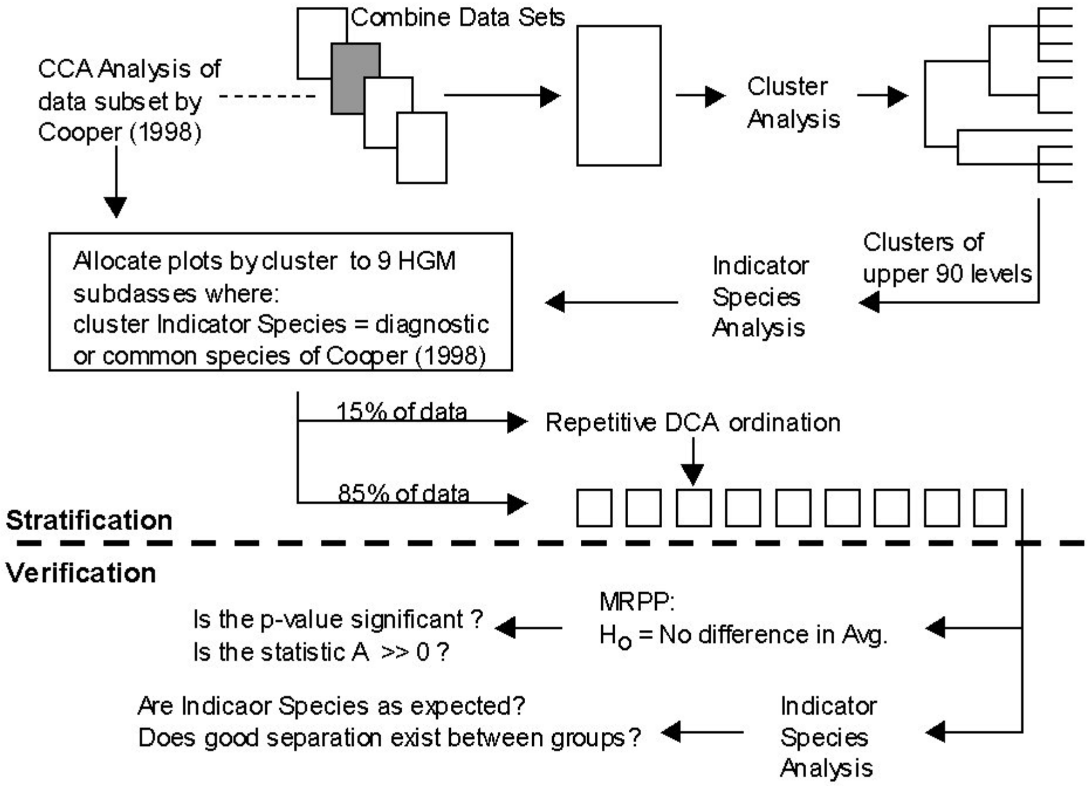

Figure 1. Outline of stratification and verification process.

Mass assignment of sampling units to HGM subclasses based on the ISA summary table resulted in the stratification of 80% of the sampling units. A second cluster analysis and ISA applied to the upper 15 levels of the cluster resulted in assignment of an additional 5% of the sampling units (see Figure 1).

The remaining 15% of unassigned sampling units were assigned based on repetitive ordination with DCA, following the example of Peet (1980). DCA revealed that the remaining sampling units were generally weedy and associated with alkaline flat and lower altitude riverine (R3, 4 and R5) subclasses. High beta diversity sometimes produced an undesirable arch effect in the ordination (Kent and Coker 1992). Because of the arch distortion, the composition of sampling units patterns was always inspected to avoid allocating dissimilar sampling units (from opposing tails of the arch). Less than 2% of the dataset remained unassigned to one of the nine subclasses following these ordinations. Unassigned sampling units, outliers, and sampling units from semi-aquatic communities were excluded from further analyses. Overall, 4,335 sampling units of the 4,527 sampling units were allocated to HGM subclasses.

Separate outlier analyses (chi-square and Sorensen distances) and DCA ordination was conducted on each HGM subclass as a final quality control on the stratification process. A small number (< 50 sampling units) of reallocations were made. These were cases where sampling units greatly influenced the ordination and were usually much more than two standard deviations from the group average distance using either distance measure.

The upper section of Table 2 shows the average within-group rank distance for each HGM subclass from the MRPP analysis. This statistic is a measure of the internal heterogeneity of the nine groups of sampling units. For example, the Depressional (1) subclass is comprised of species-poor stands dominated by *Carex utriculata*, reflected by the very low average distance for the group. The magnitude of the average within-group rank distances is related to the group heterogeneity, not necessarily sample size. For example, Flats 1 is one of the smaller groups but exhibits one of the higher amounts of internal variability, which supports Cooper's (Colorado Geologic Survey et al. 1998) assertion that the mineral soil flats subclass (Flats 1) should be subdivided when more data are available.

In addressing the question of whether the groups produced by the cluster analysis are different, the MRPP results reported in Table 2 indicate that the stratification was effective, in that overall the average within-group ranked distances were significantly different ($T = -1071.597$; $p \ll 0.001$). This is not surprising, given that the groups were largely defined by cluster analysis, a procedure which maximizes variability among groups and minimizes it within groups. With such a large sample size even a slight overall difference between groups should be detectable. It is of more interest to know whether the differences are ecologically significant, that is, to know which variables are accounting for among-group differences.

Table 3 lists all species from the analysis that had an Indicator Value greater than twenty percent and p-values < 0.05 in a Monte Carlo test of significance of the observed maximum IV, and the HGM subclasses to which they belong. The left section of Table 3 shows the HGM subclass and the maximum Indicator Value of each Indicator Species. The center section shows the Monte Carlo test results, based on 250 permutations with randomized data. The mean IV scores obtained from 250 calculations on randomized data provide a benchmark to compare with IV scores for the real (observed) data. The right section of the table shows the observed Indicator Values in each HGM subclass. The ISA shows there is a strong correspondence with the characteristic species that Cooper (Colorado Geologic Survey et al. 1998) delimited, and a large difference between a species maximum IV and the IV achieved in the other subclasses.

The species listed in Table 3 are ecologically explainable and their Indicator Values show good separation among the nine groups. Values greater than twenty percent (rather than the twenty-five percent stratification criterion) are given to better illustrate the characteristic plant assemblages. Figure 2 shows the location of the sampling units, coded by HGM subclass affiliation, that were used in the wetland community classification.

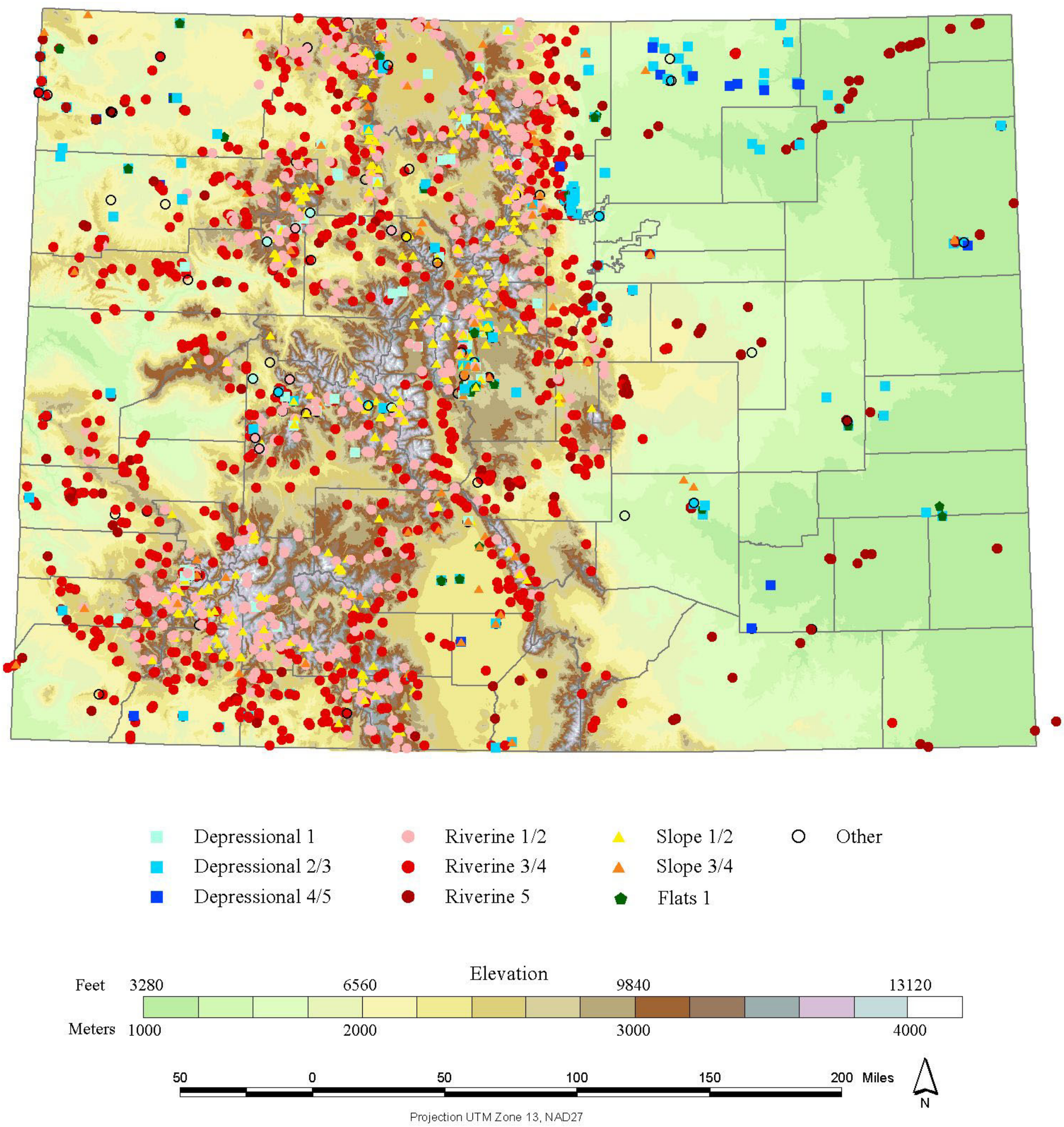

Figure 2. Map of Colorado showing sample plot locations by HGM subclass.

Table 2. MRPP statistics for rank transformed Sorensen distance matrix.

HGM Subclass	Avg. Ranked Distance	N
Depression 1	0.004	123
Riverine 1,2	0.203	775
Riverine 5	0.283	462
Slope 3,4	0.284	393
Riverine 3,4	0.311	1130
Slope 12	0.312	713
Flats 1	0.362	131
Depression 4,5	0.404	125
Depression 2,3	0.410	483
Test Statistic	**Value**	
Test statistic: T =	-1071.597	
Observed delta =	0.293	
Expected delta =	0.500	
Variance of delta =	3.73E-08	
Skewness of delta =	-0.269	
Chance-corrected within-group agreement, A =	0.414	
Probability of a smaller or equal delta, p <	1.00E-09	

Table 3. Indicator Species Analysis on HGM subclass membership.

Max observed Indicator Value (IV) by HGM subclass			IV stats for randomized groups 250 permutations			Number of sampling units and observed Indicator Value for each HGM Subclass								
						D 1	**D 2,3**	**D 4,5**	**F 1**	**R 1,2**	**R 3,4**	**R 5**	**S 1,2**	**S 3,4**
Spp ID	**Group**	**Max IV**	**Mean**	**S.Dev**	**p-value**	N= 123	483	125	131	775	1130	462	713	393
CARUTR	D 1	88	2.5	0.57	0.004	88	0	0	0	1	0	0	1	0
ELEPAL	D 2,3	41	2.3	0.61	0.004	0	41	3	0	0	0	0	0	0
SCHPUN	D 2,3	25	1.3	0.44	0.004	0	25	0	1	0	0	1	0	0
TYPLAT	D 2,3	24	1	0.37	0.004	0	24	0	0	0	0	0	0	0
ECHCRU	D 4,5	37	1	0.46	0.004	0	0	37	0	0	0	0	0	0
XANSTR	D 4,5	30	1.2	0.5	0.004	0	0	30	0	0	0	1	0	0
PERLAP	D 4,5	29	0.9	0.48	0.004	0	0	29	0	0	0	0	0	0
POLARE	D 4,5	26	0.6	0.32	0.004	0	0	26	0	0	0	0	0	0
DISSTR	F 1	55	1	0.38	0.004	0	0	0	55	0	0	0	0	0
PUCAIR	F 1	26	0.6	0.36	0.004	0	0	0	26	0	0	0	0	0
SALMON	R 1,2	39	2.7	0.56	0.004	0	0	0	0	39	1	0	1	0
MERCIL	R 1,2	39	3.3	0.64	0.004	0	0	0	0	39	3	0	3	0
CALCAN	R 1,2	33	3.3	0.68	0.004	0	0	0	0	33	2	0	4	0
CARCOR	R 1,2	32	2.9	0.64	0.004	0	0	0	0	32	1	0	4	0
SALDRU	R 1,2	26	1.9	0.47	0.004	0	0	0	0	26	2	0	0	0
PICENG	R 1,2	26	2	0.47	0.004	0	0	0	0	26	1	0	1	0
DISINV	R 1,2	22	2.5	0.56	0.004	0	0	0	0	22	9	0	0	0
SENTRI	R 1,2	22	2.5	0.65	0.004	0	0	0	0	22	1	0	6	0
HERSPH	R 1,2	22	2.8	0.67	0.004	0	0	0	0	22	12	0	0	0
ALNINC	R 3,4	37	2.7	0.55	0.004	0	0	0	0	3	37	0	0	0
POPANG	R 3,4	30	2.1	0.57	0.004	0	0	0	0	0	30	1	0	0
ROSWOO	R 3,4	30	2.7	0.61	0.004	0	0	0	0	1	30	2	0	0
MAISTE	R 3,4	24	2.6	0.66	0.004	0	0	0	0	5	23	0	0	0
SWISER	R 3,4	24	1.7	0.49	0.004	0	0	0	0	0	23	0	0	0
SALEXI	R 5	54	2.5	0.62	0.004	0	0	0	0	0	1	54	0	0
POPDEL	R 5	38	1.5	0.4	0.004	0	0	0	0	0	0	38	0	0
CARAQU	S 12	43	3.1	0.62	0.004	5	0	0	0	3	0	0	43	0
SALPLA	S 12	37	2	0.52	0.004	0	0	0	0	1	0	0	36	0
PSYLEP	S 12	35	2	0.52	0.004	0	0	0	0	1	0	0	35	0
PEDGRO	S 12	25	1.9	0.53	0.004	0	0	0	0	2	0	0	25	1
CLERHO	S 12	25	1.5	0.52	0.004	0	0	0	0	1	0	0	25	0
JUNARC	S 3,4	56	3.1	0.66	0.004	0	0	0	0	0	0	1	0	56
DESCES	S 3,4	23	2.7	0.68	0.004	0	0	0	0	1	0	0	9	23
ARGANS	S 3,4	21	1.2	0.39	0.004	0	0	0	0	0	0	0	0	21

From Hupalo et al. 2000. CARUTR - *Carex utriculata,* ELEPAL - *Eleocharis palustris,* SCHPUN - *Schoenoplectus pungens,* TYPLAT - *Typha latifolia,* ECHCRU - *Echinochloa crus-galli,* XANSTR - *Xanthium strumarium,* PERLAP - *Polygonum lapathifolium,* POLARE - *Polygonum arenastrum,* DISSTR - *Distichlis spicata,* PUCAIR - *Puccinellia nuttalliana,* SALMON - *Salix monticola,* MERCIL - *Mertensia ciliata,* CALCAN - *Calamagrostis canadensis,* CARCOR - *Cardamine cordifolia,* SALDRU - *Salix drummondiana,* PICENG - *Picea engelmannii,* DISINV - *Lonicera involucrata,* SENTRI - *Senecio triangularis,* HERSPH - *Heracleum maximum,* ALNINC - *Alnus incana ssp. tenuifolia,* POPANG - *Populus angustifolia,* ROSWOO - *Rosa woodsii,* MAISTE - *Maianthemum stellatum,* SWISER - *Cornus sericea ssp. sericea,* SALEXI - *Salix exigua,* POPDEL - *Populus deltoides,* CARAQU - *Carex aquatilis var. stans,* SALPAL - *Salix planifolia,* PSYLEP - *Caltha leptosepala ssp. leptosepala,* PEDGRO - *Pedicularis groenlandica,* CLERHO - *Rhodiola rhodanthum,* JUNARC - *Juncus arcticus,* DESCES - *Deschampsia cespitosa ssp. cespitosa,* ARGANS - *Argentina anserina.*

Tabular Analysis and identification of associations

Once samples had been allocated to HGM subgroups, tabular analysis was used to identify plant associations. Techniques were based on the procedures suggested by Mueller-Dombois and Ellenberg (1974) for classifying vegetation by tabular comparison. These methods, although dating from the days before high-speed computing, have the advantage of allowing an ecologist to examine and compare large amounts of raw data in a meaningful format, and subsequently to construct a detailed mental picture of the entire range of plant associations and variation present in the data.

For each HGM group, a raw data matrix was constructed from the database by importing the data in list form to PC-ORD, and saving the working matrix as a spreadsheet file. The total number of species in the matrix was restricted to 250 due to limitations of the spreadsheet program used (Microsoft Excel). For most groups, species occurring in fewer than five plots were omitted from the table.

The resulting data matrix, in spreadsheet form, was used to calculate the degree of constancy for each species. Both absolute constancy (number of plots in which the species occurs) and percent constancy (number of plots in which the species occurs/total number of plots) were calculated. The matrix could then be sorted by either of these scores.

Percent constancy was used to examine the data for differential species. Good differential species are generally those which occur in the mid-range of constancy (e.g. 10-60%), and are thus useful in differentiating between groups of plots. The selected range of species, together with plot identification information, was extracted to a new matrix. In this "partial table" species columns were rearranged (ordinated) to group species which have similar distribution among a series of plots together, giving a first approximation of community associations present in the HGM subgroup. The ordinated partial table was used in conjunction with expert knowledge of state and regional ecologists to assign samples to an association type.

Because some existing associations may be underrepresented in this dataset, the plots for which species had been omitted in order to fit the matrix into the spreadsheet were reexamined for possible relevance as distinct associations. Discussions with state and regional experts in wetland and riparian community types helped clarify the existence and extent of data gaps. The information was synthesized into the plant association descriptions presented in this report.

CLASSIFICATION RESULTS

Wetlands constitute only a small part of the landscape in the arid environment of Colorado. Yet they occur in a variety of forms, and their importance in maintaining natural diversity, wildlife, scenic beauty, and water quality is well-established (Cooper 1993, Sanderson and Kettler 1996, Windell et. al. 1986).

Wetlands are dynamic systems. They may change over time with changing environmental conditions. Wetland plant communities may transition into wetter open water communities or into drier upland communities. Although we may easily recognize wetlands, it is more difficult to assign a precise definition to the term wetland (see page 3). In general terms, wetlands are areas where saturation with water is the dominant factor governing soil development and determining the nature of the plants and animals that live in the soil and on the soil surface (Cowardin et al. 1979).

The seasonality of the water, the duration and depth of inundation, the water chemistry and source of the water supporting the wetland, and the vegetation and soil characteristics are some of the factors that influence wetland types. When conditions at a particular site change, the wetland changes as well. Under stable conditions, some wetlands may persist relatively unchanged for long periods (e.g. fens with peat soils more than 10,000 years old). In other types, natural dynamic processes such as flooding or successional processes such as in-filling of depressions, produce changes in wetlands over time.

Wetlands are also vulnerable to disturbance, degradation, or destruction when used for agriculture, water or other natural resource development, residential or road construction, or recreation. Dahl (2000) estimated that 50% of the wetlands in Colorado have been lost or degraded since 1980. Cooper (Colorado Geologic Survey et al. 1998) estimated that up to 90% of some wetland types may have been lost or degraded.

In Colorado, four main types of wetlands are commonly recognized: riparian lands, wet meadows, marshes, and peatlands (Jones and Cooper 1993, Colorado Geologic Survey et al. 1998). Landscape diversity, which is a result of regional and local variation in geologic substrate, geomorphology, elevation, and precipitation, creates conditions for a diversity of wetland types within these four categories. These types include seeps, springs, marshes, playas, fens, carrs, wet meadows, mineral flats, and streamside forests, woodlands, and shrublands.

This classification begins the effort to assimilate results of years of research to produce a comprehensive guide describing the variety of wetlands in Colorado, documenting distribution across the state, and evaluating relative natural heritage value. We identify plant associations by physiognomic group (forest, woodland, shrubland, herbaceous) and floristic composition according to the USNVC standard (Table 4, page 26). We also describe wetland types by hydrogeomorphic class and subclass based on hydrology, position on the landscape, and sustaining processes (Table 5, page 39). Many of the plant associations listed here were originally identified in earlier work, especially by Kittel et al. (1999a) and in numerous works by Cooper. This preliminary report focuses on major wetland plant associations, but also lists a number of provisional or potentially rare types that may occur.

A total of 184 major plant associations were identified. These associations are based on floristic data from samples collected in thousands of vegetation stands throughout Colorado. In spite of the large sample size, sampling efforts were not necessarily uniform across all habitat types of the state, and data gaps remain. For instance, aquatic plant associations are not included due to a lack of samples. A list of associations which are not described and which need further verification is presented in Table 6 (page 49), and there are undoubtedly additional types which have yet to be identified. In additon, many of the associations described may be further subdivided in the future.

Of the 184 plant associations presented here, 48 are listed as "unclassified." This means that they are legitimate associations, based on the number of sampled stands and the opinion of the authors, but that they are not yet listed in the USNVC classification. About half of the unclassified types were identified in Kittel et al. 1999a. Of the unclassified types identified in Kittel's riparian classification (1999a), most are forest or woodland types, a few are willow and other shrub types, and one is an herbaceous association. In contrast, most of the remaining unclassified associations (those not previously identified in the USNVC classification or Kittel's riparian classification) are herbaceous types. *Salix amygdaloides* is the only tree-dominated woodland type in this group. *Salix amygdaloides* has generally been considered part of *Populus deltoides* associations in Colorado. *Salix amygdaloides* associations are not common, but they do occur (five stands in our sample) and were probably more common in the past before exotic species and development altered their natural habitat. About one-fourth of the newly identified associations are dominated by exotic species, including *Tamarix ramosissima* (tamarisk or saltcedar), a common shrub or small tree in the R5 HGM subclass. Other exotic, dominant species include three forbs of drawdown zones or other disturbed areas around ponds (*Xanthium strumarium* (cockleburr), *Polygonum lapathifolia* (curly knotweed), and *Polygonum arenastrum* (oval-leaf knotweed), and one very common grass, *Agrostis gigantea* (redtop).

Wetlands by Hydrogeomorphic class and subclass

In 1998, as part of a multi-disciplinary effort (Colorado Geological Survey et al.), Cooper investigated the relationship between geomorphology, wetland vegetation, and wetland functions, and produced a first approximation of hydrogeomorphic classes and subclasses for Colorado wetlands. He described four hydrogeomorphic classes in Colorado: riverine, slope, depression, and mineral soil flats. Within a geographic region, HGM wetland classes are further subdivided into subclasses. A subclass includes all those wetlands that have essentially the same characteristics and perform the same functions. Riparian areas, loosely defined as streamside vegetation communities, may include depressional, slope, or mineral flats associations as well as riverine associations. Position on the landscape and the source of the water supporting the wetland are the critical factors distinguishing the four types. Table 5 lists plant associations by hydrogeomorphic (HGM) group.

We used the HGM system to stratify our original dataset, and below we present a review of our results by HGM class and subclass. The HGM classification groups wetland types that have similar characteristics and perform similar functions; it can be used to assist land managers to develop functional evaluations as well as to identify the wetlands under their jurisdiction. Class and subclass descriptions follow Cooper (Colorado Geologic Survey et al. 1998) and include information derived from the data analysis for this classification. The original stratification of the classification dataset combined several of Cooper's original 15 HGM subclasses into subclasses to simplify analysis (see Methods). During the process of identifying plant associations, we were able to separate one of the combined subclasses, R1/2 into the component R1 and R2 subclasses. Several subclasses are still combinations of Cooper's original set. For example, D2/3 combines the Depressional 2 and Depressional 3 subclasses. In general, and partly because indicator species were used to define HGM subclasses, most plant associations occur in only one subclass. However, there are several associations that occur in two or even three subclasses.

Mineral Soil Flats Wetlands

Mineral Soil Flats occur on relatively flat ground and are supported by precipitation and surface runoff.

Flats Subclass 1 (F1)

Cooper (1998) describes one Mineral Soil Flats subclass (F1), but suggests that this type may need to be divided when more data are available. Mineral soil flats occasionally have standing water and more frequently have a seasonally high water table. Soils are often saline due to evaporation of water containing high concentrations of dissolved solutes. Geomorphic setting includes flat sites or very shallow basins. In Colorado, mineral soil flats are especially common in South Park and the San Luis Valley, and are also found on the eastern plains, along the Front Range, in North Park, and at lower elevations on the Western Slope. Elevations of sampled stands range from 3,820 to 9,500 feet (1,160-2,900 meters). Twelve plant associations were identified in the Mineral Soil Flats subclass. All are dominated by native plant species that are tolerant of saline and alkaline soils.

Depressional Wetlands

We combined Cooper's five depressional subclasses into three groups: D1, D2/3, and D4/5. Depressional wetlands occur in shallow or deeper depressions and are supported by the water filling the depression.

Depressional Subclass 1 (D1)

Depressional wetlands in subclass 1 occur in mid-to-high elevation basins with peat soils and lake fringes with or without peat soils (Cooper 1998). Cooper also suggests that basin peatland and lake fringe types are functionally different and should be separated into different subclasses when sufficient data are available. CSWCC data included stands from the Front Range, South Park, the Park Range, and areas around Crested Butte and Telluride (6,880-10,400 feet, 2,097-3,170 m). We identified two seasonally flooded herbaceous wetland types in this subclass: *Carex utriculata,* and *Carex aquatilis-Carex utriculata.* The *Carex utriculata* type is by far the most common and widespread; the *Carex aquatilis-Carex utriculata* association is probably also common in the state but occurred in fewer than ten stands in our sample.

Depressional Subclasses 2 and 3 (D2/3)

Depressional wetlands in subclasses 2 and 3 are usually found at lower elevations and are permanently or semi-permanently flooded. The subclass includes reservoir and pond margins as well as marshes (Cooper 1998) and includes cattail, bulrush and other tall reed, sedge, grass, and rush-dominated herbaceous vegetation. We identified 16 plant associations in this subclass. All are herbaceous and able to tolerate saturated soils (seasonally, temporarily or semipermanently flooded). All but one (*Bidens cernua-Bidens frondosa)* of these associations are dominated by native graminoid species.

Depressional Subclasses 4 and 5 (D4/5)
Depressional wetlands in subclasses 4 and 5 occur in low elevation basins that are temporarily or intermittently flooded. Subclass 5 wetlands may be flooded very occasionally, sometimes only once every five to ten years as in the case of playa lakes. Perennial vegetation may be poorly developed and the depression bottom may be barren. This type may include abandoned beaver ponds, small irrigation ponds and playa lakes. They occurred between 4,500 and 8,000 feet (1,370-2,440 meters), but were uncommon above 7,500 feet (2,290 meters). We identified 13 plant associations in the Depressional 4/5 subclass. All are dominated by forbs or graminoids.

Slope Wetlands

We group Cooper's four subclasses of slope wetlands into two types here, S1/2 and S3/4. Slope wetlands occur on gentle to moderate slopes and are supported by groundwater.

Slope Subclasses 1 and 2 (S1/2)
Slope wetlands in subclass 1 are alpine and subalpine fens and wet meadows on non-calcareous substrates. Subclass 2 wetlands are subalpine and montane fens and wet meadows on calcareous substrates. Both types may be dominated by woody or herbaceous species and may have organic or mineral soils. Wetlands in slope subclass 1 are very common and widespread in mountainous regions of the state. Slope 2 wetlands are much less common and are known mainly from the meadows and fens in South Park. Wetlands in these two subclasses occurred in our dataset between 7,900 and 13,080 feet (2,400-3,990 meters). We identified 42 plant associations in these two subclasses. Two uncommon wetland types occur in this subclass: extreme rich fens and iron fens. Extreme rich fens currently are documented from South Park in Colorado (Cooper 1996, Sanderson and March 1996). The water supporting extreme rich fens is rich in calcium, magnesium, and other minerals and plant nutrients. Probably because of these unusual conditions, extreme rich fens in South Park support at least two rare plant communities, fourteen rare plants and nine rare invertebrates (Sanderson and March 1996). Iron fens occur in the Colorado mineral belt. Waters supporting these fens have high concentrations of iron and very acidic water. Only a limited suite of plants can grow in the acid conditions of these fens.

Slope Subclasses 3 and 4 (S3/4)
The Slope 3 subclass includes wet meadows at middle elevations in the mountains with a seasonally high water table and dominated by herbaceous plants. Slope 4 wetlands occur at lower elevations, but also have a seasonally high water table supporting herbaceous or occasionally shrub associations. They may occur on floodplains or at springs and may be supported by irrigation. They are widespread throughout the state. We identified 18 plant associations in the Slope 3/4 subclass, occurring between 3,950 and 12,300 feet (12,00-3,750 meters), although most were below 9,500 feet (2,900 meters). Most are seasonally or temporarily flooded and dominated by graminoid species. Two are temporarily flooded shrubland types.

Riverine Wetlands

Riverine wetlands occur along rivers and streams. Stream flow is the main source of water maintaining the riverine wetland vegetation. Riverine wetlands are important for flood control, maintaining water quality, stabilizing stream banks, and providing habitat for fish and other wildlife (Hansen et al. 1988, Brinson et al. 1981). Riparian areas are used extensively for domestic livestock grazing, gravel mining, recreation, transportation and residential development.

Riverine Subclass 1 (R1)
Wetlands in subclass R1 typically occur along steep-gradient, low-order streams and springs on coarse-textured substrate. They are especially common in the subalpine zone, but also occur on the plains (Cooper 1998). Stands used for this classification came from studies on the Front Range, from subalpine sites around Telluride and Crested Butte, from the alpine tundra of the central mountains, the Gunnison, Colorado, San Miguel, and Dolores river basins. A few stands were from South Park. Elevation of stands ranged from 7,700 to 12,000 feet (2,350-3,660 meters). Thirteen R1 plant associations were identified, mostly subalpine types. The vegetation at the headwaters of streams at lower elevations have received less attention.

Riverine Subclass 2 (R2)
Subclass R2 wetlands occur along middle elevation, moderate gradient, low- to mid- order streams on coarse and fine-textured substrates. They may contain beaver pond complexes. Preliminary analysis of this group identified 46 plant associations including coniferous and deciduous forests, shrublands, and herbaceous types. Stands occur between 6,100 and 12,300 feet (1,860-3,750 meters) but are most common between 7,500 and 11,000 feet (2,290-3,350 meters).

Riverine Subclasses 3 and 4 (R3/4)
Subclass R3 wetlands occur on middle elevation reaches of small and mid-order streams. They are often dominated by tall shrubs and trees. Subclass R4 wetlands occupy lower elevation canyons in the foothills and plateaus along larger rivers or small intermittent streams. Seventy-six plant associations were identified in these two combined subclasses. These wetland sites have coarser soils and steeper gradients than subclass R5.

Riverine Subclass 5 (R5)
Subclass R5 wetlands typically occur on low elevation floodplains of mid- to high-order streams with fine-textured substrate and usually perennial, but occasionally intermittent, flow. In this dataset, stands in this subclass occurred mostly on the eastern plains, along the Front Range, the Animas drainage, and along the lower Yampa River on the Western Slope. Associations in this subclass are most common below 7,000 feet (2,130 meters) but may occur up to 9,800 feet (2,990 meters). Thirty-four plant associations were identified in the R5 subclass. They are dominated by shrublands, grasslands or deciduous woodlands.

Further research needed

This project represents the first effort to establish a wetland classification for Colorado that includes all major wetland types found in the state. It includes both riparian and non-riparian wetlands as well as wetlands dominated by non-native plants. Colorado wetland types include riparian forests, woodlands, shrublands, and grasslands, emergent wetlands, wet meadows, fens, marshes, ephemeral pond and playa wetlands, hanging gardens, and seep and spring wetlands.

Because the data used in this classification were collected for a variety of projects and purposes, they do not constitute a uniform, random, or complete sample of the state's wetland diversity. In addition, although the dataset is large, it covers only a certain range of the habitats and geographic areas of the state. Many areas have not been surveyed and new wetland associations will likely be discovered when they are. As further information becomes available, it may become clear that some associations listed here need to be combined or divided.

A number of potential plant associations were identified on the basis of only one or two plots each (see Table 6 on page 49). Although these associations were uncommon in our dataset, many of them are expected to be more common across the landscape. Further investigation of these types should help clarify whether they are actually rare or merely have not yet been well documented.

We would like to alert the reader to a few types of wetlands that require further research for more complete description of their composition, function, and distribution in Colorado:

Playas: Shallow closed basins that are periodically or occasionally flooded.
Species composition of playas varies considerably among and within stands depending on seasonal precipitation and degree of inundation. Several potential playa associations have been identified, but further inventory is needed to fully describe and classify the full suite of playa associations. Many may fall into the *Pascopyrum smithii-Eleocharis* spp. association described briefly for Colorado and Wyoming (NatureServe 2002). A *Buchloe dactyloides-Ratibida tagetes-Ambrosia linearis* association has also been described from a very limited area of southeast Colorado (Doyle et al. 2001).

Hanging gardens: Communities found on cliff walls or alcoves.
One such association is described in this guide, the *Aquilegia micrantha-(Mimulus eastwoodiae)* Hanging Garden association. Nan Lederer (1994, unpublished paper for Colorado Natural Areas Program) described grotto associations at Castlewood Canyon State Park. In addition, Welsh (1989) has described hanging gardens from Utah. Another, the *Sullivantia hapemanii* var. *purpusii* association, occurs in western Colorado (CNHP 2002).

Alpine Wetlands:
A number of alpine wetland associations are described in this classification, primarily from the Colorado Front Range. Other alpine areas have been less systematically inventoried.

Floating and Submergent Wetlands:
Sanderson and Kettler (1996) and others have described some floating and submerged aquatic wetland associations. Our sample set did not include sufficient data to completely classify these types.

Finally, the HGM classes and subclasses for Colorado were identified recently and have been minimally tested, reviewed, and used by wetland scientists. Some subclass descriptions will need revision as more information becomes available. There is also a need to describe the functions performed by wetlands of the different HGM classes and subclasses. Some of the associations identified here were well documented in our data for one subclass, but also occurred in a few stands in other HGM subclasses. More work is needed to identify whether those associations actually belong in more than one subclass.

Table 4. Colorado Wetland Plant Associations by physiognomic group.

Only associations with an Elcode beginning with CEGL are classified by USNVC.

Forests

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL000255	Abies concolor - (Picea pungens) - Populus angustifolia / Acer glabrum Forest	White fir - (Blue spruce) - Narrowleaf cottonwood / Rocky Mountain maple	G2	S2	R3/4
CRFEXXXXX7	Abies lasiocarpa - Picea engelmannii - Populus angustifolia / Lonicera involucrata Forest	Subalpine fir - Engelmann spruce - Narrowleaf cottonwood / Twinberry honeysuckle Forest	G4	S3	R2, R3/4
CEGL000296	Abies lasiocarpa - Picea engelmannii / Alnus incana Forest	Subalpine fir - Engelmann spruce / Thinleaf alder Forest	G5	S5	R2, R3/4
CEGL000300	Abies lasiocarpa - Picea engelmannii / Calamagrostis canadensis Forest	Subalpine fir - Engelmann spruce / Bluejoint reedgrass Forest	G5	S3	R2
CRFCABLA0I	Abies lasiocarpa - Picea engelmannii / Carex aquatilis Forest	Subalpine fir - Engelmann spruce / Water sedge Forest	G4	S3	S1/2, R2
CRFFPIEN0A	Abies lasiocarpa - Picea engelmannii / Equisetum arvense Forest	Subalpine fir - Engelmann spruce / Field horsetail Forest	G4	S2	R2, R3/4
CEGL002663	Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Forest	Subalpine fir - Engelmann spruce / Tall fringed bluebells Forest	G5	S5	S1/2?, R2, R3/4
CEGL000331	Abies lasiocarpa - Picea engelmannii / Ribes spp. Forest	Subalpine fir - Engelmann spruce / Currant spp. Forest	G5	S3	R2, R3/4?
CEGL000327	Abies lasiocarpa - Picea engelmannii / Salix drummondiana Forest	Subalpine fir - Engelmann spruce / Drummond willow Forest	G5	S4	R2, R3/4
CWFDACNE2F	Acer negundo - Populus angustifolia / Celtis laevigata var. reticulata Forest	Boxelder - Narrowleaf cottonwood / Netleaf hackberry Forest	G1Q	S1Q	R3/4
CEGL000627	Acer negundo - Populus angustifolia / Cornus sericea Forest	Boxelder - Narrowleaf cottonwood / Red-osier dogwood Forest	G2	S2	R3/4

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL000625	Acer negundo / Cornus sericea Forest	Boxelder / Red-osier dogwood Forest	G3?	S2	R3/4
CEGL000628	Acer negundo / Prunus virginiana Forest	Boxelder / Chokecherry Forest	G3	S2	R3/4
CEGL002643	Populus angustifolia Sand Dune Forest	Narrowleaf cottonwood Sand Dune Forest	G1	S1	R3/4
CRFAPOBA0A	Populus balsamifera Forest	Balsam poplar Forest	GU	S2	R2, R3/4
CEGL000678	Populus deltoides / Muhlenbergia asperifolia Forest	Plains cottonwood / Alkali muhly Forest	G3	S1	R5
CEGL000563	Populus tremuloides / Acer glabrum Forest	Quaking aspen / Rocky Mountain maple Forest	G1G2	S1S2	R2, R3/4
CEGL001150	Populus tremuloides / Alnus incana ssp. tenuifolia Forest	Quaking aspen / Thinleaf alder Forest	G3	S3	R3/4
CEGL002650	Populus tremuloides / Betula occidentalis Forest	Quaking aspen / Water birch Forest	G3	S2	R3/4
CEGL000582	Populus tremuloides / Cornus sericea Forest	Quaking aspen / Red-osier dogwood Forest	G4	S2S3	R3/4
CEGL000583	Populus tremuloides / Corylus cornuta Forest	Quaking aspen / Beaked hazelnut Forest	G3	S1	R3/4
CEGL000618	Populus tremuloides / Tall forb Forest	Quaking aspen / Tall forbs Forest	G5	S5	R2, R3/4
CEGL000462	Pseudotsuga menziesii / Symphoricarpos oreophilus Forest	Douglas-fir / Mountain snowberry Forest	G5	S4	R3/4

Woodlands

CEGL000936	Acer negundo / Betula occidentalis Woodland	Boxelder / Water birch Woodland	G1G2	S1	R3/4
CEGL001085	Celtis laevigata var.reticulata Shrubland	Netleaf hackberry / Bluebunch wheatgrass Woodland	G1G2Q	S1S2	R3/4

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL000746	Juniperus scopulorum / Cornus sericea Woodland	Rocky Mountain juniper / Red-osier dogwood Woodland	G4	S2	R3/4
CEGL000894	Picea pungens / Alnus incana ssp. tenuifolia Woodland	Blue spruce / Thinleaf alder Woodland	G3	S3	R2, R3/4
CEGL002637	Picea pungens / Betula occidentalis Woodland	Blue spruce / Water birch Woodland	G2	S2	R2
CEGL000388	Picea pungens / Cornus sericea Woodland	Blue spruce / Red-osier dogwood Woodland	G4	S2	R2?, R3/4
CEGL000389	Picea pungens / Equisetum arvense Woodland	Blue spruce / Field horsetail Woodland	G3?	S2?	R3/4
CEGL002640	Populus angustifolia - Juniperus scopulorum Woodland	Narrowleaf cottonwood - Rocky Mountain juniper Woodland	G2G3	S3	R3/4
CEGL000934	Populus angustifolia - Picea pungens / Alnus incana Woodland	Narrowleaf cottonwood - Blue spruce / Thinleaf alder Woodland	G4	S4	R2?, R3/4
CEGL002641	Populus angustifolia - Pseudotsuga menziesii Woodland	Narrowleaf cottonwood - Douglas-fir Woodland	G3	S2	R3/4
CEGL002642	Populus angustifolia / Alnus incana ssp. tenuifolia Woodland	Narrowleaf cottonwood / Thinleaf alder Woodland	G3	S3	R3/4
CEGL000648	Populus angustifolia / Betula occidentalis Woodland	Narrowleaf cottonwood / Water birch Woodland	G3	S2	R3/4
CEGL002664	Populus angustifolia / Cornus sericea Woodland	Narrowleaf cottonwood / Red-osier dogwood Woodland	G4	S3	R3/4
CEGL002644	Populus angustifolia / Crataegus rivularis Woodland	Narrowleaf cottonwood / River hawthorn Woodland	G2?	S2	R3/4
CEGL000651	Populus angustifolia / Prunus virginiana Woodland	Narrowleaf cottonwood / Chokecherry Woodland	G2Q	S1	R3/4, R5
CEGL000652	Populus angustifolia / Rhus trilobata Woodland	Narrowleaf cottonwood / Skunkbush sumac Woodland	G3	S3	R3/4
CEGL002645	Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland	Narrowleaf cottonwood / Mixed willow (Mountain willow, Drummond willow, Shining willow) Woodland	G3	S3	R3/4

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL002646	Populus angustifolia / Salix drummondiana - Acer glabrum Woodland	Narrowleaf cottonwood / Drummond willow - Rocky Mountain maple Woodland	G2?	S1	R2?, R3/4
CEGL000654	Populus angustifolia / Salix exigua Woodland	Narrowleaf cottonwood / Sandbar willow Woodland	G4	S4	R3/4, R5
CEGL002647	Populus angustifolia / Salix irrorata Woodland	Narrowleaf cottonwood / Bluestem willow Woodland	G2	S2	R3/4
CEGL000655	Populus angustifolia / Salix liguifolia (=Salix eriocephala ssp. ligulifolia) - Shepherdia argentea Woodland	Narrowleaf cottonwood / Strapleaf willow - Silver buffaloberry Woodland	G2	S2	R3/4
CCNHPXXXX3	Populus angustifolia / Salix lucida ssp. caudata Woodland	Narrowleaf cottonwood / Whiplash willow Woodland	G1Q	S1	R3/4
CEGL002648	Populus angustifolia / Symphoricarpos albus Woodland	Narrowleaf cottonwood / Common snowberry Woodland	G2Q	S2Q	R3/4
CEGL000659	Populus deltoides - (Salix amygdaloides) / Salix exigua Woodland	Plains cottonwood - (Peachleaf willow) / Sandbar willow Woodland	G3G4	S3	R3/4, R5
CEGL002017	Populus deltoides - (Salix nigra) / Spartina pectinata - Carex spp. Woodland	Plains cottonwood - (Black willow) / Prairie cordgrass Woodland	G1G2	S1	R5
	Populus deltoides / Bromus inermis Woodland	Plains cottonwood / Smooth brome Woodland	NA	NA	R5
CEGL002649	Populus deltoides / Carex pellita (=lanuginosa) Woodland	Plains cottonwood / Woolly sedge Woodland	G2	S1	R5
CEGL000939	Populus deltoides / Distichlis spicata Woodland	Plains cottonwood / Inland saltgrass Woodland	G2	S2	R5
	Populus deltoides / Elymus trachycaulus Woodland	Plains cottonwood / Slender wheatgrass Woodland	GU	S2	R5
	Populus deltoides / Forestiera pubescens Woodland	Plains cottonwood / Wild-privet Woodland	GU	S2	R5
CEGL001454	Populus deltoides / Panicum virgatum - Schizachyrium scoparium Woodland	Plains cottonwood / Switchgrass - Little bluestem Woodland	G2	S2	R5
CCNHPXXX19	Populus deltoides / Pascopyrum smithii - Panicum obtusum Woodland	Cottonwood / Western wheatgrass - Vine mesquite Woodland	G2	S2	R3/4?, R5

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CPFDPODE3G	Populus deltoides / Prunus virginiana Woodland	Plains cottonwood / Chokecherry Woodland	G1Q	S1	R3/4, R5
CEGL000940	Populus deltoides / Rhus trilobata Woodland	Plains cottonwood / Skunkbush sumac Woodland	G2	S2	R3/4, R5
CCNHPXXX16	Populus deltoides / Sporobolus airoides Woodland	Plains cottonwood / Alkali sacaton Woodland	G2Q	S2	R5
CCNHPXXX17	Populus deltoides / Sporobolus compositus var. compositus Woodland	Plains cottonwood / Composite dropseed Woodland	G1Q	S1	R5
CCNHPXXX18	Populus deltoides / Sporobolus cryptandrus Woodland	Cottonwood / Sand dropseed Woodland	G1G2Q	S1S2	R5
CEGL000660	Populus deltoides / Symphoricarpos occidentalis Woodland	Plains cottonwood / Western snowberry Woodland	G2G3	S2	R3/34?, R5
CEGL002639	Pseudotsuga menziesii / Betula occidentalis Woodland	Douglas-fir / Water birch Woodland	G3?	S3	R3/4
CEGL000899	Pseudotsuga menziesii / Cornus sericea Woodland	Douglas-fir / Red-osier dogwood Woodland	G4	S2	R3/4
CEGL000947	Salix amygdaloides Woodland	Peachleaf willow Woodland	G3	S1	R3/4, R5

Shrublands

CEGL001145	Alnus incana ssp. tenuifolia - Cornus sericea Shrubland	Thinleaf alder - Red-osier dogwood Shrubland	G3Q	S3	R3/4
CEGL002651	Alnus incana ssp. tenuifolia - Salix (monticola, lucida, ligulifolia) Shrubland	Thinleaf alder - Willow (Mountain willow, Shining willow, Strapleaf willow) Shrubland	G3	S3	R3/4
CEGL002652	Alnus incana ssp. tenuifolia - Salix drummondiana Shrubland	Thinleaf alder - Drummond willow Shrubland	G3	S3	R2, R3/4
CEGL001146	Alnus incana ssp. tenuifolia / Equisetum arvense Shrubland	Thinleaf alder / Field horsetail Shrubland	G3	S3	R3/4
CEGL001147	Alnus incana ssp. tenuifolia / Mesic forb Shrubland	Thinleaf alder / Mesic forb Shrubland	G3	S3	R2, R3/4

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL001148	Alnus incana ssp. tenuifolia / Mesic graminoid Shrubland	Thinleaf alder / Mesic graminoid Shrubland	G3	S3	S3/4, R2, R3/4
CEGL002653	Betula glandulosa (=Betula nana) / Mesic forb - Mesic graminoid Shrubland	Swamp birch / Mesic forb - Mesic graminoid Shrubland	G3G4	S3	S1/2, R1, R2
CEGL001162	Betula occidentalis / Mesic forb Shrubland	Water birch / Mesic forb Shrubland	G3	S2	R3/4
CEGL002654	Betula occidentalis / Mesic graminoid Shrubland	Water birch / Mesic graminoid Shrubland	G3	S2	R3/4
CEGL001165	Cornus sericea Shrubland	Red-osier dogwood Shrubland	G4Q	S3	R3/4, R5
CRSACRRI0A	Crataegus rivularis Shrubland	River hawthorn Shrubland	G2Q	S2	R2, R3/4
CEGL001107	Dasiphora (=Pentaphylloides) floribunda / Deschampsia cespitosa Shrubland	Shrubby cinquefoil / Tufted hairgrass Shrubland	G4	S3S4	S1/2?, S3/4
	Dasiphora (=Pentaphylloides) floribunda / Juncus balticus var. montanus Shrubland	Shrubby cinquefoil / Mountain rush Shrubland	G3	S3	S1/2?, S3/4
CEGL001168	Forestiera pubescens Shrubland	Wild-privet Shrubland	G1G2	S1	R3/4
	Kalmia microphylla - Gaultheria humifusa Shrubland	Bog laurel - Alpine spicywintergreen Shrubland	G3G4	S2	S1/2
CCNHPXXX37	Picea engelmannii) / Betula glandulosa / Carex aquatilis / Sphagnum Iron Fen	Engelmann spruce / Bog birch / Water sedge / Sphagnum Iron Fen	G2	S2	S1/2
CEGL001108	Prunus virginiana - (Prunus americana) Shrubland	Chokecherry - (American plum) Shrubland	G4Q	S3	R3/4
CWSFRHTR0A	Rhus trilobata - (Salix exigua) Shrubland	Skunkbush sumac - Sandbar willow Shrubland	G2	S2	R3/4
CEGL001173	Salix bebbiana Shrubland	Bebb willow Shrubland	G3?	S2	R2, R3/4
CEGL001178	Salix boothii / Carex utriculata Shrubland	Booth willow / Beaked sedge Shrubland	G4	S3	R2

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL001180	Salix boothii / Mesic forb Shrubland	Booth willow / Mesic forb Shrubland	G3	S3	S1/2, R2
CEGL001181	Salix boothii / Mesic graminoid Shrubland	Booth willow / Mesic graminoid Shrubland	G3?	S3	R2
CEGL001244	Salix brachycarpa / Carex aquatilis Shrubland	Barrenground willow / Water sedge Shrubland	G2?	S2	S1/2, S3/4
CEGL001135	Salix brachycarpa / Mesic forb Shrubland	Barrenground willow / Mesic forb Shrubland	G4	S4	S1/2, R1, R2
	Salix candida / Triglochin maritimum Shrubland	Hoary willow / Seaside arrowgrass Shrubland	G1?	S1?	S1/2
CEGL002667	Salix drummondiana / Calamagrostis canadensis Shrubland	Drummond willow / Bluejoint reedgrass Shrubland	G3	S3	S1/2, R2
CCNHPXXX28	Salix drummondiana / Carex aquatilis Shrubland	Drummond willow / Water sedge Shrubland	G2G3	S2S3	S1/2?, R2
CEGL001192	Salix drummondiana / Mesic forb Shrubland	Drummond willow / Mesic forb Shrubland	G4	S4	S3/4, R2, R3/4
CEGL002655	Salix exigua - Salix liguifolia (=Salix eriocephala ssp. ligulifolia) Shrubland	Sandbar willow - Strapleaf willow Shrubland	G2G3	S2S3	R3/4, R5
CEGL001200	Salix exigua / Barren ground Shrubland	Sandbar willow / Barren ground Shrubland	G5	S5	D4/5, R3/4, R5
CEGL001203	Salix exigua / Mesic graminoid Shrubland	Sandbar willow / Mesic graminoid Shrubland	G5	S5	R3/4, R5
CEGL001247	Salix geyeriana - Salix monticola / Calamagrostis canadensis Shrubland	Geyer willow - Mountian willow / Bluejoint reedgrass Shrubland	G3	S3	R2
CEGL001223	Salix geyeriana - Salix monticola / Mesic forb Shrubland	Geyer willow - Mountain willow / Mesic forb Shrubland	G3	S3	R2
CEGL001205	Salix geyeriana / Calamagrostis canadensis Shrubland	Geyer willow / Bluejoint reedgrass Shrubland	G5	S3	R2
CEGL001206	Salix geyeriana / Carex aquatilis Shrubland	Geyer willow / Water sedge Shrubland	G3	S3	S1/2, R2

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL001207	Salix geyeriana / Carex utriculata Shrubland	Geyer willow / Beaked sedge Shrubland	G5	S3	R2
CEGL002666	Salix geyeriana / Mesic forb Shrubland	Geyer willow / Mesic forb Shrubland	G3	S3	R2, R3/4
CEGL001218	Salix ligulifolia (=Salix eriocephala var. ligulifolia) Shrubland	Strapleaf willow Shrubland	G2G3	S2S3	S1/2, R2, R3/4
CRWASALU1A	Salix lucida (ssp. caudata or ssp. lasiandra) Shrubland	Shining willow Shrubland	G3Q	S2S3	R2, R3/4
CEGL001222	Salix monticola / Calamagrostis canadensis Shrubland	Rocky Mountain willow / Bluejoint reedgrass Shrubland	G3	S3	R2
CEGL002656	Salix monticola / Carex aquatilis Shrubland	Rocky Mountain willow / Water sedge Shrubland	G3	S3	R2
CEGL002657	Salix monticola / Carex utriculata Shrubland	Mountain willow / Beaked sedge Shrubland	G3	S3	S1/2, R2
	Salix monticola / Equisetum arvense Shrubland	Mountain willow / Field horsetail Shrubland	G2?	S2	R2
CEGL002658	Salix monticola / Mesic Forb Shrubland	Mountain willow / Mesic forb Shrubland	G4	S3	S1/2, R2, R3/4
CEGL002659	Salix monticola / Mesic Graminoid Shrubland	Mountain willow / Mesic graminoid Shrubland	G3	S3	S1/2, S3/4, R2
CEGL001225	Salix planifolia / Calamagrostis canadensis Shrubland	Planeleaf willow / Bluejoint reedgrass Shrubland	G4	S3	S1/2, R1
CEGL002665	Salix planifolia / Caltha leptosepala Shrubland	Planeleaf willow / White marsh-marigold Shrubland	G4	S4	S1/2, R1
CEGL001227	Salix planifolia / Carex aquatilis Shrubland	Planeleaf willow / Water sedge Shrubland	G5	S4	S1/2
	Salix planifolia / Carex utriculata Shrubland	Planeleaf willow / Beaked sedge Shrubland	G3G4	S2	S1/2
CCNHPXXX26	Salix planifolia / Mesic forb Shrubland	Planeleaf willow / Mesic forb Shrubland	G4	S4	S1/2, R2

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
	Salix wolfii / Calamagrostis canadensis Shrubland	Wolf willow / Bluejoint reedgrass Shrubland	G3	S3	S1/2, R1
CEGL001234	Salix wolfii / Carex aquatilis Shrubland	Wolf willow / Water sedge Shrubland	G4	S3	S1/2, R1
CEGL001237	Salix wolfii / Carex utriculata Shrubland	Wolf willow / Beaked sedge Shrubland	G4	S3	S1/2, R1
CEGL001240	Salix wolfii / Mesic forb Shrubland	Wolf willow / Mesic forb Shrubland	G3	S3	S1/2, R1
	Sarcobatus vermiculatus / Barren ground Shrubland	Black greasewood / Barren ground Shrubland	GU	S2	F1
CEGL001363	Sarcobatus vermiculatus / Distichlis spicata Shrubland	Black greasewood / Inland saltgrass Shrubland	G4	S2	F1
CEGL001128	Shepherdia argentea Shrubland	Silver buffaloberry Shrubland	G3G4	S1	R3/4
CEGL001131	Symphoricarpos occidentalis Shrubland	Western snowberry Shrubland	G4G5	S3	R5
	Tamarix ramosissima Shrubland	Saltcedar Shrubland	NA	NA	R3/4, R5

Herbaceous Vegetation

	Agrostis gigantea Herbaceous Vegetation	Redtop Herbaceous Vegetation	NA	NA	D4/5?, S3/4
	Alopecurus aequalis Herbaceous Vegetation	Shortawn foxtail Herbaceous Vegetation	G3G4	S2	D2/3, D4/5
CEGL001464	Andropogon gerardii - Sorghastrum nutans - (Spartina pectinata) Herbaceous Vegetation	Big bluestem - Yellow indiangrass - Prairie cordgrass Herbaceous Vegetation	G2	S1S2	R5
CEGL002729	Aquilegia micrantha - (Mimulus eastwoodiae) Hanging Garden	Mancos columbine - (Eastwood's monkeyflower) Hanging Garden	G2G3	S2S3	S3/4
	Bidens cernua - Bidens frondosa Herbaceous Vegetation	Nodding beggartick - Devil's beggartick Herbaceous Vegetation	G3	S3	D2/3

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL001559	Calamagrostis canadensis Western Herbaceous Vegetation	Bluejoint reedgrass Western Herbaceous Vegetation	G4	S4	R1, R2
CEGL001954	Caltha leptosepala Herbaceous Vegetation	White marsh-marigold Herbaceous Vegetation	G4	S4	S1/2
CEGL002662	Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation	Heartleaf bittercress - Mountain bluebells - Arrowleaf ragwort Herbaceous Vegetation	G4	S4	S1/2, R1, R2
CEGL001803	Carex aquatilis - Carex utriculata Herbaceous Vegetation	Water sedge - Beaked sedge Herbaceous Vegetation	G4	S4	D1, S1/2, S/3/4
CEGL001802	Carex aquatilis Herbaceous Vegetation	Water sedge Herbaceous Vegetation	G5	S4	S1/2
CEGL001872	Carex capillaris - Polygonum viviparum Herbaceous Vegetation	Hair sedge - Serpent-grass Herbaceous Vegetation	G2	S2	S1/2
	Carex emoryi Herbaceous Vegetation	Emory's sedge Herbaceous Vegetation	G2?	S2	R5
CEGL001876	Carex illota Herbaceous Vegetation	Small-head sedge Herbaceous Vegetation	GUQ	S2	S1/2
CEGL001972	Carex microptera Herbaceous Vegetation	Smallwing sedge Herbaceous Vegetation	G4	S2?	S1/2
CEGL001813	Carex nebrascensis Herbaceous Vegetation	Nebraska sedge Herbaceous Vegetation	G4	S3	D2/3, S3/4
CEGL001818	Carex nigricans - Juncus drummondii Herbaceous Vegetation	Black alpine sedge - Drummond rush Herbaceous Vegetation	GU	S2	S1/2
CEGL001809	Carex pellita (=lanuginosa) Herbaceous Vegetation	Woolly sedge Herbaceous Vegetation	G3	S3	D2/3, S3/4, R5
CEGL002660	Carex praegracilis Herbaceous Vegetation	Clustered field sedge Herbaceous Vegetation	G3G4	S2	S3/4
CEGL001769	Carex saxatilis Herbaceous Vegetation	Russet sedge Herbaceous Vegetation	G3	S2	S1/2, S3/4
CEGL001823	Carex scopulorum - Caltha leptosepala Herbaceous Vegetation	Mountain sedge - Marsh-marigold Herbaceous Vegetation	G4	S4	S1/2

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL001825	Carex simulata Herbaceous Vegetation	Analogue sedge Herbaceous Vegetation	G4	S3	S1/2
CEGL001562	Carex utriculata Herbaceous Vegetation	Beaked sedge Herbaceous Vegetation	G5	S5	D1, D2/3, S1/2?, S3/4, R2
CEGL001868	Carex vernacula Herbaceous Vegetation	Native sedge Herbaceous Vegetation	GU	S1	S1/2
CEGL002661	Carex vesicaria Herbaceous Vegetation	Blister sedge Herbaceous Vegetation	G4Q	S1	S1/2, R3/4
	Corydalis caseana ssp. brandegei Herbaceous Vegetation	Brandegee's fumewort Herbaceous Vegetation	G2	S2	R1, R2
CEGL001599	Deschampsia caespitosa Herbaceous Vegetation	Tufted hairgrass Herbaceous Vegetation	G4	S4	S1/2, S3/4
CEGL001770	Distichlis spicata Herbaceous Vegetation	Inland saltgrass Herbaceous Vegetation	G5	S3	F1
	Echinochloa crus-galli Herbaceous Vegetation	Barnyardgrass Herbaceous Vegetation	NA	NA	D4/5
CEGL001832	Eleocharis acicularis Herbaceous Vegetation	Needle spikerush Herbaceous Vegetation	G4?	S3	D2/3, D4/5
CEGL001833	Eleocharis palustris Herbaceous Vegetation	Common spikerush Herbaceous Vegetation	G5	S4	D2/3, D4/5, S1/2
	Eleocharis parvula Herbaceous Vegetation	Dwarf spikerush Herbaceous Vegetation	GU	S2	D2/3, D4/5
CEGL001836	Eleocharis quinqueflora Herbaceous Vegetation	Few-flower spikerush Herbaceous Vegetation	G4	S3S4	S1/2
CEGL007886	Eleocharis rostellata Herbaceous Vegetation	Beaked spikerush Herbaceous Vegetation	G3	S2	S3/4
	Equisetum hyemale Herbaceous Vegetation	Scouringrush horsetail Herbaceous Vegetation	G3	S3	R3/4, R5
	Glaux maritima Herbaceous Vegetation	Sea milkwort Herbaceous Vegetation	G3	S2	F1, S3/4

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
	Glyceria grandis Herbaceous Vegetation	American mannagrass Herbaceous Vegetation	G2?	S2	D2/3, D4/5
	Glyceria striata - Mimulus guttatus - Epilobium lactiflorum Herbaceous Vegetation	Fowl mannagrass - Seep monkeyflower - Milkflower willowherb Herbaceous Vegetation	G3	S3	R1
	Glycyrrhiza lepidota - Equisetum hyemale Herbaceous Vegetation	American licorice - Scouringrush horsetail Herbaceous Vegetation	GU	S3	R3/4, R5
CEGL001798	Hordeum (=Critesion) jubatum Herbaceous Vegetation	Foxtail barley Herbaceous Vegetation	G4	S4	D2/3, D4/5
CEGL001838	Juncus balticus var. montanus Herbaceous Vegetation	Mountain rush Herbaceous Vegetation	G5	S5	D2/3, D4/5, S3/4, R3/4
CEGL002900	Kobresia myosuroides - Thalictrum alpinum Herbaceous Vegetation (Extreme rich fens)	Bellardi bog sedge - Alpine meadowrue Herbaceous Vegetation	G2	S1	S1/2
CEGL002901	Kobresia simpliciuscula - (Trichophorum pumilum) Herbaceous Vegetation	Simple bog sedge - (Rolland's bulrush) Herbaceous Vegetation	G2	S1	S1/2
	Leersia oryzoides Herbaceous Vegetation	Rice cutgrass Herbaceous Vegetation	GU	S2	D2/3
CEGL001779	Muhlenbergia asperifolia Herbaceous Vegetation	Alkali muhly Herbaceous Vegetation	G3?	S3?	F1, R5
CEGL001474	Phalaris arundinacea Herbaceous Vegetation	Reed canarygrass Herbaceous Vegetation	G5	S5	D2/3, S3/4?
CEGL001475	Phragmites australis Herbaceous Vegetation	Common reed Herbaceous Vegetation	G5	S3	R5
	Polygonum spp. - Mesic graminoid Herbaceous Vegetation	Knotweed - Mesic graminoid Herbaceous Vegetation	NA	NA	D4/5
CEGL001799	Puccinellia nuttalliana (=airoides) Herbaceous Vegetation	Nuttall's alkaligrass Herbaceous Vegetation	G3?	S3	F1
CEGL001985	Saxifraga odontoloma Herbaceous Vegetation	Streambank saxifrage Herbaceous Vegetation	GU	S2	R1
	Schoenoplectus acutus var. acutus - Schoenoplectus tabernaemontani Herbaceous Vegetation	Hardstem bulrush - Softstem bulrush Herbaceous Vegetation	G3	S2S3	D2/3 , D4/5?

Element Code	Scientific Name	Common Name	G Rank	S Rank	HGM group
CEGL001843	Schoenoplectus maritimus (=Bolboschoenus maritimus) Herbaceous Vegetation	Cosmopolitan bulrush Herbaceous Vegetation	G4	S2	F1
CEGL001587	Schoenoplectus pungens Herbaceous Vegetation	Threesquare bulrush Herbaceous Vegetation	G3G4	S3	D2/3
	Scirpus nevadensis (=Amphiscirpus nevadensis) Herbaceous Vegetation	Nevada bulrush Herbaceous Vegetation	G4	S2	F1
CEGL001588	Spartina gracilis Herbaceous Vegetation	Alkali cordgrass Herbaceous Vegetation	GU	S2	F1
CEGL001476	Spartina pectinata Western Herbaceous Vegetation	Prairie cordgrass Western Herbaceous Vegetation	G3?	S3	R5
CEGL001685	Sporobolus airoides Southern Plains Herbaceous Vegetation	Alkali sacaton Southern Plains Herbaceous Vegetation	G3Q	S3	F1, R3/4, R5
	Suaeda calceoliformis Herbaceous Vegetation	Pursh seepweed Herbaceous Vegetation	GU	S2	F1
	Triglochin maritimum - Triglochin palustris Herbaceous Vegetation	Seaside arrowgrass - Meadow arrowgrass Herbaceous Vegetation	GU	S3	F1, S1/2
CEGL002010	Typha angustifolia - Typha latifolia - (Typha domiguensis) Herbaceous Vegetation	Cattail Herbaceous Vegetation	G5	S4	D2/3, D4/5?
	Veronica anagallis-aquatica - (Juncus bufonius) Herbaceous Vegetation	Water speedwell - Toad rush Herbaceous Vegetation	GU	S2	D4/5
	Xanthium strumarium Herbaceous Vegetation	Rough cocklebur Herbaceous Vegetation	NA	NA	D4/5

Table 5. Wetland Plant Associations of Colorado by HGM group

Only associations with an Elcode beginning with CEGL are classified by USNVC.

Element Code	Scientific Name	Common Name
Mineral Flats 1		
CEGL001770	Distichlis spicata Herbaceous Vegetation	Inland saltgrass Herbaceous Vegetation
	Glaux maritima Herbaceous Vegetation	Sea milkwort Herbaceous Vegetation
CEGL001779	Muhlenbergia asperifolia Herbaceous Vegetation	Alkali muhly Herbaceous Vegetation
CEGL001799	Puccinellia nuttalliana (=airoides) Herbaceous Vegetation	Nuttall's alkaligrass Herbaceous Vegetation
	Sarcobatus vermiculatus / Barren ground Shrubland	Black greasewood / Barren ground Shrubland
CEGL001363	Sarcobatus vermiculatus / Distichlis spicata Shrubland	Black greasewood / Inland saltgrass Shrubland
CEGL001843	Schoenoplectus maritimus (=Bolboschoenus maritimus) Herbaceous Vegetation	Cosmopolitan bulrush Herbaceous Vegetation
	Scirpus nevadensis (=Amphiscirpus nevadensis) Herbaceous Vegetation	Nevada bulrush Herbaceous Vegetation
CEGL001588	Spartina gracilis Herbaceous Vegetation	Alkali cordgrass Herbaceous Vegetation
CEGL001685	Sporobolus airoides Southern Plains Herbaceous Vegetation	Alkali sacaton Southern Plains Herbaceous Vegetation
	Suaeda calceoliformis Herbaceous Vegetation	Pursh seepweed Herbaceous Vegetation
	Triglochin maritimum - Triglochin palustris Herbaceous Vegetation	Seaside arrowgrass - Meadow arrowgrass Herbaceous Vegetation
Depressional 1		
CEGL001803	Carex aquatilis - Carex utriculata Herbaceous Vegetation	Water sedge - Beaked sedge Herbaceous Vegetation
CEGL001562	Carex utriculata Herbaceous Vegetation	Beaked sedge Herbaceous Vegetation
Depressional 2/3		
	Alopecurus aequalis Herbaceous Vegetation	Shortawn foxtail Herbaceous Vegetation
	Bidens cernua - Bidens frondosa Herbaceous Vegetation	Nodding beggartick - Devil's beggartick Herbaceous Vegetation
CEGL001813	Carex nebrascensis Herbaceous Vegetation	Nebraska sedge Herbaceous Vegetation
CEGL001809	Carex pellita (=lanuginosa) Herbaceous Vegetation	Woolly sedge Herbaceous Vegetation
CEGL001562	Carex utriculata Herbaceous Vegetation	Beaked sedge Herbaceous Vegetation
CEGL001832	Eleocharis acicularis Herbaceous Vegetation	Needle spikerush Herbaceous Vegetation

Element Code	Scientific Name	Common Name
CEGL001833	Eleocharis palustris Herbaceous Vegetation	Common spikerush Herbaceous Vegetation
	Eleocharis parvula Herbaceous Vegetation	Dwarf spikerush Herbaceous Vegetation
	Glyceria grandis Herbaceous Vegetation	American mannagrass Herbaceous Vegetation
CEGL001798	Hordeum (=Critesion) jubatum Herbaceous Vegetation	Foxtail barley Herbaceous Vegetation
CEGL001838	Juncus balticus var. montanus Herbaceous Vegetation	Mountain rush Herbaceous Vegetation
	Leersia oryzoides Herbaceous Vegetation	Rice cutgrass Herbaceous Vegetation
CEGL001474	Phalaris arundinacea Herbaceous Vegetation	Reed canarygrass Herbaceous Vegetation
	Schoenoplectus acutus var. acutus - Schoenoplectus tabernaemontani Herbaceous Vegetation	Hardstem bulrush - Softstem bulrush Herbaceous Vegetation
CEGL001587	Schoenoplectus pungens Herbaceous Vegetation	Threesquare bulrush Herbaceous Vegetation
CEGL002010	Typha angustifolia - Typha latifolia - (Typha domiguensis) Herbaceous Vegetation	Cattail Herbaceous Vegetation

Depressional 4/5

	Alopecurus aequalis Herbaceous Vegetation	Shortawn foxtail Herbaceous Vegetation
	Echinochloa crus-galli Herbaceous Vegetation	Barnyardgrass Herbaceous Vegetation
CEGL001832	Eleocharis acicularis Herbaceous Vegetation	Needle spikerush Herbaceous Vegetation
CEGL001833	Eleocharis palustris Herbaceous Vegetation	Common spikerush Herbaceous Vegetation
	Eleocharis parvula Herbaceous Vegetation	Dwarf spikerush Herbaceous Vegetation
	Glyceria grandis Herbaceous Vegetation	American mannagrass Herbaceous Vegetation
CEGL001798	Hordeum (=Critesion) jubatum Herbaceous Vegetation	Foxtail barley Herbaceous Vegetation
CEGL001838	Juncus balticus var. montanus Herbaceous Vegetation	Mountain rush Herbaceous Vegetation
	Polygonum spp. - Mesic graminoid Herbaceous Vegetation	Knotweed - Mesic graminoid Herbaceous Vegetation
CEGL001200	Salix exigua / Barren ground Shrubland	Sandbar willow / Barren ground Shrubland
CEGL002010	Typha angustifolia - Typha latifolia - (Typha domiguensis) Herbaceous Vegetation	Cattail Herbaceous Vegetation
	Veronica anagallis-aquatica - (Juncus bufonius) Herbaceous Vegetation	Water speedwell - Toad rush Herbaceous Vegetation
	Xanthium strumarium Herbaceous Vegetation	Rough cocklebur Herbaceous Vegetation

Slope 1/2

CRFCABLA0I	Abies lasiocarpa - Picea engelmannii / Carex aquatilis Forest	Subalpine fir - Engelmann spruce / Water sedge Forest
CEGL002653	Betula glandulosa (=Betula nana) / Mesic forb - Mesic graminoid Shrubland	Swamp birch / Mesic forb - Mesic graminoid Shrubland
CEGL001954	Caltha leptosepala Herbaceous Vegetation	White marsh-marigold Herbaceous Vegetation

Element Code	Scientific Name	Common Name
CEGL002662	Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation	Heartleaf bittercress - Mountain bluebells - Arrowleaf ragwort Herbaceous Vegetation
CEGL001803	Carex aquatilis - Carex utriculata Herbaceous Vegetation	Water sedge - Beaked sedge Herbaceous Vegetation
CEGL001802	Carex aquatilis Herbaceous Vegetation	Water sedge Herbaceous Vegetation
CEGL001872	Carex capillaris - Polygonum viviparum Herbaceous Vegetation	Hair sedge - Serpent-grass Herbaceous Vegetation
CEGL001876	Carex illota Herbaceous Vegetation	Small-head sedge Herbaceous Vegetation
CEGL001972	Carex microptera Herbaceous Vegetation	Smallwing sedge Herbaceous Vegetation
CEGL001818	Carex nigricans - Juncus drummondii Herbaceous Vegetation	Black alpine sedge - Drummond rush Herbaceous Vegetation
CEGL001769	Carex saxatilis Herbaceous Vegetation	Russet sedge Herbaceous Vegetation
CEGL001823	Carex scopulorum - Caltha leptosepala Herbaceous Vegetation	Mountain sedge - Marsh-marigold Herbaceous Vegetation
CEGL001825	Carex simulata Herbaceous Vegetation	Analogue sedge Herbaceous Vegetation
CEGL001868	Carex vernacula Herbaceous Vegetation	Native sedge Herbaceous Vegetation
CEGL002661	Carex vesicaria Herbaceous Vegetation	Blister sedge Herbaceous Vegetation
CEGL001599	Deschampsia caespitosa Herbaceous Vegetation	Tufted hairgrass Herbaceous Vegetation
CEGL001833	Eleocharis palustris Herbaceous Vegetation	Common spikerush Herbaceous Vegetation
CEGL001836	Eleocharis quinqueflora Herbaceous Vegetation	Few-flower spikerush Herbaceous Vegetation
	Kalmia microphylla - Gaultheria humifusa Shrubland	Bog laurel - Alpine spicywintergreen Shrubland
CEGL002900	Kobresia myosuroides - Thalictrum alpinum Herbaceous Vegetation (Extreme rich fens)	Bellardi bog sedge - Alpine meadowrue Herbaceous Vegetation
CEGL002901	Kobresia simpliciuscula - (Trichophorum pumilum) Herbaceous Vegetation	Simple bog sedge - (Rolland's bulrush) Herbaceous Vegetation
CCNHPXXX37	Picea engelmannii) / Betula glandulosa / Carex aquatilis / Sphagnum Iron Fen	Engelmann spruce / Bog birch / Water sedge / Sphagnum Iron Fen
CEGL001180	Salix boothii / Mesic forb Shrubland	Booth willow / Mesic forb Shrubland
CEGL001244	Salix brachycarpa / Carex aquatilis Shrubland	Barrenground willow / Water sedge Shrubland
CEGL001135	Salix brachycarpa / Mesic forb Shrubland	Barrenground willow / Mesic forb Shrubland
	Salix candida / Triglochin maritimum Shrubland	Hoary willow / Seaside arrowgrass Shrubland
CEGL002667	Salix drummondiana / Calamagrostis canadensis Shrubland	Drummond willow / Bluejoint reedgrass Shrubland
CEGL001206	Salix geyeriana / Carex aquatilis Shrubland	Geyer willow / Water sedge Shrubland
CEGL001218	Salix ligulifolia (=Salix eriocephala var. ligulifolia) Shrubland	Strapleaf willow Shrubland
CEGL002657	Salix monticola / Carex utriculata Shrubland	Mountain willow / Beaked sedge Shrubland
CEGL002658	Salix monticola / Mesic Forb Shrubland	Mountain willow / Mesic forb Shrubland
CEGL002659	Salix monticola / Mesic Graminoid Shrubland	Mountain willow / Mesic graminoid Shrubland
CEGL001225	Salix planifolia / Calamagrostis canadensis Shrubland	Planeleaf willow / Bluejoint reedgrass Shrubland
CEGL002665	Salix planifolia / Caltha leptosepala Shrubland	Planeleaf willow / White marsh-marigold Shrubland
CEGL001227	Salix planifolia / Carex aquatilis Shrubland	Planeleaf willow / Water sedge Shrubland
	Salix planifolia / Carex utriculata Shrubland	Planeleaf willow / Beaked sedge Shrubland
CCNHPXXX26	Salix planifolia / Mesic forb Shrubland	Planeleaf willow / Mesic forb Shrubland

Element Code	Scientific Name	Common Name
	Salix wolfii / Calamagrostis canadensis Shrubland	Wolf willow / Bluejoint reedgrass Shrubland
CEGL001234	Salix wolfii / Carex aquatilis Shrubland	Wolf willow / Water sedge Shrubland
CEGL001237	Salix wolfii / Carex utriculata Shrubland	Wolf willow / Beaked sedge Shrubland
CEGL001240	Salix wolfii / Mesic forb Shrubland	Wolf willow / Mesic forb Shrubland
	Triglochin maritimum - Triglochin palustris Herbaceous Vegetation	Seaside arrowgrass - Meadow arrowgrass Herbaceous Vegetation
Slope 3/4		
	Agrostis gigantea Herbaceous Vegetation	Redtop Herbaceous Vegetation
CEGL001148	Alnus incana ssp. tenuifolia / Mesic graminoid Shrubland	Thinleaf alder / Mesic graminoid Shrubland
CEGL002729	Aquilegia micrantha - (Mimulus eastwoodiae) Hanging Garden	Mancos columbine - (Eastwood's monkeyflower) Hanging Garden
CEGL001803	Carex aquatilis - Carex utriculata Herbaceous Vegetation	Water sedge - Beaked sedge Herbaceous Vegetation
CEGL001813	Carex nebrascensis Herbaceous Vegetation	Nebraska sedge Herbaceous Vegetation
CEGL001809	Carex pellita (=lanuginosa) Herbaceous Vegetation	Woolly sedge Herbaceous Vegetation
CEGL002660	Carex praegracilis Herbaceous Vegetation	Clustered field sedge Herbaceous Vegetation
CEGL001769	Carex saxatilis Herbaceous Vegetation	Russet sedge Herbaceous Vegetation
CEGL001562	Carex utriculata Herbaceous Vegetation	Beaked sedge Herbaceous Vegetation
CEGL001107	Dasiphora (=Pentaphylloides) floribunda / Deschampsia cespitosa Shrubland	Shrubby cinquefoil / Tufted hairgrass Shrubland
	Dasiphora (=Pentaphylloides) floribunda / Juncus balticus var. montanus Shrubland	Shrubby cinquefoil / Mountain rush Shrubland
CEGL001599	Deschampsia caespitosa Herbaceous Vegetation	Tufted hairgrass Herbaceous Vegetation
CEGL007886	Eleocharis rostellata Herbaceous Vegetation	Beaked spikerush Herbaceous Vegetation
	Glaux maritima Herbaceous Vegetation	Sea milkwort Herbaceous Vegetation
CEGL001838	Juncus balticus var. montanus Herbaceous Vegetation	Mountain rush Herbaceous Vegetation
CEGL001244	Salix brachycarpa / Carex aquatilis Shrubland	Barrenground willow / Water sedge Shrubland
CEGL001192	Salix drummondiana / Mesic forb Shrubland	Drummond willow / Mesic forb Shrubland
CEGL002659	Salix monticola / Mesic Graminoid Shrubland	Mountain willow / Mesic graminoid Shrubland
Riverine 1		
CEGL002653	Betula glandulosa (=Betula nana) / Mesic forb - Mesic graminoid Shrubland	Swamp birch / Mesic forb - Mesic graminoid Shrubland
CEGL001559	Calamagrostis canadensis Western Herbaceous Vegetation	Bluejoint reedgrass Western Herbaceous Vegetation
CEGL002662	Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation	Heartleaf bittercress - Mountain bluebells - Arrowleaf ragwort Herbaceous Vegetation
	Corydalis caseana ssp. brandegei Herbaceous Vegetation	Brandegee's fumewort Herbaceous Vegetation

Element Code	Scientific Name	Common Name
	Glyceria striata - Mimulus guttatus - Epilobium lactiflorum Herbaceous Vegetation	Fowl mannagrass - Seep monkeyflower - Milkflower willowherb Herbaceous Vegetation
CEGL001135	Salix brachycarpa / Mesic forb Shrubland	Barrenground willow / Mesic forb Shrubland
CEGL001225	Salix planifolia / Calamagrostis canadensis Shrubland	Planeleaf willow / Bluejoint reedgrass Shrubland
CEGL002665	Salix planifolia / Caltha leptosepala Shrubland	Planeleaf willow / White marsh-marigold Shrubland
	Salix wolfii / Calamagrostis canadensis Shrubland	Wolf willow / Bluejoint reedgrass Shrubland
CEGL001234	Salix wolfii / Carex aquatilis Shrubland	Wolf willow / Water sedge Shrubland
CEGL001237	Salix wolfii / Carex utriculata Shrubland	Wolf willow / Beaked sedge Shrubland
CEGL001240	Salix wolfii / Mesic forb Shrubland	Wolf willow / Mesic forb Shrubland
CEGL001985	Saxifraga odontoloma Herbaceous Vegetation	Streambank saxifrage Herbaceous Vegetation

Riverine 2

CRFEXXXXX7	Abies lasiocarpa - Picea engelmannii - Populus angustifolia / Lonicera involucrata Forest	Subalpine fir - Engelmann spruce - Narrowleaf cottonwood / Twinberry honeysuckle Forest
CEGL000296	Abies lasiocarpa - Picea engelmannii / Alnus incana Forest	Subalpine fir - Engelmann spruce / Thinleaf alder Forest
CEGL000300	Abies lasiocarpa - Picea engelmannii / Calamagrostis canadensis Forest	Subalpine fir - Engelmann spruce / Bluejoint reedgrass Forest
CRFCABLA0I	Abies lasiocarpa - Picea engelmannii / Carex aquatilis Forest	Subalpine fir - Engelmann spruce / Water sedge Forest
CRFFPIEN0A	Abies lasiocarpa - Picea engelmannii / Equisetum arvense Forest	Subalpine fir - Engelmann spruce / Field horsetail Forest
CEGL002663	Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Forest	Subalpine fir - Engelmann spruce / Tall fringed bluebells Forest
CEGL000331	Abies lasiocarpa - Picea engelmannii / Ribes spp. Forest	Subalpine fir - Engelmann spruce / Currant spp. Forest
CEGL000327	Abies lasiocarpa - Picea engelmannii / Salix drummondiana Forest	Subalpine fir - Engelmann spruce / Drummond willow Forest
CEGL002652	Alnus incana ssp. tenuifolia - Salix drummondiana Shrubland	Thinleaf alder - Drummond willow Shrubland
CEGL001147	Alnus incana ssp. tenuifolia / Mesic forb Shrubland	Thinleaf alder / Mesic forb Shrubland
CEGL001148	Alnus incana ssp. tenuifolia / Mesic graminoid Shrubland	Thinleaf alder / Mesic graminoid Shrubland
CEGL002653	Betula glandulosa (=Betula nana) / Mesic forb - Mesic graminoid Shrubland	Swamp birch / Mesic forb - Mesic graminoid Shrubland
CEGL001559	Calamagrostis canadensis Western Herbaceous Vegetation	Bluejoint reedgrass Western Herbaceous Vegetation
CEGL002662	Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation	Heartleaf bittercress - Mountain bluebells - Arrowleaf ragwort Herbaceous Vegetation
CEGL001562	Carex utriculata Herbaceous Vegetation	Beaked sedge Herbaceous Vegetation
	Corydalis caseana ssp. brandegei Herbaceous Vegetation	Brandegee's fumewort Herbaceous Vegetation
CRSACRRI0A	Crataegus rivularis Shrubland	River hawthorn Shrubland
CEGL000894	Picea pungens / Alnus incana ssp. tenuifolia Woodland	Blue spruce / Thinleaf alder Woodland
CEGL002637	Picea pungens / Betula occidentalis Woodland	Blue spruce / Water birch Woodland
CEGL000934	Populus angustifolia - Picea pungens / Alnus incana Woodland	Narrowleaf cottonwood - Blue spruce / Thinleaf alder Woodland
CRFAPOBA0A	Populus balsamifera Forest	Balsam poplar Forest

Element Code	Scientific Name	Common Name
CEGL000563	Populus tremuloides / Acer glabrum Forest	Quaking aspen / Rocky Mountain maple Forest
CEGL000618	Populus tremuloides / Tall forb Forest	Quaking aspen / Tall forbs Forest
CEGL001173	Salix bebbiana Shrubland	Bebb willow Shrubland
CEGL001178	Salix boothii / Carex utriculata Shrubland	Booth willow / Beaked sedge Shrubland
CEGL001180	Salix boothii / Mesic forb Shrubland	Booth willow / Mesic forb Shrubland
CEGL001181	Salix boothii / Mesic graminoid Shrubland	Booth willow / Mesic graminoid Shrubland
CEGL001135	Salix brachycarpa / Mesic forb Shrubland	Barrenground willow / Mesic forb Shrubland
CEGL002667	Salix drummondiana / Calamagrostis canadensis Shrubland	Drummond willow / Bluejoint reedgrass Shrubland
CCNHPXXX28	Salix drummondiana / Carex aquatilis Shrubland	Drummond willow / Water sedge Shrubland
CEGL001192	Salix drummondiana / Mesic forb Shrubland	Drummond willow / Mesic forb Shrubland
CEGL001247	Salix geyeriana - Salix monticola / Calamagrostis canadensis Shrubland	Geyer willow - Mountian willow / Bluejoint reedgrass Shrubland
CEGL001223	Salix geyeriana - Salix monticola / Mesic forb Shrubland	Geyer willow - Mountain willow / Mesic forb Shrubland
CEGL001205	Salix geyeriana / Calamagrostis canadensis Shrubland	Geyer willow / Bluejoint reedgrass Shrubland
CEGL001206	Salix geyeriana / Carex aquatilis Shrubland	Geyer willow / Water sedge Shrubland
CEGL001207	Salix geyeriana / Carex utriculata Shrubland	Geyer willow / Beaked sedge Shrubland
CEGL002666	Salix geyeriana / Mesic forb Shrubland	Geyer willow / Mesic forb Shrubland
CEGL001218	Salix ligulifolia (=Salix eriocephala var. ligulifolia) Shrubland	Strapleaf willow Shrubland
CRWASALU1A	Salix lucida (ssp. caudata or ssp. lasiandra) Shrubland	Shining willow Shrubland
CEGL001222	Salix monticola / Calamagrostis canadensis Shrubland	Rocky Mountain willow / Bluejoint reedgrass Shrubland
CEGL002656	Salix monticola / Carex aquatilis Shrubland	Rocky Mountain willow / Water sedge Shrubland
CEGL002657	Salix monticola / Carex utriculata Shrubland	Mountain willow / Beaked sedge Shrubland
	Salix monticola / Equisetum arvense Shrubland	Mountain willow / Field horsetail Shrubland
CEGL002658	Salix monticola / Mesic Forb Shrubland	Mountain willow / Mesic forb Shrubland
CEGL002659	Salix monticola / Mesic Graminoid Shrubland	Mountain willow / Mesic graminoid Shrubland
CCNHPXXX26	Salix planifolia / Mesic forb Shrubland	Planeleaf willow / Mesic forb Shrubland

Riverine 3/4

CEGL000255	Abies concolor - (Picea pungens) - Populus angustifolia / Acer glabrum Forest	White fir - (Blue spruce) - Narrowleaf cottonwood / Rocky Mountain maple
CRFEXXXXX7	Abies lasiocarpa - Picea engelmannii - Populus angustifolia / Lonicera involucrata Forest	Subalpine fir - Engelmann spruce - Narrowleaf cottonwood / Twinberry honeysuckle Forest
CEGL000296	Abies lasiocarpa - Picea engelmannii / Alnus incana Forest	Subalpine fir - Engelmann spruce / Thinleaf alder Forest
CRFFPIEN0A	Abies lasiocarpa - Picea engelmannii / Equisetum arvense Forest	Subalpine fir - Engelmann spruce / Field horsetail Forest
CEGL002663	Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Forest	Subalpine fir - Engelmann spruce / Tall fringed bluebells Forest
CEGL000327	Abies lasiocarpa - Picea engelmannii / Salix drummondiana Forest	Subalpine fir - Engelmann spruce / Drummond willow Forest

Element Code	Scientific Name	Common Name
CWFDACNE2F	Acer negundo - Populus angustifolia / Celtis laevigata var. reticulata Forest	Boxelder - Narrowleaf cottonwood / Netleaf hackberry Forest
CEGL000627	Acer negundo - Populus angustifolia / Cornus sericea Forest	Boxelder - Narrowleaf cottonwood / Red-osier dogwood Forest
CEGL000936	Acer negundo / Betula occidentalis Woodland	Boxelder / Water birch Woodland
CEGL000625	Acer negundo / Cornus sericea Forest	Boxelder / Red-osier dogwood Forest
CEGL000628	Acer negundo / Prunus virginiana Forest	Boxelder / Chokecherry Forest
CEGL001145	Alnus incana ssp. tenuifolia - Cornus sericea Shrubland	Thinleaf alder - Red-osier dogwood Shrubland
CEGL002651	Alnus incana ssp. tenuifolia - Salix (monticola, lucida, ligulifolia) Shrubland	Thinleaf alder - Willow (Mountain willow, Shining willow, Strapleaf willow) Shrubland
CEGL002652	Alnus incana ssp. tenuifolia - Salix drummondiana Shrubland	Thinleaf alder - Drummond willow Shrubland
CEGL001146	Alnus incana ssp. tenuifolia / Equisetum arvense Shrubland	Thinleaf alder / Field horsetail Shrubland
CEGL001147	Alnus incana ssp. tenuifolia / Mesic forb Shrubland	Thinleaf alder / Mesic forb Shrubland
CEGL001148	Alnus incana ssp. tenuifolia / Mesic graminoid Shrubland	Thinleaf alder / Mesic graminoid Shrubland
CEGL001162	Betula occidentalis / Mesic forb Shrubland	Water birch / Mesic forb Shrubland
CEGL002654	Betula occidentalis / Mesic graminoid Shrubland	Water birch / Mesic graminoid Shrubland
CEGL002661	Carex vesicaria Herbaceous Vegetation	Blister sedge Herbaceous Vegetation
CEGL001085	Celtis laevigata var.reticulata Shrubland	Netleaf hackberry / Bluebunch wheatgrass Woodland
CEGL001165	Cornus sericea Shrubland	Red-osier dogwood Shrubland
CRSACRRI0A	Crataegus rivularis Shrubland	River hawthorn Shrubland
	Equisetum hyemale Herbaceous Vegetation	Scouringrush horsetail Herbaceous Vegetation
CEGL001168	Forestiera pubescens Shrubland	Wild-privet Shrubland
	Glycyrrhiza lepidota - Equisetum hyemale Herbaceous Vegetation	American licorice - Scouringrush horsetail Herbaceous Vegetation
CEGL001838	Juncus balticus var. montanus Herbaceous Vegetation	Mountain rush Herbaceous Vegetation
CEGL000746	Juniperus scopulorum / Cornus sericea Woodland	Rocky Mountain juniper / Red-osier dogwood Woodland
CEGL000894	Picea pungens / Alnus incana ssp. tenuifolia Woodland	Blue spruce / Thinleaf alder Woodland
CEGL000388	Picea pungens / Cornus sericea Woodland	Blue spruce / Red-osier dogwood Woodland
CEGL000389	Picea pungens / Equisetum arvense Woodland	Blue spruce / Field horsetail Woodland
CEGL002640	Populus angustifolia - Juniperus scopulorum Woodland	Narrowleaf cottonwood - Rocky Mountain juniper Woodland
CEGL002641	Populus angustifolia - Pseudotsuga menziesii Woodland	Narrowleaf cottonwood - Douglas-fir Woodland
CEGL002642	Populus angustifolia / Alnus incana ssp. tenuifolia Woodland	Narrowleaf cottonwood / Thinleaf alder Woodland
CEGL000648	Populus angustifolia / Betula occidentalis Woodland	Narrowleaf cottonwood / Water birch Woodland
CEGL002664	Populus angustifolia / Cornus sericea Woodland	Narrowleaf cottonwood / Red-osier dogwood Woodland
CEGL002644	Populus angustifolia / Crataegus rivularis Woodland	Narrowleaf cottonwood / River hawthorn Woodland
CEGL000651	Populus angustifolia / Prunus virginiana Woodland	Narrowleaf cottonwood / Chokecherry Woodland
CEGL000652	Populus angustifolia / Rhus trilobata Woodland	Narrowleaf cottonwood / Skunkbush sumac Woodland
CEGL002645	Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland	Narrowleaf cottonwood / Mixed willow (Mountain willow, Drummond willow, Shining willow) Woodland

Element Code	Scientific Name	Common Name
CEGL002646	Populus angustifolia / Salix drummondiana - Acer glabrum Woodland	Narrowleaf cottonwood / Drummond willow - Rocky Mountain maple Woodland
CEGL000654	Populus angustifolia / Salix exigua Woodland	Narrowleaf cottonwood / Sandbar willow Woodland
CEGL002647	Populus angustifolia / Salix irrorata Woodland	Narrowleaf cottonwood / Bluestem willow Woodland
CEGL000655	Populus angustifolia / Salix liguifolia (=Salix eriocephala ssp. ligulifolia) - Shepherdia argentea Woodland	Narrowleaf cottonwood / Strapleaf willow - Silver buffaloberry Woodland
CCNHPXXXX3	Populus angustifolia / Salix lucida ssp. caudata Woodland	Narrowleaf cottonwood / Whiplash willow Woodland
CEGL002648	Populus angustifolia / Symphoricarpos albus Woodland	Narrowleaf cottonwood / Common snowberry Woodland
CEGL002643	Populus angustifolia Sand Dune Forest	Narrowleaf cottonwood Sand Dune Forest
CRFAPOBA0A	Populus balsamifera Forest	Balsam poplar Forest
CEGL000659	Populus deltoides - (Salix amygdaloides) / Salix exigua Woodland	Plains cottonwood - (Peachleaf willow) / Sandbar willow Woodland
	Populus deltoides / Bromus inermis Woodland	Plains cottonwood / Smooth brome Woodland
CPFDPODE3G	Populus deltoides / Prunus virginiana Woodland	Plains cottonwood / Chokecherry Woodland
CEGL000940	Populus deltoides / Rhus trilobata Woodland	Plains cottonwood / Skunkbush sumac Woodland
CEGL000563	Populus tremuloides / Acer glabrum Forest	Quaking aspen / Rocky Mountain maple Forest
CEGL001150	Populus tremuloides / Alnus incana ssp. tenuifolia Forest	Quaking aspen / Thinleaf alder Forest
CEGL002650	Populus tremuloides / Betula occidentalis Forest	Quaking aspen / Water birch Forest
CEGL000582	Populus tremuloides / Cornus sericea Forest	Quaking aspen / Red-osier dogwood Forest
CEGL000583	Populus tremuloides / Corylus cornuta Forest	Quaking aspen / Beaked hazelnut Forest
CEGL000618	Populus tremuloides / Tall forb Forest	Quaking aspen / Tall forbs Forest
CEGL001108	Prunus virginiana - (Prunus americana) Shrubland	Chokecherry - (American plum) Shrubland
CEGL002639	Pseudotsuga menziesii / Betula occidentalis Woodland	Douglas-fir / Water birch Woodland
CEGL000899	Pseudotsuga menziesii / Cornus sericea Woodland	Douglas-fir / Red-osier dogwood Woodland
CEGL000462	Pseudotsuga menziesii / Symphoricarpos oreophilus Forest	Douglas-fir / Mountain snowberry Forest
CWSFRHTR0A	Rhus trilobata - (Salix exigua) Shrubland	Skunkbush sumac - Sandbar willow Shrubland
CEGL000947	Salix amygdaloides Woodland	Peachleaf willow Woodland
CEGL001173	Salix bebbiana Shrubland	Bebb willow Shrubland
CEGL001192	Salix drummondiana / Mesic forb Shrubland	Drummond willow / Mesic forb Shrubland
CEGL002655	Salix exigua - Salix liguifolia (=Salix eriocephala ssp. ligulifolia) Shrubland	Sandbar willow - Strapleaf willow Shrubland
CEGL001200	Salix exigua / Barren ground Shrubland	Sandbar willow / Barren ground Shrubland
CEGL001203	Salix exigua / Mesic graminoid Shrubland	Sandbar willow / Mesic graminoid Shrubland
CEGL002666	Salix geyeriana / Mesic forb Shrubland	Geyer willow / Mesic forb Shrubland
CEGL001218	Salix ligulifolia (=Salix eriocephala var. ligulifolia) Shrubland	Strapleaf willow Shrubland
CRWASALU1A	Salix lucida (ssp. caudata or ssp. lasiandra) Shrubland	Shining willow Shrubland
CEGL002658	Salix monticola / Mesic Forb Shrubland	Mountain willow / Mesic forb Shrubland
CEGL001128	Shepherdia argentea Shrubland	Silver buffaloberry Shrubland

Element Code	Scientific Name	Common Name
CEGL001685	Sporobolus airoides Southern Plains Herbaceous Vegetation	Alkali sacaton Southern Plains Herbaceous Vegetation
	Tamarix ramosissima Shrubland	Saltcedar Shrubland
Riverine 5		
CEGL001464	Andropogon gerardii - Sorghastrum nutans - (Spartina pectinata) Herbaceous Vegetation	Big bluestem - Yellow indiangrass - Prairie cordgrass Herbaceous Vegetation
	Carex emoryi Herbaceous Vegetation	Emory's sedge Herbaceous Vegetation
CEGL001809	Carex pellita (=lanuginosa) Herbaceous Vegetation	Woolly sedge Herbaceous Vegetation
CEGL001165	Cornus sericea Shrubland	Red-osier dogwood Shrubland
	Equisetum hyemale Herbaceous Vegetation	Scouringrush horsetail Herbaceous Vegetation
	Glycyrrhiza lepidota - Equisetum hyemale Herbaceous Vegetation	American licorice - Scouringrush horsetail Herbaceous Vegetation
CEGL001779	Muhlenbergia asperifolia Herbaceous Vegetation	Alkali muhly Herbaceous Vegetation
CEGL001475	Phragmites australis Herbaceous Vegetation	Common reed Herbaceous Vegetation
CEGL000651	Populus angustifolia / Prunus virginiana Woodland	Narrowleaf cottonwood / Chokecherry Woodland
CEGL000654	Populus angustifolia / Salix exigua Woodland	Narrowleaf cottonwood / Sandbar willow Woodland
CEGL000659	Populus deltoides - (Salix amygdaloides) / Salix exigua Woodland	Plains cottonwood - (Peachleaf willow) / Sandbar willow Woodland
CEGL002017	Populus deltoides - (Salix nigra) / Spartina pectinata - Carex spp. Woodland	Plains cottonwood - (Black willow) / Prairie cordgrass Woodland
	Populus deltoides / Bromus inermis Woodland	Plains cottonwood / Smooth brome Woodland
CEGL002649	Populus deltoides / Carex pellita (=lanuginosa) Woodland	Plains cottonwood / Woolly sedge Woodland
CEGL000939	Populus deltoides / Distichlis spicata Woodland	Plains cottonwood / Inland saltgrass Woodland
	Populus deltoides / Elymus trachycaulus Woodland	Plains cottonwood / Slender wheatgrass Woodland
	Populus deltoides / Forestiera pubescens Woodland	Plains cottonwood / Wild-privet Woodland
CEGL000678	Populus deltoides / Muhlenbergia asperifolia Forest	Plains cottonwood / Alkali muhly Forest
CEGL001454	Populus deltoides / Panicum virgatum - Schizachyrium scoparium Woodland	Plains cottonwood / Switchgrass - Little bluestem Woodland
CCNHPXXX19	Populus deltoides / Pascopyrum smithii - Panicum obtusum Woodland	Cottonwood / Western wheatgrass - Vine mesquite Woodland
CPFDPODE3G	Populus deltoides / Prunus virginiana Woodland	Plains cottonwood / Chokecherry Woodland
CEGL000940	Populus deltoides / Rhus trilobata Woodland	Plains cottonwood / Skunkbush sumac Woodland
CCNHPXXX16	Populus deltoides / Sporobolus airoides Woodland	Plains cottonwood / Alkali sacaton Woodland
CCNHPXXX17	Populus deltoides / Sporobolus compositus var. compositus Woodland	Plains cottonwood / Composite dropseed Woodland
CCNHPXXX18	Populus deltoides / Sporobolus cryptandrus Woodland	Cottonwood / Sand dropseed Woodland
CEGL000660	Populus deltoides / Symphoricarpos occidentalis Woodland	Plains cottonwood / Western snowberry Woodland
CEGL000947	Salix amygdaloides Woodland	Peachleaf willow Woodland
CEGL002655	Salix exigua - Salix liguifolia (=Salix eriocephala ssp. ligulifolia) Shrubland	Sandbar willow - Strapleaf willow Shrubland

Element Code	Scientific Name	Common Name
CEGL001200	Salix exigua / Barren ground Shrubland	Sandbar willow / Barren ground Shrubland
CEGL001203	Salix exigua / Mesic graminoid Shrubland	Sandbar willow / Mesic graminoid Shrubland
CEGL001476	Spartina pectinata Western Herbaceous Vegetation	Prairie cordgrass Western Herbaceous Vegetation
CEGL001685	Sporobolus airoides Southern Plains Herbaceous Vegetation	Alkali sacaton Southern Plains Herbaceous Vegetation
CEGL001131	Symphoricarpos occidentalis Shrubland	Western snowberry Shrubland
	Tamarix ramosissima Shrubland	Saltcedar Shrubland

Table 6. Undescribed associations which need more data.

Associations incorporated into the USNVC, but not described in this guide (these associations may be described from other states or in other sources):
Artemisia tridentata spp. / *Leymus cinereus* Shrubland *Betula occidentalis / Cornus sericea* Shrubland *Carex limosa* Herbaceous Vegetation *Carex nebrascensis - Catabrosa aquatica* Herbaceous Vegetation *Glyceria borealis* Herbaceous Vegetation *Panicum obtusum - Buchloe dactyloides* Herbaceous Vegetation *Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation *Pascopyrum smithii - Eleocharis spp.* Herbaceous Vegetation *Pascopyrum smithii* Herbaceous Vegetation *Picea engelmannii / Caltha leptosepala* Forest *Picea engelmannii / Cornus sericea* Woodland *Pinus ponderosa / Alnus incana* ssp. *tenuifolia* Woodland *Populus fremontii / Salix goodingii* Woodland *Populus tremuloides / Calamagrostis canadensis* Forest *Populus tremuloides / Salix drummondiana* Forest *Pseudotsuga menziesii / Acer glabrum* Forest *Quercus gambelii / Symphoricarpos oreophilus* Shrubland *Salicornia rubra* Herbaceous Vegetation *Salix boothii / Calamagrostis canadensis* Shrubland *Salix drummondiana / Carex utriculata* Shrubland *Salix planifolia / Deschampsia caespitosa* Shrubland *Sarcobatus vermiculatus / Suaeda moquinii* Shrubland
Associations not listed in the USNVC, needing further verification:
Acer negundo - Juniperus scopulorum/Salix exigua Woodland *Artemisia cana* Shrubland *Baccharis salicina* Shrubland *Bothriochloa springfieldii* Herbaceous Vegetation *Calamagrostis stricta* Western Herbaceous Vegetation *Carex scirpoidea* Herbaceous Vegetation *Catabrosa aquatica - Mimulus ssp.* Herbaceous Vegetation *Elaeagnus angustifolia* Woodland *Eleocharis quinqueflora - Triglochin spp.* Herbaceous Vegetation *Fraxinus anomala - Quercus gambelii* Shrubland *Heterotheca villosa* Herbaceous Vegetation *Hippurus vulgaris* Herbaceous Vegetation *Menyanthes trifoliata* Herbaceous Vegetation *Pascopyrum smithii - (Buchloe dactyloides) - Ambrosia linearis - Ratibida tagetes* Playa Herbaceous Vegetation *Populus* x *acuminata* Woodland *Populus angustifolia /* Mesic graminoid Woodland

Salix exigua / Eleocharis palustris Shrubland
Salix exigua / Equisetum hyemale Shrubland
Salix exigua / Schoenoplectus pungens Shrubland
Salix fragilis Woodland
Salix geyeriana - Salix monticola / Carex aquatilis Shrubland
Salix geyeriana - Salix monticola / Mesic graminoid Shrubland
Scirpus pallidus Herbaceous Vegetation
Sparganium eurycarpum Herbaceous Vegetation
Sporobolus airoides - Panicum obtusum Herbaceous Vegetation
Sullivantia hapemanii var. *purpusii* Hanging Garden

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APPENDIX A – DATA SOURCES

Two of the data sources below are compilations from the results of other studies. Therefore, the table lists both data sources, the original sources indented below the compiled source. Not all data of Cooper (Colorado Geologic Survey et al. 1998) was used in current analysis. For example, sampling units that did not have spatial coordinates and sampling units from Kittel's studies.

Source	**Location**
Cooper 1998 (n= 2376)	
Cooper 1986	Cross Creek Valley
Cooper 1987	E-470 Beltway - E of Denver
Cooper 1988	Boulder Valley and Bonny Reservoir
Cooper 1990	South Park
Cooper 1993	Crested Butte area
Cooper 1995	Telluride Mt. Village
Cooper 1995	Yampa River canyon, Green River - Lodore Canyon and Whirlpool Split
Cooper 1996	High Creek Fen, South Park
Cooper and Cottrell 1988	Rollinsville area
Cooper and Cottrell 1989	Cherry Creek - SE Denver
Cooper and Cottrell 1990	Northern CO Front Range
Cooper and Gilbert 1990	Telluride region
Cooper and Merritt 1996	Park Range, North Park
Cooper and Severn 1992	San Luis Valley
Komarkova 1979	Front Range alpine
McKee et al. 1995	Animas and La Plata rivers
Merritt 1996	Larimer County plains
Merritt 1997	Green River, Allen Bottom, Yampa River, Deer Lodge Park
Kittel et al. 1999a (n= 1925)	
Kettler and McMullen 1996	Routt National Forest
Kittel and Lederer 1993	San Miguel, Dolores, and Yampa river basins
Kittel et al. 1994	Colorado River basin and White River basin
Kittel et al. 1995	Gunnison River basin
Kittel et al. 1996	Arkansas River basin
Kittel et al. 1997	South Platte River basin
Kittel et al. 1999a	Lower San Juan River and North Platte River basins
Kittel et al. 1999b	Rio Grande and Closed basins, Rio Grande National Forest
Richard et al. 1996	San Juan National Forest
Sanderson and Kettler 1996 (n= 1/20)	Central Colorado West Slope
Hupalo 1999 unpublished[a] (n= 90)	East slope alpine and plains

a: Unpublished data collected in 1999 for this project, methods are documented below the data source listing.

Data Sources:

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APPENDIX B – HGM INDICATOR SPECIES

Listed are the ninety-nine common and diagnostic species delimited by Cooper (Colorado Geologic Survey et al. 1998, Figure 7) for each of 15 HGM subclasses. The subclasses are defined in Table 1 of the report.

SppID	Scientific Name	Common Name	HGM
AGRGIG	*Agrostis gigantea*	redtop	R4
ALNINC	*Alnus incana ssp. tenuifolia*	thinleaf alder	R3
ALOAEQ	*Alopecurus aequalis*	shortawn foxtail	D2
AMPNEV	*Scirpus nevadensis*	Nevada bulrush	F1
ARGANS	*Argentina anserina*	silverweed cinquefoil	S3
BECSYZ	*Beckmannia syzigachne*	American sloughgrass	D3
BOLMAR	*Schoenoplectus maritimus*	cosmopolitan bulrush	F1
BROINE	*Bromus inermis ssp. inermis var. inermis*	smooth brome	R4
CALCAN	*Calamagrostis canadensis*	bluejoint reedgrass	R1
CALSTR	*Calamagrostis stricta*	slimstem reedgrass	S3
CARAQU	*Carex aquatilis var. stans*	water sedge	S1
CARCOR	*Cardamine cordifolia*	heartleaf bittercress	R1
CAREMO	*Carex emoryi*	Emory's sedge	R5
CARLAN	*Carex pellita*	woolly sedge	R4
CARLIM	*Carex limosa*	mud sedge	D1
CARNEB	*Carex nebrascensis*	Nebraska sedge	S4
CARNIG	*Carex nigricans*	black alpine sedge	S1
CARSCO	*Carex scopulorum*	mountain sedge	S1
CARSIM	*Carex simulata*	analogue sedge	S2
CARUTR	*Carex utriculata*	beaked sedge	D1
CHERUB	*Chenopodium chenopodioides*	low goosefoot	D5
CHRLIN	*Chrysothamnus linifolius*	spearleaf rabbitbrush	R5
CORCOR	*Corylus cornuta*	beaked hazelnut	R4
CRIJUB	*Hordeum jubatum ssp. jubatum*	foxtail barley	R4
DESCES	*Deschampsia cespitosa*	tufted hairgrass	S3
DISSTR	*Distichlis spicata*	inland saltgrass	F1
ELEANG	*Elaeagnus angustifolia*	Russian olive	R5
ELEOBT	*Eleocharis engelmannii*	Engelmann spikerush	D4
ELEPAL	*Eleocharis palustris*	common spikerush	D3
ELEQUI	*Eleocharis quinqueflora*	fewflower spikerush	S2
ELEROS	*Eleocharis rostellata*	beaked spikerush	D4
EPICIL	*Epilobium ciliatum ssp. glandulosum*	fringed willowherb	D2
EQUARV	*Equisetum arvense*	field horsetail	R3
GEUMAC	*Geum macrophyllum var. perincisum*	largeleaf avens	R2
GLAMAR	*Glaux maritima*	sea milkwort	F1
GLYGRA	*Glyceria grandis*	American mannagrass	D2
GLYSTR	*Glyceria striata*	fowl mannagrass	R1
GNAULI	*Gnaphalium uliginosum*	marsh cudweed	D4
HERSPH	*Heracleum maximum*	common cowparsnip	R2
HIPVUL	*Hippuris vulgaris*	common mare's-tail	D1
JUNARC	*Juncus balticus var. montanus*	mountain rush	S3
JUNBUF	*Juncus bufonius*	toad rush	D4
JUNTOR	*Juncus torreyi*	Torrey's rush	R4
KOBMYO	*Kobresia myosuroides*	Bellardi bog sedge	S2
KOBSIM	*Kobresia simpliciuscula*	simple bog sedge	S2
LEMMIN	*Lemna minor*	common duckweed	D2
LOBSIP	*Lobelia siphilitica*	great blue lobelia	D3
LYCAME	*Lycopus americanus*	American water horehound	R5

SppID	Scientific Name	Common Name	HGM
MENTRI	*Menyanthes trifoliata*	buckbean	D1
MERCIL	*Mertensia ciliata*	tall fringed bluebells	R1
MIMGUT	*Mimulus guttatus*	seep monkeyflower	R1
NEGACE	*Acer negundo var. interius*	boxelder	R4
OXYFEN	*Oxypolis fendleri*	Fendler's cowbane	R1
PEDCRE	*Pedicularis crenulata*	meadow lousewort	S3
PEDGRO	*Pedicularis groenlandica*	elephanthead lousewort	S1
PENFLO	*Dasiphora floribunda*	shrubby cinquefoil	S3
PERLAP	*Polygonum lapathifolium*	curlytop knotweed	D4
PHAARU	*Phalaris arundinacea*	reed canarygrass	D3
PHRAUS	*Phragmites australis*	common reed	R5
PICPUN	*Picea pungens*	blue spruce	R3
POAPRA	*Poa pratensis*	Kentucky bluegrass	R3
POPANG	*Populus angustifolia*	narrowleaf cottonwood	R3
POPDEL	*Populus deltoides*	eastern cottonwood	R5
PSYLEP	*Caltha leptosepala ssp. leptosepala*	white marsh marigold	S1
PUCAIR	*Puccinellia nuttalliana*	Nuttall's alkaligrass	F1
RANREP	*Ranunculus flammula var. filiformis*	greater creeping spearwort	F1
RHUARO	*Rhus trilobata var. trilobata*	skunkbush sumac	R5
ROSWOO	*Rosa woodsii*	Woods' rose	R3
RUDAMP	*Rudbeckia laciniata var. ampla*	cutleaf coneflower	R3
SAGLAT	*Sagittaria latifolia*	broadleaf arrowhead	D2
SALAMY	*Salix amygdaloides*	peachleaf willow	R5
SALBOO	*Salix boothii*	Booth willow	R2
SALCAN	*Salix candida*	sageleaf willow	S2
SALEXI	*Salix exigua*	narrowleaf willow	R5
SALFRA	*Salix fragilis*	crack willow	R5
SALGEY	*Salix geyeriana*	Geyer willow	R2
SALIRR	*Salix irrorata*	dewystem willow	R4
SALLIG	*Salix ligulifolia*	strapleaf willow	R3
SALMON	*Salix monticola*	Rocky Mountain willow	R2
SALPLA	*Salix planifolia*	planeleaf willow	S1
SARVER	*Sarcobatus vermiculatus*	greasewood	F1
SCHLAC	*Schoenoplectus acutus var. acutus / tabernaemontani*	hardstem bulrush / softstem bulrush	D2
SCIPAL	*Scirpus pallidus*	cloaked bulrush	D2
SENTRI	*Senecio triangularis*	arrowleaf ragwort	S1
SPAEUR	*Sparganium eurycarpum*	broadfruit bur-reed	D2
SPAGRA	*Spartina gracilis*	alkali cordgrass	R5
SPAPEC	*Spartina pectinata*	prairie cordgrass	R5
SPEMED	*Spergularia maritima*	media sandspurry	F1
SPOAIR	*Sporobolus airoides*	alkali sacaton	F1
SUACAL	*Suaeda calceoliformis*	Pursh seepweed	F1
SWISER	*Cornus sericea ssp. sericea*	red-osier dogwood	R3
TAMRAM	*Tamarix ramosissima*	saltcedar	R5
THAALP	*Thalictrum alpinum*	alpine meadow-rue	S2
TRIMAR	*Triglochin maritimum*	seaside arrowgrass	S2
TRIPAL	*Triglochin palustre*	marsh arrowgrass	S2
TYPANG	*Typha angustifolia*	narrowleaf cattail	D2
TYPLAT	*Typha latifolia*	broadleaf cattail	D2
VITRIP	*Vitis riparia*	riverbank grape	R5
XANSTR	*Xanthium strumarium*	rough cockleburr	D5

APPENDIX C:
The Natural Heritage Network Ranking System

Just as ancient artifacts and historic buildings represent our cultural heritage, a diversity of plant and animal species and their habitats represent our "natural heritage." Colorado's natural heritage encompasses a wide variety of ecosystems from tallgrass prairie and shortgrass high plains to alpine cirques and rugged peaks, from canyon lands and sagebrush deserts to dense subalpine spruce-fir forests and wide-open tundra.

These widely diversified habitats are determined by water availability, temperature extremes, altitude, geologic history, and land use history. The species that inhabit each of these ecosystems have adapted to the specific set of conditions found there. But, because human influence today touches every part of the Colorado environment, we are responsible for understanding our impacts and carefully planning our actions to ensure our natural heritage persists for future generations.

Some generalist species, like house finches, have flourished over the last century, having adapted to habitats altered by humans. However, many other species are specialized to survive in vulnerable Colorado habitats; among them are Pikes Peak spring parsley (a wildflower), the Arkansas darter (a fish), and the Pawnee montane skipper (a butterfly). These species have special requirements for survival that may be threatened by incompatible land management practices and competition from non-native species. Many of these species have become imperiled not only in Colorado, but also throughout their range of distribution, some existing in fewer than five populations in the entire world. The decline of these specialized species often indicates disruptions that could permanently alter entire ecosystems. Thus, recognition of rare and imperiled species is crucial to preserving Colorado's diverse natural heritage.
Colorado is inhabited by some 800 vertebrate species and subspecies, and tens of thousands of invertebrate species. In addition, the state has approximately 4,300 species of plants and more than 450 recognized plant communities that represent terrestrial and wetland ecosystems. It is this rich natural heritage that has provided the basis for Colorado's diverse economy. Some components of this heritage have always been rare, while others have become imperiled with human-induced changes in the landscape. This decline in biological diversity is a global trend resulting from human population growth, land development, and subsequent habitat loss. Globally, the loss in species diversity has become so rapid and severe that Wilson (1988) has compared the phenomenon to the great natural catastrophes at the end of the Paleozoic and Mesozoic eras.

The need to address this loss in biological diversity has been recognized for decades in the scientific community. However, many conservation efforts made in this country were not based upon preserving biological diversity; instead, they primarily focused on preserving game animals, striking scenery, and locally favorite open spaces. To address the absence of a methodical, scientifically based approach to preserving biological diversity, Dr. Robert Jenkins of The Nature Conservancy pioneered the Natural Heritage Methodology in the early '70s. Recognizing that rare and imperiled species are more likely to become extinct than common ones, the Natural Heritage Methodology ranks species according to their rarity or degree of imperilment. The ranking system is scientifically based upon the number of known locations of the species as well as its biology and known threats. By ranking the relative rareness or imperilment of a species, the quality of its populations, and the importance of associated conservation sites, the methodology can facilitate the prioritization of conservation efforts so the most rare and imperiled species may be preserved first. As the scientific community began to realize that plant communities are as important as individual species, this methodology has also been applied to ranking and preserving rare plant communities, and the best examples of common communities.

The Natural Heritage Methodology is used by Natural Heritage Programs throughout North, Central, and South America, forming an international database network. The 85 Natural Heritage Network data centers are located in each of the 50 U.S. states, five provinces of Canada, and 13 countries in South and Central America and the Caribbean. This network enables scientists to monitor the status of species from a state, national, and global perspective. Information collected by the Natural Heritage Programs can provide a means to protect species before the need for legal endangerment status arises. It can also enable conservationists and natural resource managers to make informed, objective decisions in prioritizing and focusing conservation efforts.

What is Biological Diversity?

Protecting biological diversity has become an important management issue for many natural resource professionals. Biological diversity at its most basic level includes the full range of species on Earth, from single-celled species such as bacteria and protists through the multicellular kingdoms of plants and animals. At finer levels of organization, biological diversity includes the genetic variation within species, both among geographically separated populations and among individuals within a single population. On a wider scale, diversity includes variations in the biological communities in which species live, the ecosystems in which communities exist, and the interactions between these levels. All levels are necessary for the continued survival of species and plant communities, and all are important for the well being of humans. It stands to reason that biological diversity should be of concern to all people.

The biological diversity of an area can be described at four levels:

1. **Genetic Diversity** — the genetic variation within a population and among populations of a plant or animal species. The genetic makeup of a species varies between populations within its geographic range. Loss of a population results in a loss of genetic diversity for that species and a reduction of total biological diversity for the region. Once lost, this unique genetic information cannot be reclaimed.

2. **Species Diversity** — the total number and abundance of plant and animal species and subspecies in an area.

3. **Community Diversity** — the variety of plant communities within an area that represent the range of species relationships and inter-dependence. These communities may be diagnostic or even restricted to an area. It is within communities that all life dwells.

4. **Landscape Diversity** — the type, condition, pattern, and connectedness of natural communities. A landscape consisting of a mosaic of natural communities may contain one multifaceted ecosystem, such as a wetland ecosystem. A landscape also may contain several

distinct ecosystems, such as a riparian corridor meandering through shortgrass prairie. Fragmentation of landscapes, loss of connections and migratory corridors, and loss of natural communities all result in a loss of biological diversity for a region. Humans and the results of their activities are integral parts of most landscapes.

The conservation of biological diversity must include all levels of diversity: genetic, species, community, and landscape. Each level is dependent on the other levels and inextricably linked. In addition, and all too often omitted, humans are also closely linked to all levels of this hierarchy. We at the Colorado Natural Heritage Program believe that a healthy natural environment and a healthy human environment go hand in hand, and that recognition of the most imperiled species is an important step in comprehensive conservation planning.

Colorado's Natural Heritage Program

To place this document in context, it is useful to understand the history and functions of the Colorado Natural Heritage Program (CNHP).

CNHP is the state's primary comprehensive biological diversity data center, gathering information and field observations to help develop statewide conservation priorities. After operating in the Colorado Division of Parks and Outdoor Recreation for 14 years, the Program was relocated to the University of Colorado Museum in 1992, and to the College of Natural Resources at Colorado State University in 1994, where it has operated ever since.
The multi-disciplinary team of scientists, planners, and information managers at CNHP gathers comprehensive information on the rare, threatened, and endangered species and significant plant communities of Colorado. Life history, status, and locational data are incorporated into a continually updated data system. Sources include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and our own staff of botanists, ecologists, and zoologists.

The Biological and Conservation Data System (BCD), developed by The Nature Conservancy, is used by all natural heritage programs to house data about imperiled species. These data include taxonomic group, global and state rarity rank, federal and state legal status, observation source, observation date, county, township, range, watershed, and other relevant facts and observations. CNHP also uses the Biological Diversity Tracking System (BIOTICS) for digitizing and mapping occurrences of rare plants, animals, and plant communities. These rare species and plant communities are referred to as **elements of natural diversity** or simply **elements**.

Concentrating on site-specific data for each element enables CNHP to evaluate the significance of each location for the conservation of biological diversity in Colorado and in the nation. By using species imperilment ranks and quality ratings for each location, priorities can be established to guide conservation action. A continually updated locational database and priority-setting system such as that maintained by CNHP provides an effective, proactive land-planning tool.

To assist in biological diversity conservation efforts, CNHP scientists strive to answer questions such as:

- What species and ecological communities exist in the area of interest?

- Which are at greatest risk of extinction or are otherwise significant from a conservation perspective?
- What are their biological and ecological characteristics, and where precisely are these priority species or communities found?
- What is their condition at these locations, and what processes or activities are sustaining or threatening them?
- Where are the most important sites to protect?
- Who owns or manages those places deemed most important to protect, and what is threatening those places?
- What actions are needed for the protection of those sites and the significant elements of biological diversity they contain?
- How can we measure our progress toward conservation goals?

CNHP has effective working relationships with several state and federal agencies, including the Colorado Department of Natural Resources, the Colorado Division of Wildlife, the Bureau of Land Management, and the U.S. Forest Service. Numerous local governments and private entities, such as consulting firms, educators, landowners, county commissioners, and non-profit organizations, also work closely with CNHP. Use of the data by many different individuals and organizations encourages a proactive approach to conservation, thereby reducing the potential for conflict.

The Natural Heritage Ranking System

Key to the functioning of Natural Heritage Programs is the concept of setting priorities for information gathering and inventory. The number of possible facts and observations that can be gathered about the natural world is essentially limitless. The financial and human resources available to gather such information are not. Because biological inventories tend to be woefully underfunded, there is a premium on devising systems that are both effective in providing information that meets users' needs and efficient in gathering that information. The cornerstone of heritage inventories is the use of a ranking system to achieve these twin objectives of effectiveness and efficiency.

Ranking species and ecological communities according to their imperilment status provides guidance for where natural heritage programs should focus their information-gathering activities. For species deemed secure, only general information needs to be maintained by natural heritage programs. Fortunately, the more common and secure species constitute the majority of most groups of organisms. On the other hand, for those species that are by their nature rare or otherwise threatened, more detailed information is needed. Because of these species' very rarity, gathering comprehensive and detailed population data on them is possible, even if difficult. Gathering similarly comprehensive information on more abundant species would pose a far greater challenge.

To determine the status of species within Colorado, CNHP gathers information on plants, animals, and plant communities. Each of these elements of natural diversity is assigned a rank that indicates its relative degree of imperilment on a five-point scale (for example, 1 = extremely rare/imperiled, 5 = abundant/secure). The primary criterion for ranking elements is the number of occurrences (in other words, the number of known distinct localities or populations). This factor is weighted more heavily than other factors because an element found in one place is more imperiled than something found in twenty-one places. Also of importance is the size of the geographic range, the number of individuals, trends in population and distribution, identifiable threats, and the number of already protected occurrences.

Element imperilment ranks are assigned both in terms of the element's degree of imperilment within Colorado (its State or S-rank) and the element's imperilment over its entire range (its Global or G-rank). Taken together, these two ranks indicate the degree of imperilment of an element. For example, the lynx, which is thought to be secure in northern North America but is known from fewer than 5 current locations in Colorado, is ranked G5S1 (globally secure, but critically imperiled in this state). The Rocky Mountain Columbine (*Aquilegia saximontana*), which is known only in Colorado from about 30 locations, is ranked a G3S3 (vulnerable both in the state and globally, since it only occurs in Colorado and then in small numbers). Further, a tiger beetle that is only known from one location in the world at the Great Sand Dunes National Monument is ranked G1S1 (critically imperiled both in the state and globally, because it exists in a single location). CNHP actively collects, maps, and electronically processes specific occurrence information for animal and plant species considered from extremely imperiled to vulnerable in the state (S1 - S3). Several factors, such as rarity, evolutionary distinctiveness, and endemism (restrictiveness of habitat), contribute to the conservation priority of each species. Certain species are "watchlisted," meaning that specific occurrence data are collected and periodically analyzed to determine whether more active tracking is warranted. A complete description of each of the Natural Heritage ranks is provided in Table 2.

This single rank system works readily for all species except those that are migratory. Animals that migrate may spend only a portion of their life cycles within the state. In these cases, it is necessary to distinguish between breeding, non-breeding, and resident species. As noted in Table 2, ranks followed by a "B," for example S1B, indicate that the rank applies only to the status of breeding occurrences. Similarly, ranks followed by an "N," for example S4N, refer to non-breeding status, typically during migration and winter. Elements without this notation are believed to be year-round residents within the state.

Table C - 1. Definition of Natural Heritage Imperilment Ranks

Global imperilment ranks are based on the range-wide status of a species. State imperilment ranks are based on the status of a species in an individual state. State and Global ranks are denoted with an "S" or a "G" respectively, followed by a number or letter. **These ranks should not be interpreted as legal designations.**

G/S1	***Critically imperiled globally/state because of rarity (5 or fewer occurrences in the world/state; or 1,000 or fewer individuals), or because some factor of its biology makes it especially vulnerable to extinction.***
G/S2	***Imperiled globally/state because of rarity (6 to 20 occurrences, or 1,000 to 3,000 individuals), or because other factors demonstrably make it very vulnerable to extinction throughout its range.***
G/S3	***Vulnerable through its range or found locally in a restricted range (21 to 100 occurrences, or 3,000 to 10,000 individuals).***
G/S4	***Apparently secure globally/state, though it may be quite rare in parts of its range, especially at the periphery. Usually more than 100 occurrences and 10,000 individuals.***
G/S5	***Demonstrably secure globally/state, though it may be quite rare in parts of its range, especially at the periphery.***
G/SX	***Presumed extinct globally, or extirpated within the state.***
G#?	***Indicates uncertainty about an assigned global rank.***
G/SU	***Unable to assign rank due to lack of available information.***
GQ	***Indicates uncertainty about taxonomic status.***
G/SH	***Historically known, but usually not verified for an extended period of time.***
G#T#	***Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.***
S#B	***Refers to the breeding season imperilment of elements that are not permanent residents.***
S#N	***Refers to the non-breeding season imperilment of elements that are not permanent residents. Where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used.***
SZ	***Migrant whose occurrences are too irregular, transitory, and/or dispersed to be reliably identified, mapped, and protected.***
SA	***Accidental in the state.***
SR	***Reported to occur in the state but unverified.***
S?	***Unranked. Some evidence that species may be imperiled, but awaiting formal rarity ranking.***

Note: Where two numbers appear in a state or global rank (for example, S2S3), the rank of the element is unclear but likely within the stated range.

Legal Designations

Natural Heritage imperilment ranks should not be interpreted as legal designations. Although most species protected under state or federal endangered species laws are extremely rare, not all rare species receive legal protection. Legal status is designated by either the U.S. Fish and Wildlife Service under the Endangered Species Act or by the Colorado Division of Wildlife under Colorado Statutes 33-2-105 Article 2. In addition, the U.S. Forest Service recognizes some species as “Sensitive,” as does the Bureau of Land Management. Table 3 defines the special status assigned by these agencies and provides a key to abbreviations used by CNHP.

Candidate species for listing as endangered or threatened under the Endangered Species Act are indicated with a “C”. While obsolete legal status codes (Category 2 and 3) are no longer used, CNHP will continue to maintain them in its Biological and Conservation Data system for reference.

Table C-2. Federal and State Agency Special Designations.

Federal Status:
1. U.S. Fish and Wildlife Service (58 Federal Register 51147, 1993) and (61 Federal Register 7598, 1996)

LE	Listed Endangered: defined as a species, subspecies, or variety in danger of extinction throughout all or a significant portion of its range.
E(S/A)	Endangered: treated as endangered due to similarity of appearance with listed species.
LT	Listed Threatened: defined as a species, subspecies, or variety likely to become endangered in the foreseeable future throughout all or a significant portion of its range.
P	Proposed: taxa formally proposed for listing as Endangered or Threatened (a proposal has been published in the Federal Register, but not a final rule).
C	Candidate: taxa for which substantial biological information exists on file to support proposals to list them as endangered or threatened, but no proposal has been published yet in the Federal Register.

2. U.S. Forest Service (Forest Service Manual 2670.5) (noted by the Forest Service as "S")

FS	Sensitive: those plant and animal species identified by the Regional Forester for which population viability is a concern as evidenced by: • Significant current or predicted downward trends in population numbers or density. • Significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

3. Bureau of Land Management (BLM Manual 6840.06D) (noted by BLM as "S")

BLM	Sensitive: those species found on public lands, designated by a State Director, that could easily become endangered or extinct in a state. The protection provided for sensitive species is the same as that provided for C (candidate) species.

State Status:
The Colorado Division of Wildlife has developed categories of imperilment for nongame species (refer to the Colorado Division of Wildlife's Chapter 10 – Nongame Wildlife of the Wildlife Commission's regulations). The categories being used and the associated CNHP codes are provided below.

E	Endangered: those species or subspecies of native wildlife whose prospects for survival or recruitment within this state are in jeopardy, as determined by the Commission.
T	Threatened: those species or subspecies of native wildlife which, as determined by the Commission, are not in immediate jeopardy of extinction but are vulnerable because they exist in such small numbers, are so extremely restricted in their range, or are experiencing such low recruitment or survival that they may become extinct.
SC	Special Concern: those species or subspecies of native wildlife that have been removed from the state threatened or endangered list within the last five years; are proposed for federal listing (or are a federal listing "candidate species") and are not already state listed; have experienced, based on the best available data, a downward trend in numbers or distribution lasting at least five years that may lead to an endangered or threatened status; or are otherwise determined to be vulnerable in Colorado.

Element Occurrence Ranking

Actual locations of elements, whether they are single organisms, populations, or plant communities, are referred to as **element occurrences**. The element occurrence is considered the most fundamental unit of conservation interest and is at the heart of the Natural Heritage Methodology. To prioritize element occurrences for a given species, an element occurrence rank (EO-Rank) is assigned according to the ecological quality of the occurrences whenever sufficient information is available. This ranking system is designed to indicate which occurrences are the healthiest and ecologically the most viable, thus focusing conservation efforts where they will be most successful. The EO-Rank is based on three factors:

> Size – a measure of the area or abundance of the element's occurrence, relative to other known, and/or presumed viable, examples. Takes into account factors such as area of occupancy, population abundance, population density, population fluctuation, and minimum dynamic area (which is the area needed to ensure survival or re-establishment of an element after natural disturbance).
>
> Condition/Quality – an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence. This includes factors such as reproduction, age structure, biological composition (such as the presence of exotic versus native species), structure (for example, canopy, understory, and ground cover in a forest community), and biotic interactions (such as levels of competition, predation, and disease).
>
> Landscape Context – an integrated measure of two factors: the dominant environmental regimes and processes that establish and maintain the element, and connectivity. *Dominant environmental regimes and processes* include herbivory, hydrologic and water chemistry regimes (surface and groundwater), geomorphic processes, climatic regimes (temperature and precipitation), fire regimes, and many kinds of natural disturbances. *Connectivity* includes such factors as a species having access to habitats and resources needed for life cycle completion, fragmentation of ecological communities and systems, and the ability of the species to respond to environmental change through dispersal, migration, or re-colonization.

Each of these factors is rated on a scale of A through D, with A representing an excellent grade and D representing a poor grade. These grades are then averaged to determine an appropriate EO-Rank for the occurrence. If not enough information is available to rank an element occurrence, an EO-Rank of E is assigned. EO-Ranks and their definitions are as follows:

EO Rank	Description
A	excellent estimated viability
B	good estimated viability
C	fair estimated viability
D	poor estimated viability
E	verified extant (viability not assessed)
H	historical
F	failed to find
X	extirpated